Identifying Gaps in Meteorology Knowledge Required to Further Develop Wind Energy

Sue Ellen Haupt[1]

1. National Center for Atmospheric Research, Boulder, COLORADO, United States

In recent years, much progress has been made in leveraging meteorological knowledge to enable deployment and efficient operation of wind energy. Yet, more work is needed to further optimize our use of the wind resource. Several international initiatives are underway to identify gaps in knowledge and suggest research directions needed to fill those gaps with a goal to enable wind energy to become the backbone of a carbon neutral energy system.

International Energy Agency (IEA) Task #109 has convened a Technical Expert Meeting (TEM) on Grand Challenges in Wind Energy in Boulder, CO, US in February and March 2023. This meeting gathered a cadre of international experts on wind energy and focused on five major topics of research: 1) the atmosphere, including wind resources, atmospheric science, and the physics of air flow at wind farms; 2) the turbine, meaning system dynamics and materials involved in wind turbines and wind farm technology; 3) the plant and grid, which requires optimization and control of wind farm operation and maintenance for reliability and resiliency; 4) environmental co-design needed to situate wind farms under local constraints and opportunities; and 5) social impacts and issues that leverage social science to identify how wind plants can add value to host communities. The experts discussed how each major issue impacts the potential cost and value as well as deployment and considered the important linkages between the major topics to make a series of recommendations.

A second initiative is sponsored by the US Department of Energy Wind Energy Technology Office (DOE WETO) to identify research needed to advance offshore wind deployment. The US has a goal to deploy 30 GW of offshore wind by 2030 with a ramp up to 110 GW by 2050. To do that requires substantial research in the offshore environment of the US, including some features unique to the US east and west coasts. Led by a verification and validation project team, this project built a series of Phenomena Identification and Ranking Tables (PIRTs) for categories including 1) Mesoscale-Atmospheric Boundary Layer (ABLE-Farm/farm interaction, 2) ABL-Turbine-Wake interactions, 3) Water/hydrodynamics issues, and 4) Soil-structure research needed. The PIRTs were developed via a series of meetings, which culminated in an in-person meeting in Boulder, CO in late February. The goal of this effort was to define the long-term needs of offshore wind energy computational modeling validation. The focus of these meetings was to identify and prioritize critical phenomena required for offshore wind plant modeling needs. These prioritized phenomena will be used to identify validation experiments that require future funding as well as investments that are needed to enable such experiments, such as data analysis approaches and instrumentation development.

This talk will review the outcome of these initiatives and discuss the integrated research needs, focusing on the atmospheric science portions. It is expected that the results of this series of meetings will determine research directions to further deploy wind power and to integrate it into the energy system of the future.