**Application of WRF and Fluent for Wind Energy Forecasting**

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### Project Objectives

**Forecasting for Wind Energy**

- Grid Integration
  - Develop forecast methodology
  - Reliably forecast power production in MW
  - Produce 5 minute, 1 hour and 24 hour forecasts
  - Weather forecast using WRF, Weather Research and Forecasting, a mesoscale meteorological model
  - Couple WRF with FLUENT computational fluid dynamics (CFD) model
    - CFD model for individual wind farms
    - Complex terrain effects
    - Buoyancy effects
    - Wind fields and turbulence
  - Develop met tower network and SODAR field data to improve accuracy and forecast ramp events
  - Evaluate forecast model accuracy

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### CFD Model

**Mesh Inputs**

- 30 meter USGS DEM (digital elevation map) data
- DEM turned into Gambit (ANSYS mesh software) face
- Mesh domain built above surface
- Hexagonal mesh with surface boundary layer
- 2 meter resolution in surface layer
- 2 million cells model a 2.4 km by 2.6 km by 600 meter volume domain.

**CFD Model**

- FLUENT: ANSYS commercial CFD code for science and engineering
- k-ε turbulence closure
- Good compromise between accuracy and speed
- Second order upwind scheme
- Numerical solution convergence requires up to 12 hours run time on a 2 processor Linux workstation

### Results

- **FLUENT neutral model results for wind speed contours at 80 m, 2/10/09 at 6 AM. WRF input wind was 318° (blue arrow) at 12.51 m/s. At 80 m, SODAR recorded 13.2 m/s wind at 310°.**

- **FLUENT buoyancy model results for wind speed contours at 80 m, 1/4/09 at 1 PM. WRF input wind was 100° (blue arrow) at 11.4 m/s. SODAR recorded 11.2 m/s wind at 100° at 80 m during the same time period.**

### Next Steps

- Complete data network
  - Install 30 m tower
  - Update existing towers
- Refine FLUENT model
- Generate CFD lookup tables
- Compare model power forecast to wind farm SCADA
- Run actual forecasts
- Complete final BPA grant report

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**Wind Farm**

- **Wind Rose Graph**
  - Wind farm contour map showing turbine and SODAR locations.
  - The yellow square is the CFD domain area.
  - The wind rose shows the predominant NW-SE wind pattern.

**Forecast Network**

- Top instrument height, distance, direction and ramp forecast time from wind farm
  - 80 m tower 69 km NW ~ 3 hours upwind
  - 30 m tower 51 km NW ~ 2 hours upwind
  - 50 m tower 5 km NW
  - SODAR at the wind farm
  - 50 m tower 56 km SE ~ 2.5 hours upwind

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**Thank you for assistance and advice:**

Dr. Inanc Senocak and Marty Lukes, Boise State University College of Engineering

Dr. John Gardner, Boise State University Dept. of Energy Research, Policy and Campus Sustainability

Kurt Myers, Idaho National Lab

Doug Taylor, John Deere Wind Energy

Second Wind Triton SODAR

Bonneville Power Administration (BPA)

Research Funding: BPA Contract 00039902