Testimony of
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Before
North Dakota Legislative Branch
House Finance and Taxation Public Hearing
On
Grants For Grid Reliability and Resiliency

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Good morning. Thank you for the opportunity to testify. I'm a Senior Fellow at the Manhattan Institute where I focus on science, technology, and energy issues. I am also a Faculty Fellow at the McCormick School of Engineering at Northwestern University where the focus is on future manufacturing technologies. And, for the record, I'm a strategic partner in a venture fund focused on software startups in energy tech.

Since this hearing is concerned with ensuring the future reliability of electric grids, permit me to begin with an observation from one of the 20th century's most notable futurists, the late Arthur C. Clarke.

On the first year of the 21st century, the National Academy of Sciences published a list of the most important inventions of the previous 100 years: Number one was the electric grid. In the afterword, Clarke wrote about how easy it is for us to take historical accomplishments "so completely for granted" and that the "harnessing and taming of electricity, first for communications and then for power, is the event that divides our age from all those that have gone before."

Until the modern era, economic and social progress had been hobbled by the episodic nature of energy availability. In our data-centric, increasingly electrified society, always-available power is more vital than ever. That's why more than 90% of America's electricity, comes from sources that can operate whenever needed.

For hydrocarbon-based systems in particular, availability is achieved by storing fuel. On average, energy and electricity supply chains store about one to two *months'* worth of demand at any given time.[1] And it costs less than $1 a barrel to store oil or natural gas (the latter in oil-equivalent terms) for a couple of months.[2] Storing coal is even cheaper.

Since hydrocarbons are so easily and inexpensively stored, idle or under-utilized power plants can be dispatched—ramped up and down—to follow cyclical demand for electricity. Wind turbines and solar arrays, of course, cannot be dispatched when there's no wind or sun. And worse, as a matter of geophysics, such machines produce energy, averaged over a year, only about 25%–30% of the time, often less.[3]

At low levels of market penetration, the variability of wind can be compensated for by—and at the expense of—conventional power plants. This has been the option pursued in Germany, for example, where that nation has literally built two complete electric grids by

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[1] EIA, "Natural Gas Storage Dashboard"; "Crude Oil and Petroleum Products"; "Coal Stockpiles at U.S. Coal Power Plants Have Fallen Since Last Year," Nov. 9, 2017.

[2] "Why Too Much Oil in Storage Is Weighing on Prices," *Economist*, Mar. 16, 2017; Nathalie Hinchey, "Estimating Natural Gas Salt Cavern Storage Costs," Center for Energy Studies, Rice University, 2018.

[3] Landon Stevens, "The Footprint of Energy: Land Use of U.S. Electricity Production," Strata, June 2017.

keeping most of its legacy hydrocarbon-powered grid as backup. That has obvious and significant cost implications. The other option increasingly proposed is to use batteries. But rather than about $1 to store a barrel's worth of energy, today's batteries cost roughly $200 to store that quantity in equivalent terms.[4]

Even that understates the real costs of storing wind energy because one also needs to build excess capacity to meet both peak demand *and* have enough extra to have a surplus to store for later. This means, on average, a pure wind/solar system would necessarily have to be about twofold to threefold bigger than the capacity of a hydrocarbon grid it would replace. That translates directly into an enormous cost penalty, even if the per-kW costs were all comparable.[5]

So far, the consequences of having a small share percent of America's electricity supplied by variable power has been compensated for by the availability of conventional generation. That cover evaporates as the share of variable power rises and as 'free' backup from power plants in neighboring states disappear as they too pursue the same path.

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[4] Lazard, "Lazard's Levelized Cost of Energy Analysis"; utility-scale lithium battery LCOE @ $108–$140/MWh converts to $180–$230/BOE (barrel of oil energy equivalent).

[5] Stephen Brick and Samuel Thernstrom, "Renewables and Decarbonization: Studies of California, Wisconsin, and Germany," *Electricity Journal* 29, no. 3 (April 2016): 6–12.