

Renewable Energy Supply as a System of Systems: Offshore Wind and Onshore Solar

Southeastern Virginia

ENERGY TECHNOLOGY PARTNERSHIP FORUM

College of William and Mary Alumni House

Williamsburg, VA

13 April 2010



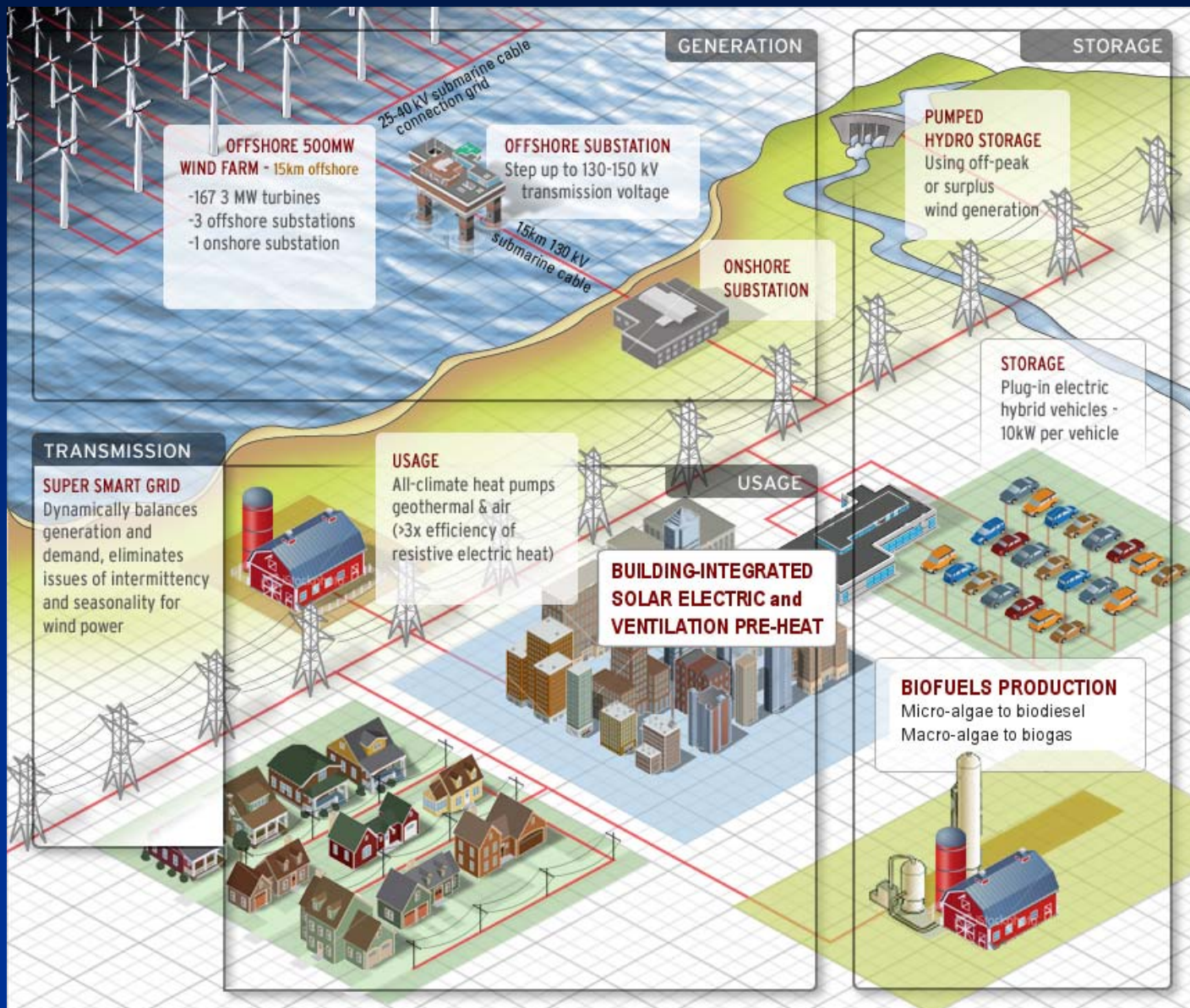
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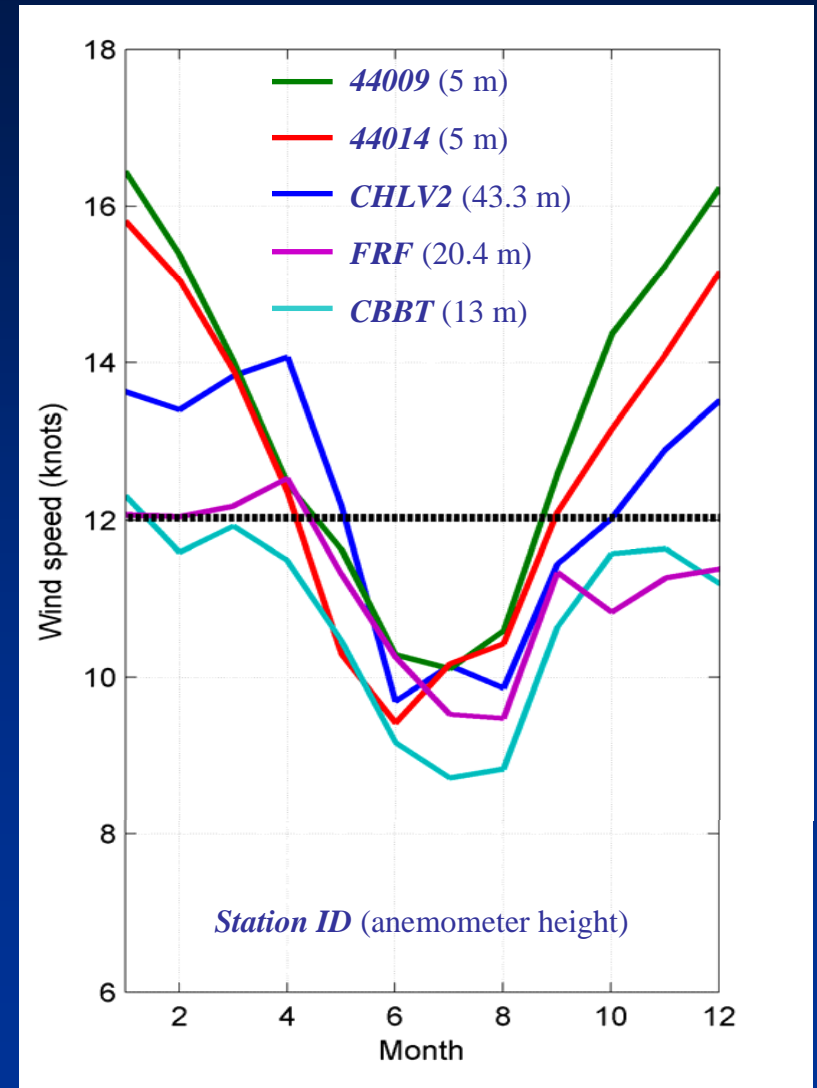
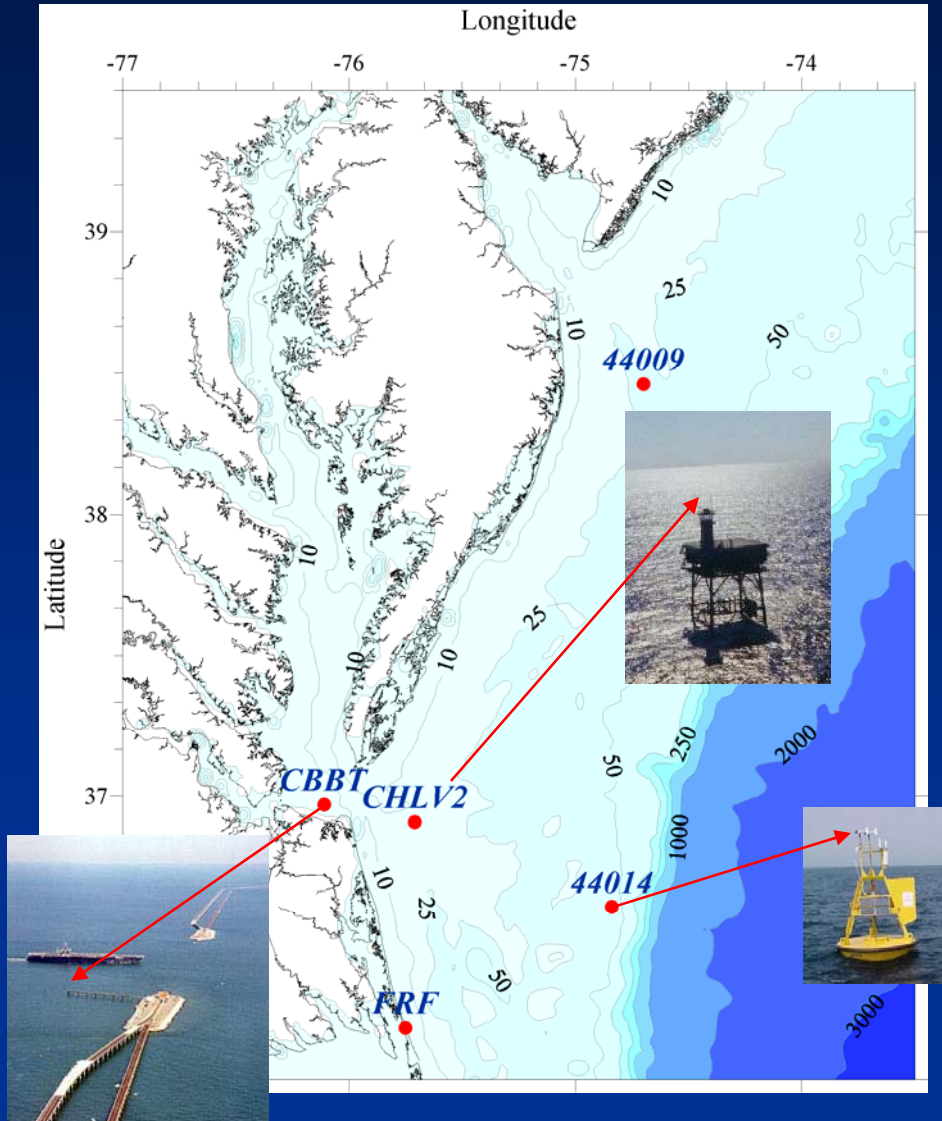
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Offshore Wind and Onshore Solar can be Cornerstones of a Larger, Integrated Energy System



Offshore Wind is a Winter-Peaking Resource



Offshore Wind Turbines are Commercially Available Now

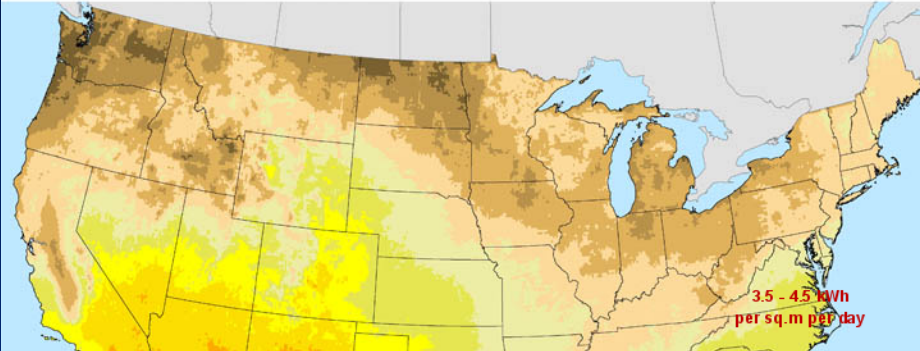


Left photo is of Vestas 3 MW turbines with 90-m rotor diameter and 70-m hub height on steel monopile foundations at Thanet 300 MW project off southeastern England. Right photo is of Siemens 2.3 MW turbines with 83-m rotor diameter and 69-m hub height on concrete gravity base foundations at 166 MW Nysted project off Denmark.

Onshore Solar is a Summer-Peaking Resource

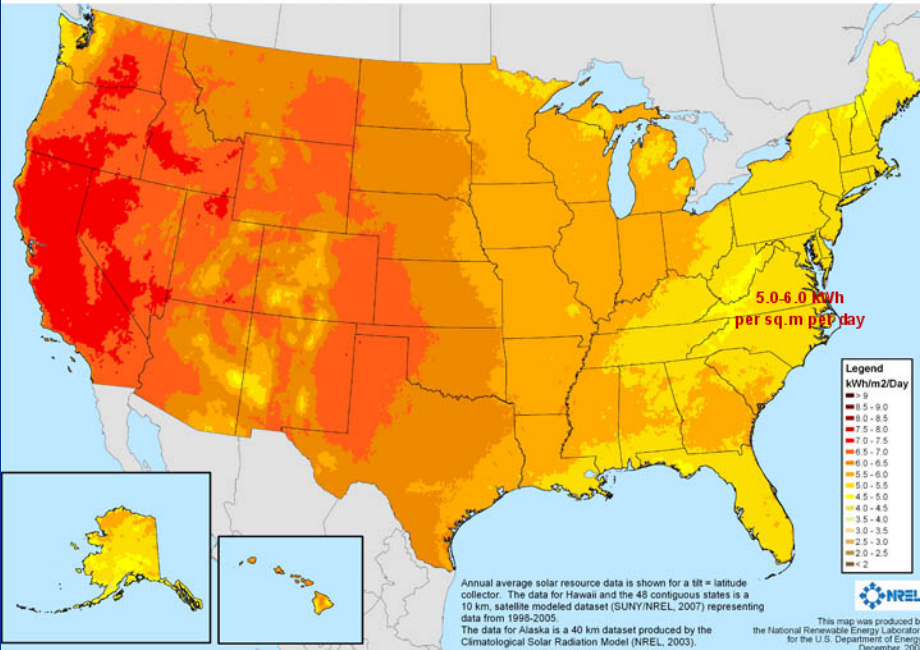
Photovoltaic Solar Resource:
Flat Plate Tilted South at Latitude

January



Photovoltaic Solar Resource:
Flat Plate Tilted South at Latitude

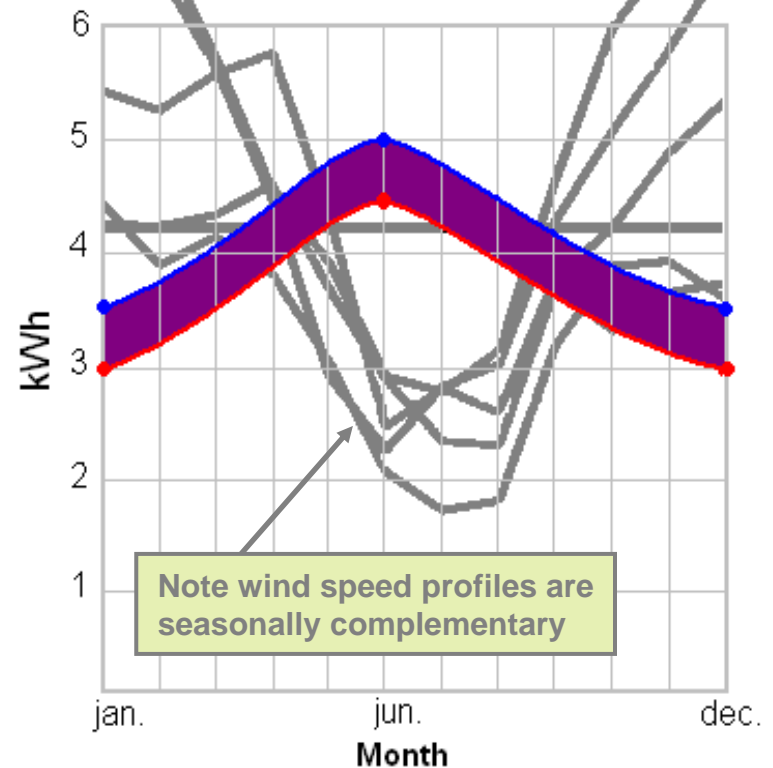
July



Direct Beam Solar Radiation

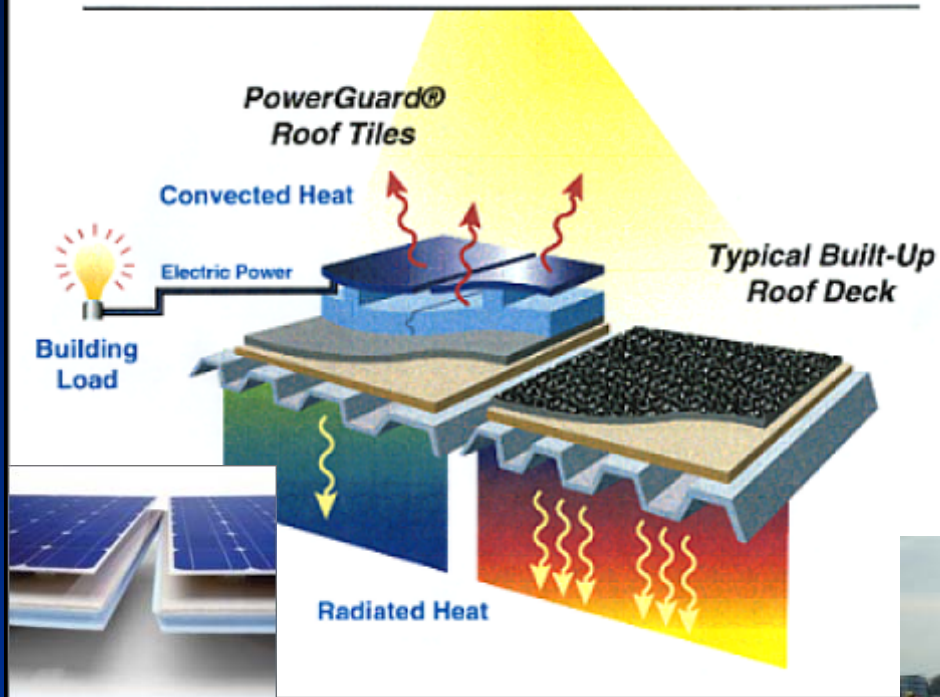
- Maximum Radiation
- Minimum Radiation
- Wind Velocity (see previous slide)

(in kilowatt hours per meter squared per day)

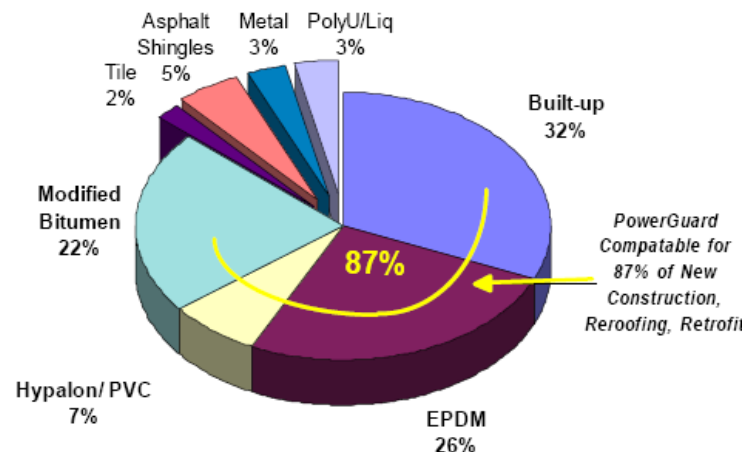


Building-Integrated Photovoltaic Roofing Tiles are Commercially Available Now

PowerGuard® - Power Generation & HVAC Savings

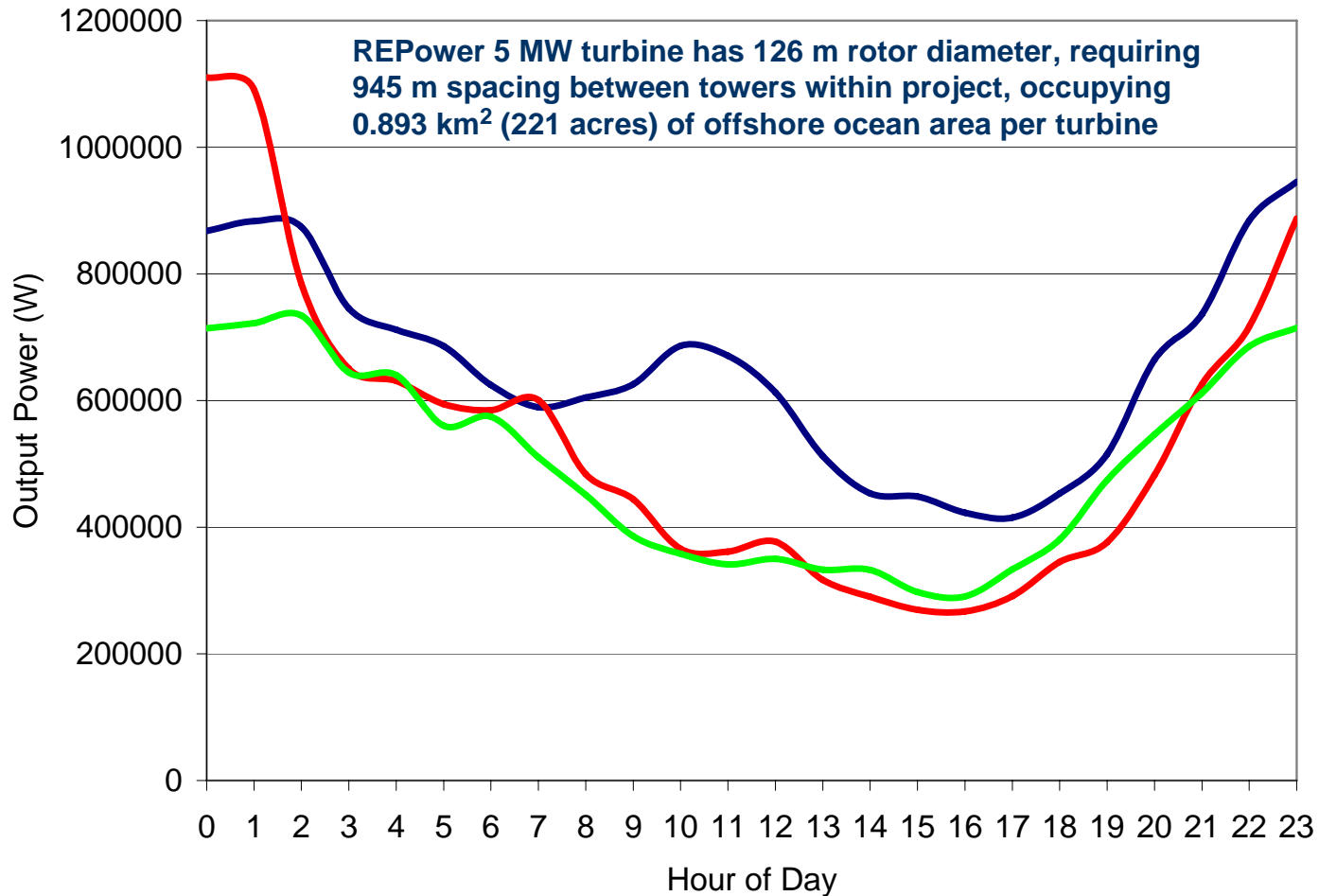


Commercial Roofing Market \$ 16 Billion / yr.



Hourly Output Profile of One 5 MW Offshore Wind Turbine in Summer

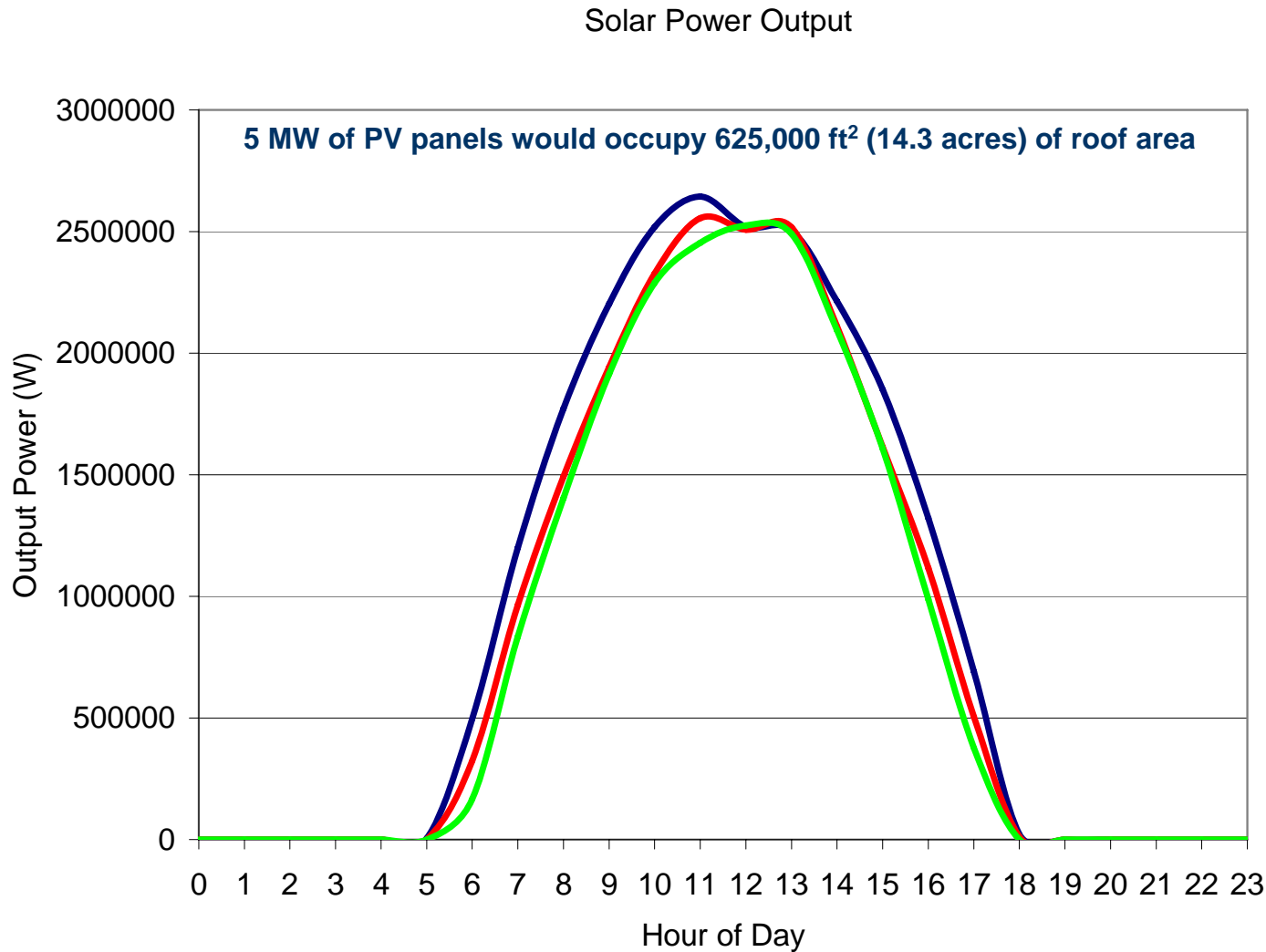
RE 5.0M Output Power



- June
- July
- August

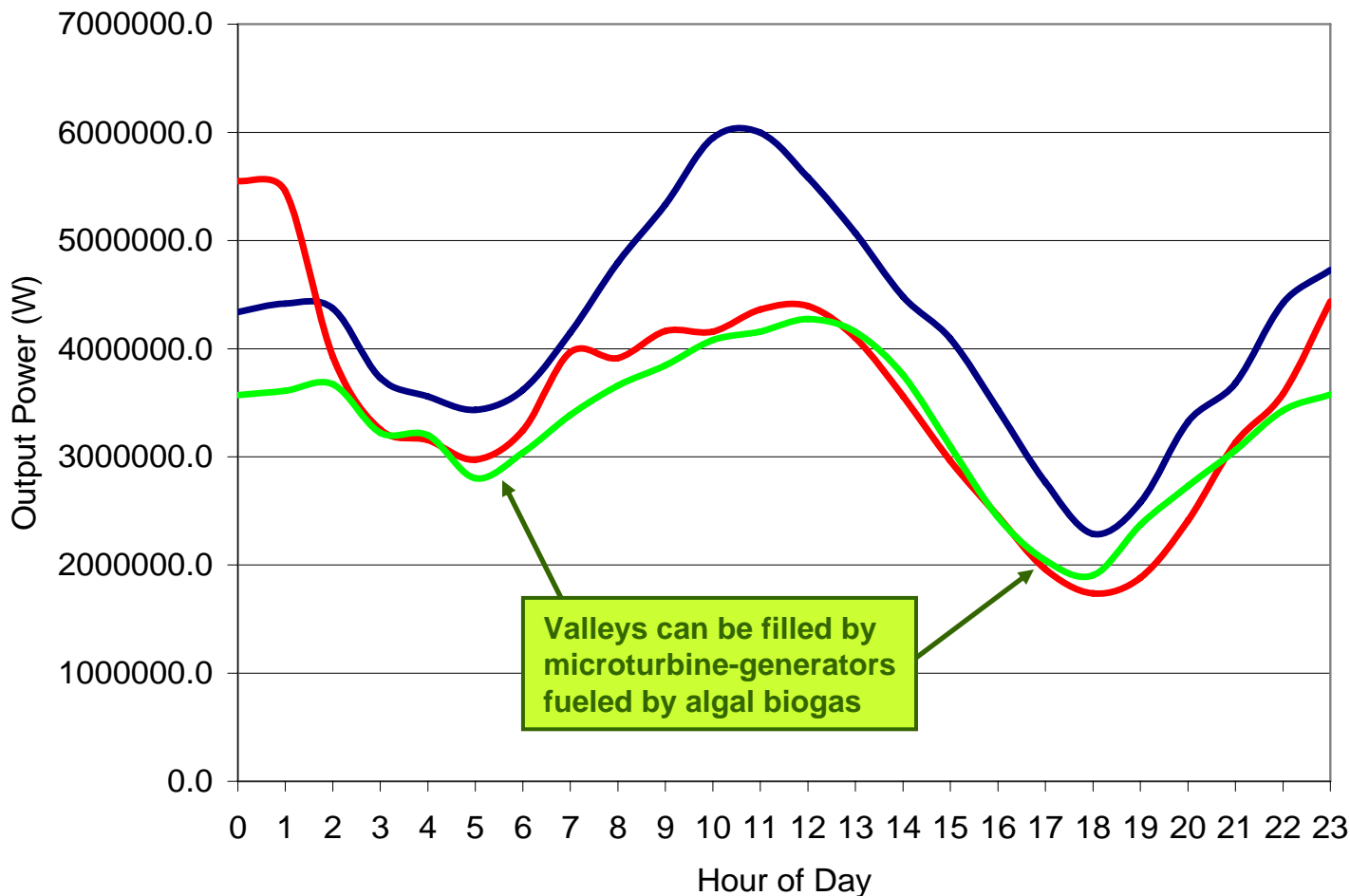


Hourly Output Profile of Ten 500 kW Photovoltaic Roofs in Summer



Hourly Output Profile of Combined Offshore Wind Turbine and PV Roofs in Summer

Combined Wind a Solar Power Output Curves



- June
- July
- August

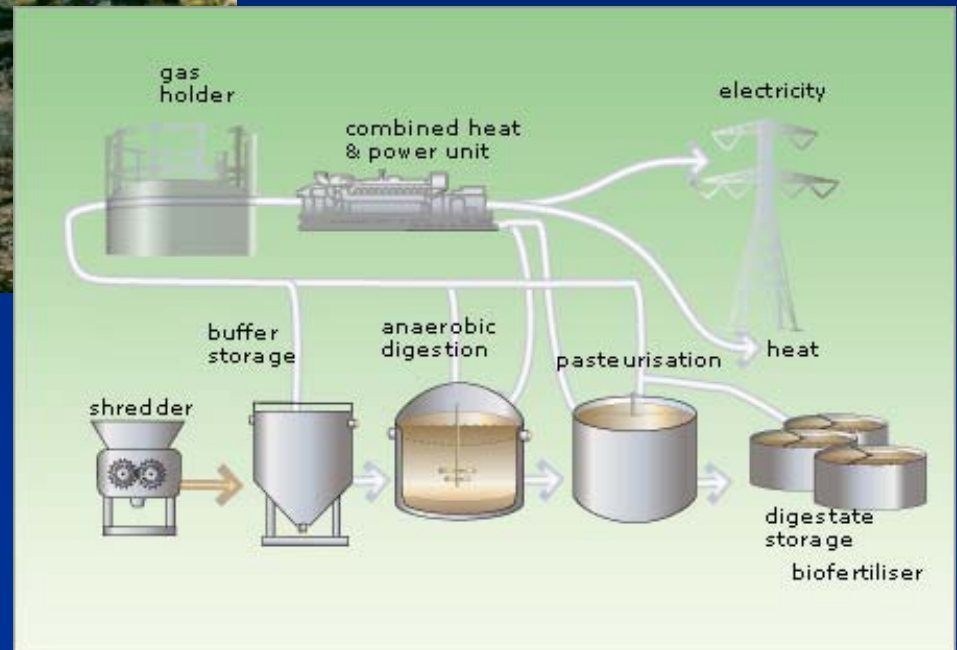


Algal Biogas for Electric Power in the Future



Anaerobic digestion of seaweed naturally produces methane

Replicating the same process for combined heat and power



Candidate Seaweed Species Native to the Mid-Atlantic Coastal Region



- Along Mid-Atlantic and Southeastern beaches *Gracilaria* and *Ulva* can wash ashore and pile up in windrows where natural decomposition produces methane and hydrogen sulfide
- *Ulva* expected to yield 214,400 ft³ of methane per acre of pond area per year
- *Gracilaria* expected to yield 514,500 ft³ of methane per acre of pond area per year

Tokyo Gas 10 kW Demonstration Project

Ulva
harvest



Ulva
slurry



Digester



After two weeks in anaerobic digester, one dry ton of *Ulva* yields 600 cubic feet of biogas (60% CH₄ and 40% CO₂), which supplies a 9.8 kW micro-turbine generator

Thank You!



Any questions?

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