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National Center for Atmospheric Research
Position Statement to National Science Foundation
2013 National Workshop on Energy Cyber-Physical Systems

The National Center for Atmospheric Research is pleased to present its position on fundamental issues and enabling strategic approaches to achieve future cyber-controlled energy infrastructures. In particular, we would like to address the importance of the various ways weather impacts the overall energy production and distribution system. Furthermore, weather analysis and forecasting systems can be viewed as cyber-physical systems in themselves and, as such, represent significant components of an energy cyber-physical system. Integrating weather related information, derived by fusing various types of data (observations, model output, etc.), in a cyber-physical energy system would make the system more robust, safe, responsive, and adaptive. We therefore state that the knowledge of potential weather impacts on energy systems must be built into cyber-controlled systems if they are to be effective in the natural environment.

<u>Needs and Issues Related to Weather Impact on Cyber-controlled Energy Systems:</u> Such systems are intimately connected with the natural environment, including the weather/climate system and its natural fluctuations. Some examples of specific areas of interaction include:

- Variations in energy demand are critically dependent on weather, particularly temperature, humidity, insolation, and wind conditions. In particular, building energy usage is a major portion of the demand side and its requirements depend on weather and climate. These variations in demand drive energy production, allocation, and distribution strategies.
- It is expected that the contribution of renewable energy to total energy production will continue to grow over many decades. However, production of renewable energy varies depending on current weather conditions and fluctuations in that production impacts the entire supply side planning as well as transmission and distribution needs.
- Fossil fuel related weather sensitivities to energy production include issues such as the need to curtail energy production in the Gulf of Mexico when hurricanes are approaching or when the metocean environment is hazardous. Weather also directly impacts energy exploration and extraction.
- Capabilities of the distribution network are dependent on weather conditions, including temperature, winds, and precipitation. Weather impacts both the electrical transmission system and natural gas extraction and pipelines.
- Maintenance planning and decisions depend on the weather, ranging from very short time scale reactive strategies through seasonal scheduling of routine maintenance.
- Extreme weather can have a large impact on the energy system, both on the transmission and distribution system, power production capabilities, and load and usage parameters.

- All physical energy systems are vulnerable to climate change.

Areas for Cyber Solution Strategies Related to Weather Information Systems:

- Natural disaster management: Managing natural disaster impacts on the energy system depends critically on accurate weather information, beginning with pre-event forecasts for planning, mid-event situational awareness to mitigate the impact, and post-event analysis for physical system repair and planning strategies for improved reactions.
- Utility decision support integrating renewables: To optimize the use of renewable energy requires weather decision support systems to forecast the available energy for supply and distribution planning. These weather decision support systems would predict load in addition to projected power production.
- Transmission and distribution planning and stabilization: Cyber-information structures with weather information would allow better usage of the distribution network, alleviating imbalances and allowing better planning for maintenance.
- Information sharing issues: The degree to which utilities and energy companies share their information impacts the ability of the weather community to assess how weather affects energy production.
- Big data: Cyber-physical systems critically depend on efficient and effective digital collection, quality control, curation, and analysis of large amounts of data. The weather community has established a number of data collection, storage, and processing standards; however, energy cyber-physical systems present new challenges and therefore require new approaches toward integrating data from a wide range of sources.
- Proactive control strategies: Weather information is essential to optimizing control strategies at all scales, including power plant production (renewables and beyond), transmission control, and the interaction between utilities and balancing authorities.
- Balancing authority weather information: Because balancing authorities work over a large geographic area, weather information systems allow them to consider the impact of weather on various aspects of the business (renewable production, impact to transmission, etc.) to balance the impact over a larger region.

Capabilities of the Weather Community in Meeting the Needs: The weather community has been working with the energy community to determine the best ways to integrate weather and climate information into energy systems. One example is the formation of an Energy Committee as part of the American Meteorology Society that has been holding conferences on Weather, Climate, and the New Energy Economy. Another is the emergence of an international committee that has been fostering connections through several International Conferences on Energy and Meteorology. The integration of weather and climate information into energy systems inherently includes cyber-physical systems. The community has been working together to meet the needs discussed above as well as developing weather decision support systems for a wide range of energy needs.

NCAR's mission is "to conduct research that contributes to the depth of fundamental understanding of the atmosphere and its interaction with society and the environment and develop and transfer knowledge and technology that expands the reach of atmospheric science." NCAR has a successful history of transferring technology and knowledge to U.S. government agencies, the private sector, and foreign governments. NCAR is eager to collaborate with other organizations to address the challenges involved in creating effective cyber-physical energy systems. Such collaboration includes, but is not limited to, sharing knowledge, data, code, models, and instrumentation. Specific to the interface of energy with weather, NCAR has been working with utilities, balancing authorities, government agencies, and foreign governments to address the impact of weather on energy systems, including developing cyber decision support systems. We have gained substantial experience in wind and solar energy prediction on multiple time scales (ramp events, next-day, weekly), load prediction, and impacts on renewable generation based on future climate scenarios. We have also studied the impact of severe weather on the energy system. NCAR looks forward to connecting with universities and other research and stakeholder organizations to further address these fundamental and interesting challenges.

Summary: There are a plethora of weather and climate impacts on the energy infrastructure. Thus, in designing any cyber-physical infrastructures, it is critical to integrate advanced weather decision support systems.