

# Offshore Wind Resources in the Southeast

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# Introduction

- Feasibility study carried out on offshore wind energy potential in coastal Georgia
  - Funded by NSF PFI grant: *InfiniEnergy*, A Coastal Georgia Partnership for Innovation



# Misconceptions

- The world is flat?
- The universe revolves around the earth?
- Fossil fuels are renewable?
- There is no wind in the Southeastern US?



# Recent Studies

- Stanford (2003)
  - “The greatest previously uncharted reservoir of wind power in the continental United States is offshore and near shore along the southeastern and southern coasts”

J. Geophysical Res., **108**, D9, 4289 ACL 10-1:10-20



# Current Study

- South Atlantic Bight
  - 6 years of highly creditable wind data
  - 50 m above ocean surface



# SE Continental Shelf

- Up to 95 miles wide
- < 50 m deep
- Conventional foundation technology
- Plenty of shallow water over horizon

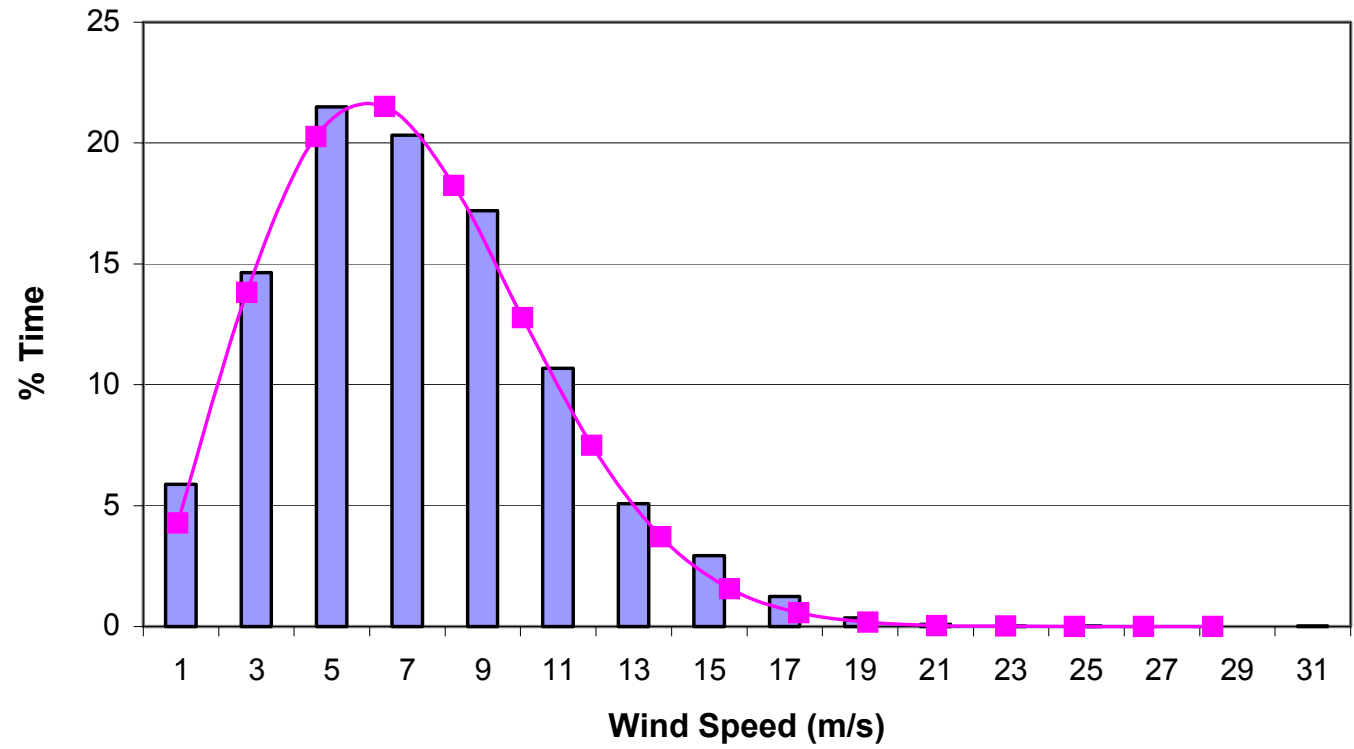


# Wind Data Details

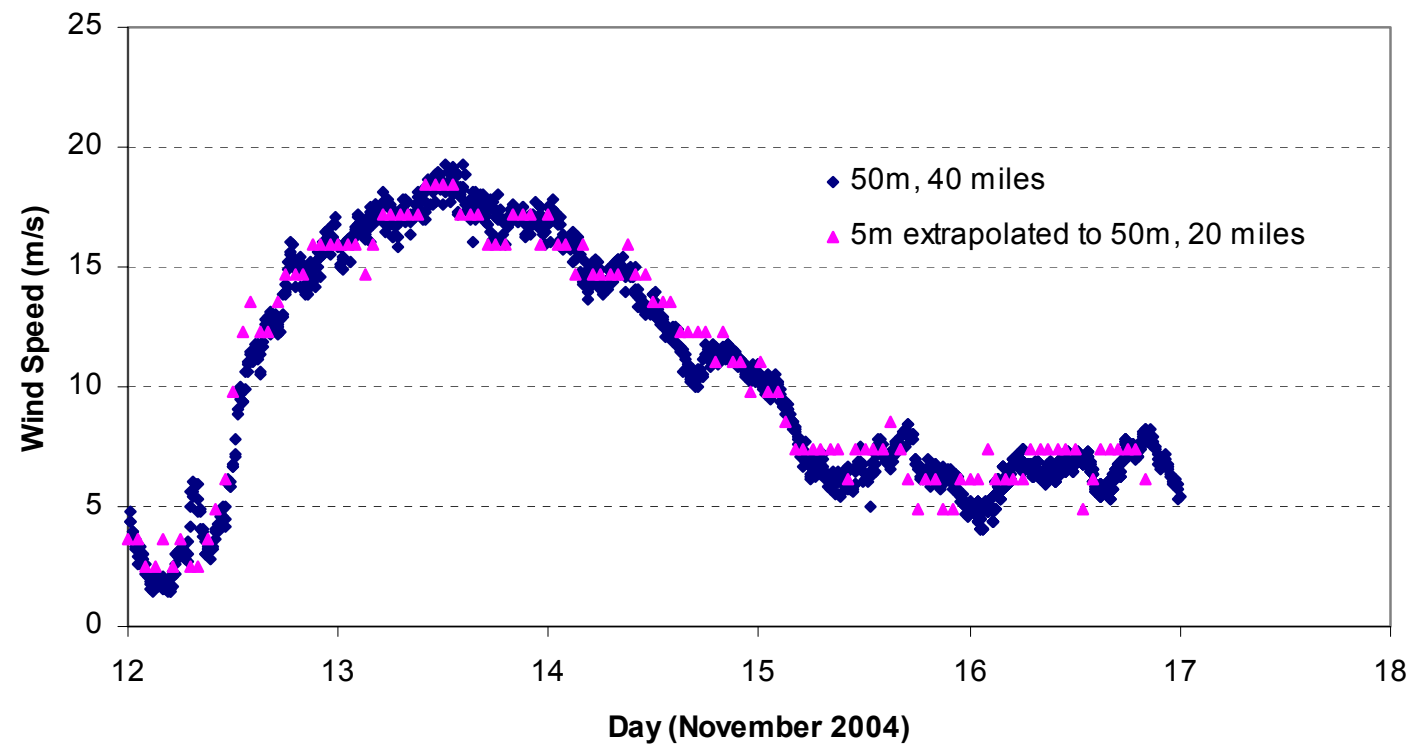
- 40 miles offshore
- 50m above ocean surface
- 27m water depth
- 6 Minute Interval Data from 6/1999- present
  - Wind Speed @ 50m
    - Min, Max & Deviation
  - Wind Direction @ 50m
    - Deviation



# Annual Wind Speed Distribution (Year 2000)



# Preliminary Correlation of Data with Location



# Wind Classification System (m/s)

Class	50 m		
1	0	to	5.6
2	5.6	to	6.4
3	6.4	to	7
4	7	to	7.5
5	7.5	to	8
6	8	to	8.8
7	8.8	to	11.9



# Data from 2000

Month	Avg. Wind Speed	Month	Avg. Wind Speed
	(m/s)		(m/s)
1	8.228	7	6.939
2	7.672	8	5.784
3	7.696	9	7.527
4	7.758	10	6.901
5	6.388	11	6.722
6	6.112	12	7.501

<b>Average</b>	<b>7.13 m/s</b>	<b>Class 4</b>
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# Sample Wind Turbine Specifications

- 2.0 MW
  - Hub height: 80m
  - Rotor Diam: 90m
  - Swept Area: 6362 m<sup>2</sup>
  - 3.5-25 m/s
  - Nominal wind speed: 11.5 m/s
- 3.6 MW
  - Hub height: ~70m-100m
  - Rotor Diam.: 104m
  - Swept Area: 8495m<sup>2</sup>
  - 3.5-27 m/s
  - Nominal wind speed: 14m/s



# Changes in Hub Height

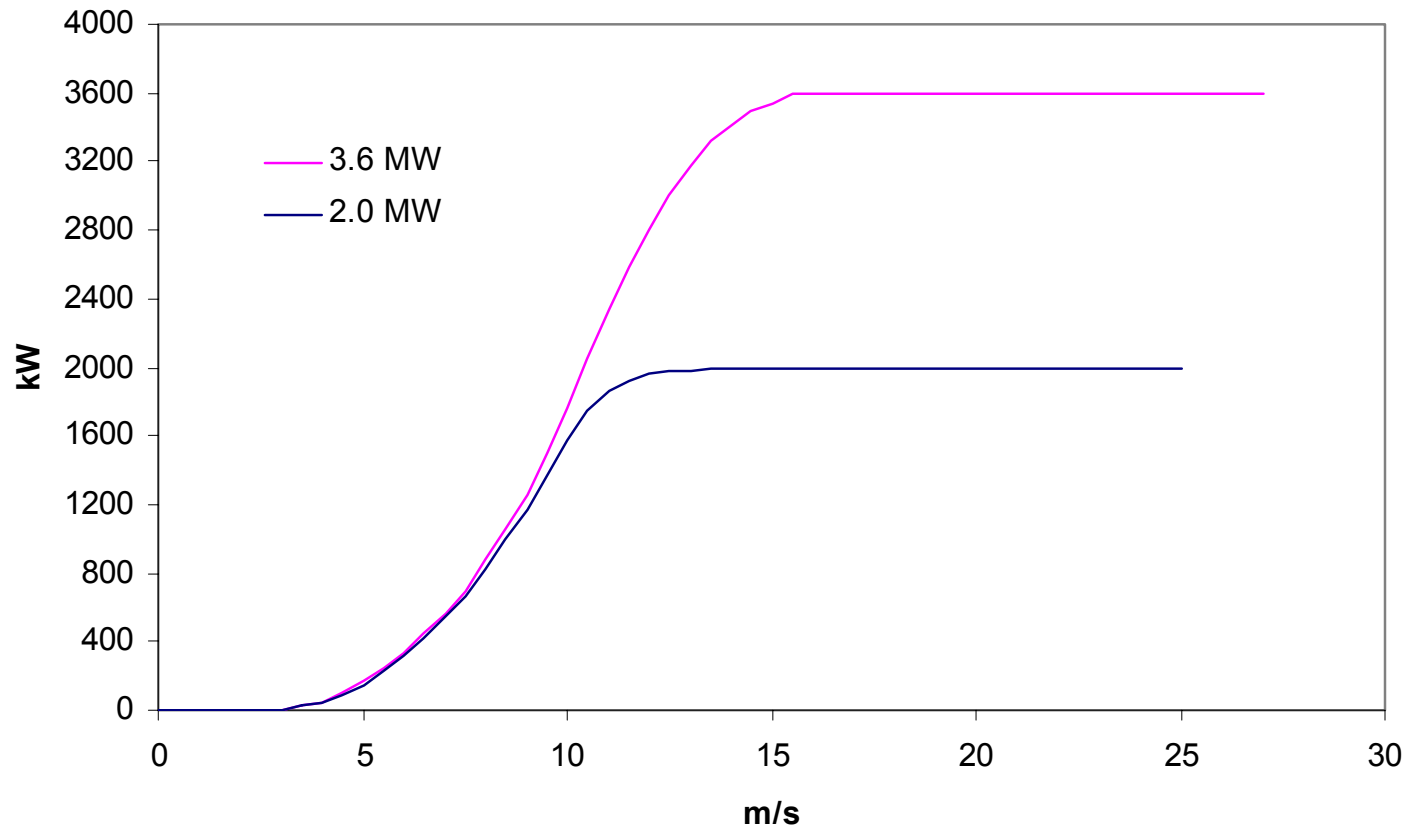
- Logarithmic Law for adjustment to hub height,  $z$ :

$$V_z = V_{50} \frac{\ln\left(\frac{z}{l}\right)}{\ln\left(\frac{50}{l}\right)}$$

– roughness length,  $l = 0.0002$  m (open water)



# Wind Power Curves



# Calculated kWh/year

Month	Avg Wind Speed @ 50m (m/s)	3.6 MW (kWh)	2.0 MW (kWh)
1	8.228	1006285	762476
2	7.672	850539	690222
3	7.696	909261	728187
4	7.758	882793	686909
5	6.388	534055	505100
6	6.112	410366	398667
7	6.939	607202	572262
8	5.784	412981	369585
9	7.527	776555	616632
10	6.901	703779	535884
11	6.722	701735	585399
12	7.501	841035	641322
<b>Annual</b>	<b>7.13</b>	<b>8,636,585</b>	<b>7,092,647</b>



# Capacity Factors

- 3.6 MW Turbine
  - 27.4%
- 2.0 MW Turbine
  - 40.5%



# European Wind Farms

Farm #	Year	Turbines (#)	Manufacturer	Size (MW)	Capacity Factor (%)	Farm Size (MW)
1	1990	1	WindWorld	0.22	-	0.22
2	1991	11	Bonus	0.45	25.8	4.95
3	1994	4	NedWind	0.5	22.8	2
4	1995	10	Vestas	0.5	28.5	5
5	1996	28	Nordtank	0.6	24.9	16.8
6	1998	5	WindWorld	0.55	34.4	2.75
7	2000	7	Enron Wind	1.5	40.1	10.5
8	2000	2	Vestas	2	34.2	4
9	2001	20	Bonus	2	26	40
10	2001	5	Neg Micon	2	34.2	10



# (cont.) European Wind Farms

Farm #	Year	Turbines (#)	Manufacturer	Size (MW)	Capacity Factor	Farm Size (MW)
11	2002	80	Vestas	2	42.8	160
12	2003	8	Vestas & Bonus	2&2.3	39.8	17.2
13	2003	10	Bonus	2.3	38.1	23
14	2003	4	Vestas, Nordex & Bonus	2, 2.3 & 2.3	31.9	10.6
15	2003	72	Bonus	2.3	36	158.4
16	2003	7	GE Wind	3.6	43	25.2
17	2003	30	Vestas	2	45.6	60



# Construction Cost Estimates

	\$/kW	% of Total
Grid Connect	547	28.3
Turbine Cost	944	48.8
Monopile Foundation	296	15.3
Other Capital Costs	148	7.6
<b>Total turbine costs</b>	<b>1935</b>	<b>-</b>

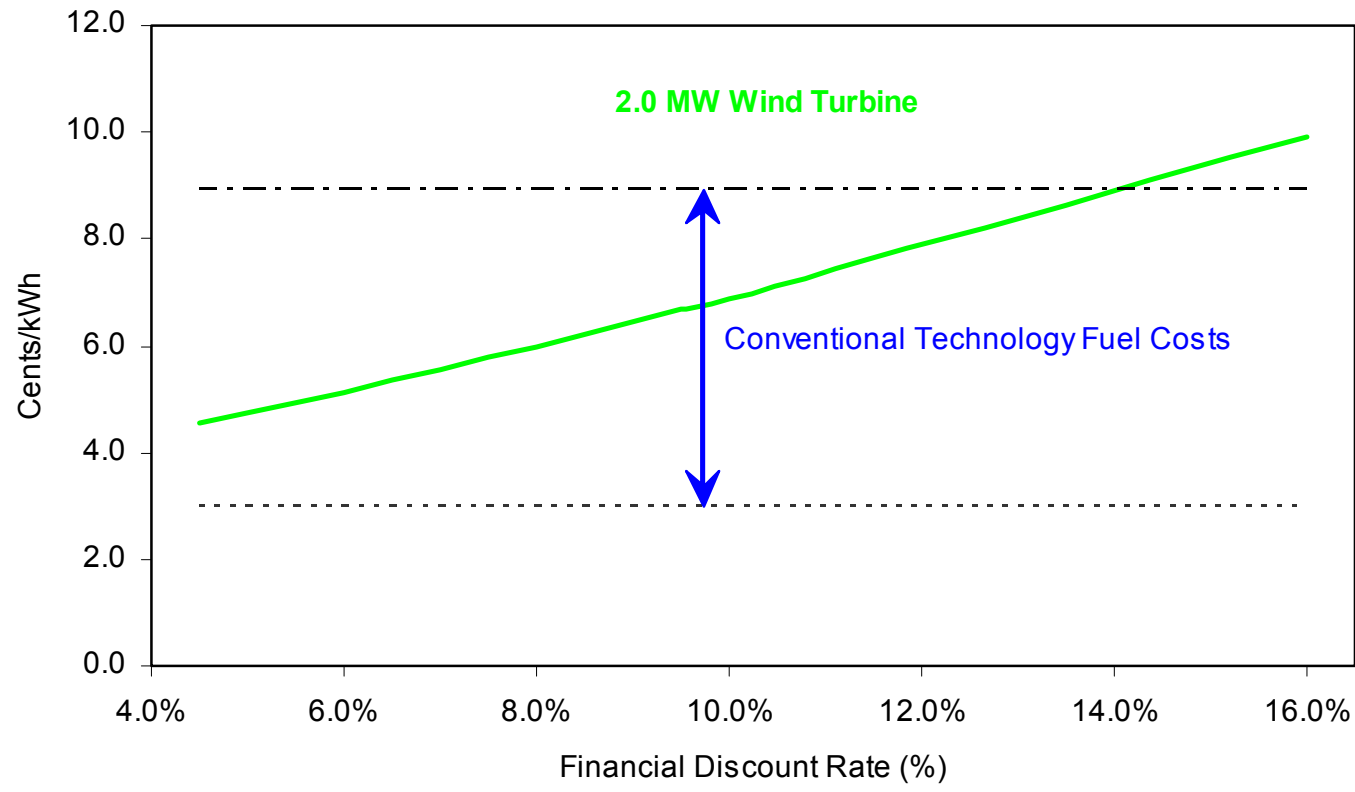
Future Offshore, A Strategic Framework for the Offshore Wind Industry, UK Department of Trade and Industry, 2002.



# Estimated Cost of Energy

20 Year Amortization

Cost includes 1.8 cents/kWh O&M and Production Tax Credit



# Zero-Emissions Benefits

- NO<sub>x</sub>, SO<sub>x</sub>
- Emissions Trading Evaluation:
  - ~1 cent/kWh



# Conclusion

- Study concludes that offshore wind energy in the Southeast warrants further study
  - Resource more significant than early reports
  - Could generate economically competitive electricity

