The Great Lakes basin holds the world's largest supply of surface freshwater and is home to over 35 million people. Climate change is predicted to have major impacts on the natural resources of this system, which will exacerbate existing problems and create new challenges. This series of policy briefs explores several impacts of climate change and emphasizes the need for responsible stewardship of our vital water resources.

Climate Change Impacts on Energy in the Great Lakes Basin

The Great Lakes basin produces a large amount of energy. In 2011, the basin contained 583 power-generating facilities capable of producing nearly 670,000 MW of electricity, which is enough energy to power about 45 million homes (GLC 2011). Most of that power comes from coal-fired power plants, which produce 39.4 percent of the basin's electricity. Natural gas, nuclear power, and hydropower produce 28.9, 16, and 9.1 percent of the region's power, respectively. The average power plant in the Great Lakes basin is 41 years old, with ages ranging from 1-109 years old.

This level of energy production requires vast amounts of water (Figures 1 & 2). Coal-powered thermoelectric plants are the largest water users, withdrawing 15,924 million gallons per day (MGD) and consuming 160 MGD (GLC 2011). Nuclear power plants are the next largest users, withdrawing 7,638 MGD and consuming 227 MGD. Plants generating power from natural gas, oil, and renewable sources withdraw another combined 1,435 MGD from the basin. Overall, the energy sector in the Great Lakes basin is highly reliant on the system's freshwater resources.

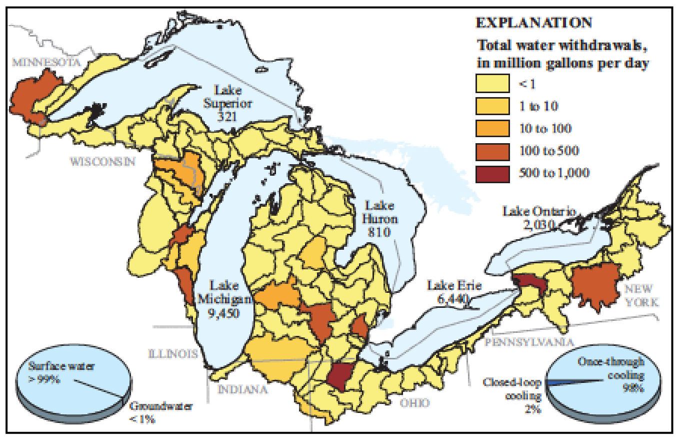

Figure 1. Energy sector water withdrawal rates in U.S. Great Lakes states. Source: Mills & Sharpe 2010.

Impacts of Climate Change

Climate change is predicted to have a variety of effects on water resources in the Great Lakes basin. General circulation models (GCMs) predict changes in several climate parameters that will affect water quality and quantity. By 2090, air temperature is predicted to increase 1-7°C, which will drive warmer water temperatures (Lofgren *et al.* 2002, Gregg et al. 2012). Evaporation rates are expected to increase 16-39 percent by 2090 (Lofgren *et al.* 2002), due largely to an annual winter ice cover that has decreased by 71 percent since 1973 (Gregg *et al.* 2012). Higher evaporation rates will likely drive down lake levels, with some models estimating a decrease of as much as 2.5 meters by 2090 (Lofgren *et al.* 2002). Climate change will also alter weather patterns in the Great Lakes basin. Occurrences of extreme weather events, such as intense storms and prolonged droughts, are expected to increase, but predicted trends in overall precipitation are more ambiguous, with GCM predictions ranging from a 20 percent increase to a 9 percent decrease (Lofgren *et al.* 2002).

Several of these climate change effects will have negative impacts on the energy sector. First, warmer intake water will reduce the cooling efficiency of thermopower plants, thus inhibiting their capacity to generate power safely. In July 2006, the Cook Nuclear Plant in Michigan was shut down due to high-temperature intake waters caused by an intense heat wave (Krier 2012). Conditions inside the containment building became too warm to accomplish daily tasks and the plant remained closed for 5 days until air and water temperatures decreased to viable levels. Warmer intake water also leads to warmer discharge water, which can pose a threat to the surrounding environment. Power plants will increasingly find themselves in noncompliance with heat discharge permits issued by state authorities. Already, there have been a handful of cases where the Illinois Environmental Protection Agency (IEPA) has had to make exceptions and allow power plants to discharge water at higher temperatures than their permits allow due to the high temperatures of intake water (Meyer & Wernau 2012).

Lower lake levels and prolonged periods of drought will also reduce the quantity of water available for energy production. In the case of thermopower plants, inadequate intake water means a reduction in cooling efficiency and a subsequent reduction in power generation capacity. For hydropower plants, inadequate intake water directly reduces power generation. Michigan's Cloverland Electric Cooperative experienced a 60-80 percent decrease in energy output from its Sault Sainte Marie hydropower plant in 2012 (Kowalski 2013). The plant withdraws its water from a canal near Ashmum Bay, which, like the rest of Lake Superior, was experiencing record-low water levels. A temporary fix that involved lowering 2,000 concrete blocks into the bay to raise water levels cost the utility approximately $300,000.

Finally, an increased storm activity in the Great Lakes basin may damage energy infrastructure, thereby decreasing energy capacity. Coastal power plants are susceptible to increased wave action and shoreline erosion. An aging system of transmission lines will not be able to withstand more intense storm activity. Wind turbines may experience wind conditions outside of their safe operating limits. Overall, existing energy infrastructure will have to adapt to maintain current capacity in coming decades under such intense weather conditions.

Policies Moving Forward

Great Lakes policymakers must focus on several key areas in order to address the impacts of climate change on the energy sector. The first is to promote water-efficient power plant technology. The majority of existing thermoelectric power plants use an open-cycle cooling system that requires the withdrawal of large amounts of water. Power plants equipped with an alternative closed-cycle cooling system withdraw 97-99 percent less water, yet produce comparable amounts of energy (GLC 2011). Adopting such technology would vastly reduce the amount of intake water needed for cooling and the amount of high-temperature water discharged into the environment.

Another way policymakers can blunt the impact of climate change is by increasing the resilience of energy infrastructure throughout the basin. A higher frequency of intense storms will likely cause extensive damage to the existing facilities and equipment that produce and transmit electricity. Policymakers should concentrate efforts on reinforcing coastal energy facilities, hardening transmission lines, and expanding the safe operating limits of energy production equipment, such as wind turbines.

Furthermore, policymakers can reduce the impact of climate change by reducing overall energy demand in the basin. Policy that promotes industrial, municipal, and individual energy conservation and efficiency would greatly reduce the growing strain on energy capacity in the basin. While programs addressing this issue exist in many Great Lakes states and provinces, increasing demand from a growing population requires a redoubling of efforts to meet the future energy needs of the basin.

Finally, policymakers must limit the amount of water withdrawn from the basin in order to maintain lake levels. The Great Lakes Compact, which was signed in 2008 and is a binding interstate compact between the 8 U.S. Great Lakes states, prohibits the withdrawal of water by cities and counties outside of the Great Lakes basin (WDNR 2013). While this prohibition is currently helping to maintain lake levels, future challenges to the Compact may ease withdrawal restrictions, allowing diversions to carry water out of the basin. Policymakers must uphold and strengthen the Compact's restrictions to avoid direct human-caused decreases in lake levels.

Fuel Type	Great Lakes	Groundwater	Other Surface Water
Coal	11556	405	3963
Nuclear	7638	0	0
Oil	267	0.4	0
Gas	670	2	181
Renewables	5	215	95

Figure 2. Daily water withdrawal rates, in millions of gallons per day (MGD), of thermoelectric power plants in the Great Lakes basin. Source: GLC 2011.

In conclusion, energy and water in the Great Lakes basin have a close-knit relationship that will be negatively impacted by climate change. In the coming decades, increased water temperatures, lower lake levels, and a higher frequency of intense weather events will likely lower power plant efficiency and damage existing energy infrastructure. Policymakers must address these challenge by promoting initiatives and regulations that increase power plant efficiency, increase infrastructure resilience, decrease overall energy demand, and decrease water diversions from the basin.

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