UVIG Forecasting Workshop, June 20-22, 2017

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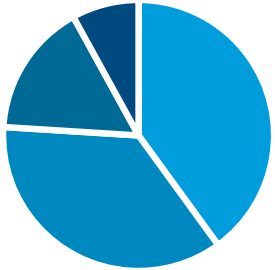
DUKE ENERGY®

Business Segments

Regulated Utilities	Commercial Businesses
▪ Regulated generation, electric and gas transmission distribution systems ▪ Duke Energy Carolinas ▪ Duke Energy Progress ▪ Duke Energy Indiana ▪ Duke Energy Ohio/Kentucky ▪ Duke Energy Florida	**Commercial Power** ▪ Duke Energy Renewables

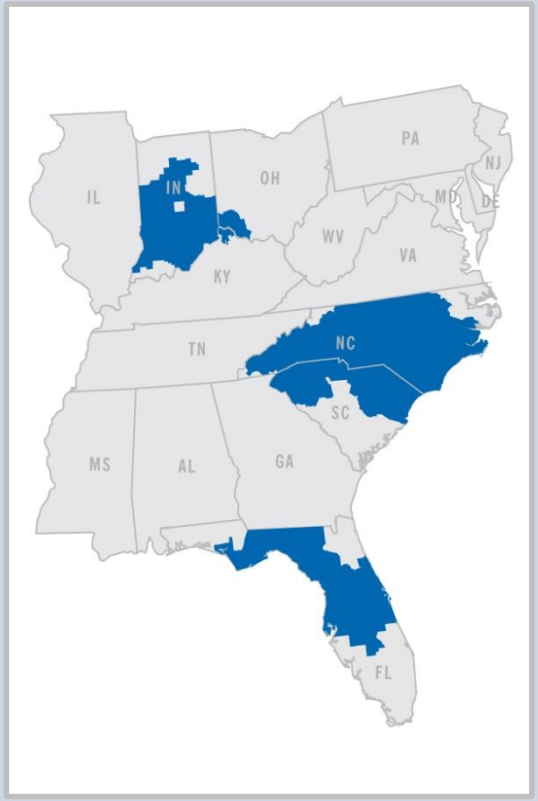
Regulated Utilities
(percent owned capacity)



Coal	38%
Natural Gas/Fuel Oil	38%
Nuclear	17%
Hydro/Renewables	7%

Regulated Utilities

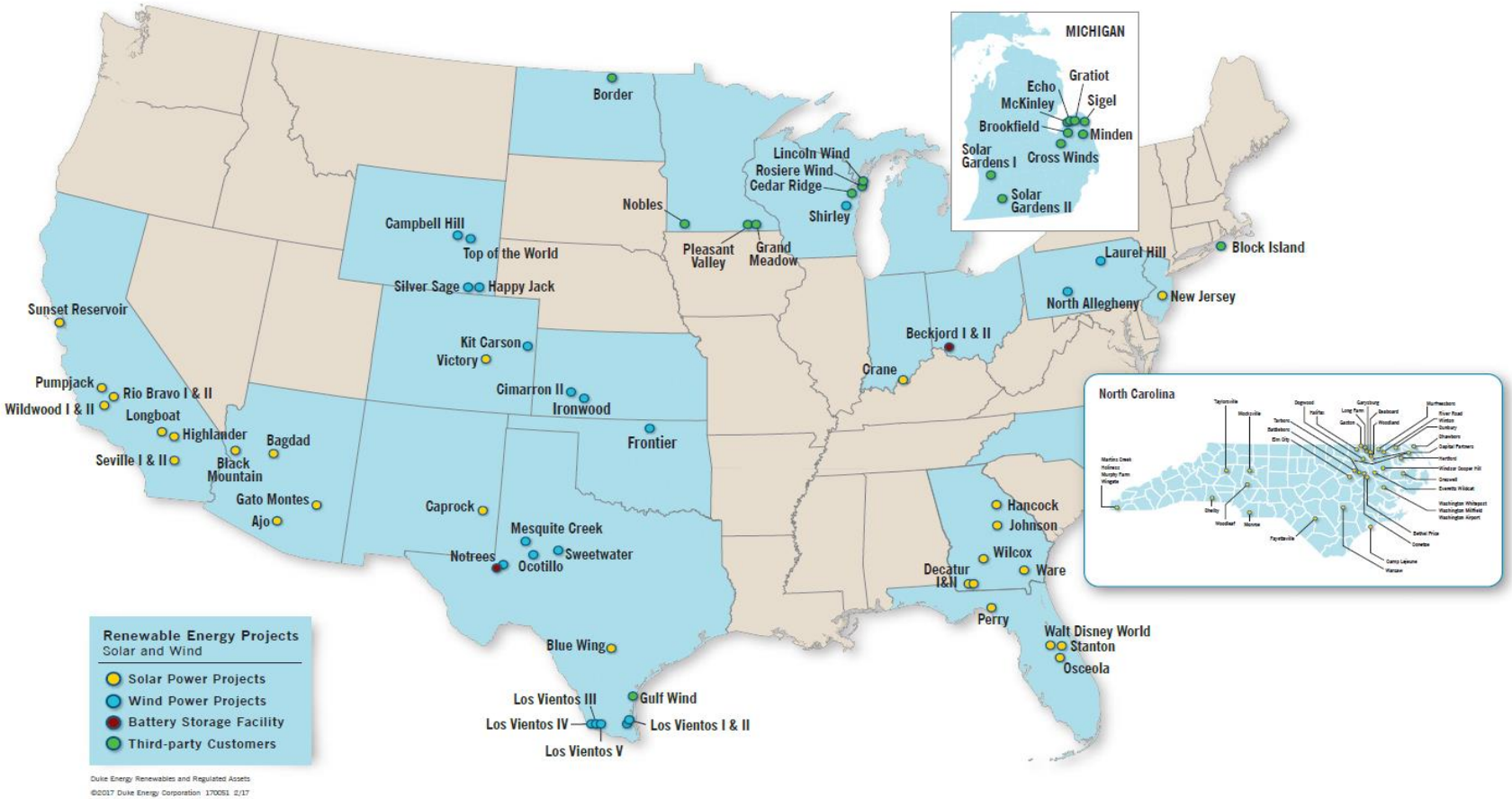
- Largest business segment and primary source of earnings growth
- 6 states: North Carolina, South Carolina, Florida, Indiana, Ohio, Kentucky
- 95,000 square miles of service area
- 49,600 MW of generation capacity
- 7.5 million retail electric customers in 6 States
- Renewable and energy efficiency programs
- Nearly 30,000 Employees



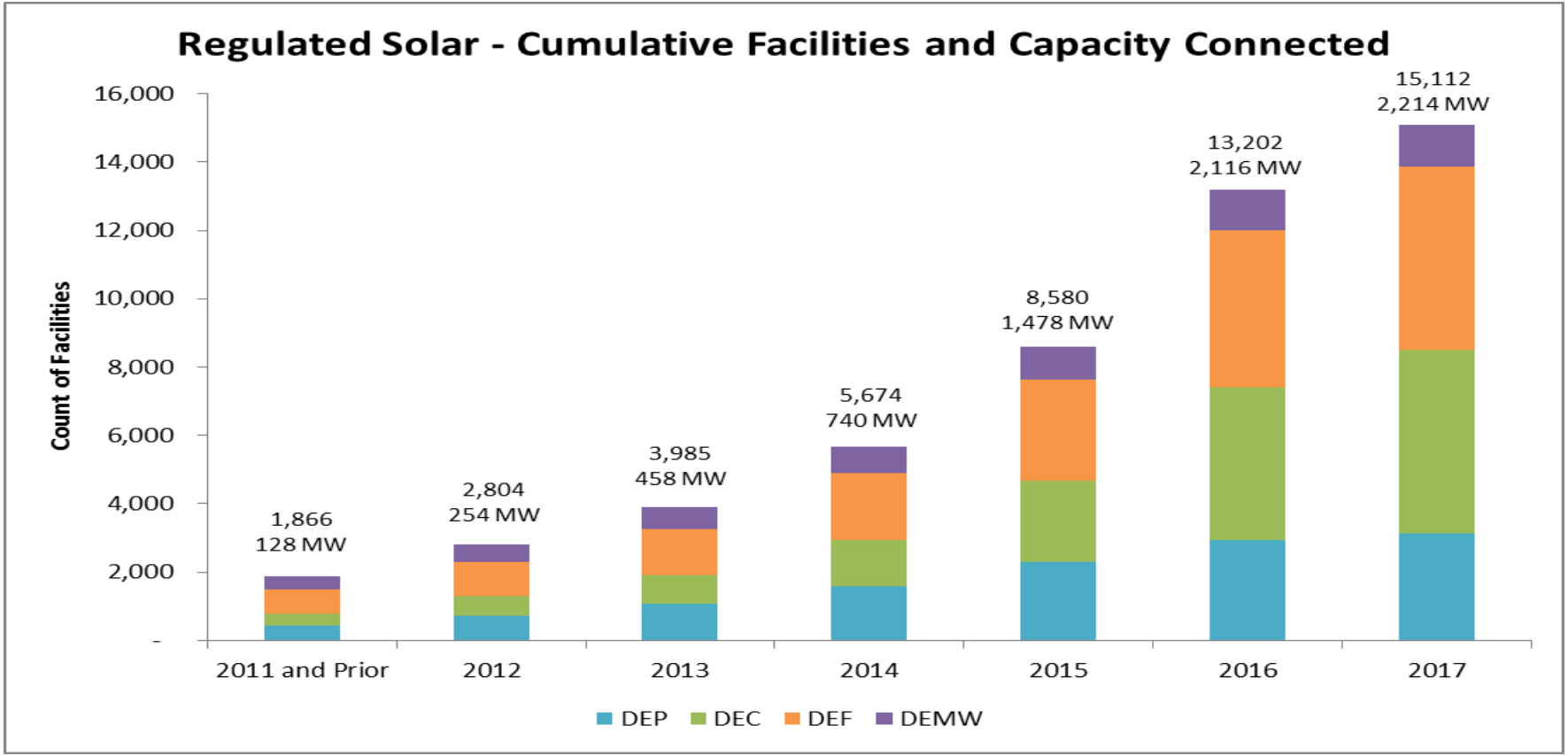
Duke Energy Renewables

- Approximately 3,190 MW of wind and solar projects operating in 12 states
  - Including 2,300 MW of Wind
  - Over 850 MW of Solar
  - 40 MW of Battery Storage
- Since 2007, invested more than $3 billion to grow wind and solar business

Duke Energy Solar, Wind and Storage Portfolio Nationally



Solar Expanding Rapidly In Duke's Regulated Jurisdictions



A few reasons why we need Meteorologists at Duke Energy?

- **Weather is the primary driver of electricity demand**
  - Hotter temps in the summer = Greater A/C demand thus higher loads
  - Colder temps in the winter = Greater heating demand thus higher loads
- **Weather can affect electricity supply including renewable energy sources**
  - Hydro generation, wind generation and solar generation
- **Weather affects electricity reliability**
  - Storms lead to power outages
  - A proactive response requires good pre-storm forecasts on impacts and resource needs
- **Regulatory requirements for nuclear power plants**
  - Governance of the meteorological monitoring programs for 6 nuclear power plants
  - Data QA/QC
  - Supporting emergency response organization
  - Dispersion modeling

Duke Energy Meteorology Group

- Staff of 6 meteorologists
  - 3 with masters degrees
  - 4 Certified Consulting Meteorologists
  - Nearly 100 years of combined utility experience at Duke Energy
- A “shared resource”
  - Support regulated, non-regulated and commercial operations

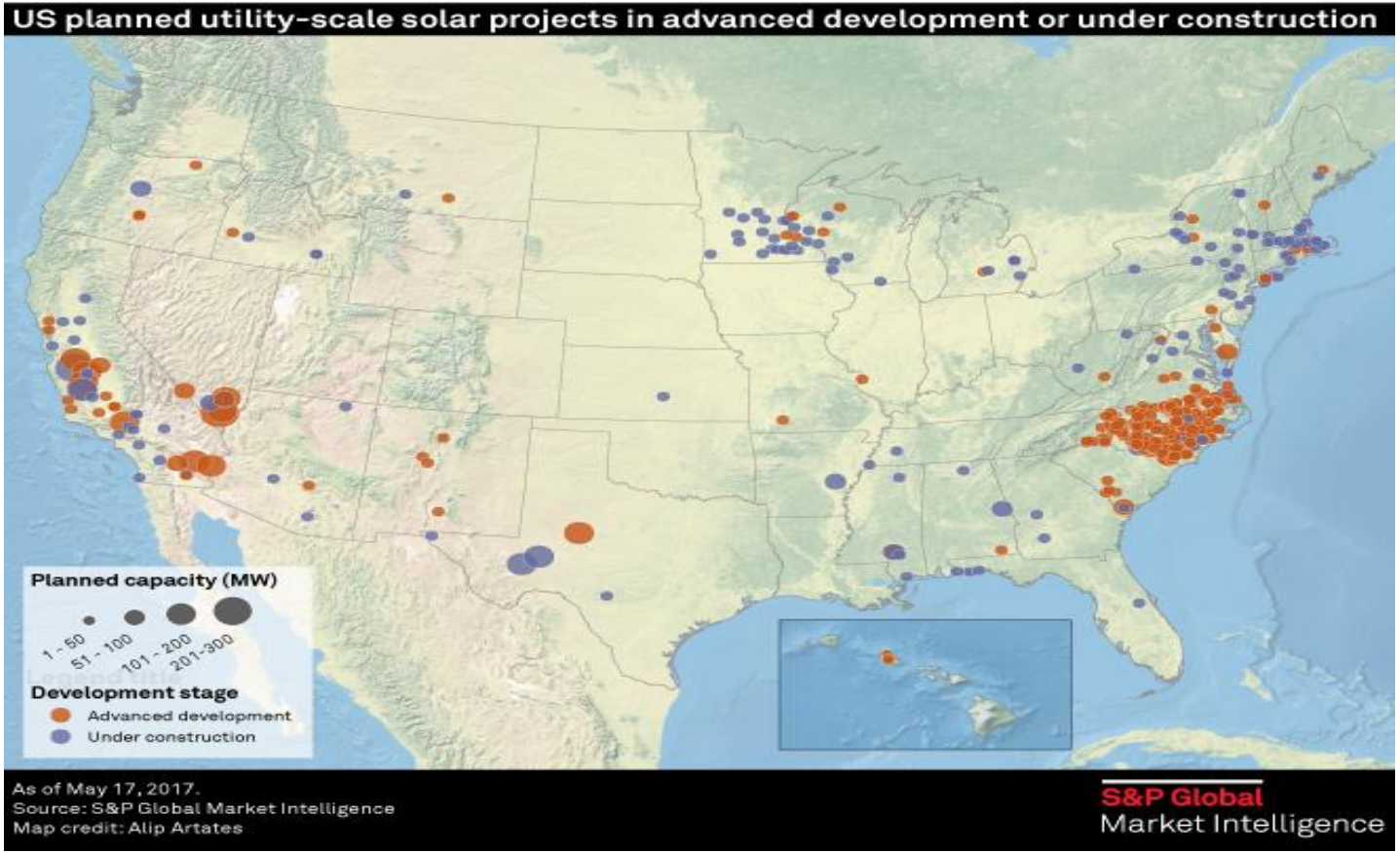
Meteorology Group Functional Support

- Meteorology support for Portfolio Optimization for Regulated and Commercial Trading and Dispatch
- Storm support/weather support for the Enterprise including T&D, Call Centers, Nuclear, and Commercial Operations
- Meteorological support for Nuclear Stations
- Meteorological support for Hydro Operations
- Meteorological support for both regulated and commercial Wind and Solar

Daily to Seasonal Operational Uses of Weather Forecasts/Data

- Generation System Dispatch/Load Forecasting
- Precipitation Forecast for Daily Hydro Planning/Dispatch
- Renewables – Solar/Wind
- Storm Prediction – Resource modeling for storm impacts
- Extreme weather impacts for generation planning/maintenance and grid operations
- Transmission Line ratings
- Jurisdictional requirements for Non-Pay disconnects
- High bill analysis
- Earnings
- Monthly and seasonal forecasts for system planning/operations
- Thermal modeling

North Carolina No. 2 in The Nation for Solar



Weather Models used in Irradiance Forecasting

- The solar forecast ensemble approaches uses a weighted average of the numerical weather models.

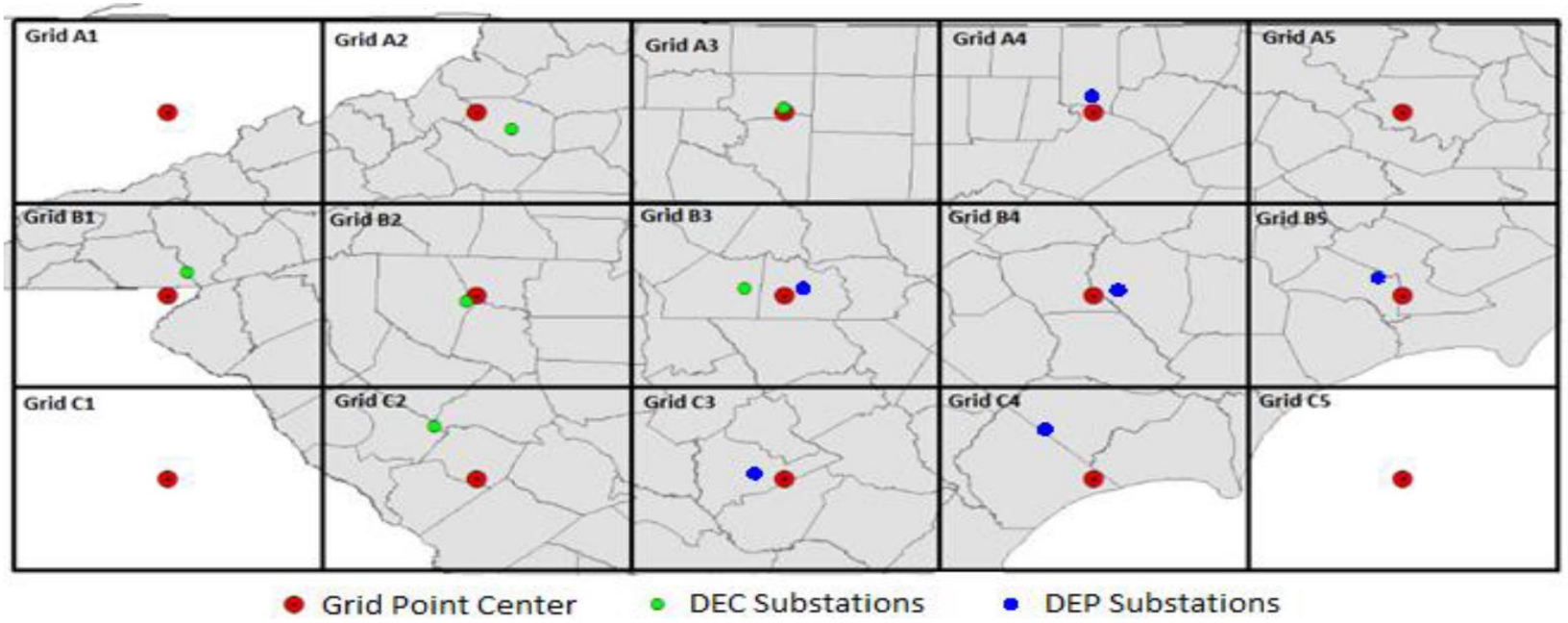
Model	Model (long)	Resolution	Model Update Rate	Output Interval	Time Horizon	Ensemble Weighting <= 18 hours	>18 Hours
GFS	Global Forecasting System	13 km	6 hours	3 hours & 6 hours	168 hours	35%	55%
NAM	North American Model	12 km	6 hours	3 hours	84 hours	25%	45%
HRRR	High- Resolution Rapid Refresh	3 km	1 hour	1 hour	18 hours	40%	N/A
ECMWF	European Model	18 km	12 hours	6 hours	240 hours	Coming soon…	Coming soon…

Solar Irradiance Forecast Products

- Single-model forecast approach uses:
  - HRRR out to 15 hours
  - NAM to 84 hours
  - GFS to 168 hours
  - Based on a spatially weighted average at a point and 4 surrounding points
- Ensemble forecast approach:
  - Utilizes the NCEP operational models
    - (and eventually the ECMWF)
  - Allows for the development of a forecast confidence interval based both on model spread and average error

Irradiance Forecasting Grid

- Sensor locations within 80 by 80 km Grid boxes

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