Assessing the Impact of Exceptional Drought on Emissions and ElectricityGeneration:The Case ofTexas

Jamal Mamkhezri[a] *and Gregory L. Torell*[b]

Electricity sales in Texas spiked during a prolonged heat wave and subsequent severe drought in the summer of 2011, and electricity prices increased across the state. The highest system-wide hourly peak demand to that point occurred in August of 2011, reaching 68,305 MW. During this time, at least one plant curtailed night-time operations, several plants switched from their normal sources of water to alternate sources or added new pumps to reach existing sources, and operators prepared emergency plans to enact demand management and bring mothballed plants online. Though the increase in electricity prices was caused in part by increased demand for air conditioning, some of the increase in prices could also be explained by drought-induced shifts in plant availability or increased costs of obtaining sufficient cooling water supplies. The simultaneous supply and demand shocks led to extremely high prices, increased electricity demands, and increased water demands.

Drought frequency and severity is forecasted to increase in the coming decades. While projections of precipitation show little change most of the world, projections of atmospheric demand for moisture show an increase in land surface in drought from 5-45%. Prolonged periods of drought are particularly threatening to the thermoelectric power sector, which is reliant on large water withdrawals for cooling. Texas provides an ideal setting to investigate how the electricity market responds to exceptional drought conditions. The state of Texas has a single, rather isolated, and integrated electricity market which reports generator-level offer prices and quantities at a sub-hourly frequency. The Texas electricity sector is water-intensive, accounting for nearly half of all water withdrawals in Texas. Importantly, the state has a variety of climatic regions. From 2010 through 2017, all but two counties experienced exceptional drought conditions and all counties experienced some level of non-exceptional drought conditions. This variation in exceptional drought conditions is essential to identifying the effect of water scarcity on the electricity supply and, subsequently, on emissions, making Texas an ideal case study.

The effects of water scarcity on power plant cooling and emissions are widely addressed in the engineering and climate science literature, as well as in the energy economics literature. The consensus of these literatures is that during drought episodes, electricity demand (especially in the residential sector), transmission losses, and congestion increase, leading to a need for a greatergeneration. The fuel portfolio that provides electricity to meet the excess demand, which varies region to region, impacts the electricity price and quantity, and subsequently, the emitted emissions. Previous studies find that drought increases net emissions during drought periods, while few researchers find the opposing effect can hold for certain regions. We build on this literature and add to this body of ongoing research by empirically assessing the effect of exceptional drought‡ on electricity grid outcomes in the Electricity Reliability Council of Texas (ERCOT) region.

The objective of this paper is to test whether exceptional drought conditions have a significant effect on electricity price and quantity offerings of electricity plants for the years 2010–2017

a Corresponding author: Department of Economics, Applied Statistics, and International Business, New Mexico State University. E-mail: jamalm@nmsu.edu.

b Agricultural Economics and Agricultural Business, New Mexico State University. E-mail: gtorell@nmsu.edu.

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using intra-hourly ERCOT data. We further estimate the effect of exceptional drought[a] on emissions intensity of electricity production during that period. We find that the effect of exceptional drought on electricity supply varies with the generator's cooling technology type. Generators with water-intensive cooling technologies respond to exceptional drought conditions by raising their average offer prices. However, generators that use dry cooling technologies do not raise offer prices but increase the total quantity offer during exceptional drought periods. These offer price changes lead to lower emissions plants being dispatched during exceptional droughts in ERCOT, resulting in an overall reduction of emissions during our study period. We contribute to this literature by utilizing more granular level and updated data, intra-hourly price and quantity data, and estimate the impact of exceptional drought on the electricity market and emissions in Texas interconnection from 2010–2017 and find results that contradict existing understandings. Another contribution of this paper is that we focus on individual supply curves in the form of generation unit offers to avoid the potential endogeneity problems associated with the joint determination of market quantities and prices.

These results have important implications for state-level electricity regulators. Increasingly frequent and severe droughts could reduce output and raise prices offered by generators using water-intensive cooling technologies. Regulators charged with promoting market stability should take into account climate change projections regarding drought when formulating rules for cooling technology.Both water-intensive and dry cooling technologies are needed to efficiently supply the market during normal periods and prolonged, exceptional droughts. Our results add understanding to the impacts of exceptional drought on the electricity sector; if exceptional drought has significant effects on electricity prices and electricity grid outcomes, public policy towards electricity markets and drought management will need to be aware of these effects as it can have an impact on the risk of grid failure (brownouts or blackouts) and private and social welfare. Understanding the effect of drought on electric generation, and the resilience of the electric sector to water scarcity, will be important in a variety of policy contexts.

a Our exceptional drought measure is a measure of the percent of each county experiencing exceptional drought, where zero indicates no exceptional drought in a county, and 100% indicates the entire county experiencing exceptional drought.