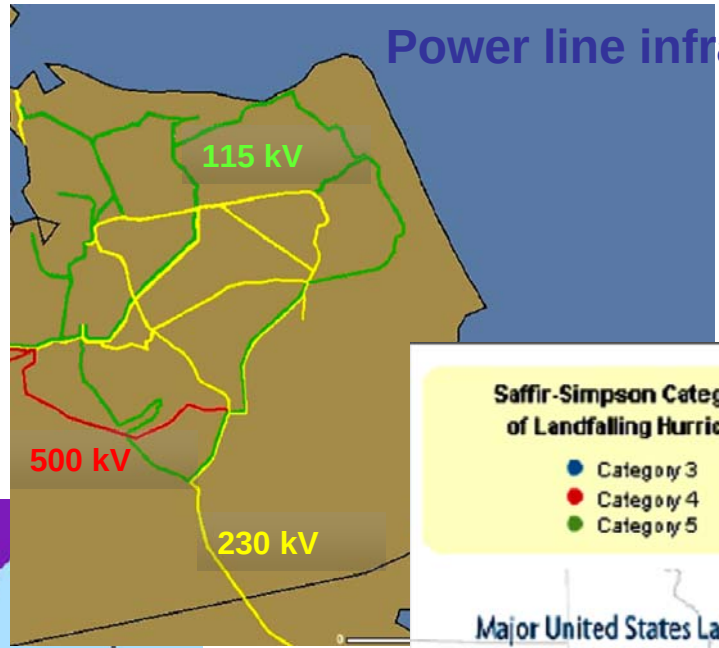
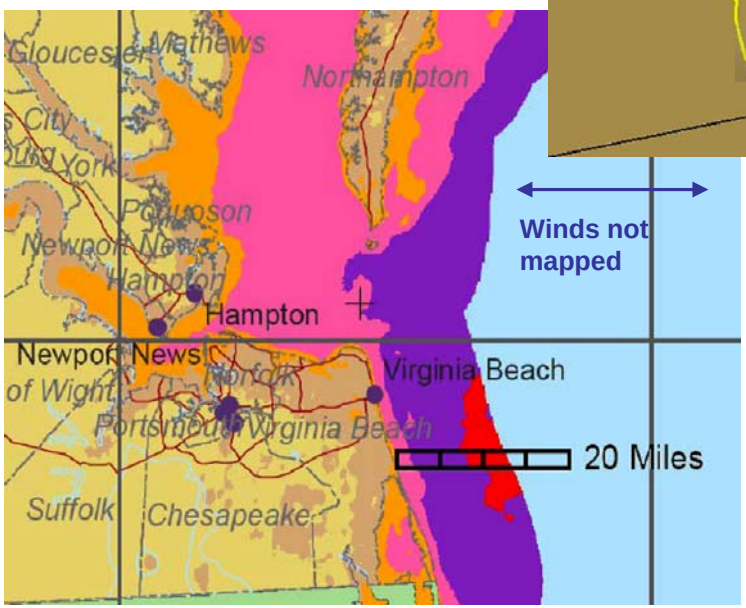
Offshore wind power resource in the Virginia Coastal Ocean

Jose L. Blanco
Larry P. Atkinson
George Hagerman

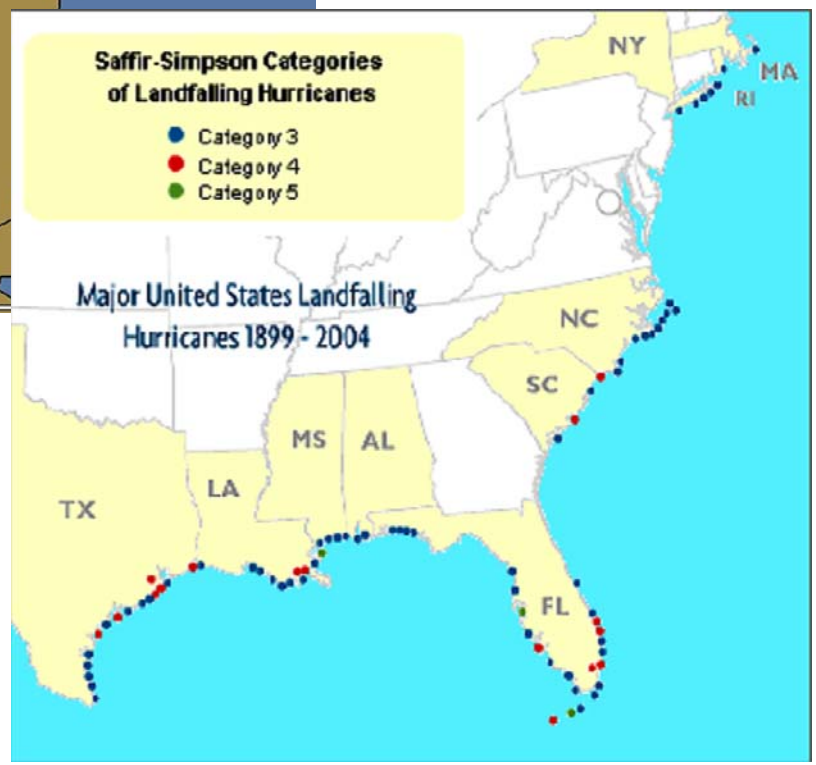
Virginia has Unique Advantages for Offshore Wind Energy Development

Class 6 wind energy resource located within 10-15 miles (16-24 km) of shoreline and close to major, growing centers of power demand

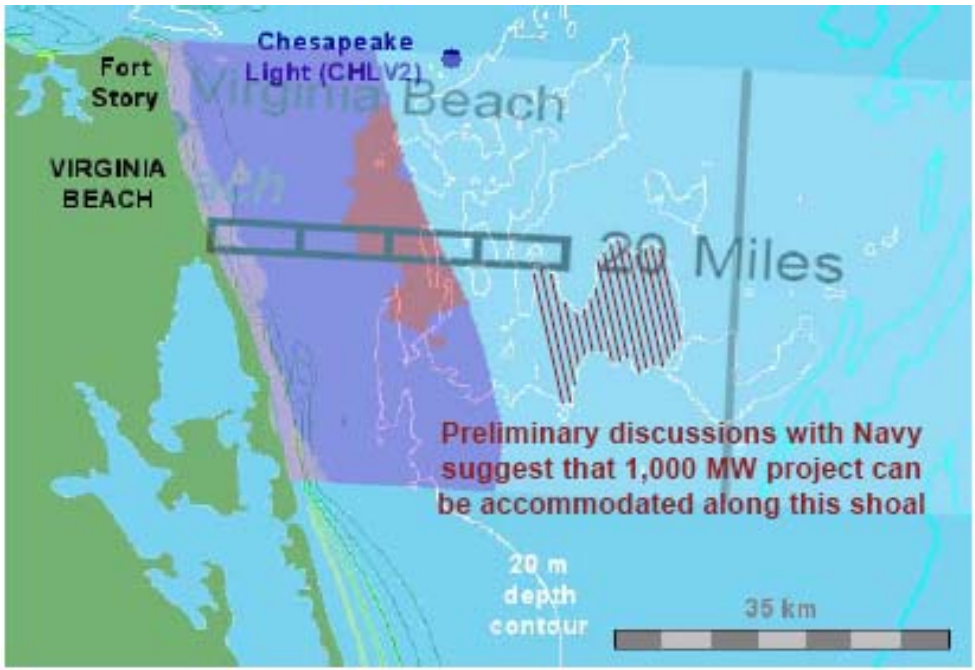




Minimal probability of major hurricane strike (Categories 3 through 5)



Near-Term R&D: Effects of Offshore Wind Projects on Marine Environment



Baseline data needed on offshore wind & wave climate, physical, geological, and biological environment.

Near-Term R&D: Effects of Offshore Wind Projects on Marine Environment

Shipwrecks and light towers on mid-Atlantic sandy bottoms are colonized by rich fouling communities that attract fish. Research needed to assess artificial reef effect of wind turbine foundations and anti-scour mats.

Stakeholder consultations needed to determine appropriate usage: recreational diving and sport fishing, or marine sanctuary, or perhaps both?

Migratory shorebirds tend to hug the coast, foraging in marshes and lagoons and thus may not be affected by "over the horizon" wind projects. What are effects on pelagic seabirds and on migratory shorebirds when blown offshore by storms?

Near-Term R&D: Mapping Marine Energy Resources & Environment into GIS Product

Virginia Coastal Geospatial and Educational Mapping System

….a gateway to information on the location, value and management of Virginia's coastal resources

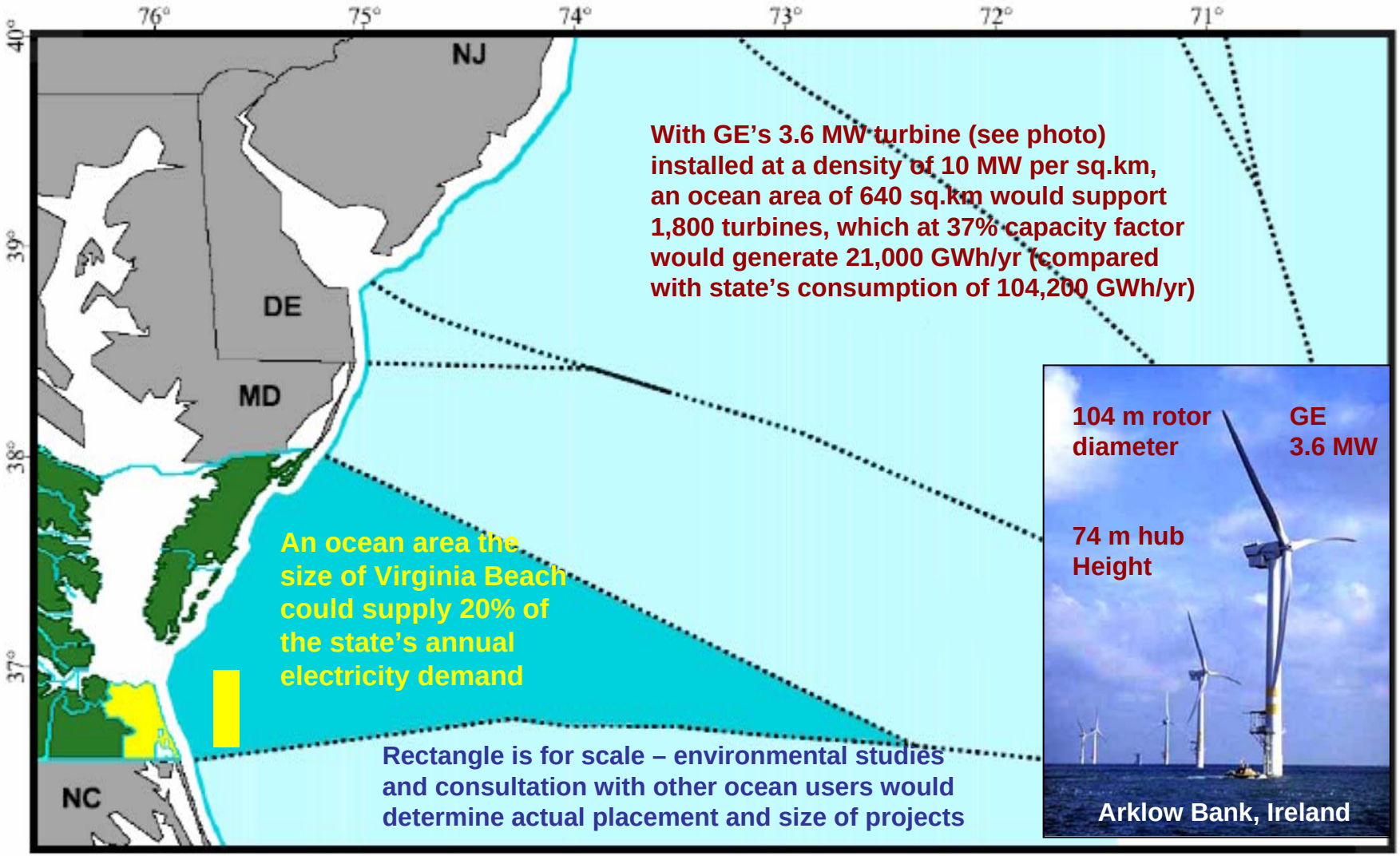
Virginia Coastal Zone MANAGEMENT PROGRAM

What Is Coastal GEMS?

- A gateway to Virginia's coastal resource data and maps; coastal laws and policies; facts on coastal resource values; and direct links to collaborating agencies responsible for current data. Access Coastal GEMS at www.deq.virginia.gov/coastal/coastalgems.html.

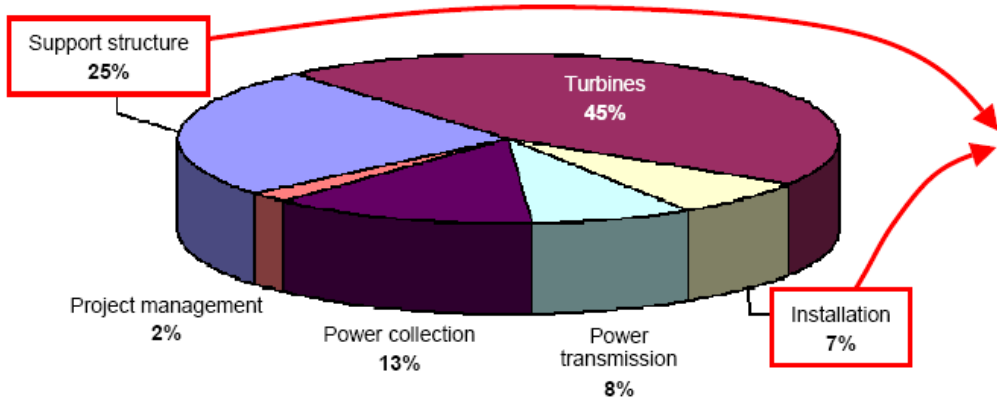
- A growing inventory of water and land based natural resources, conservation planning tools, and planning examples that can help us to protect Virginia's coastal ecosystems.
- A tool to promote community involvement and environmental education.

Update Estimate of Energy Contribution



Update Estimate of Economic Benefits

Typical capital cost breakdown for monopile-based offshore wind project



32% of capital cost is in local fabrication and installation

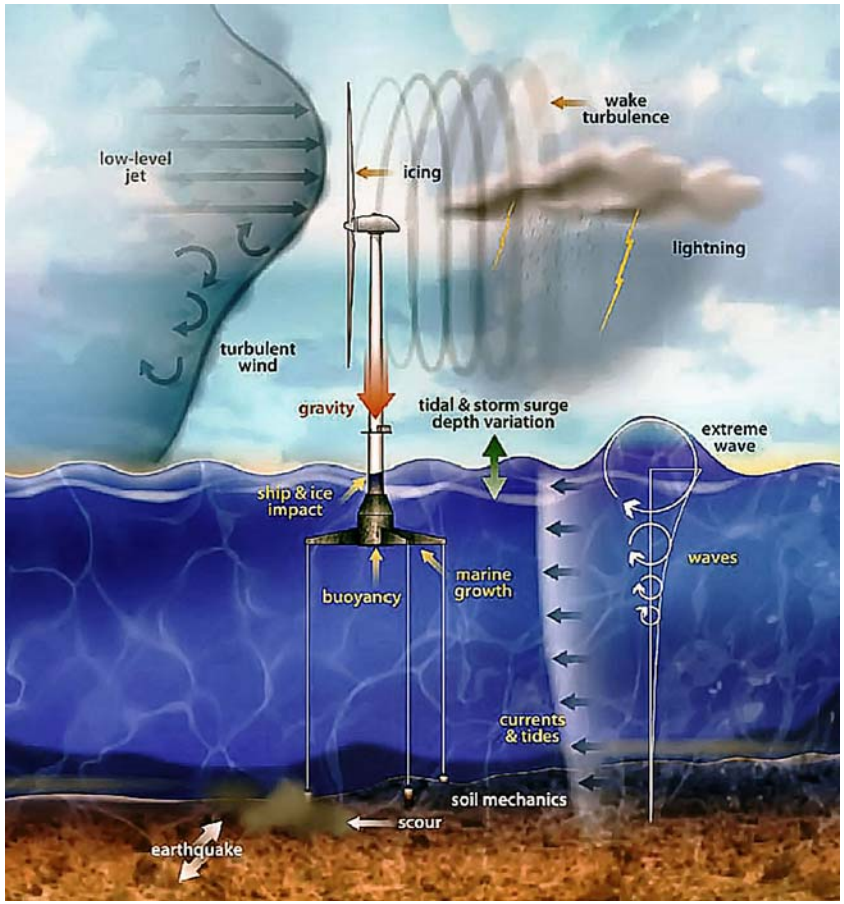
Estimated maritime industry value of fabrication, installation, and service contracts to supply 20% of Virginia's electricity:

- **Total installed turbine capacity = 6,500 MW**
- **At $1,600 per installed kW, total capital investment = $10.4 billion**
- **Assuming an installation rate of 325 MW per year= $520 million per year over 20-year build-out**
- **Value of local fabrication and installation contracts = $166 million per year until fully built out**
- **Value of local offshore service contracts (at $30/kW/yr) = $195 million per year after fully built out**

Required Data For Offshore Sitting & Design

Wind - Waves - Currents

- Avg. Speeds – annual, monthly,
- diurnal (at hub height)
- Speed Frequency Distribution
- Wind Shear
- Turbulence Intensity
- Wind Direction Rose
- Extreme Gusts & return periods
- Coincident Sea-State Conditions
- Water and air temperatures
- Waves spectra and return period



Near-Term R&D: Effects of Offshore Wind Projects on Marine Environment

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

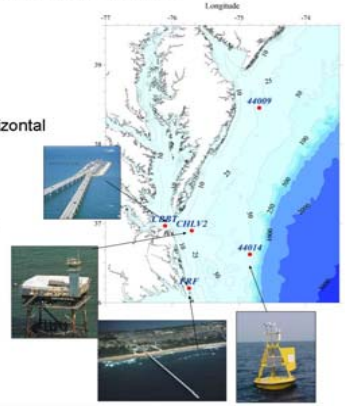
WIND

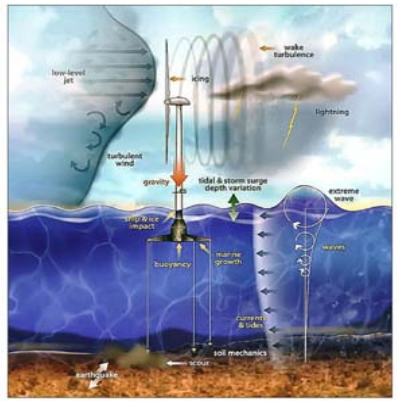
Strength and variability of the wind for design and power

- 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]

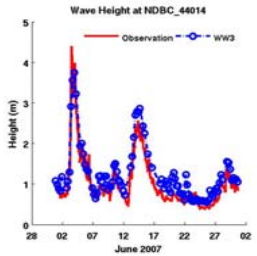




WAVES

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

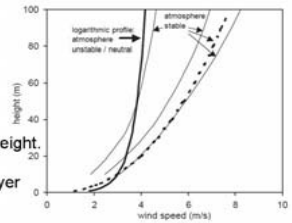


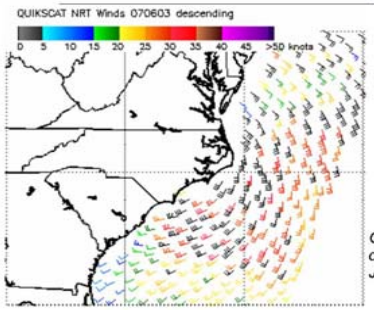
Waves reached heights of 5 m during the wind storm of June 3, 2007

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





From Satellite
QuikScat, SAR and Calipso

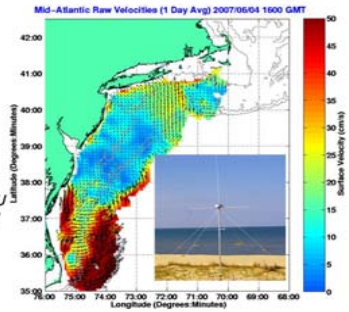
[Agreements with NASA for funding and collaboration]

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 the wind storm of June 3, 2007

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

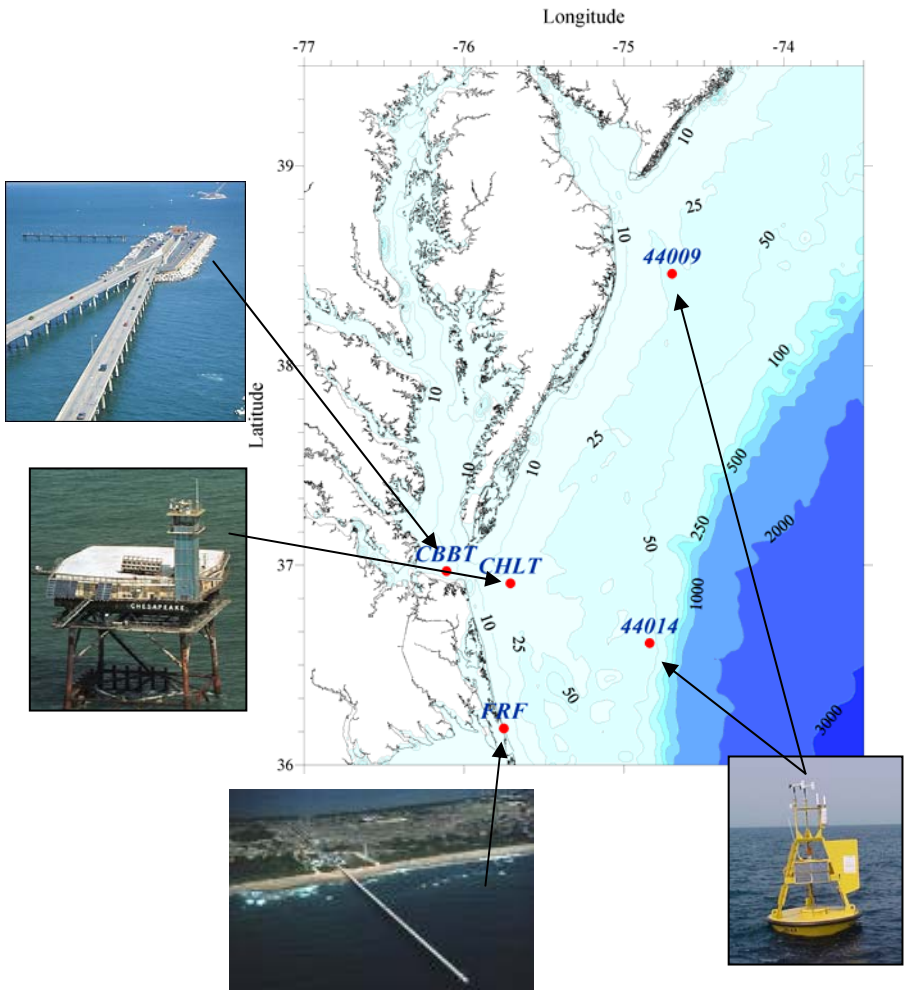
The Goal

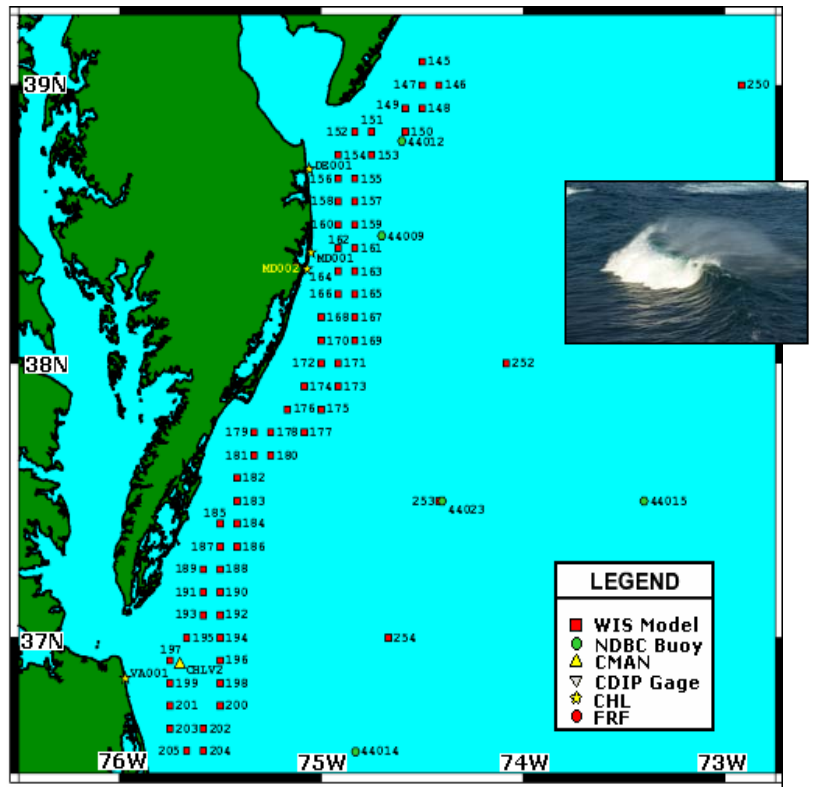
Nysted Wind Park in the southern part of the Baltic Sea. Nysted has 72 wind turbines rated at 2.3 MW each.

Contact: Larry P. Atkinson[1] Jose L. Blanco[1] and George Hagerman[2]
[1]Center for Coastal Physical Oceanography, OEAS Department, Old Dominion University [2]Virginia Tech Advanced Research Institute
email: latkinso@odu.edu; jlblanco@ccpo.odu.edu; hagerman@vt.edu

Near-Term R&D: Effects of Offshore Wind Projects on Marine Environment

Wind, waves and currents



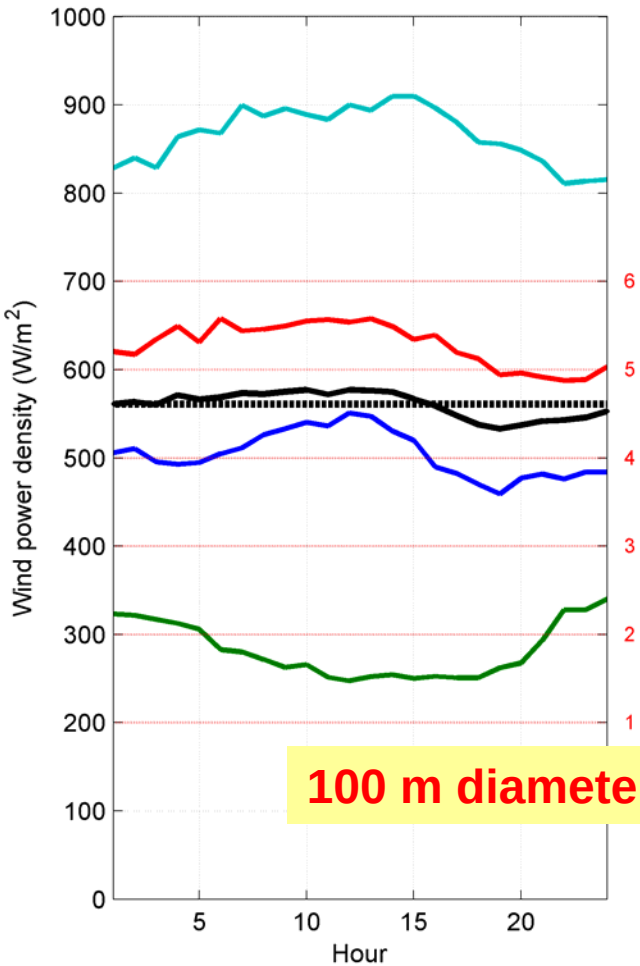


20-Yr Hindcast (WIS, 1980-1999) and Measured Wind and Wave Data off Virginia (U.S. Army Corps of Engineers)

Near-Term R&D: Effects of Offshore Wind Projects on Marine Environment

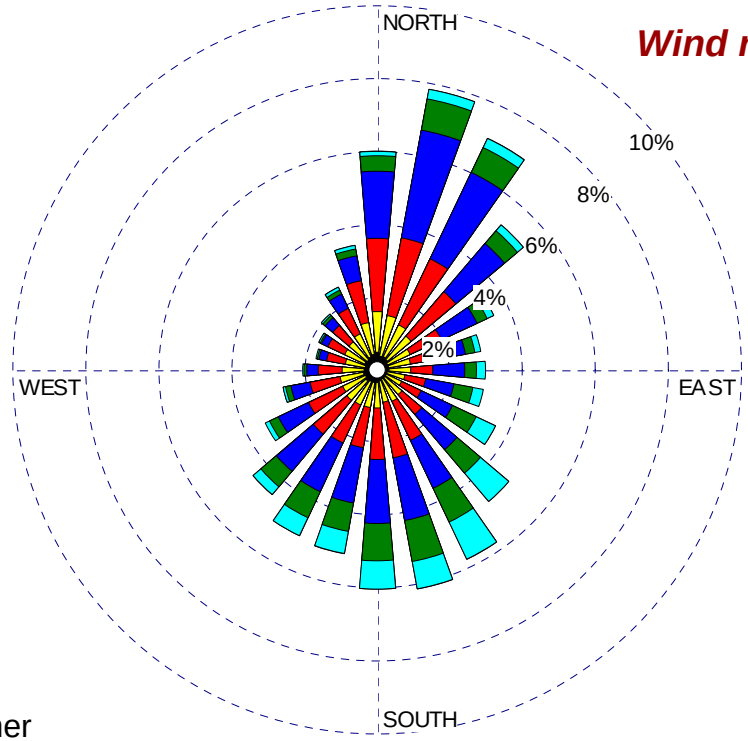
16 years climatology of hourly wind for NOAA Buoy 44014

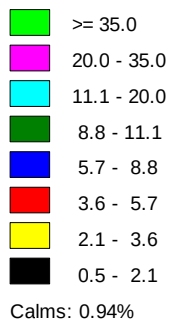
Diurnal Wind power density (W/m2)



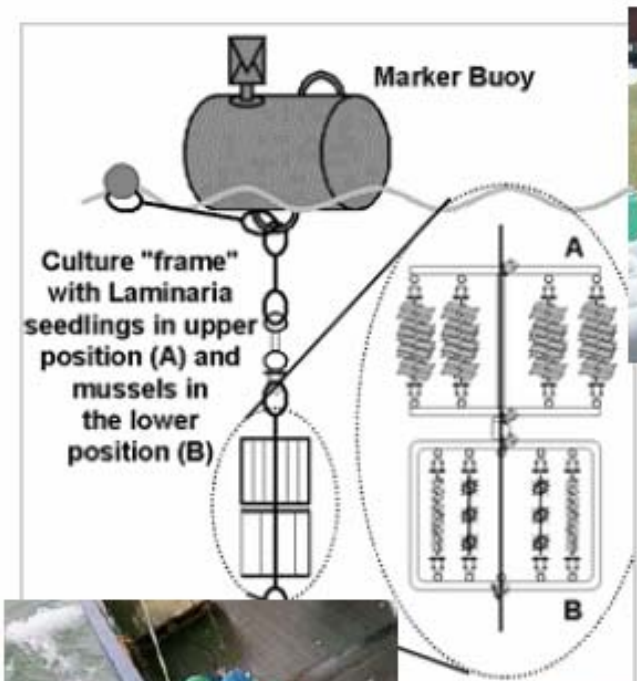
100 m diameter rotor => ~2 MW

Wind rose





Mid-Term R&D: Rope Culture of Mussels and/or Algae to Enhance Business Case



Build on German field studies done for North Sea offshore wind farms

Summary

Energy and economic benefits to Virginia

- Credible prospects for supplying 20% of Virginia's electricity demand
- Credible prospects for $150-200 million in new maritime business
- Enabling research needs state funding to realize these benefits

Appropriate Research to aid decision makers

- Wind, wave, current, sea bottom characteristics are being studied to good decisions can be made.
- If data is not available and is needed we will attempt to make the measurements: marine boundary layer for example.

Potential to attract large-scale federal RD&D funding

- University-industry studies of various hybrid combinations among wind, wave, solar, and marine bio-fuels would lay the groundwork for ARPA-E demonstration project