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Residential- and commercial-scale distributed wind energy in North Dakota, USA

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ABSTRACT

We use one year of hourly wind speed measurements at 14 sites across North Dakota to evaluate how both residential- and commercial-scale (utility-scale) wind turbines can help to meet electricity needs within the state. Data are available from April 2004 through March 2005, a period with slightly lower mean wind speeds as compared to a long-term climatology; thus our calculations represent a conservative estimate of wind power for these sites. We assume the wind patterns at each site are representative of the county as a whole and, using capacity factors of 20% (residential) and 35% (commercial), we estimate the amount of electricity that can be generated for the county and compare it to county-based estimates of electricity usage. Our results show that a residential-scale turbine could provide between 90% and 165% of annual net per-person electricity usage in these 14 counties, depending on the wind speed. In addition, for the counties with the smallest populations, only six commercial-scale turbines are needed to meet the net annual county electricity usage; the most populous county would require up to 69 turbines. An evaluation of month-to-month electricity supply and demand showed that between 9% and 20% (13% and 29%) of monthly electricity needs for a county with low (high) average wind speeds could be met if 30% of the county's households had a residential-scale turbine. Our results show that residential-scale turbines have the potential to contribute meaningfully to a distributed-generation wind energy landscape.

1. Introduction

Wind power is expected to be an important source of renewable energy in the United States [1]. Much of the wind resource in the U.S. is located in less populated areas far from large load centers [2] and in many cases transmission capacity has been a significant constraint in delivering wind power to more populated regions [1]. As a result there is interest in the potential for smaller, distributed wind energy installations that may reduce the need for extensive (and expensive) long-distance, high-voltage transmission lines [3]. Distributed wind generation also has the benefit of reducing the inherent variability of wind speeds, resulting in a more predictable pattern of energy generation [4–6].

North Dakota is estimated to have a wind resource equivalent to 1.2 trillion kWh annually [7], the greatest in the United States (Fig. 1); however, the state has few large load centers and there are constraints on long-distance transmission to more distant load centers [3]. In this paper we investigate the potential for distributed wind energy – both commercial- and residential-scale – to be a local source of electricity for sparsely populated North Dakota. Distributed generation can help to overcome long-distance infrastructure challenges and is implemented at a scale commensurate with existing economic and political structures (townships, counties). Wind energy in North Dakota also would reduce the state's reliance on coal, which supplies 93% of the state's energy usage [9].

Our research uses one year of wind speed data from 14 sites in North Dakota (Fig. 2 and Table 1) to calculate the amount of energy that could be generated by residential- and commercial-scale wind turbines. We also estimate the electricity usage for the counties in which each site is located to evaluate the potential for distributed turbines, of either or both types, to serve as a local source of energy for county residents. Scenarios including both commercial- and residential-scale turbines suggest the possibilities for wind energy generation to meet the electricity demand in sparsely populated North Dakota.

2. Data and methodology

2.1. Wind speed data

We use wind speed measurements from 14 sites across North Dakota that cover the period 1 April 2004 to 31 March 2005. These

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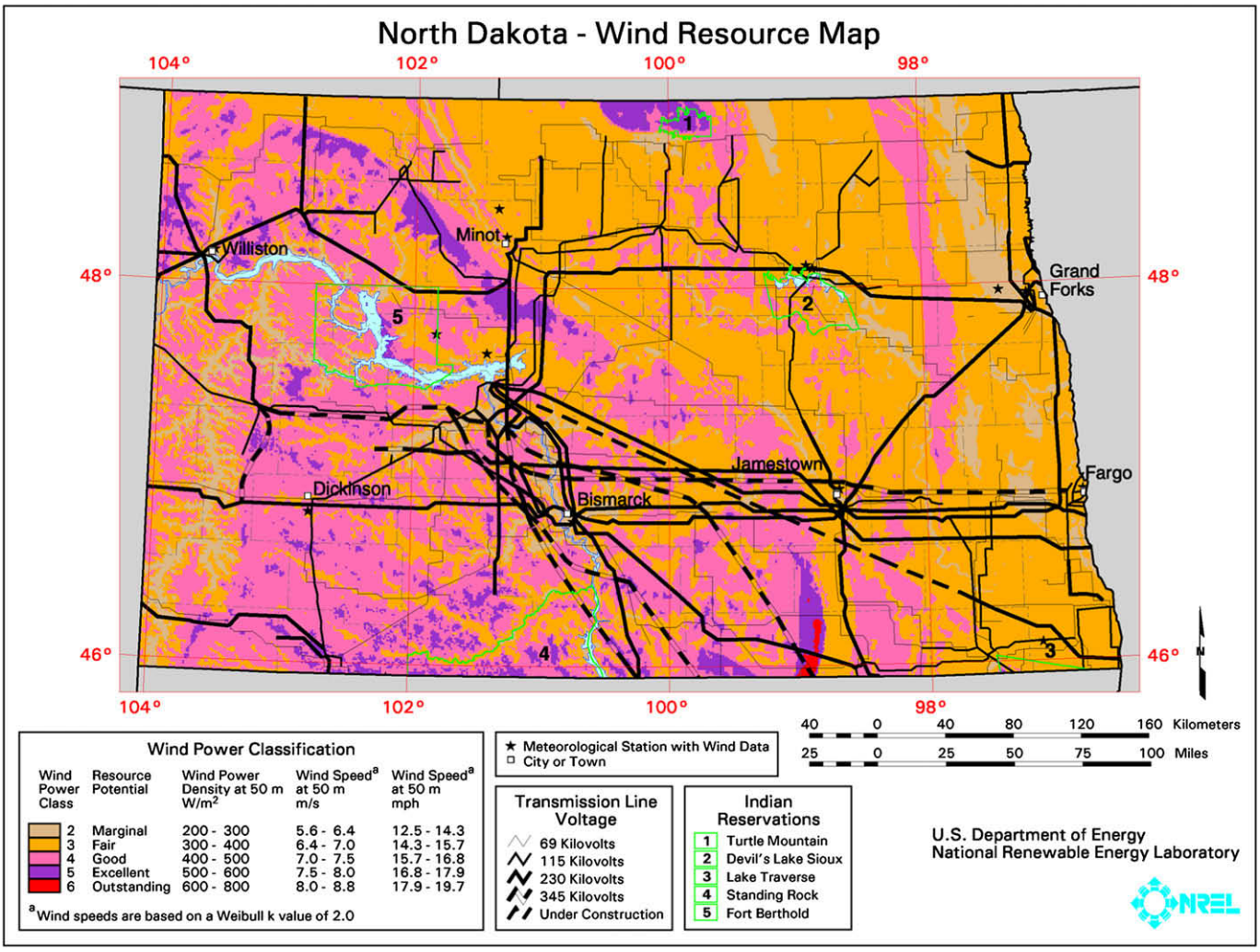

Fig. 1. Wind power map of North Dakota (Source: [8]).

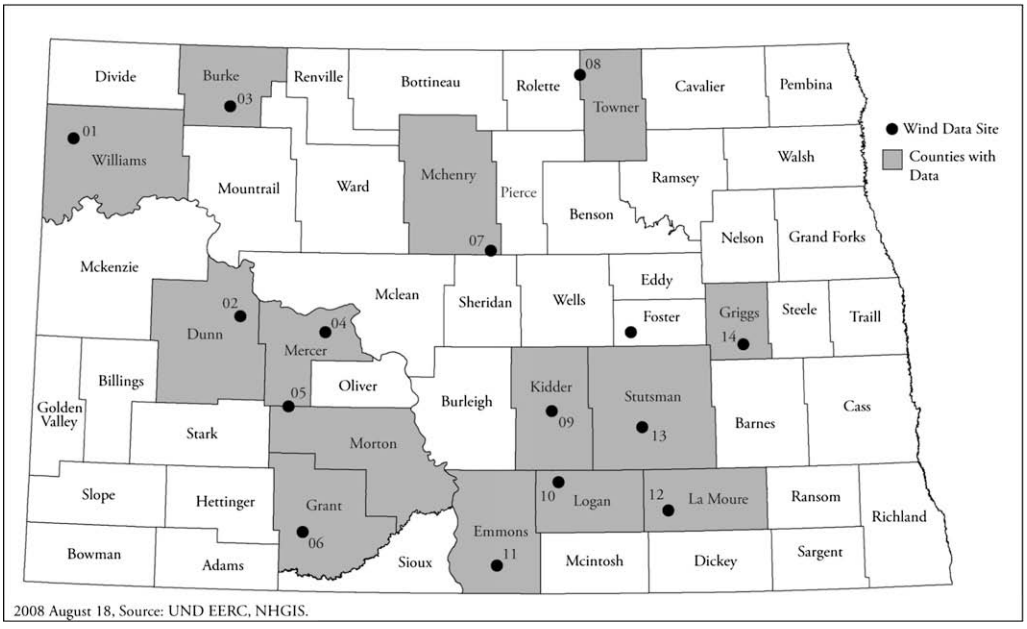

Fig. 2. Wind speeds sites in North Dakota. Sites are described in Table 1.