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The Texas 2021 cold spell in a climate-power system perspective

Katharina Gruber¹, Tobias Gauster², Luis Ramirez-Camargo^{3,4}, Gregor Laaha², and Johannes Schmidt¹

¹Institute for Sustainable Economic Development, University of Natural Resources and Life Sciences, Vienna

²Institute of Statistics, University of Natural Resources and Life Sciences, Vienna

³Electric Vehicle and Energy Research Group (EVERGI), Mobility, Logistics and Automotive Technology Research Centre (MOBI), Department of Electrical Engineering and Energy Technology, Vrije Universiteit Brussel, Brussels, Belgium

⁴Flanders Make, 3001 Heverlee, Belgium

Between February 15th and 16th 2021 a cold spell reached Texas, causing large-scale rolling blackouts in the Texan power system. These were driven in part by a significant increase in electricity demand for heating, and in part by the loss of power generation capacity in the system.

We use (i) ERA-5 temperatures weighted according to population to predict load, (ii) temperatures weighted according to power plant locations, and (iii) temperatures weighted according to Texas gas fields, together with (iv) data on outages of gas and coal power plants, to (a) study the event in February, and (b) estimate the severity of this event based on seven decades of data (1950-2021). To characterise the power demand, we used population weighted temperature and time variables as surrogates.

We find that the February of 2021 event was a very cold year compared to other winters in the period of 2004-2020, from which we use observations of load on the electricity network. There were, however, colder events before 2004. Predicted electricity demand was higher than in any other winter in our simulation, although deeper temperatures were observed before. This is due to the particular timing of temperature fluctuations, with cold episodes coinciding with daily and weekly demand patterns in an unfortunate way. Predicted demand in February 2021 was, however, never higher than the highest observed load during hot hours in summer.

From synoptic signal analysis, we further estimate that a catastrophic failure of gas power plants occurred at temperatures below -7.3°C , and of coal power plants at -9.2°C . However, lower temperatures before 2004 did not cause any catastrophic failures. In contrast, the problems at gas power plants started when the gas field output weighted temperature fell to -10.2°C . This is a temperature never observed since 2004, indicating that the reason for outage may be related to gas and not power production. In the period since 1950-2003, temperatures as low or lower have been observed. However, the 2021 event is exceptional in terms of how long temperatures were below 0°C before the system failed.

Wind power plants also failed to operate due to icing conditions. This seems to be, however, a very rare event. We did not find any other significant difference in wind power generation simulated

from ERA5 wind data to observed wind generation in Texas in the period 2016-2019 under freezing conditions. This also points to very special conditions in the 2021 winter event. We find however, that in lower temperatures, capacity factors of the installed wind park tend to decrease.