SEA POWER

Georgia's Offshore and Nearshore Wind Resource Coincidence with Electrical Demand Load

Offshore and nearshore wind resources can provide energy at high-demand peak periods.

Electric utilities in the southeast usually experience high-demand peak electrical demand during the summertime. To supply power at peak demand, utilities may rely on more expensive power plants, like combustion natural gas turbines. However, a natural phenomenon in coastal and offshore areas may help supplant these higher cost peaking power plants. The Sea Breeze Effect occurs when cool ocean air rushes inland where warmer air is rising; this effect is prominent on hot summer afternoons when utility load demands are high.

Georgia's offshore wind resources would be able to provide high value, and high demand energy when it is needed the most: hot summer afternoons. Based on this research, Georgia's Sea Breeze Effect is positively correlated with Georgia Power's hourly electrical demand during summertime. Therefore, offshore wind energy resources have good coincidence with electrical demand load.

Findings

Georgia's offshore and nearshore wind resources are positively correlated with utility demand during the peak-demand energy months of June, July and August.

As electrical demand increases in the summer afternoons, offshore and nearshore wind resources generally increase.

Offshore and nearshore wind farms may be able to offset more expensive peaking power stations by providing valuable peak power.

Offshore and nearshore wind capacity factors are highest during the winter months of December, January and February.

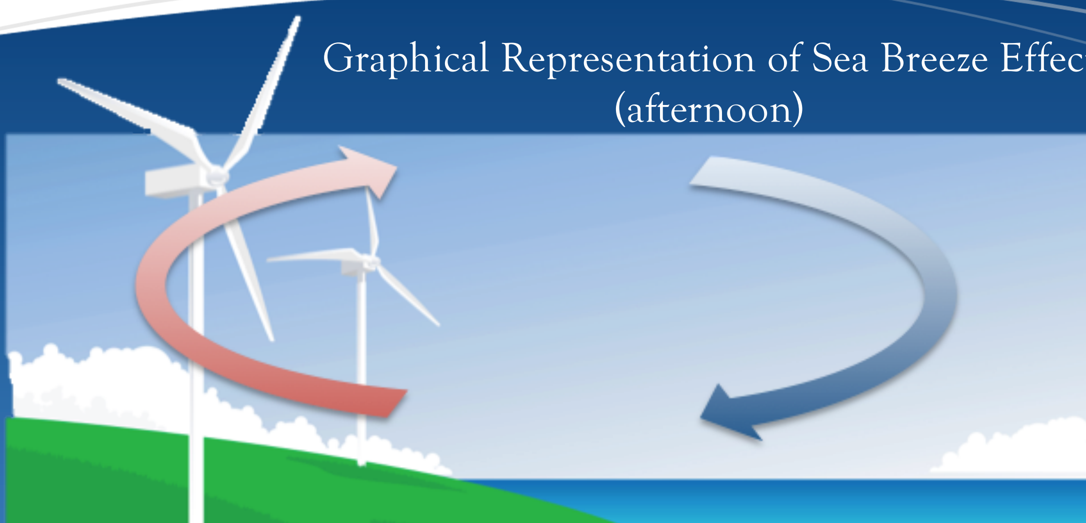
Wind energy has rarely been viewed as a peaking generation resource.

Wind energy is playing a more predominant role in electricity generation around the world and especially in the United States. Despite the surge in wind energy development, common misconceptions about this resource still remain. One of these misconceptions is that the wind does not blow (and thus, cannot create electricity) when electric power utilities require that electricity the most. To the contrary, wind farms in nearshore and offshore areas are likely to have exceptional coincidence with electrical demand load; especially with electric utilities in the southeast due to the Sea Breeze Effect. The Sea Breeze Effect is the process whereby winds move inward from the ocean to the land, and back again, due to temperature differences between the landmass and ocean. To test this premise, electrical generation data from three theoretical offshore wind farms off Georgia's coast were compared against an hourly demand load profile of a major electric utility in Georgia.

The Sea Breeze Effect puts a different spin on that point of view.

The Sea Breeze Effect occurs in coastal areas. As the ocean and landmasses warm and cool in a cyclical fashion throughout the days and nights, the two bodies lose and gain heat at different rates. Water radiates and absorbs heat from the sun at a slower rate than land. During hot summer afternoons, as the land heats up at a faster rate than the ocean, the hot air mass above the land rises creating a vacuum. That vacuum is then filled by the cooler air mass above the ocean. From the shore, an observer should feel a sea breeze coming from the ocean in the late afternoons on hot summer days. This effect can occur at anytime of year. During the winter, for example, an opposite sea breeze can be felt early in the mornings when the colder land air mass is rushing over the shore to fill the void left by the warmer ocean air rising.[1] If nearshore or offshore wind farms can capture sea breezes, those wind farms will be well positioned to supply the real-time needs of a utility.

Graphical Representation of Sea Breeze Effect (afternoon)

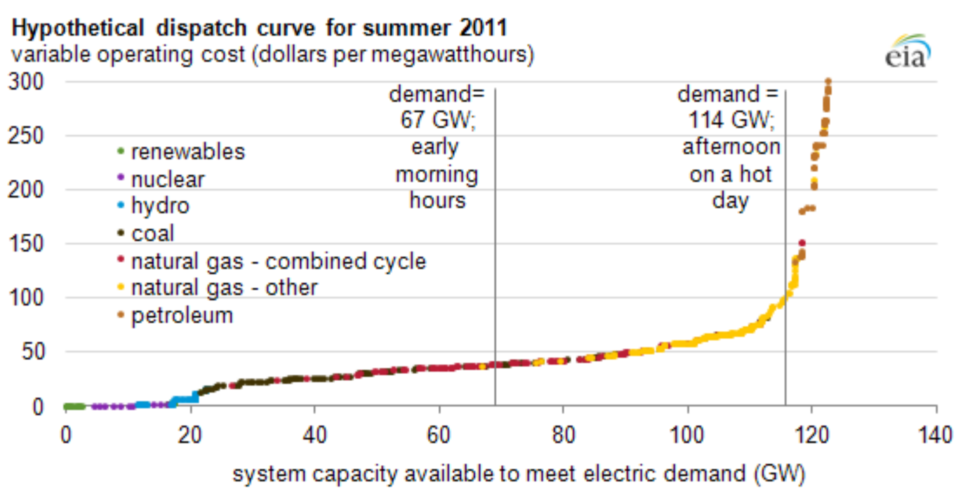


Temperature differences between a landmass and a body of water drive the Sea Breeze Effect. Landmasses heat up quicker than bodies of water. As the landmass air warms, it begins to rise. With the rising air, a vaccum is created and the relatively cooler air over a body of water (which is heavier and closer to ground level) begins to fill the vaccum – creating a summer afternoon's breeze offshore and nearshore.

Peak-Power is High Value Power.

Peaking generation power plants are used minimally, but are required to quickly generate electricity and rapidly ramp up to meet the required electrical load. Peaking generation power plants can use diesel, petroleum, or more commonly, natural gas as a fuel source.[5] The power plant's minimal use, rapid and inefficient response as well as the use of fuels that are subject to price volatility make peaking generation an expensive generation resource. Nevertheless, peaking generation provides vital electrical resources when utilities need it most to prevent brownouts and blackouts. As such, utilities will pay more for peaking generation to ensure electrical reliability.

If offshore wind farms are capable of supplying peak power, utilities would not have to rely on more expensive peaking generation units.



Source: U.S. Energy Information Administration.[6]

Note: The dispatch curve above is for a hypothetical collection of generators and does not represent an actual electric power system or model results. The capacity mix (of available generators) differs across the country; for example, the Pacific Northwest has significant hydroelectric capacity, and the Northeast has low levels of coal capacity. This dispatch curve does not show all costs associated with electric generation, such as capital costs.

Sea Breeze Effect Occurs Offshore and Nearshore.

In 2007, an American offshore wind development firm published a report on offshore wind energy's capability of matching a utility's summer demand.[2] The Cape Wind project off the coast of Massachusetts has a tower constructed several miles offshore that collects wind speed data. The data show that if that project were constructed, the electricity it would produce would coincide with summertime peak electrical generating demand. Cape Wind provides anecdotal evidence for the Sea Breeze Effect's implications for offshore wind development.

Similar evidence suggests the Sea Breeze Effect also occurs in nearshore areas. In 2011, on a hot afternoon in Texas, numerous natural gas power plants and at least one coal-fired power plant suddenly went offline due to excessive heat.[3] Newly built coastal wind farms provided power when the Texas grid manager needed the electricity most due in part to the sea breeze effect, helping to prevent a brownout or blackout.[4] Therefore, the Sea Breeze Effect is not only a phenomenon for offshore, but also nearshore areas.

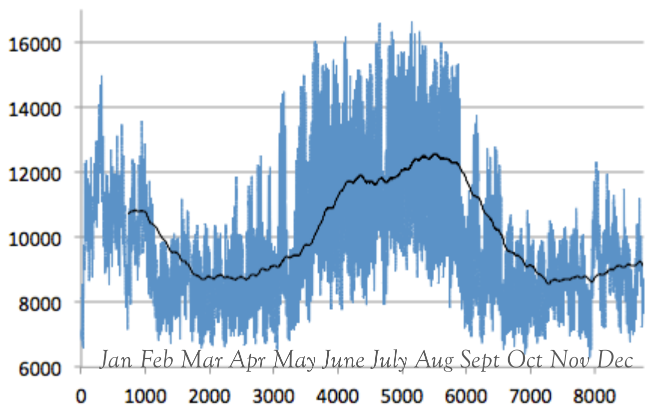
Georgia's Power Demands are Highest in the Summer.

Georgia Power is the largest electric utility in Georgia and the largest subsidiary company of Southern Company.[7] The hour-by-hour electrical demand load profile of Georgia Power is available through the Federal Energy Regulatory Commission Form 714, along with Southern Company's hourly generation cost (system lambda).[8]

Georgia Power's electrical demand tends to peak in the summer months from late May to early September (represented approximately by hours 3,500 – 6,000). During the wintertime, peak electrical demand also occurs from December to February (represented approximately by hours 8,000-8,760 and hours 0-1,000), albeit at a lesser scale relative to the summer months. Of the top 10% of electrical demand hours, the vast majority of them occur in June, July and August (see Chart 3).

Another way to determine the importance of electrical generation is to evaluate at the cost of electricity at a particular hour. The higher the electrical cost, presumably the more important electrical generation becomes at that particular time. One way to determine these costs is by evaluating a utility's cost to generate the next megawatt-hour (MWh) of electricity, also called the "system lambda".[9] For Southern Company (the parent company of Georgia Power), the 2011 top 10% of system lambda costs ranged from about $51 per MWh to about $264 per MWh. Like the top 10% of electrical demand hours, most of the top 10% system lambda costs in 2011 occurred during the summer months of June, July and August (see Chart 4).

Chart 2: Georgia Power Annual Electrical Demand 2011 (MW, by hour)



Source: Georgia Power, FERC Form 714.
Rolling average indicated by black line.
Hour 0 = 12AM, January 1, 2011

Chart 3: Top 10% Hourly Demand Load Occurrences (Average 2006-2008)

May	13
June	223
July	249
August	321
September	70

Source: Georgia Power, FERC Form 714.

Chart 4: Top 10% System Lambda Cost Occurrences (2011)

January	61
February	2
March	5
April	22
May	90
June	176
July	191
August	213
September	69
October	15
November	14
December	18

Source: Southern Company, FERC Form 714.

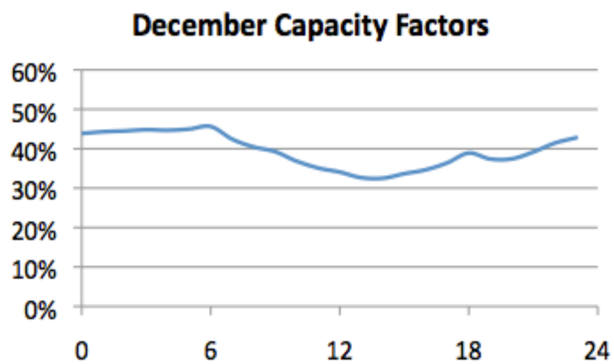
Georgia's Sea Breeze Effect is Strongest in the Summer.

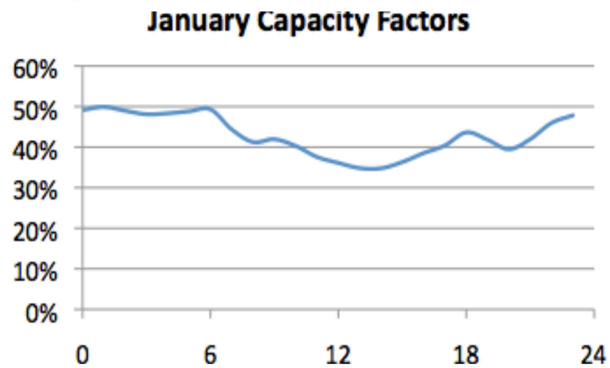
A report completed in 2011 by AWS Truepower estimated offshore wind energy output for three potential offshore wind farms off Georgia's northeastern coast.[10] For each of the three potential wind farms, 10-minute scale wind speed data files were created based on historical data from January 1, 1999 to December 31, 2008. For the purposes of this report, the data files were aggregated from 2006-2008 (to match data available from Georgia Power) and narrowed down to the wintertime and summertime periods to evaluate wind energy's output during peak demand periods.

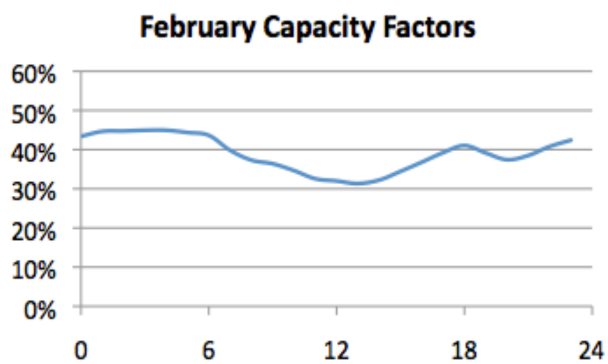
As can be seen by Chart 5, the Sea Breeze Effect during the summer months is most pronounced in the afternoon (especially around 5PM). However, a similar effect is seen earlier in the day during the summertime (peaking around 9AM). Two Sea Breeze Effects can also be seen during the wintertime with the greater effect occurring in the morning (peaking around 7AM) and the lesser effect occurring in the evening (peaking around 6PM).

Chart 5: Seasonal Offshore Wind Energy Output by Hour (Average 2006-2008)

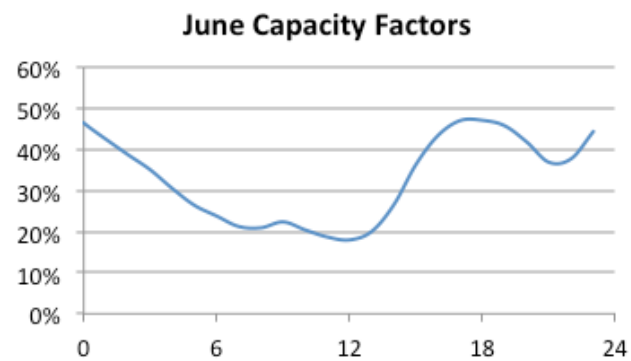
Georgia Wintertime Output

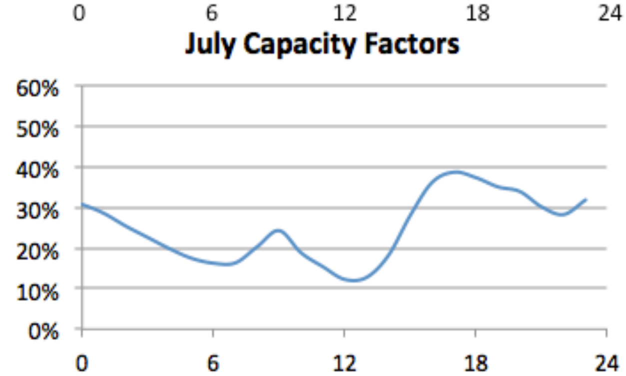


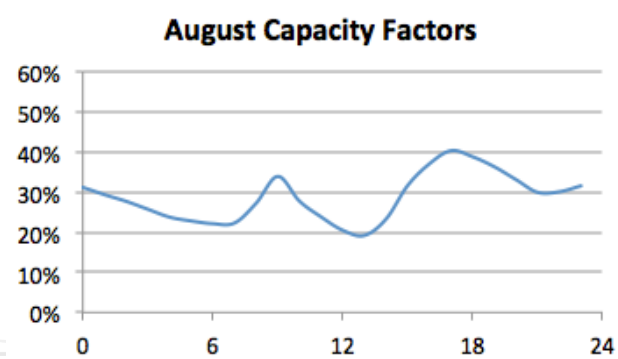




Georgia Summertime Output







Georgia's Sea Breeze Effect Matches Peak Demand.

Modeled offshore wind generation off of Georgia's coast continually increases from 12PM to 5PM particularly during the summertime. Two sea breeze effects are noticeable from Georgia's offshore wind resource; a small one in the morning peaking around 9AM and a large one in the late afternoon peaking around 5PM. Georgia's offshore wind resource is readily available during Georgia Power's top 10% load hours (top 876 hours in a year). During Georgia Power's average top 10% load hours from 2006-2008, the average capacity factor for offshore wind resources was approximately 30%. Modeled offshore wind resources match Southern Company's top 10% system lambda hourly costs (top 876 hours in a year) better than top load hours. During Southern Company's top 10% system lambda hourly costs in 2011, the average capacity factor for Georgia's modeled offshore wind resources was approximately 33%. The vast majority of both the peak load hours and peak system costs occur in the months of June, July and August.

Wintertime offshore wind energy generation resources are generally more abundant than the summertime resources. However, due to the strong focus on system peak loads and system lambda costs, wintertime offshore wind resources are potentially less valuable to Georgia Power. Nevertheless, wintertime offshore wind resources obtain higher capacity factors and fluctuate less than the summertime resources.

August tends to be the month with the highest peak loads, the highest number of peak load hours and highest number of top system lambda costs. As such, August is a particularly important month for offshore wind resources to correlate to electrical demand. On an annual basis, Georgia's offshore wind energy resources have a moderately negative correlation* (-0.33), meaning that as electrical demand increases, offshore wind output decreases slightly and vice versa. However, during the month of August, Georgia's offshore wind resource shows a moderately positive correlation with electrical demand (0.38), meaning as demand increases or decreases, offshore wind tends to follow those trends. A positive correlation also occurs in July (0.32) and June (0.16). Offshore wind resources during the winter months have a moderately negative correlation with electrical demand load to a greater degree than the annual correlation. However, daylight (6AM-7PM) correlation is positive for both summertime and wintertime seasons.

**Correlation identifies a statistical relationship between two variables. A +1 correlation shows a perfect relationship, a -1 correlation shows a perfectly opposed relationship and a 0 correlation shows no relationship.*

By the Numbers

30%

Average Capacity Factor during Top 10% Load Hours (2006-2008)

33%

Average Capacity Factor during Top 10% System Lambda Hourly Costs (2011)

37%

Average Annual Capacity Factor (2006-2008)

+0.38

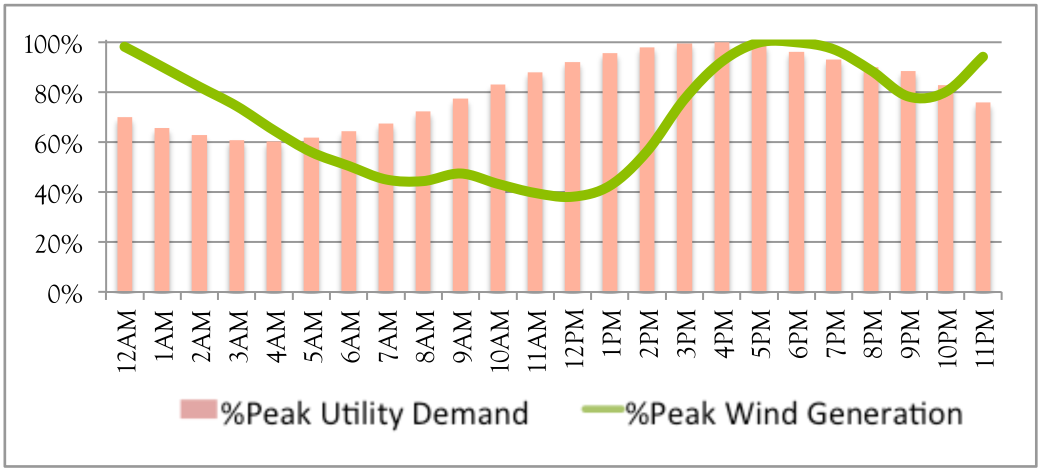
August Offshore Wind Positively Correlated with Electric Demand

Chart 6: Offshore Wind Correlation with Electric Demand

	Correlation	
	24-hr	**Daylight**
June	0.16	0.57
July	0.32	0.40
August	0.38	0.29
December	-0.42	0.70
January	-0.58	0.76
February	-0.59	0.34
Annual	-0.33	0.21

Chart 7: Hourly offshore wind output (percentage of peak generation) and hourly Georgia Power demand load curve (percentage of peak load) by month (2006-2008)

June

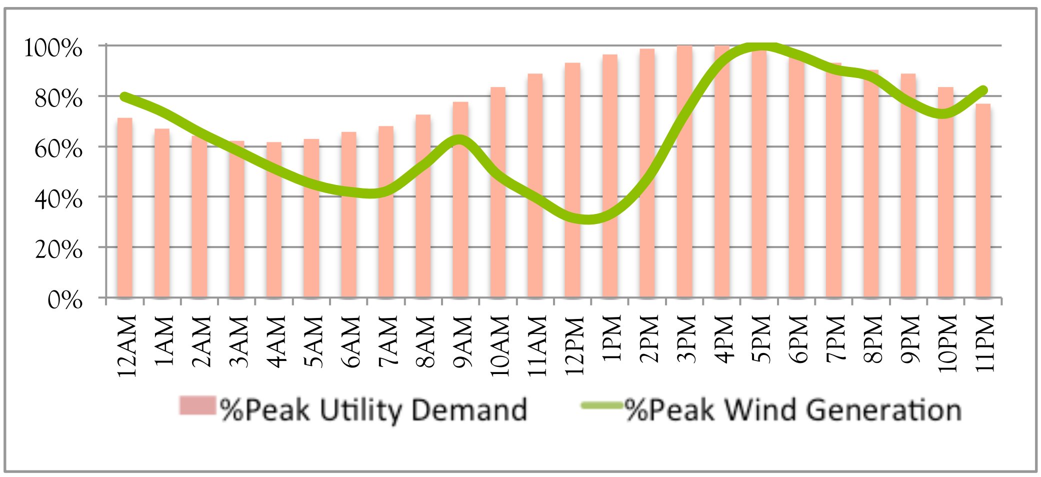


33%
Avg. Capacity Factor

0.16
Hourly Correlation

0.57
Daylight Correlation (6AM-7PM)

July

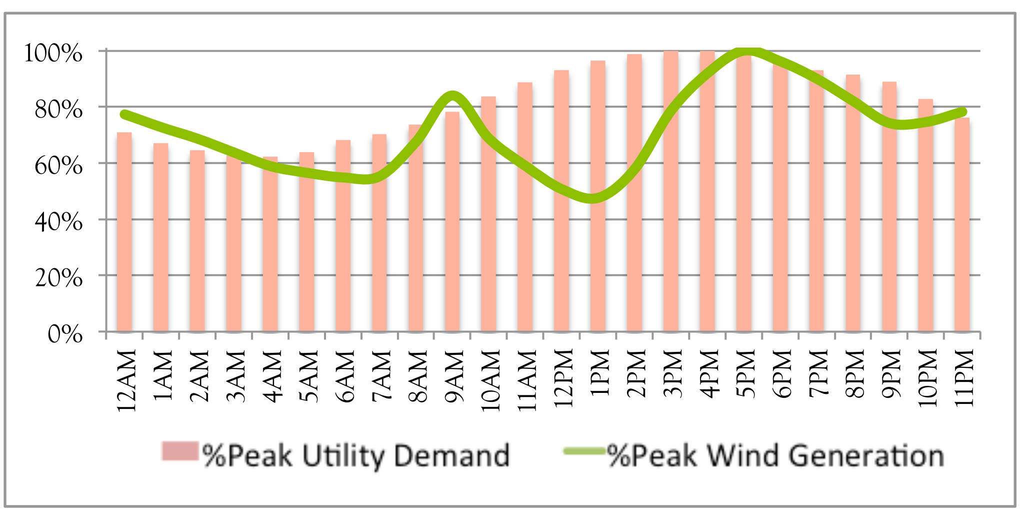


25%
Avg. Capacity Factor

0.32
Hourly Correlation

0.40
Daylight Correlation (6AM-7PM)

August



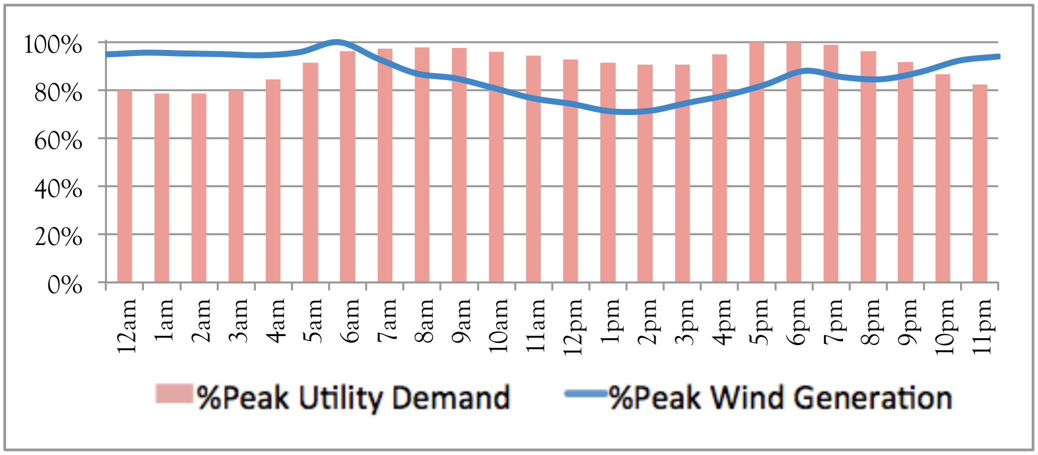
29%
Avg. Capacity Factor

0.38
Hourly Correlation

0.29
Daylight Correlation (6AM-7PM)

Chart 8: Hourly offshore wind output (percentage of peak generation) and hourly Georgia Power demand load curve (percentage of peak load) by month (2006-2008)

December

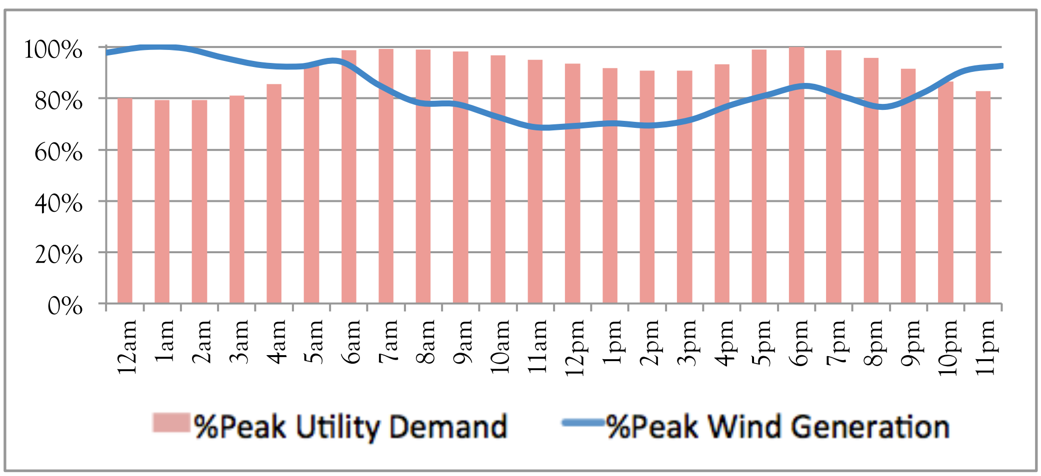


39%
Avg. Capacity Factor

-0.42
Hourly Correlation

0.70
Daylight Correlation (6AM-7PM)

January

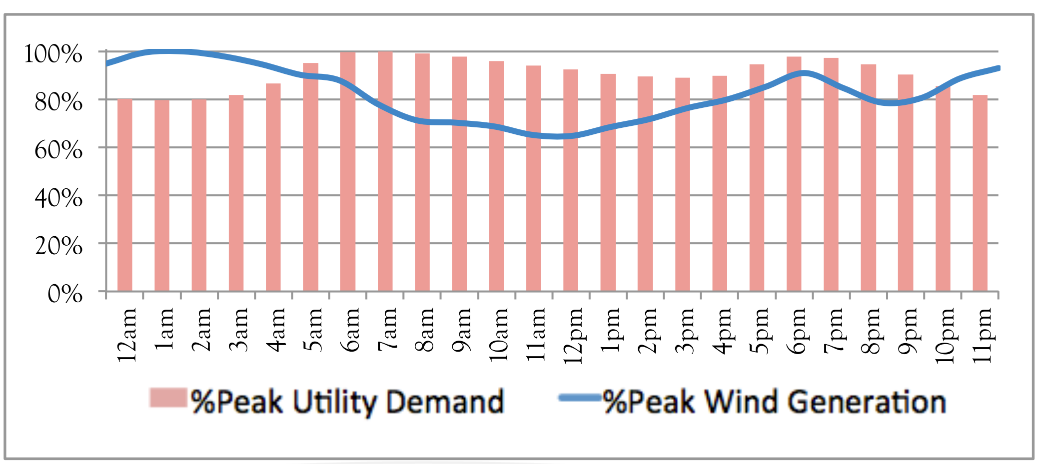


43%
Avg. Capacity Factor

-0.58
Hourly Correlation

0.76
Daylight Correlation (6AM-7PM)

February



39%
Avg. Capacity Factor

-0.59
Hourly Correlation

0.34
Daylight Correlation (6AM-7PM)

Conclusions

Currently, no offshore wind farms have been built off the United States. Bureaucratic red tape and hesitation to adopt new technology has thus far hampered this multi-billion dollar opportunity here. Abroad and especially in Europe offshore wind farms have been operational for over two decades. As the United States waits to develop this opportunity, it is becoming increasingly clear that offshore and nearshore wind farms can benefit from a unique natural phenomenon that occurs along coastlines. The Sea Breeze Effect occurs in coastal areas offshore and nearshore where a temperature differential between the land and sea causes a change in the wind. This phenomenon warrants a different evaluation of the value of offshore and nearshore wind farm development.

Offshore wind resources tend to be available when load demands are high. Georgia's electricity demands tend to peak in the summertime. During summertime, the state's offshore winds are positively correlated with Georgia Power's hourly electrical demand. Electricity demand tends to be higher during daylight hours when people are most active. Between the hours of 6AM and 7PM (inclusive), correlation between offshore wind resources and utility demand tend to be moderately positive during the summertime but strongly positive during the wintertime.

Offshore and nearshore wind energy would provide high value power. One common misconception is that wind energy should be compared against base load electric generation (e.g., coal or nuclear power); however, this research shows offshore wind and nearshore wind resources act more like peaking generation resources. Traditional peaking power plants, like natural gas combustion turbines, are usually a utility's highest cost power resource and are readily called upon during high load demands in the hot summer afternoons. Like solar power, offshore and nearshore wind resources naturally provide peak power generation during the summertime afternoons. These findings highlight the beneficial value of offshore and nearshore wind resources.

Methodology

Hourly demand loads for Georgia Power were collected from the Federal Energy Regulatory Commission Form 714, Part 3, Schedule 2, Respondent ID 296, EIA Code 7140. Hourly loads for 2006, 2007 and 2008 were averaged together on an hourly, and monthly basis.[11] February 29th, 2008 was removed from the dataset as it was the only leap year day.

Wind output data were provided by AWS Truepower in association with development of the report, *Building an Infrastructure for Ocean Based Renewable Energy in the Southeast U.S.: Phase 2B Southeast Mesoscale Study*, April 4, 2011.[12] According to AWS Truepower,

"Using a mesoscale numerical weather prediction model at 20 km resolution, AWST modeled 10 years of wind resource at locations most suitable for offshore wind farm development identified in a previous phase of the project. Model wind speeds were validated by measurements from offshore moored stations in the region. Gross and net power output was calculated for each wind farm location, taking into account losses and turbine availability associated with typical offshore wind farms. Capacity factors were calculated for each site using 8 MW/km the maximum carrying capacity of each wind farm development area. Capacity factors were found to be consistent to those in previous offshore wind studies. Monthly average gross and net capacity factors."

Wind output data were provided on a ten-minute scale from 1999-2008. Gross power output for Study Block 7, 8 and 9 (study blocks closest to Georgia) were aggregated on an hourly, and monthly basis for 2006, 2007 and 2008. Total potential capacity for the three blocks added together is 2,050 megawatts. Data were made available in Greenwich Mean Time (GMT) and were subsequently altered to Eastern Standard Time (GMT-5) or Eastern Daylight Time (GMT-4) depending on the season. February 29th, 2008 was removed from the datasets.

Establishing Percentage of Peak Generation and Peak Demand

In order to better compare utility demand to offshore wind generation, hourly demand load data and wind output data were converted in percentages.

Percentage of Peak Generation = Wind Hourly Capacity Factor / Wind Hourly Highest Capacity Factor

Percentage of Peak Demand = Hourly Demand / Highest Hourly Demand

Offshore wind generation was converted into hourly capacity factors (output divided by total potential capacity). The highest achieved average capacity factors for each evaluated month (January, February, June, July, August and December) was noted as peak generation. For each month, the average hourly capacity factors were divided by the peak generation (that month's highest average capacity factor) to create a percentage of peak generation. For utility demand load, the average hourly output (in megawatts) was plotted for each evaluated month. The highest achieved average hourly output was noted as peak demand. For each month, the average hourly outputs were divided by the peak demand. Pearson correlation coefficient tests were run on the percentage of peak generation and percentage of peak demand datasets to establish correlation and direction.

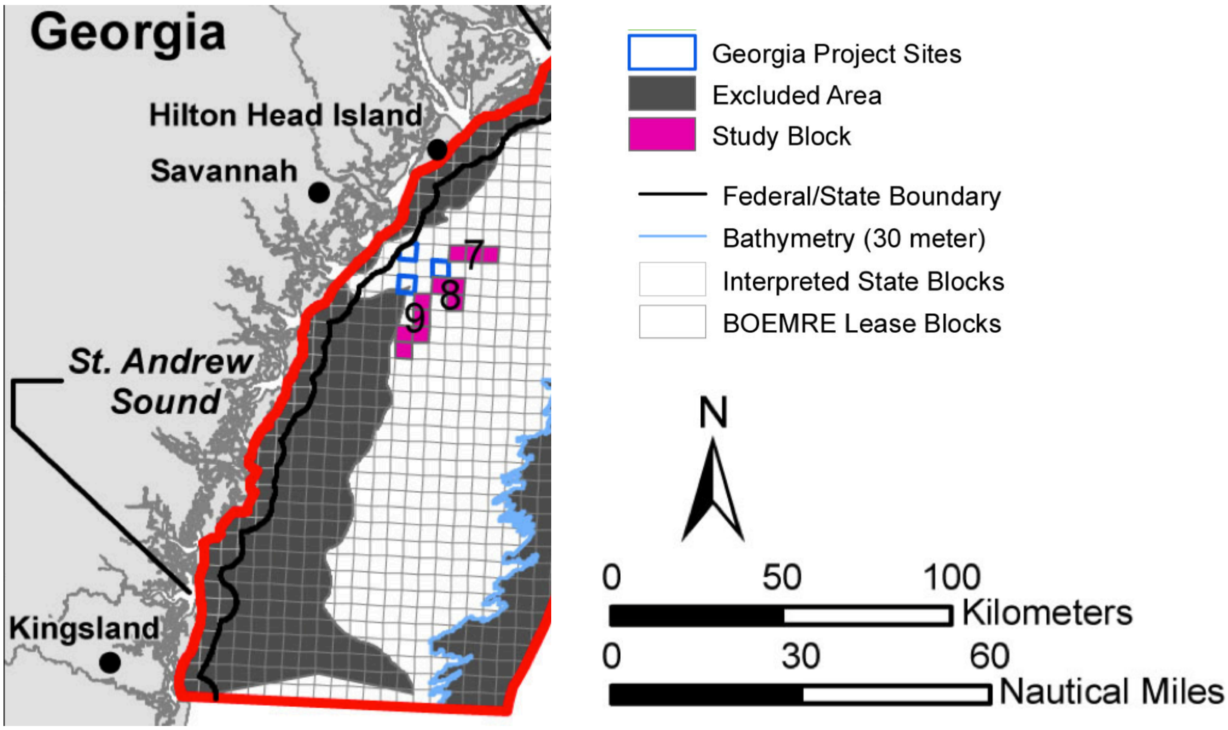
Summertime Datasets for Wind Generation and Power Demand (2006-2008, average)

June			July			August		
Time	Wind Generation (MW)	Georgia Power Load (MW)	Time	Wind Generation (MW)	Georgia Power Load (MW)	Time	Wind Generation (MW)	Georgia Power Load (MW)
12am	948.3	10026.6	12am	632.4	10299.7	12am	639.8	10772.3
1am	870.4	9414.2	1am	584.2	9671.0	1am	601.5	10207.6
2am	793.0	8992.6	2am	519.9	9259.1	2am	567.5	9804.0
3am	718.1	8727.9	3am	462.8	8990.3	3am	527.1	9546.9
4am	624.4	8654.3	4am	405.8	8915.0	4am	486.9	9478.7
5am	540.6	8864.5	5am	357.7	9106.2	5am	467.2	9728.5
6am	487.3	9230.5	6am	332.9	9496.4	6am	453.4	10371.9
7am	434.8	9675.6	7am	334.4	9836.1	7am	456.6	10701.6
8am	428.5	10362.7	8am	416.3	10479.2	8am	557.8	11192.1
9am	457.9	11100.2	9am	497.1	11236.2	9am	694.4	11897.0
10am	417.8	11893.3	10am	385.7	12070.3	10am	568.7	12713.9
11am	382.5	12616.5	11am	315.2	12824.2	11am	487.9	13493.2
12pm	368.0	13209.1	12pm	250.9	13445.5	12pm	419.3	14146.0
1pm	410.6	13719.8	1pm	261.6	13933.9	1pm	393.3	14666.2
2pm	544.0	14054.5	2pm	373.0	14249.9	2pm	477.1	15019.6
3pm	745.3	14274.7	3pm	575.5	14429.2	3pm	648.7	15198.6
4pm	890.2	14329.4	4pm	742.0	14441.6	4pm	759.1	15206.6
5pm	964.0	14167.1	5pm	792.6	14267.6	5pm	826.2	15005.2
6pm	964.8	13798.7	6pm	764.6	13915.1	6pm	795.0	14603.4
7pm	937.6	13340.9	7pm	718.4	13454.6	7pm	744.0	14141.1
8pm	856.1	12904.8	8pm	694.8	13058.4	8pm	678.4	13916.2
9pm	755.3	12670.9	9pm	616.9	12841.8	9pm	613.2	13517.4
10pm	773.1	11858.7	10pm	578.5	12060.0	10pm	616.2	12594.6
11pm	908.9	10870.9	11pm	652.2	11112.9	11pm	646.5	11585.8

Wintertime Datasets for Wind Generation and Power Demand (2006-2008, average)

January			February			December		
Time	Wind Generation (MW)	Georgia Power Load (MW)	Time	Wind Generation (MW)	Georgia Power Load (MW)	Time	Wind Generation (MW)	Georgia Power Load (MW)
12am	1042.6	8715.1	12am	908.8	8745.3	12am	873.0	8181.1
1am	1066.3	8622.0	1am	953.4	8666.2	1am	880.7	8057.8
2am	1061.1	8642.6	2am	957.5	8703.2	2am	877.6	8051.7
3am	1022.6	8830.3	3am	938.7	8903.3	3am	875.1	8202.0
4am	991.1	9324.5	4am	906.5	9434.0	4am	870.8	8644.3
5am	986.1	10198.9	5am	864.4	10356.4	5am	882.9	9373.5
6am	1007.1	10749.3	6am	842.7	10847.4	6am	920.9	9844.3
7am	908.8	10794.2	7am	747.6	10879.5	7am	858.1	9976.0
8am	836.0	10773.2	8am	682.9	10800.7	8am	801.1	10027.7
9am	829.0	10683.4	9am	673.5	10658.4	9am	782.4	9981.6
10am	778.7	10501.2	10am	658.4	10450.9	10am	745.0	9835.7
11am	733.7	10296.3	11am	624.4	10242.2	11am	705.9	9657.0
12pm	738.1	10121.5	12pm	620.7	10058.8	12pm	684.4	9512.2
1pm	749.3	9942.8	1pm	656.0	9872.4	1pm	656.0	9369.8
2pm	740.4	9818.9	2pm	687.6	9735.0	2pm	657.6	9269.3
3pm	763.6	9826.5	3pm	732.4	9693.0	3pm	688.7	9292.5
4pm	823.0	10085.9	4pm	765.8	9783.5	4pm	717.7	9720.2
5pm	868.4	10721.4	5pm	816.8	10299.3	5pm	758.6	10237.7
6pm	904.7	10833.9	6pm	871.4	10647.6	6pm	811.0	10229.9
7pm	856.8	10714.3	7pm	811.4	10575.8	7pm	786.6	10115.2
8pm	817.6	10397.6	8pm	753.2	10295.9	8pm	779.1	9859.7
9pm	877.8	9932.4	9pm	771.4	9832.6	9pm	807.0	9402.2
10pm	965.7	9384.0	10pm	849.6	9307.1	10pm	850.3	8861.5
11pm	988.4	8985.2	11pm	891.2	8919.9	11pm	866.0	8430.2

Map for Study Blocks 7, 8, 9 (See Reference #12)



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The Southern Alliance for Clean Energy has been a leading voice for energy policy to protect the quality of life and treasured places in the Southeast since 1985. Our dedicated and diverse staff is poised to tackle our region's energy challenges and harness the economic opportunities presented by clean renewable energy. SACE advocates for federal, state and local climate policy solutions, energy efficiency programs and policies, and renewable energy such as solar, wind, and sustainable bioenergy. We promote clean fuels and vehicles, oppose nuclear and coal-fired power plant expansion, and encourage the retirement of old, dirty inefficient coal-fired power plants in our region.

For over 25 years, SACE has worked as a strong defender of the environment, challenging the status quo and working to minimize the impact of the energy sector on our region's communities, natural resources and economies. We are committed to ensuring that communities throughout the Southeast never have to choose between a healthy environment and a stable economy.

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