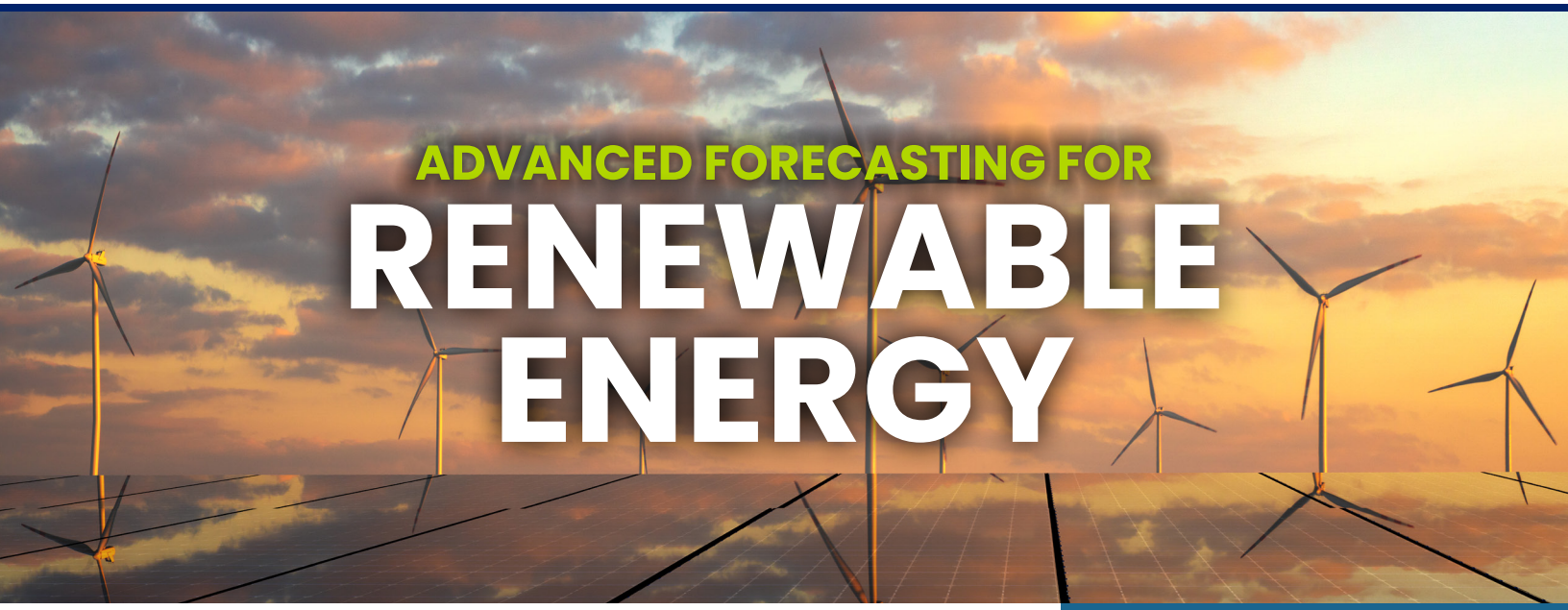

ADVANCED FORECASTING FOR

RENEWABLE ENERGY

Saving Money & Cutting Emissions

NSF NCAR Research Applications Laboratory (RAL) scientists are developing improved forecasting systems that predict energy generation at wind and solar power plants. These forecasts improve grid reliability, minimize operating costs for utility companies, save customers money, and improve the environment by reducing harmful emissions from fossil-fuel power plants. Accurate forecasts are increasingly critical as wind and solar power comprise ever-growing shares of our energy portfolio.

UTILITIES DEPEND ON ACCURATE FORECASTS

Electric utilities and independent system operators (ISOs) are required to make critical decisions on a daily basis with regard to energy generation, distribution, demand, storage, and integration. Accurate knowledge of the present and future state of the atmosphere is vital in making these decisions. Wind and solar energy are among the most difficult weather-driven variables to forecast. Topography, surface roughness, ground cover, temperature inversions, foliage, gravity waves, low-level jets, clouds, and aerosols, all affect wind and solar energy generation.

As wind and solar energy portfolios continue to expand, and we add storage to the mix as we transition toward carbon-free energy generation, the need to address these forecast challenges is taking on new urgency. Wind and solar energy forecast inaccuracies frequently lead to substantial economic losses in energy markets,

Benefits & Impacts

- Integrate wind & solar power onto the grid
- Effective utility participation in energy markets
- Better forecasts save utilities & customers money
- By maximizing wind & solar use, emissions are minimized

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while accurate forecasts save utilities and customers millions of dollars annually, while also minimizing carbon and other pollutant emissions from fossil-fuel power plants.

FORECASTING SOLUTIONS

RAL scientists and software engineers have developed weather forecasting models and machine learning (ML) algorithms specifically tailored for use in renewable energy forecasting systems. WRF-Solar® is a version of the NSF NCAR-developed Weather Research and Forecasting (WRF) model with a set of enhancements specially designed to improve solar forecast accuracy for both intra-day and day-ahead time horizons. The MAD-WRF model combines the improved physics in WRF-Solar with assimilation of satellite and surface observations to start the model with clouds in the right places, which further reduces solar forecasting errors in the first few hours. RAL scientists have also partnered with other national labs to better couple mesoscale and microscale phenomena to improve wind forecasts in complex terrain, where many wind farms are located.

DICast® has long been at the core of RAL forecasting systems, including for renewable energy, and statistically optimizes forecast model output based on recent performance. More recent ML-based techniques like StatCast-Wind and StatCast-Solar deliver further improvements by being trained on long histories of forecasts and observations at wind and solar power plants to learn the relationships between different variables, and using real-time observations to correct near-term forecasts. Additionally, the analog ensemble (AnEn) has proven to be a powerful tool to reduce forecast errors and deliver reliable probabilistic forecast information without the significant computational expense of running a full ensemble of weather prediction models.

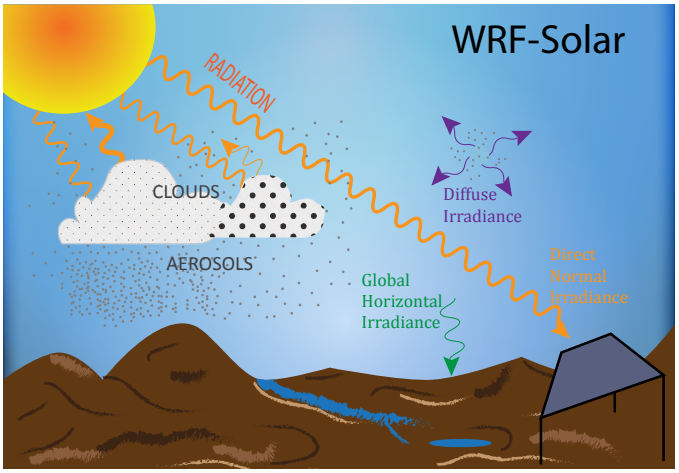

Diagram of WRF-Solar physics improvements

Shagaya Renewable Energy Park in Kuwait

Variations of these solutions have been developed for and used by clients ranging from Xcel Energy, the U.S. Department of Energy, the New York State Energy Research and Development Authority, the Kuwait Institute for Scientific Research, and more.

NEW OPPORTUNITIES

Improved weather prediction and precise spatial analysis of small-scale weather events are crucial for energy management, as is the need to further develop and implement advanced technologies. This is particularly true as distributed (rooftop) energy generation proliferates, and with the increasing deployment of large-scale storage and electric vehicles. Energy system planners also need awareness of our changing climate and how wind and solar energy resources and their variability may be impacted regionally in coming decades. RAL scientists are actively engaged with industry decision-makers, both domestically and internationally, on how best to foresee and respond to short- and long-term changes in atmospheric conditions to mitigate risks associated with weather, particularly wind and solar energy prediction.

Renewable Energy
ral.ucar.edu/renewable-energy

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