# Coastal Ocean Research to Facilitate Safe and Efficient Development of Offshore Renewable Energy

Virginia Coastal Energy Research Consortium (VCERC) · Virginia Tech Advanced Research Institute · Old Dominion University · James Madison University

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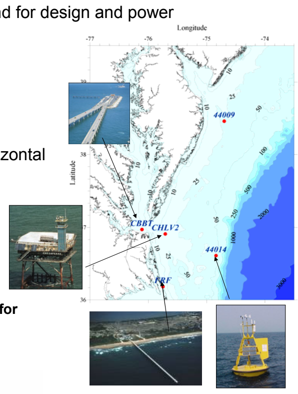
## Study of wind waves and currents

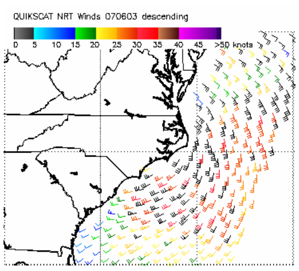
### WIND

Strength and variability of the wind for design and power

- Data from
  - Meteorological networks
  - Satellite wind
- Analyze for
  - Variability – vertical and horizontal
  - Average power available
  - Extreme events




**From Meteorological network**
NOAA, NWS & NDBC
**[agreements with NOAA and ACOE for collaboration]**




**From Satellite**
QuikScat, SAR and Calipso

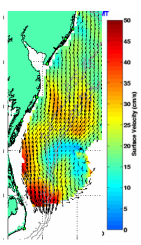
**[Agreements with NASA for funding and collaboration]**

*QuikSCAT wind vectors during the wind storm of June 3, 2007*

### OCEAN CURRENTS

Strength of ocean currents for design and possible power

- Data from
  - high frequency radar systems along the coast
  - offshore moorings and NOAA buoys
- Analyze for
  - Extreme events
  - Average conditions

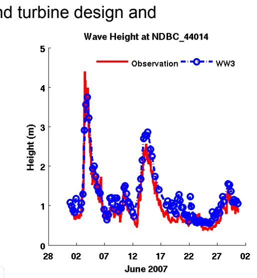



*Surface currents measured by ODU and collaborators' radar systems during February 15, 2008*

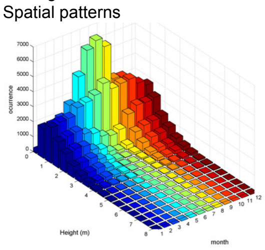
### WAVES

Characteristics needed for platform and turbine design and control and maintenance.

- Data from
  - NDBC Data Buoys
  - Wavewatch III and other models
- Analyze for
  - Extreme heights
  - Average conditions
  - Spatial patterns




*Waves reached heights of 5 m during the wind storm of June 3, 2007*

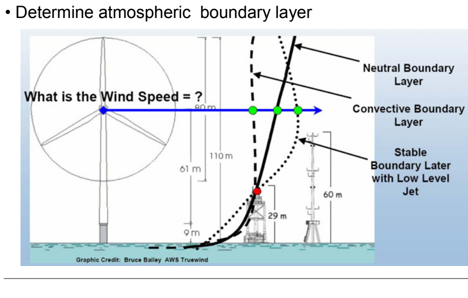



*Occurrence of wave height by month Period 1990 – 2007. Buoy 44014*

### WIND PROFILE

Understanding the variability in the wind above the ocean surface is vital to wind farm design.

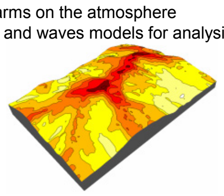
- Data from
  - Wind profilers installed by VCERC at CHLT, Duck or Tangier
- Analyze for
  - Vertical variability in relation to hub height.
  - Variations with season and weather
  - Determine atmospheric boundary layer




### MODELS

Modeling ocean and atmosphere for analysis and prediction

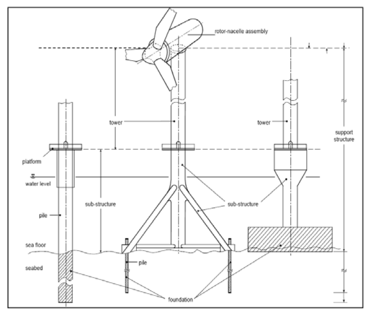
- Effects of wind farm structures on the flow and stratification field
- Effect of wind farms on the atmosphere
- Use of the wind and waves models for analysis and prediction



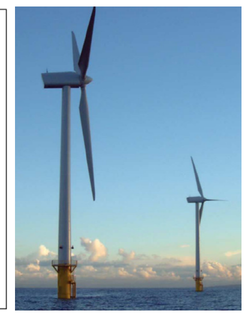
## Support Structure Design

The support structure for each turbine unit costs about 40% of the initial construction and installation costs. The support structure must be designed to withstand loads from winds, waves, and currents at the site.

Monopile structures (see photo) are used at 71% of the European sites in water depths ranging from 1 to 22 meters (3 to 72 feet) . For the feasibility study off Virginia's coast, the monopile design will be in water depths ranging from 15 to 25 meters (50 to 82 feet). One unique design concern not found in Europe is hurricane force winds on locked turbine blades and the overturning forces they create on the monopile.



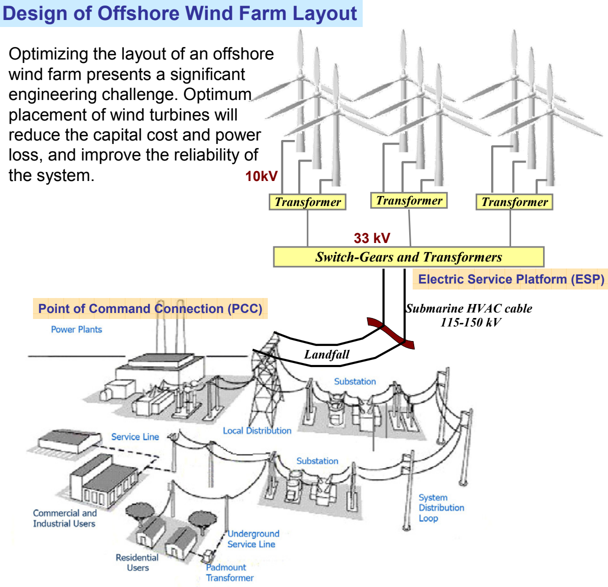

C. N. Elkinton, et al 2005



Blyth offshore wind farm: the first in the UK. Photo: AMEC Border Wind

## Design of Offshore Wind Farm Layout

Optimizing the layout of an offshore wind farm presents a significant engineering challenge. Optimum placement of wind turbines will reduce the capital cost and power loss, and improve the reliability of the system.




**Cost and performance for a 100 MW wind farm**

| | |
|---|---|
| Collection Cable Cost | $31.0 |
| Transmission Cable Cost | $31.0 |
| Collection Losses (MW) | 4.27 |
| Transmission Losses (MW) | 3.5 |
| Total Cost and Unit Cost | $66.5 and $0.665/kW |
| Total Losses (MW) | 4.27 + 3.5 = 7.77 |

**100 MW (7X7) Wind Farm Parameters**

| | |
|---|---|
| Wind Turbine rating | 2.0 MW |
| Rotor Diameter | 90 m |
| Number of Wind Turbines | 49 |
| Number of Turbines per Row | 07 |
| Number of Rows | 07 |
| Distance between Turbines | 630 m |
| Distance between Rows | 630 m |
| Cable length between Turbines and Rows | 830 m |
| Collection cable length | 35 Km |
| Sub-Station Distance to shore | 30 Km |
| Length of On-shore Transmission | 5-10 Km |

**Transformer Unit Costs**

| Location | Voltage and Capacity | Unit cost | Total Cost |
|---|---|---|---|
| Wind Turbine | 33kV, 2.0 MW | $0.032 | $1.568(for 49) |
| Offshore Substation | 33/115 kV, 120 MVA | $1.680 | $1.68 |
| Onshore Substation | 115/500 kV, 120 MVA | $1.200 | $1.20 |

*All costs are in millions Dollar ($) and all power losses are in MW at rated power*

## Possible location of the Offshore Wind Farm off Virginia Beach

There are many activities off our coast. Shipping lanes and military operations constrain available sea space near shore. This diagram shows how the wind farm might fit in.