Let's Convert the PES Refinery Site into an Offshore Wind Turbine Construction & Maintenance Facility

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Converting the PES refinery site into an Offshore Wind Turbine construction and maintenance facility

1) **Will create several tens of thousands of long term, well paying jobs.**

2) **Will create opportunities for numerous secondary supply businesses.**

3) **Will show that Philadelphia and the Delaware River tri-state region are progressive, forward looking, and environmentally responsible. This image of our region will attract other companies and industries.**

4) **Is environmentally wise and will eliminate a dangerous local source of pollution that threatens the health and well being of our citizens.**

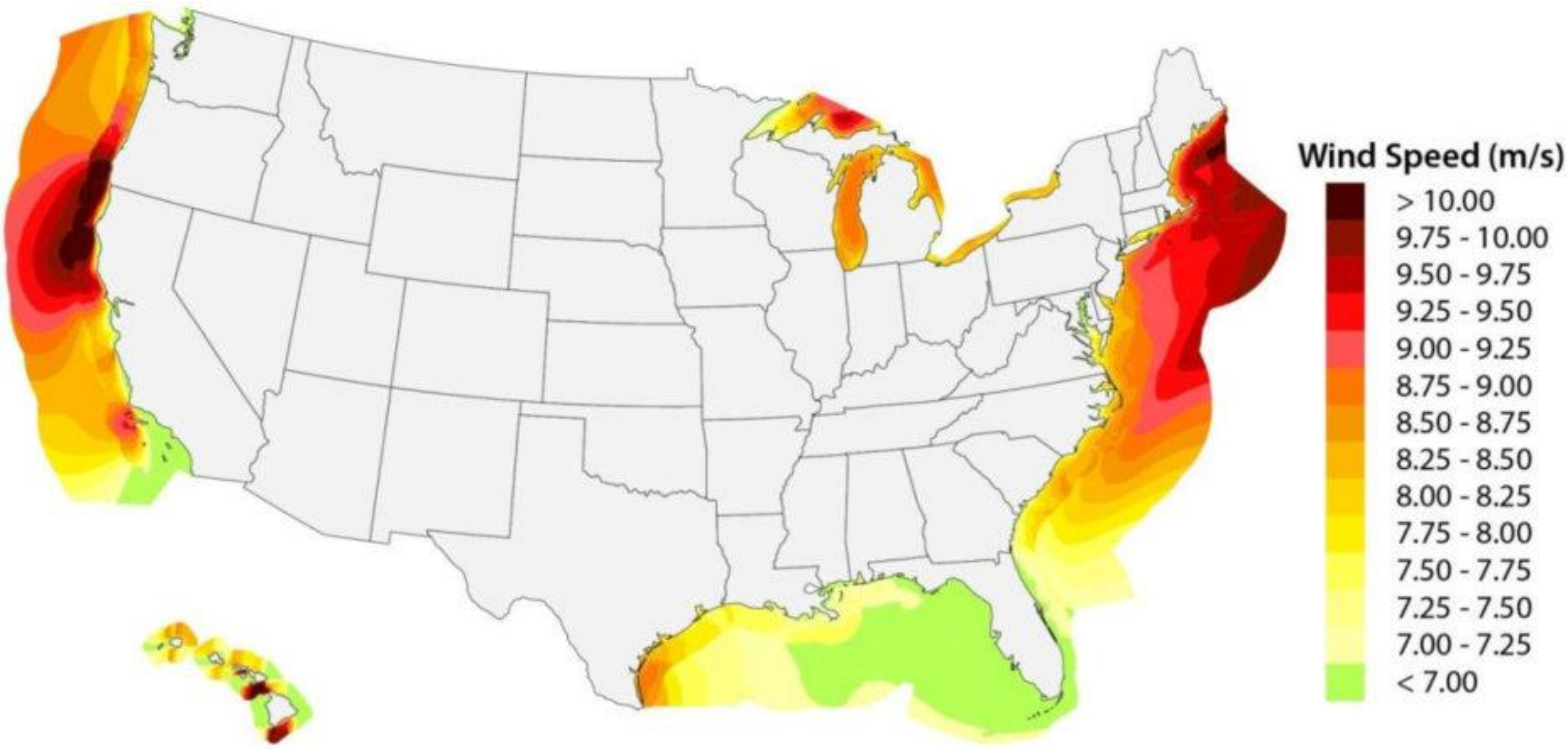
Why Offshore Wind Turbines?

The mid and north Atlantic offshore regions have superb winds– high velocity and steady – see map on next slide.

These offshore winds are the best source of renewable energy for the mid-Atlantic region of the U.S. – New Jersey, Pennsylvania, Delaware, Maryland, D.C. and Virginia

The recent development of giant wind turbines (over 10 million watts per turbine) and the price reduction per megawatt of these turbines make this approach financially attractive and is projected to be the lowest cost source of electricity for this region in the coming decade.

Offshore Wind - 100 meters above the ocean surface



Navigant – Levelized Cost of energy-2017
note that “wind” (onshore) has the lowest cost per watt. The new, gigantic wind turbines will approach this cost.

Where Should these Turbines be built?

A 10 megawatt turbine has blades that are 110 meters (360 ft) long and a tower that is about 150 meters (500 ft) high. These elements cannot be transported over land and so must be built along a river or bay and transported by ship. There are a limited number of ports in the mid-Atlantic region that are suitable. Ours is one of those.

Mega-turbines have doubled in power every 10 years. By about 2030, turbines will be 20 megawatts and blade and tower lengths will increase by about 40% - to 500 ft long blades and 700 ft high towers. The refinery site can accommodate the construction of these enormous components.

Tower of G.E. 12 megawatt Haliade-X Wind Turbine

Blade of G.E. 12 megawatt Haliade-X Wind Turbine

Is there Competition?

YES!!!

1) Baltimore is beginning to build turbines for an offshore site near Ocean City,

2) Norfolk – Newport News has extensive plans for such a construction facility,

3) New Jersey has several potential sites,

4) Wilmington, N.C. has plans for such a construction site,

5) Five 6 megawatt turbines were assembled in Rhode Island in 2016 and are now operating near Block Island. Additional turbine construction will happen at Rhode Island ports.

Economic Analysis of Offshore Wind Turbine Construction & Maintenance Facility

- **In February 2015, the National Renewable Energy Laboratory, (NREL), published "Offshore Wind Jobs & Economic Development Impacts in the U.S. – Four Regional Scenarios". One of these four was the mid-Atlantic region (New Jersey to Virginia).**

- **We combined that analysis, the numbers in the most recent "Annual Energy Outlook – 2019" and the present size and cost of offshore wind turbines to generate this jobs and business volume model for an offshore wind turbine construction and maintenance facility for the mid-Atlantic region.**

U.S. Annual Electricity Consumption & Total Number of Turbines Required

In 2018 the U.S. consumed 4 trillion (4×10^{12}) kilowatt hours of electricity.

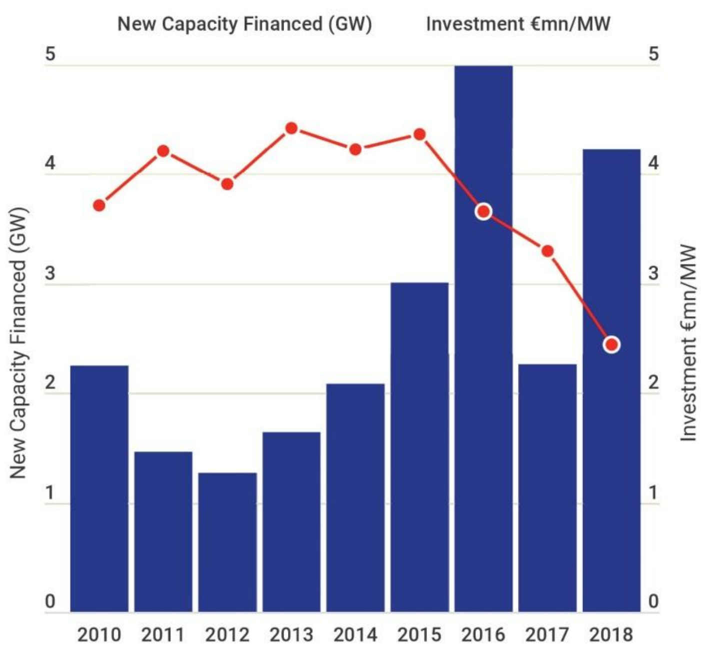
The population of the mid-Atlantic region = 1/8 of the U.S., so we consumed 500 billion (5×10^{11}) kilowatt hours of electricity.

One turbine generates 10 million (10^7) watts for 4380 hours/year (50% capacity factor), or 43.8 million (4.38×10^7) kilowatt hours/year. [G.E. assumes 63% capacity factor & so 5.5×10^7 kilowatt hours/year]

Number of turbines required = (5×10^{11})/ (4.38×10^7) = 11,416.

Offshore wind costs fall 45%

The investment cost of offshore wind in Europe has fallen from €4.41 million/MW in 2013 to €2.45 million/MW in 2018. This is due to the rise of competitive tendering, larger turbines, and more capacity.



source: WindEurope

The rapid fall in offshore wind costs has corresponded with the introduction of competitive auctions across Europe, notably in the Netherlands and Germany where zero-euro bids were successful, resulting in cheaper projects.

It is also inline with the development of the current generation of 6-10MW turbines forcing their way on to the market, indicating costs are set to fall even further as the 10-12MW machines currently being developed are selected.

Note that the 2018 offshore turbine construction cost is €2.45 per watt. We will use that number in our estimates on the next slide. The construction price continues to drop.

Turbines Production Rate & Cost

- **Assume that a turbine has a 25 year lifetime, and that we produce these 11,416 turbines in 25 years (2025 → 2050, or 457/year. Then in year 26, we produce the replacements for the turbines made in year 1, etc.**

- **The Annual Energy Outlook projects that by 2050 our electricity consumption will increase by ~25%. That raises annual turbine production by 25% to 570, or about 2.3 turbines per day.**

- **Including the electricity consumed by electric cars by 2050 will increase the required turbine production rate to 2.5 to 3.0/day.**

- **Using the 2018 European turbine production cost of $2.50/watt or $25 Million/turbine gives an annual gross volume of $15 – 19 billion.**

Number of Jobs & Number of Construction Sites

- **The "medium" scenario prediction in the 2015 NREL paper for 2030 is 22,000 turbine construction jobs and 10,000 operation & maintenance jobs for the mid-Atlantic region. Combining this job number with the annual gross volume gives about $530,000 gross volume per employee. This includes salary, benefits, cost of materials and cost of facilities. – *Seems in a reasonable range.***

- **Will there be just one mid-Atlantic construction facility, or two or even three. Even the last case of three sites still results in about 10,000 jobs per site and an annual volume close to $6 billion per site.**

In Conclusion

- **There are a number of assumptions in this economic analysis-**
- **1) what fraction of the region's electricity comes from wind?**
- **2) Will we transition from 10 megawatt to 20 megawatt turbines, or even 30 megawatt during this period and how will that impact cost and productivity?**
- **3) How will wind generated electricity compare with solar panel generated electricity during the next 25 – 50 years?**
- **4) What will be the impact of automation on jobs and productivity?**
- **Whatever those answers, we cannot neglect this opportunity.**

It only comes once.

The next four slides show offshore wind turbine construction and maintenance facilities in the Netherlands, in the U.K., in France and in Germany. There are more such facilities in Europe and elsewhere.

Also, we show a turbine being assembled by a crane mounted on a "jack up" vessel, an offshore wind turbine farm off the coast of the U.K. and the five 6 megawatt turbines operating near Block Island.

The final slide shows the dependence of average wind speed on height above the ocean. The greater the height, the larger the average wind velocity and so the average power generated by a turbine. Those higher velocities and resultant greater energy generated per year will result in lower electric power costs.

Offshore turbine facility – Vissingen, Netherlands

Siemens Offshore Wind Turbine Facility in Hull, UK.

Constructed jointly by Siemens and Associated British Ports

Adwen (Areva-Gamesa) turbine assembly facility in Dieppe Le Treport & Yeu-Noirmoutier, France

The Siemens Cuxhaven (Germany) offshore wind turbine constructon facility

Offshore Turbine Being Assembled in situ by a Crane Mounted on a "Jack Up" Vessel

British Offshore Wind Farm

Block Island Wind Turbines

Tall, (150 meters high), offshore towers generate twice as much power as shorter (80 meters high) onshore towers .

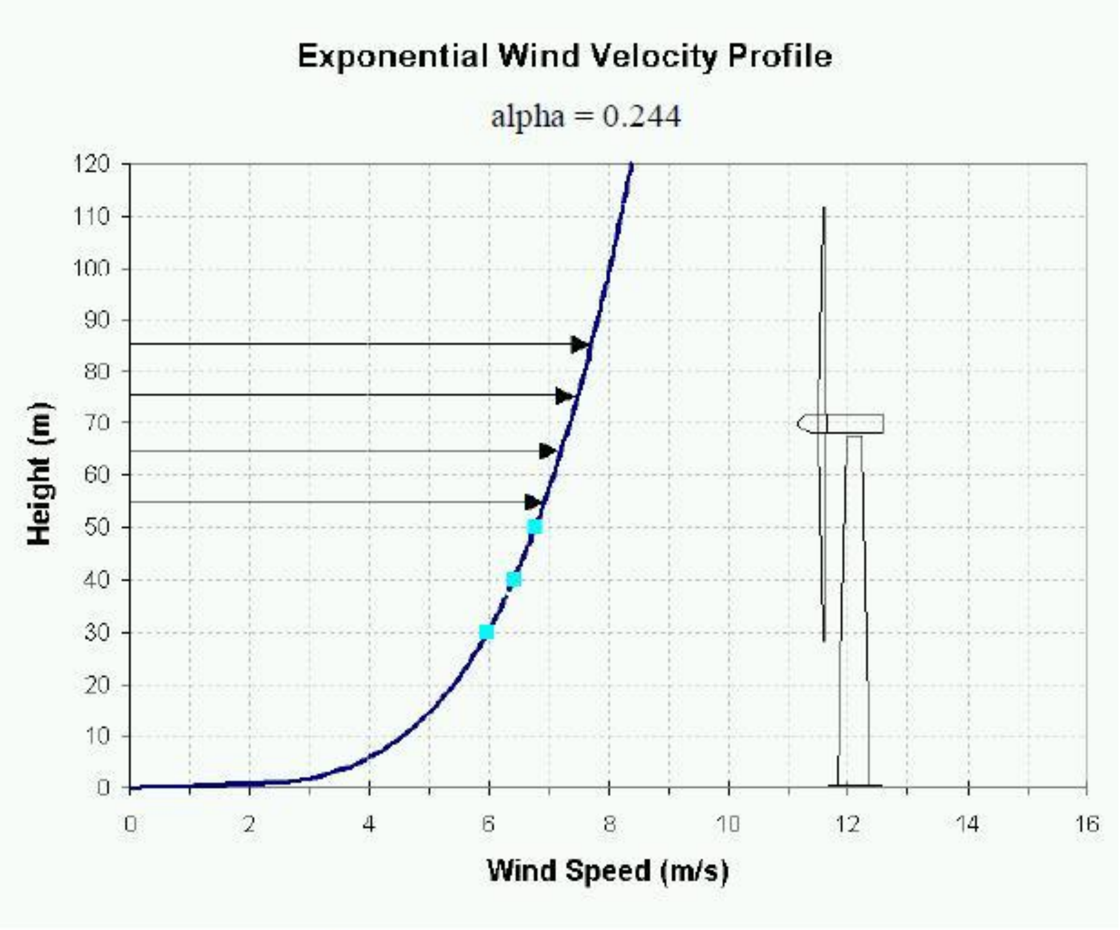


Figure 3 Annual Average Wind Shear at WCROC Site

Ratio of velocity at 150 meters to that At 80 meters = 1.3

Power varies as v^3, Or $(1.3)^3 = 2.2$