SOLAR 2013: OVERCOMING BARRIERS TO DISTRIBUTED WIND ENERGY IN THE MID-ATLANTIC

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ABSTRACT

The development of distributed wind energy has progressed steadily in many areas of the country but has lagged in Maryland, Virginia and North Carolina. Distributed wind energy applications are an attractive option in some Mid-Atlantic States and may be the key to unlocking the potential of a large and economically viable resource. Although the economic value of distributed wind plants is not significantly less than elsewhere, especially in coastal areas, deployment has been slow. Two issues that contribute to this apathetic growth are discussed in this paper. First, there is a general lack of wind resource measurement data especially at potentially good wind sites and therefore existing sources and models may be under predicting the potential. Early regional wind maps showed marginal wind energy potential at 50 meter height. Today it is known that better resources exist at hub height and above on today's commercial turbines. Second, the Federal wind program focused most attention on defined resources the Midwest. Another reason for slow growth is that weak policies act as a deterrent to the entire multistate region. In Maryland and Virginia, existing renewable portfolio programs can be satisfied with renewable energy credits ("RECs") generated by projects that existed long before the portfolio standards or can be purchased elsewhere in the country (except solar RECs must originate Maryland). Crediting pre-existing biomass projects with RECs diminishes the efficacy of portfolio programs. North Carolina limits REC to new sources but has conservative goals and other limitations due to view-shed issues. Maryland recently introduced net metering rules that are attractive to wind and solar by allowing some customers to sell electricity back up to 200% of the normal consumption. The price is retail or about 8-10 cents/kWh less transport and administration fees. This is allowed for projects smaller than two megawatts. As the flaws in the renewable portfolio programs are fixed and the significant economic value of the existing incentives are recognized, distributed wind is likely to be the precursor to large scale wind deployment in the mid-Atlantic region.

1. MID-ADLANTIC WIND DEPLOYMENT STATUS

The Mid-Atlantic states, including Delaware, Maryland, North Carolina, and Virginia, have areas with excellent wind energy potential yet there are only two utility scale projects installed to date and two more are under construction now in Maryland. This underdevelopment of wind energy projects for bulk power generation continues despite a growing demand for electricity that is among the highest in the nation. Ample wind resources are available at Appalachian mountain ridgeline sites, on the coastal plains, at shallow sheltered water sites in Delaware and Chesapeake Bays, Albemarle and Pamlico Sounds, and at deeper water sites off the Atlantic coast. See Table 1. Surrounding states of Pennsylvania and West Virginia in similar wind and terrain conditions have seen much larger scale deployments and numerous projects are underway. The question is why is wind power development in the Mid-Atlantic lagging behind states?

2. BARRIERS AND MITIGATION MEASURES

The primary Mid-Atlantic regional barriers to wind development were defined and strategies were suggested in a report prepared for U.S. Department of Energy by Princeton Energy Resources International (PERI)[1]. Barriers were grouped into four general categories; policy and regulatory issues, wind resource uncertainty, business/ economic issues, and public interest. These issues and

TABLE 1:DOE ESTIMATES OF LAND-BASED AND OFFSHORE WIND ENERGY POTENTIAL BY 2030 (BUT NOT COUNTING POTENTIAL SITES IN BAYS AND SOUNDS).

	Windy Land Area ≥ 30% Gross Capacity Factor at 80 m					Land-Based Wind Energy Potential		Offshore Potential
State	Total (km^2)	Excluded (km^2)	Available (km^2)	Available % of State	% of Total Windy Land Excluded	Installed Capacity (MW)	Annual Generation (GWh)	Estimated Capacity (MW)
Maryland	567.7	271.1	296.6	1.18%	47.80%	1,483	4,269	53,782
North Carolina	1,155.60	994.1	161.5	0.13%	86.00%	807	2,395	Very Large
Delaware	36.6	34.7	1.9	0.04%	94.80%	9.5	26	Similar to Maryland
Virginia	1,567.20	1,208.50	358.7	0.35%	77.10%	1,793	5,395	94,448

categories are not wholly independent of each other and do interact. Wind resources in the region were addressed in four areas – Ridgeline sites in the Appalachian Mountains in the western portion of the region, Coastal land areas, shallow Bays and Sounds in the east, and offshore on the continental shelf in the Atlantic Ocean. Some of the potential ridgeline sites in this area have been determined to be "off limits" by state or local governments concerned with the potential adverse impact on view sheds, noise, and avian species collision issues. Coastal, bay and offshore wind resources have not been adequately characterized, although limited data indicates suitable resources are available. State-level support for wind power varies widely within the region and, to a substantial degree, the push for development of potential offshore wind resources has eclipsed state policy development for onshore and shallow water wind power development. These factors combine to increase economic uncertainty and wind power business risk, but concerns about increasing electricity imports, long-term energy and environmental costs, and interest in local job creation are driving changes to mitigate barriers to wind development.

3. WIND RESOURCE UNCERTAINTY

There is a paucity of wind resource data suitable for planning utility-scale wind plants in the Mid-Atlantic. Data presented in the National Renewable Energy Laboratory (NREL) regional wind resource maps are based mainly on atmospheric models that are adjusted by including data from available measurements. Unfortunately in the selected states much of the existing data comes from National Oceanic and Atmospheric (NOAA), National Weather Service, Environmental Protection Agency sites, airports, and other stations that typically measure winds at the standard 10 m height above ground level (AGL).

Only actual wind measurements at 70 m turbine hub height or above were used in the Mid-Atlantic study. These multi-year data were considered to be more reliable for predicting diurnal and seasonal energy production than for existing models.

Seven regional measurement sites were selected for the Mid- Atlantic study; their locations are shown in Figure 1. These sites include four described in detail in a Tall Tower Wind Study for NREL[3]. The wind measurement data sets included: three levels on two towers 80 to 110 m height in Virginia by James Madison University, one 80 m tower in Pennsylvania by St. Francis University, and high resolution weather balloon data from U.S. Army at Aberdeen Test Center in Maryland. Additional data up to 91 m height came from NASA's Wallops Island site; Crisfield, Maryland (only at 77 m level collected under a Maryland Energy Administration program); and NOAA measurements at 43 m from Chesapeake Light tower in the ocean off the Virginia coast. Together these seven data sets were used to estimate the average wind speeds in each of the four market areas. These data were used to calculate average diurnal wind speeds and plant capacity factors for on-peak and off-peak energy output as well as monthly and seasonal differences used in economic models discussed later. Results were compared to modeled estimates from other DOE studies.

Wind characteristics used in most prior DOE Mid-Atlantic regional resource mapping and integration studies were based primarily on measurements below 50 m AGL extrapolated to rotor height. For example, wind data sources used in the DOE, Eastern Wind Integration Study (EWITS)[3] shown in Figure 2 differed from the seven tall towers measurements in some but not all cases. The Ridgeline wind speeds and capacity factors were similar. But looking at the average wind speeds and the high wind shear at the Wallops and Eastville sites on Delmarva lead to the conclusion that average onshore coastal area wind speeds at those heights may be underestimated by at least one wind power class.

As previously mentioned, there exists at present little information anywhere in the Mid-Atlantic about the vertical wind profile at heights 50-150 m that are important for wind turbines. Extrapolations from 10 m buoy or 50 m winds often use the so called $1/7^{th}$ power law model, but this approximation likely underestimates the wind, especially in the stably stratified nocturnal boundary layer. Models

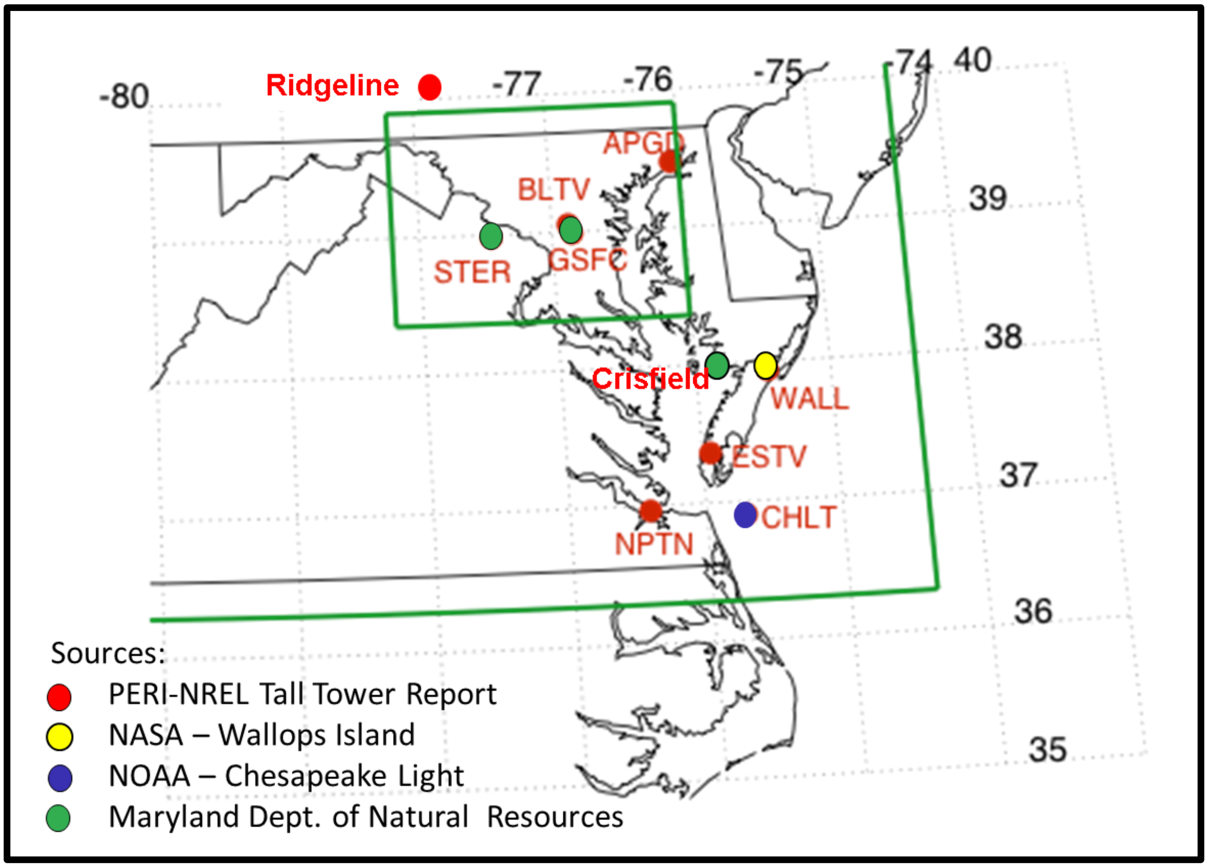

Fig. 1: Wind measurement sites in Mid-Atlantic Study. Including data collected by St. Francis University and James Madison University, NASA and NOAA tall tower measurements; US Army weather baloons and wind profiler measurements by Howard University.

continue to have difficulty accurately simulating the stable boundary layer because the intermittency of the turbulence is not easily parameterized. Models continue to have difficulty accurately simulating the stable boundary layer because the intermittency of the turbulence is not easily parameterized. The change in wind speed with height is also strongly dependent on time of day, with larger increases at night relative to day, and it is likely to be highly variable at coastal locations.

Examples of differences between the Delmarva measurements and EWITS are shown in Figure 3. Day-to-day model/data differences are shown in Figure 3a; cross-rotor wind speed differences of 2 m/s are not uncommon. Differences in the amplitude of diurnal cycle at the Newport News site are shown in Figure 3b where EWITS appears to underestimate night and pre-noon winds but overestimate evening winds.

The reverse is true on the ocean as shown in Figure 3c. The analysis showed that the EWITS estimates for average seasonal wind speed offshore were about 15% higher than estimates in this study. These differences are considered to be statistically and economically significant.

Despite these uncertainties it was necessary to estimate daily average wind speeds for each season for the economic models. Two averages were calculated for each day of the month based on the measurements in that market area. Average for on-peak pricing was from 0700 in the morning till 2300 at night. Average wind during the remaining hours was considered off-peak to be consistent with PJM pricing policy.

An additional wind resource uncertainty is the resource potential of terrain induced low level winds across the Mid-Atlantic coastal plain. These are sometimes referred to as low level jets (LLJ). For example, the nocturnal LLJ could occasionally increase wind plant production during spring and summer months. These jets arise from large scale topographic/thermal forcing due to surface cooling of the elevated western region during the warm season. The spatial characteristics of the LLJ are shown in Figure 4 which shows a model simulation for one night on August 3, 2007

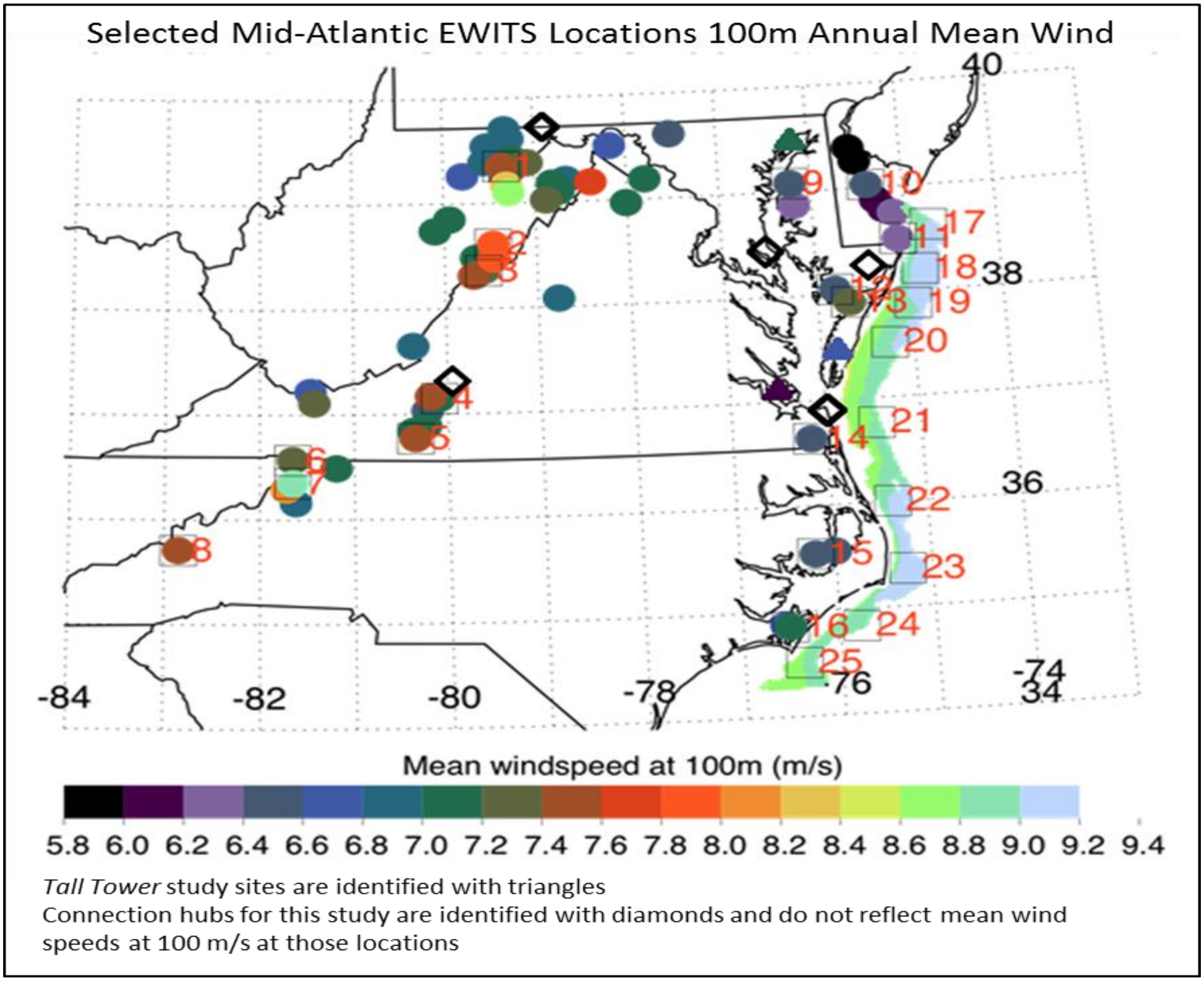

Fig. 2: Measurement sites for selected PJM nodes in EWITS. Total of 25 sites were chosen as a subset modeled to represent the range of conditions along the Appalachians, coastline and offshore. Numbered sites included Mountain: 1-8, Coast: 9-16 Offshore: 17-25. Sites are colored according to estimated annual mean wind speed at 100 m AGL for the EWITS study. Additional offshore measurements are not shown individually. There are no locations in the Delaware, Chesapeake Bays and the Sounds in North Carolina.

using the state-of-the-art Weather Research and Forecast (WRF) model at 9 km resolution. This figure shows winds at 312 m height but direct measurements on that date show that the jet can significantly increase wind speeds at turbine rotor height. The extent to which the LLJ is a wind resource for the coastal plains during the summer is currently unclear because of its sporadic and relatively unanticipated occurrence.

Many factors contribute to uncertainty regarding the regional wind resource characteristics. The primary issues are: 1) the lack of long-term, hub height or above wind measurements, 2) the atmospheric complexity and variability at the land-sea boundary, and 3) the presence of terrain induced low level winds that are known to exist but their characteristics and relevance for Mid-Atlantic wind energy is not clear.

Yet the measurements and wind models both show clearly that there are large areas in the Mid-Atlantic with wind resources that are suitable for commercial wind power plant development. At the same time the issues and the limited resource data can create unwarranted uncertainty for developers. Communities can help to overcome these added risks with pilot projects and added incentives discussed later in this paper.

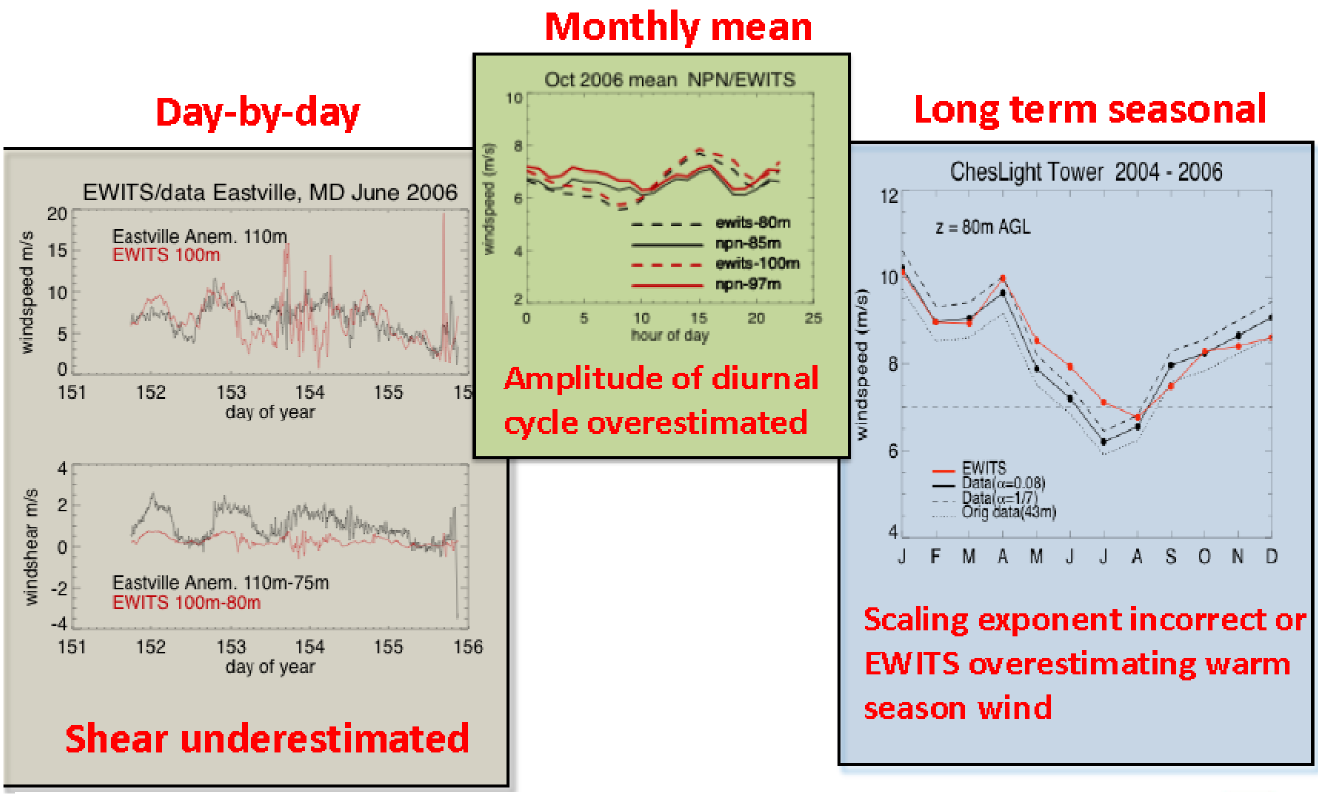

Fig. 3: Differences between measured wind data and EWITS models. (3a) showing shear differences, (3b) diurnal differences, and (3c) showing offshore seasonal differences.

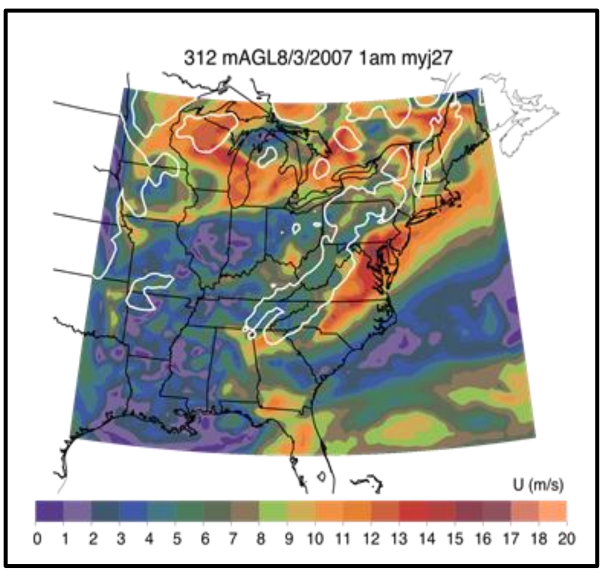

Fig. 4: Terrain induced low level winds. Based on WRF model for 0100 hour Eastern Time on 3 August 2007 at 312 m AGL.

The recommended approach to reduce these uncertainties about the wind resource is a coordinated regional wind resource measurement campaign. This can be similar to the intensive efforts that DOE supported previously in the mid-western states.

4. <u>POLICY AND REGULATORY ISSUES</u>

In each State in the region, policies and programs are in place that are intended to support the development of wind and other forms of renewable energy through renewable portfolio standards or goals (RPS/RPG) and incentives. A review of the detailed structure of renewable portfolio programs in each jurisdiction revealed that these programs currently transfer payments from ratepayers to pre-existing facilities that fall into broadly defined categories of "renewable resources," and are not providing an incentive for the development of new renewable resources. Grant programs are available in Maryland and elsewhere but are limited in scope and amount and do not generally rise to levels that would provide a significant incentive for commercial scale wind power development. Certain local zoning and noise ordinances have been enacted that effectively bar wind power development in those jurisdictions. In North Carolina, a misinterpretation of a state stature by the Attorney General and the Public Utility Commission has chilled development of almost all of that state's ridgeline resources.

Structural flaws in the RPS in Maryland and RPG in Virginia render them to be ineffective as the intended incentive for development of wind. Renewable Energy

Certificates (RECs) required to fulfill the mandates are allowed to come from anywhere in the PJM regional grid system and there is no requirement for creating new facilities. An exception is that new solar projects in Maryland must be located in-state to meet a separate 2% "carve out" mandate. Consequently other REC requirements are being fulfilled largely with "anyway" credits. Many credits are generated from facilities that were built long ago and would operate anyway for reasons other than RPS/RPG. These facilities include hydropower plants installed in the early 1900s for economic reasons and pulp mills that have for decade's combusted pulping wastes (known as black liquor) for their plant energy needs. In Maryland in 2010, 42.8 percent of the RECs to meet the standard came from black liquor, some credits originating in Virginia. North Carolina is an exception. There the State RPS requires that RECs be limited to facilities deployed after the RPS law was passed and that 75 percent must come from in-state sources. However, North Carolina has set a low RPS requirement gradually increasing to 12.5 percent by 2020 and has not yet reached levels sufficient to incentivize commercial wind power development.

In Virginia electric power business is regulated by the State Corporation Commission. In prior cases this Commission has ruled that the portfolio goal shall be treated as a ceiling for renewable energy sold under the Commonwealth's RPG program, rather than as a minimum target to be met or exceeded. In one land-mark case, the Commission ruled power purchase agreements (PPA) for new wind power generation were not "reasonable and prudent" as required by the RPG statute. They determined that the goals of the RPG were caps on the amount of renewables supported under the program and that any new renewable generation that was not needed to meet the currently applicable goal was not prudent. The Commission suggested that if low cost RECs generated by pre-existing sources were available as a lower cost method of compliance, and that was preferable to new wind plants.

Delaware's RPS recognizes the "anyway credit" issue and provides a complicated but clear resolution of competing interests. The State has a requirement of 25 percent by 2025 with a solar photovoltaic "carve outs" that currently are set at 0.40 percent and rising over time to 3.50 percent in 2025. Additional support for renewables was demonstrated with special legislation that supported the Delaware PSC approval of a power purchase agreement (PPA) for offshore wind power at prices substantially higher than for fossil fuel-fired generation. Delaware has promulgated reasonable siting and noise requirements for residential wind power units. And a Delaware statute specifically precludes local governments from adopting more restrictive requirements.

Simple modifications would improve the effectiveness of the RPS/RPG in Maryland and Virginia. Adding requirements that all, or a large portion, of REC's originate from in-state sources built after passage of the standards would open substantial indigenous new energy sources and create hundreds of local jobs.

5. COMMUNITY ENERGY ROLE

Distributed generation and community based projects are often a useful mechanism to stimulate renewable energy development in untapped regions with suitable renewable resources. It can be seen from initial projects in western Maryland and in other states, that privately owned projects can encounter local opposition that can delay or even defeat otherwise viable enterprises.

Distributed generation and municipally owned projects is a proven business structure for wind plants in mid-western and eastern states in the U.S. and extensively in the European Union countries. Most of the roughly 2,400 MW in wind plants located on Jutland peninsula in Denmark are owned by small groups of farmers[4]. The advantages of this approach include pooling of resources, shared risk, economy of scale, municipal financing rates, and possible tax breaks. Most important is that local community involvement helps to increase project acceptance and to facilitate approvals.

In the U.S. about 2 percent (155 MW) of independent power producers built in 2011 were considered to be community wind projects. These include towns, schools, and commercial and farmer groups. Most of these projects are owned by or benefit one or more members of the local community to a greater extent than typically occurs with a commercial wind project. According to AWEA (2012 report), 6.7% of 2011 capacity additions qualified as community wind projects. Similar project structure is often used for solar PV projects.

6. NET METERING BONUS

The value of community involvement and investment is recognized with net metering rules in 43 states, the District of Columbia and four territories. In Maryland the unique net metering rule can be an especially attractive incentive. In this case, a community energy project, electric cooperatives and some other groups may net meter electricity up to 200% of the customer's baseline annual electricity use. Projects are limited to a maximum 2 MW renewable energy system; defined as either photovoltaic, wind, biomass, fuel cell, anaerobic digestion, small hydroelectric, fuel cell using renewable fuel, or combined heat and power cogeneration (limited to 30 kW) and can be installed and operated either by the owner or through a third-party. The retail price is paid for excess electricity delivered to the grid after a fee for transportation and administration is deducted.

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8. REFERENCES

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