

SIMULATIONS

**006 Cape Hatteras
Lighthouse
Misty Night**



VISUALIZATION STUDY FOR OFFSHORE NORTH CAROLINA
006 Cape Hatteras Lighthouse, Misty Night, Existing Conditions



SIMULATION

006 Cape Hatteras Lighthouse

Misty Night

Siemens SWT-3.6-107

10 nm

Simulation
006 Cape Hatteras Lighthouse
 Misty Night
 Siemens SWT-3.6-107
 10 nm

GENERAL INFORMATION

Base Photograph

Photo Name: HLS_0001-UV
 Date: April 14, 2012
 Time: 8:57 PM
 GPS Coordinates¹: lat 35.250515°, long -75.528815°
 Viewpoint Elevation: 172'

Weather

Moon is below horizon
 Weather Conditions: Starlit (see notes)
 Visibility²: 10 mi
 Wave Height: Unknown
 Period: Unknown

Camera

Camera Make/Model: Nikon D7000
 Sensor Dimensions: 23.6 mm X 15.6 mm
 Lens Make/Model: Nikkor DX AF-S 35 mm
 Lens Focal Length: 35 mm
 35 mm Equivalent Focal Length: 52.5 mm
 Horizontal and Vertical Angles of View:
 37.3° wide and 25.3° high
 Camera Height: 1.5 m (5')
 Camera Azimuth³: 199°

Wind Turbine Information

Number: 200
 Make and Model: Siemens SWT-3.6-107
 Height/Dimensions:
 Support Structure/Monopile Ht.: 13 m (43')
 Hub Ht. (above Monopile): 80 m (262')
 Rotor Diameter: 107 m (351')
 Total Height to Tip of Blade: 147 m (481')
 Service Platform: A bldg. 50'H X 100'W X 200' L
 elevated 50' above the water

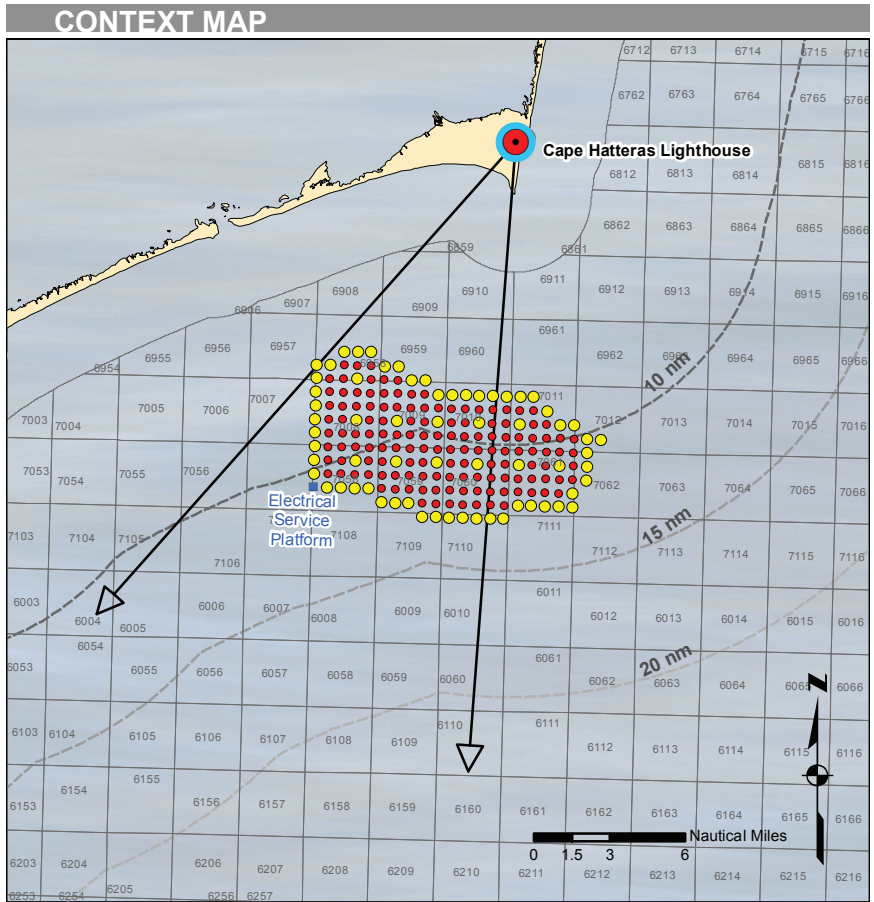
VIEWING INSTRUCTIONS

The simulation is properly printed on an 11" X 17" sheet at actual size. If viewed on a computer monitor, use the highest screen resolution. The simulated image is at the proper perspective when viewed at 23.5" from the eye, or at a distance of approx. twice the image height.

PANORAMA



Simulation location within the panorama view (190° X 60°) from the Cape Hatteras site



NOTES

- The resulting image represents an impression of how the wind project lighting might appear if it were surrounded by a light mist on an otherwise clear night.
- The simulated light is derived from a photograph of an LED L-864 FAA warning light taken at Lempster, NH on a clear night from a distance of 15 nm. The photograph of the light as displayed on a Lenovo W520 laptop computer at a screen resolution of 1600 X 900 was compared to the light as actually seen. The selected image most closely captured what was actually seen.
- The "halo" effect caused by a light mist was simulated by (1) increasing the width and height of the light's image by three times and (2) giving a transparency of 75% to simulate the light's dimming due to dispersion. Lastly, WindPRO's fog "visibility distance" setting was set to 17.5 nm to simulate dimming of the light due to interfering water vapor.
- The image was taken with a UV filter.
- Refraction Coefficient⁴ (k) = .075



VISUALIZATION STUDY FOR OFFSHORE NORTH CAROLINA

006 Cape Hatteras Lighthouse, Misty Night, Siemens SWT-3.6-107, 10 nm



SIMULATION

**006 Cape Hatteras
Lighthouse**

Misty Night

Siemens SWT-3.6-107

15 nm

Simulation
006 Cape Hatteras Lighthouse
 Misty Night
 Siemens SWT-3.6-107
 15 nm

GENERAL INFORMATION

Base Photograph

Photo Name: HLS_0001-UV
 Date: April 14, 2012
 Time: 8:57 PM
 GPS Coordinates¹: lat 35.250515°, long -75.528815°
 Viewpoint Elevation: 172'

Weather

Moon is below horizon
 Weather Conditions: Starlit (see notes)
 Visibility²: 10 mi
 Wave Height: Unknown
 Period: Unknown

Camera

Camera Make/Model: Nikon D7000
 Sensor Dimensions: 23.6 mm X 15.6 mm
 Lens Make/Model: Nikkor DX AF-S 35 mm
 Lens Focal Length: 35 mm
 35 mm Equivalent Focal Length: 52.5 mm
 Horizontal and Vertical Angles of View:
 37.3° wide and 25.3° high
 Camera Height: 1.5 m (5')
 Camera Azimuth³: 199°

Wind Turbine Information

Number: 200
 Make and Model: Siemens SWT-3.6-107
 Height/Dimensions:
 Support Structure/Monopile Ht.: 13 m (43')
 Hub Ht. (above Monopile): 80 m (262')
 Rotor Diameter: 107 m (351')
 Total Height to Tip of Blade: 147 m (481')
 Service Platform: A bldg. 50'H X 100'W X 200' L
 elevated 50' above the water

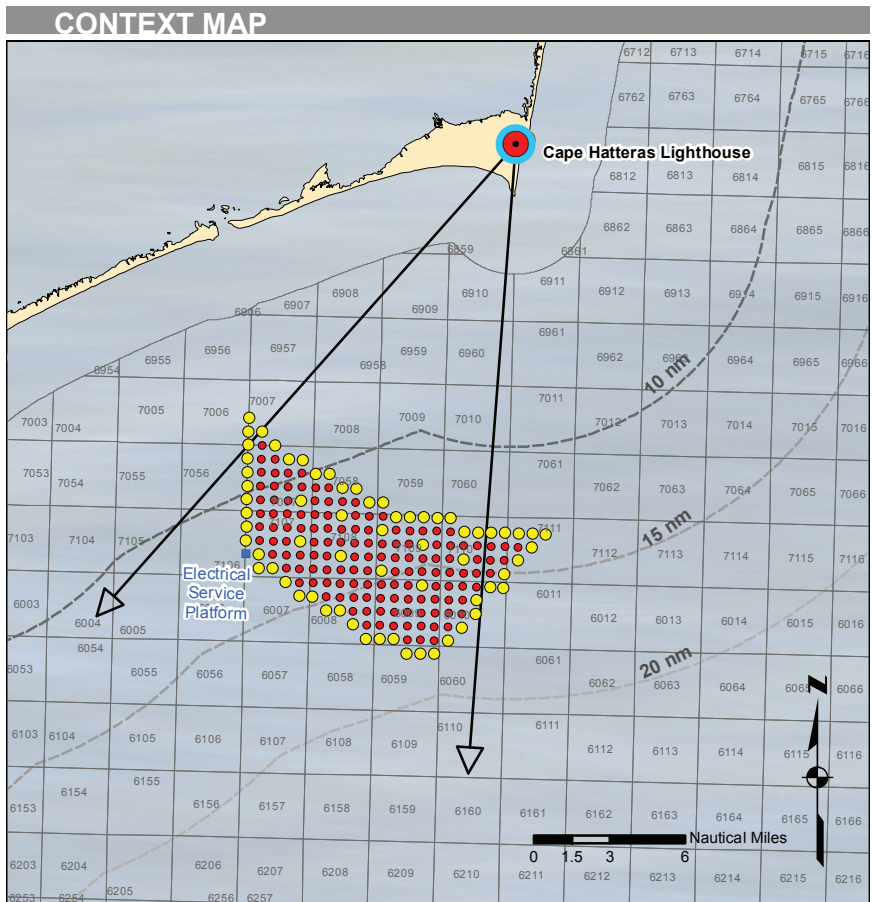
VIEWING INSTRUCTIONS

The simulation is properly printed on an 11" X 17" sheet at actual size. If viewed on a computer monitor, use the highest screen resolution. The simulated image is at the proper perspective when viewed at 23.5" from the eye, or at a distance of approx. twice the image height.

PANORAMA



Simulation location within the panorama view (190° X 60°) from the Cape Hatteras site



NOTES

- The resulting image represents an impression of how the wind project lighting might appear if it were surrounded by a light mist on an otherwise clear night.
- The simulated light is derived from a photograph of an LED L-864 FAA warning light taken at Lempster, NH on a clear night from a distance of 15 nm. The photograph of the light as displayed on a Lenovo W520 laptop computer at a screen resolution of 1600 X 900 was compared to the light as actually seen. The selected image most closely captured what was actually seen.
- The "halo" effect caused by a light mist was simulated by (1) increasing the width and height of the light's image by three times and (2) giving a transparency of 75% to simulate the light's dimming due to dispersion. Lastly, WindPRO's fog "visibility distance" setting was set to 22.5 nm to simulate dimming of the light due to interfering water vapor.
- The image was taken with a UV filter.
- Refraction Coefficient⁴ (k) = .075



VISUALIZATION STUDY FOR OFFSHORE NORTH CAROLINA

006 Cape Hatteras Lighthouse, Misty Night, Siemens SWT-3.6-107, 15 nm



SIMULATION

**006 Cape Hatteras
Lighthouse**

Misty Night

Siemens SWT-3.6-107

20 nm

Simulation
006 Cape Hatteras Lighthouse
 Misty Night
 Siemens SWT-3.6-107
 20 nm

GENERAL INFORMATION

Base Photograph

Photo Name: HLS_0001-UV
 Date: April 14, 2012
 Time: 8:57 PM
 GPS Coordinates¹: lat 35.250515°, long -75.528815°
 Viewpoint Elevation: 172'

Weather

Moon is below horizon
 Weather Conditions: Starlit (see notes)
 Visibility²: 10 mi
 Wave Height: Unknown
 Period: Unknown

Camera

Camera Make/Model: Nikon D7000
 Sensor Dimensions: 23.6 mm X 15.6 mm
 Lens Make/Model: Nikkor DX AF-S 35 mm
 Lens Focal Length: 35 mm
 35 mm Equivalent Focal Length: 52.5 mm
 Horizontal and Vertical Angles of View:
 37.3° wide and 25.3° high
 Camera Height: 1.5 m (5')
 Camera Azimuth³: 199°

Wind Turbine Information

Number: 200
 Make and Model: Siemens SWT-3.6-107
 Height/Dimensions:
 Support Structure/Monopile Ht.: 13 m (43')
 Hub Ht. (above Monopile): 80 m (262')
 Rotor Diameter: 107 m (351')
 Total Height to Tip of Blade: 147 m (481')
 Service Platform: A bldg. 50'H X 100'W X 200' L
 elevated 50' above the water

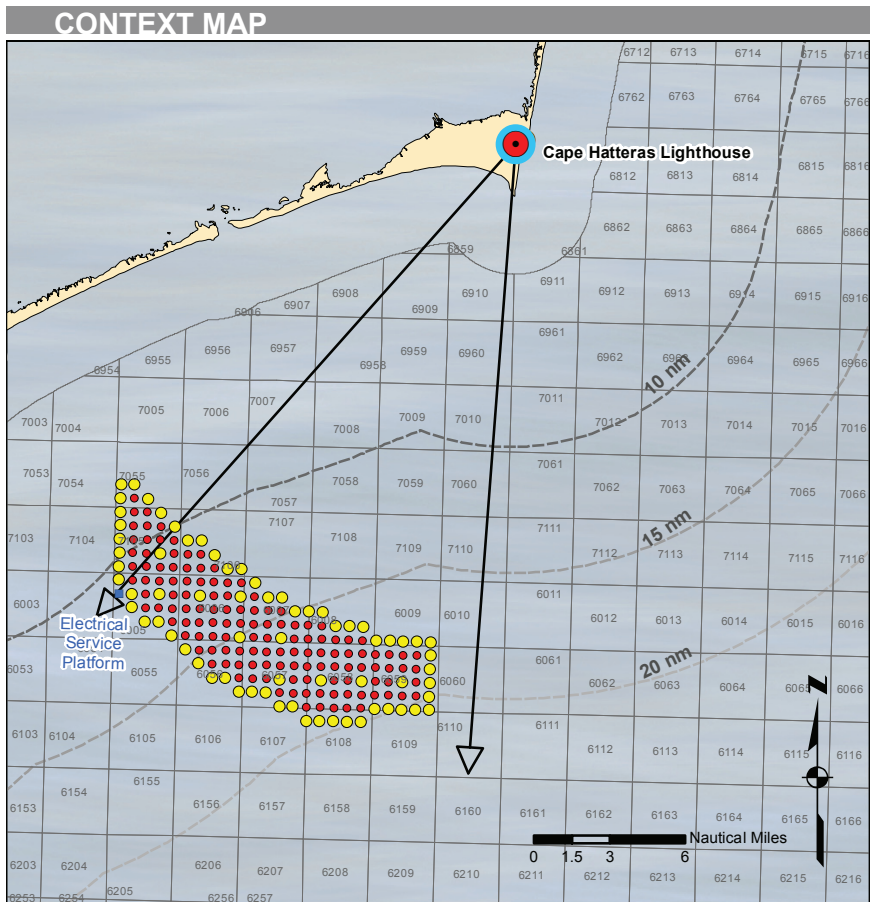
VIEWING INSTRUCTIONS

The simulation is properly printed on an 11" X 17" sheet at actual size. If viewed on a computer monitor, use the highest screen resolution. The simulated image is at the proper perspective when viewed at 23.5" from the eye, or at a distance of approx. twice the image height.

PANORAMA



Simulation location within the panorama view (190° X 60°) from the Cape Hatteras site



NOTES

- The resulting image represents an impression of how the wind project lighting might appear if it were surrounded by a light mist on an otherwise clear night.
- The simulated light is derived from a photograph of an LED L-864 FAA warning light taken at Lempster, NH on a clear night from a distance of 15 nm. The photograph of the light as displayed on a Lenovo W520 laptop computer at a screen resolution of 1600 X 900 was compared to the light as actually seen. The selected image most closely captured what was actually seen.
- The "halo" effect caused by a light mist was simulated by (1) increasing the width and height of the light's image by three times and (2) giving a transparency of 75% to simulate the light's dimming due to dispersion. Lastly, WindPRO's fog "visibility distance" setting was set to 27.5 nm to simulate dimming of the light due to interfering water vapor.
- The image was taken with a UV filter.
- Refraction Coefficient⁴ (k) = .075



VISUALIZATION STUDY FOR OFFSHORE NORTH CAROLINA

006 Cape Hatteras Lighthouse, Misty Night, Siemens SWT-3.6-107, 20 nm



SIMULATION

006 Cape Hatteras Lighthouse

Misty Night

Vestas V164-7.0 MW

10 nm

Simulation
006 Cape Hatteras Lighthouse
 Misty Night
 Vestas V164-7.0 MW
 10 nm

GENERAL INFORMATION

Base Photograph

Photo Name: HLS_0001-UV
 Date: April 14, 2012
 Time: 8:57 PM
 GPS Coordinates¹: lat 35.250515°, long -75.528815°
 Viewpoint Elevation: 172'

Weather

Moon is below horizon
 Weather Conditions: Starlit (see notes)
 Visibility²: 10 mi
 Wave Height: Unknown
 Period: Unknown

Camera

Camera Make/Model: Nikon D7000
 Sensor Dimensions: 23.6 mm X 15.6 mm
 Lens Make/Model: Nikkor DX AF-S 35 mm
 Lens Focal Length: 35 mm
 35 mm Equivalent Focal Length: 52.5 mm
 Horizontal and Vertical Angles of View:
 37.3° wide and 25.3° high
 Camera Height: 1.5 m (5')
 Camera Azimuth³: 199°

Wind Turbine Information

Number: 200
 Make and Model: Vestas V164-7.0 MW
 Height/Dimensions:
 Support Structure/Monopile Ht.: 13 m (43')
 Hub Ht. (above Monopile): 105 m (345')
 Rotor Diameter: 164 m (538')
 Total Height to Tip of Blade: 200 m (656')
 Service Platform: A bldg. 50'H X 100'W X 200' L
 elevated 50' above the water

VIEWING INSTRUCTIONS

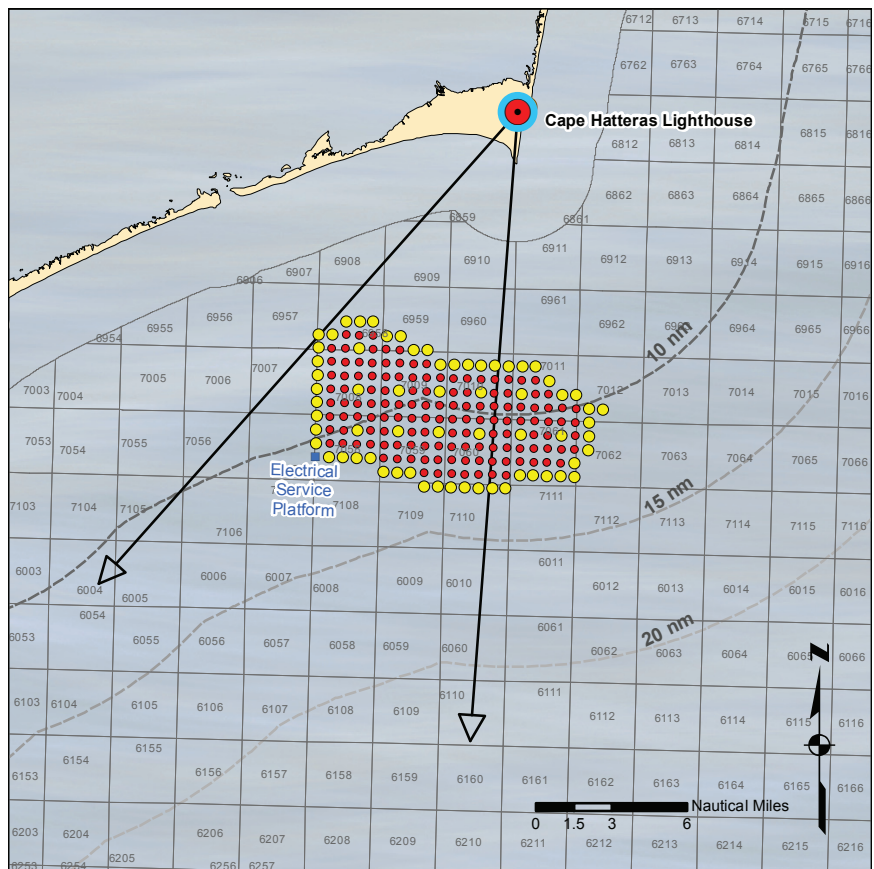
The simulation is properly printed on an 11" X 17" sheet at actual size. If viewed on a computer monitor, use the highest screen resolution. The simulated image is at the proper perspective when viewed at 23.5" from the eye, or at a distance of approx. twice the image height.

PANORAMA



Simulation location within the panorama view (190° X 60°) from the Cape Hatteras site

CONTEXT MAP



NOTES

- The resulting image represents an impression of how the wind project lighting might appear if it were surrounded by a light mist on an otherwise clear night.
- The simulated light is derived from a photograph of an LED L-864 FAA warning light taken at Lempster, NH on a clear night from a distance of 15 nm. The photograph of the light as displayed on a Lenovo W520 laptop computer at a screen resolution of 1600 X 900 was compared to the light as actually seen. The selected image most closely captured what was actually seen.
- The "halo" effect caused by a light mist was simulated by (1) increasing the width and height of the light's image by three times and (2) giving a transparency of 75% to simulate the light's dimming due to dispersion. Lastly, WindPRO's fog "visibility distance" setting was set to 17.5 nm to simulate dimming of the light due to interfering water vapor.
- The image was taken with a UV filter.
- Refraction Coefficient⁴ (k) = .075



VISUALIZATION STUDY FOR OFFSHORE NORTH CAROLINA

006 Cape Hatteras Lighthouse, Misty Night, Vestas V164-7.0 MW, 10 nm



SIMULATION

006 Cape Hatteras Lighthouse

Misty Night

Vestas V164-7.0 MW

15 nm

Simulation
006 Cape Hatteras Lighthouse
 Misty Night
 Vestas V164-7.0 MW
 15 nm

GENERAL INFORMATION

Base Photograph

Photo Name: HLS_0001-UV
 Date: April 14, 2012
 Time: 8:57 PM
 GPS Coordinates¹: lat 35.250515°, long -75.528815°
 Viewpoint Elevation: 172'

Weather

Moon is below horizon
 Weather Conditions: Starlit (see notes)
 Visibility²: 10 mi
 Wave Height: Unknown
 Period: Unknown

Camera

Camera Make/Model: Nikon D7000
 Sensor Dimensions: 23.6 mm X 15.6 mm
 Lens Make/Model: Nikkor DX AF-S 35 mm
 Lens Focal Length: 35 mm
 35 mm Equivalent Focal Length: 52.5 mm
 Horizontal and Vertical Angles of View:
 37.3° wide and 25.3° high
 Camera Height: 1.5 m (5')
 Camera Azimuth³: 199°

Wind Turbine Information

Number: 200
 Make and Model: Vestas V164-7.0 MW
 Height/Dimensions:
 Support Structure/Monopile Ht.: 13 m (43')
 Hub Ht. (above Monopile): 105 m (345')
 Rotor Diameter: 164 m (538')
 Total Height to Tip of Blade: 200 m (656')
 Service Platform: A bldg. 50'H X 100'W X 200' L
 elevated 50' above the water

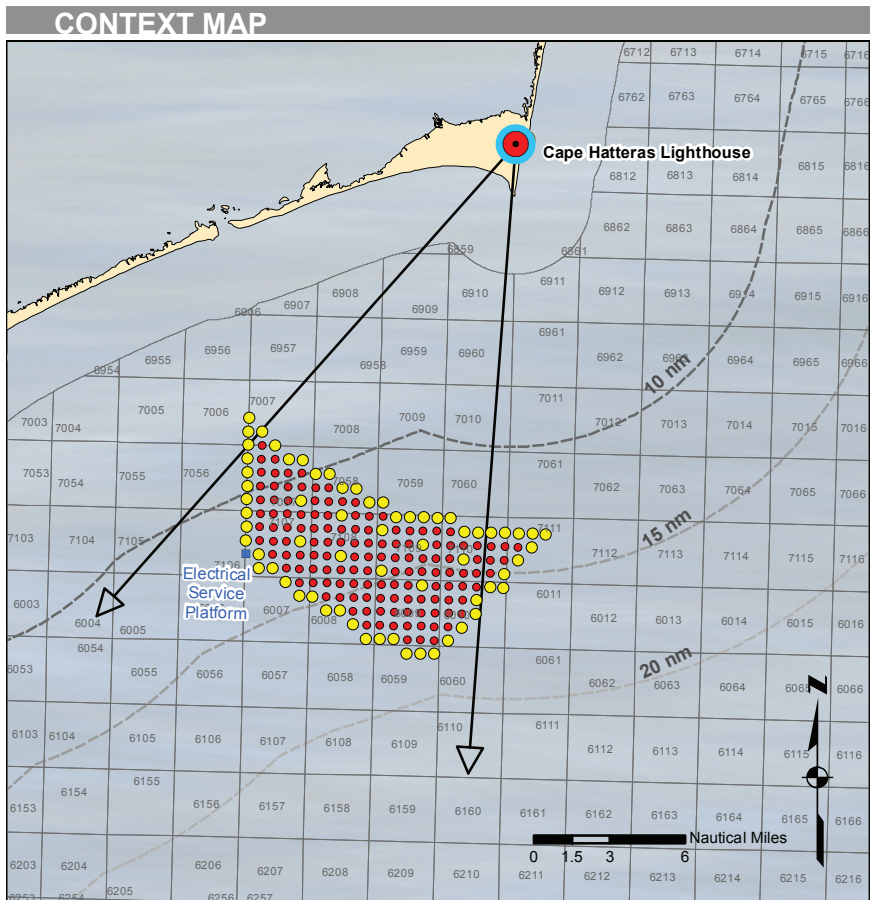
VIEWING INSTRUCTIONS

The simulation is properly printed on an 11" X 17" sheet at actual size. If viewed on a computer monitor, use the highest screen resolution. The simulated image is at the proper perspective when viewed at 23.5" from the eye, or at a distance of approx. twice the image height.

PANORAMA



Simulation location within the panorama view (190° X 60°) from the Cape Hatteras site



NOTES

- The resulting image represents an impression of how the wind project lighting might appear if it were surrounded by a light mist on an otherwise clear night.
- The simulated light is derived from a photograph of an LED L-864 FAA warning light taken at Lempster, NH on a clear night from a distance of 15 nm. The photograph of the light as displayed on a Lenovo W520 laptop computer at a screen resolution of 1600 X 900 was compared to the light as actually seen. The selected image most closely captured what was actually seen.
- The "halo" effect caused by a light mist was simulated by (1) increasing the width and height of the light's image by three times and (2) giving a transparency of 75% to simulate the light's dimming due to dispersion. Lastly, WindPRO's fog "visibility distance" setting was set to 22.5 nm to simulate dimming of the light due to interfering water vapor.
- The image was taken with a UV filter.
- Refraction Coefficient⁴ (k) = .075



VISUALIZATION STUDY FOR OFFSHORE NORTH CAROLINA

006 Cape Hatteras Lighthouse, Misty Night, Vestas V164-7.0 MW, 15 nm



SIMULATION

006 Cape Hatteras Lighthouse

Misty Night

Vestas V164-7.0 MW

20 nm

Simulation
006 Cape Hatteras Lighthouse
 Misty Night
 Vestas V164-7.0 MW
 20 nm

GENERAL INFORMATION

Base Photograph

Photo Name: HLS_0001-UV
 Date: April 14, 2012
 Time: 8:57 PM
 GPS Coordinates¹: lat 35.250515°, long -75.528815°
 Viewpoint Elevation: 172'

Weather

Moon is below horizon
 Weather Conditions: Starlit (see notes)
 Visibility²: 10 mi
 Wave Height: Unknown
 Period: Unknown

Camera

Camera Make/Model: Nikon D7000
 Sensor Dimensions: 23.6 mm X 15.6 mm
 Lens Make/Model: Nikkor DX AF-S 35 mm
 Lens Focal Length: 35 mm
 35 mm Equivalent Focal Length: 52.5 mm
 Horizontal and Vertical Angles of View:
 37.3° wide and 25.3° high
 Camera Height: 1.5 m (5')
 Camera Azimuth³: 199°

Wind Turbine Information

Number: 200
 Make and Model: Vestas V164-7.0 MW
 Height/Dimensions:
 Support Structure/Monopile Ht.: 13 m (43')
 Hub Ht. (above Monopile): 105 m (345')
 Rotor Diameter: 164 m (538')
 Total Height to Tip of Blade: 200 m (656')
 Service Platform: A bldg. 50'H X 100'W X 200' L
 elevated 50' above the water

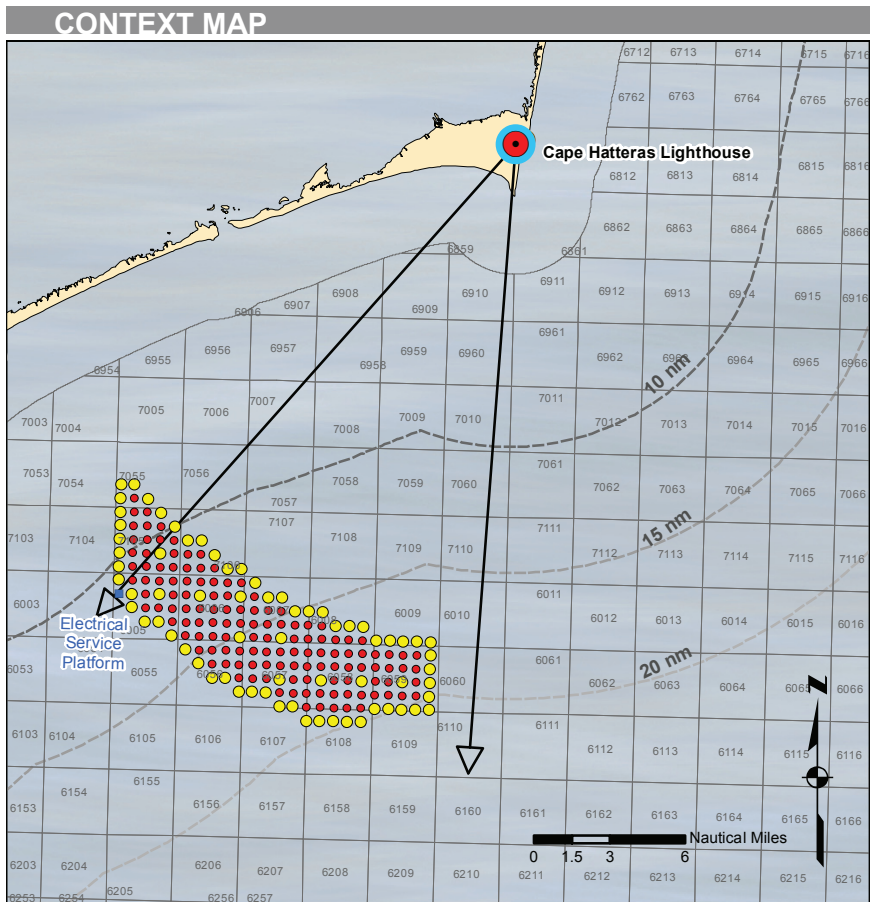
VIEWING INSTRUCTIONS

The simulation is properly printed on an 11" X 17" sheet at actual size. If viewed on a computer monitor, use the highest screen resolution. The simulated image is at the proper perspective when viewed at 23.5" from the eye, or at a distance of approx. twice the image height.

PANORAMA



Simulation location within the panorama view (190° X 60°) from the Cape Hatteras site



NOTES

- The resulting image represents an impression of how the wind project lighting might appear if it were surrounded by a light mist on an otherwise clear night.
- The simulated light is derived from a photograph of an LED L-864 FAA warning light taken at Lempster, NH on a clear night from a distance of 15 nm. The photograph of the light as displayed on a Lenovo W520 laptop computer at a screen resolution of 1600 X 900 was compared to the light as actually seen. The selected image most closely captured what was actually seen.
- The "halo" effect caused by a light mist was simulated by (1) increasing the width and height of the light's image by three times and (2) giving a transparency of 75% to simulate the light's dimming due to dispersion. Lastly, WindPRO's fog "visibility distance" setting was set to 27.5 nm to simulate dimming of the light due to interfering water vapor.
- The image was taken with a UV filter.
- Refraction Coefficient⁴ (k) = .075



VISUALIZATION STUDY FOR OFFSHORE NORTH CAROLINA

006 Cape Hatteras Lighthouse, Misty Night, Vestas V164-7.0 MW, 20 nm

INFORMATION PAGE FOOTNOTES

¹GPS Coordinates

Location coordinates as used in WindPRO to register the wireframe diagram to the photograph. Due to slight errors and lens distortion, these values may differ at the fourth significant digit as obtained from a handheld GPS device at the time the photographs were taken and as shown on the Project Location Map.

²Visibility

Visibility is obtained from the closest airport weather station (see chart at right). The chart shows which weather station was used for each site. Visibility is measured up to ten statute miles.

³Camera Azimuth

Camera azimuth was obtained using a magnetic compass at the time of photography. However magnetic anomalies in the study area make some of these measurements unreliable. The camera azimuth reported here is for true north and reflects the bearing used to register the wind turbines to the photograph in WindPRO.

⁴Refraction Coefficient

The correction for refraction comes from Technical Appendix F Earth Curvature and Refraction of Light, in the report *Visual Representation of Windfarms Good Practice Guidance*, prepared for Scottish Natural Heritage (h+m 2006). The coefficient of refraction k is commonly defined as the ratio between the radius of the earth and the radius of the light in the line of sight between an object and the observer (Hirt 2010). The value reported here is half this value, but it is multiplied by two in the Technical Appendix's equation.

ABBREVIATIONS

nm	nautical miles
mi	statute miles
mm	millimeters
m	meters
sec.	seconds
'	feet
"	inches
°	degrees
lat	latitude
long	longitude

REFERENCES

h+m and envision. 2006. Visual Representation of Windfarms Good Practice Guidance. Scottish Natural Heritage.

Hirt C., Guillaume S., Wisbar A., Bürki B. and Sternberg, H. 2010. Monitoring of the refraction coefficient of the lower atmosphere using a controlled set-up of simultaneous reciprocal vertical angle measurements. *Journal of Geophysical Research*, 115, D21102, doi:10.1029/2010JD014067

Closest Airport Weather Station to Sites

Site	Weather Station Location NC
001 Corolla Lighthouse	Kill Devil Hills
002 Beach at Duck	Kill Devil Hills
003 Kitty Hawk	Kill Devil Hills
004 Coquina Beach	Kill Devil Hills
005 Bodie Island Lighthouse	Hatteras
006 Cape Hatteras Lighthouse	Hatteras
007 Lighthouse Beach	Hatteras
008 Ocracoke Beach	Hatteras
009 Portsmouth Life Saving Station Tower	Hatteras
010 Long Point Camps	Hatteras
011 Great Island Camps	Beaufort
012 Cape Lookout Lighthouse	Beaufort
013 Cape Point	Beaufort
014 Atlantic Beach	Beaufort
015 Bald Head Island	Southport
016 Oak Island	Southport
017 Holden Beach	Southport
018 Sunset Beach	Southport