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Wind Power Silent Revolution: New Wind Turbines for Light Wind Sites

A guest article by French expert Bernard Chabot

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Onshore wind power development will be more and more based on the use of wind sites of lower quality in terms of average annual wind speed than those that were available at the start of the large scale wind power market deployment. This is particularly true in Europe where the best sites are increasingly already taken. Some years ago, this would have led to the conclusion that capacity factors on those lower quality sites would be very low. But on the contrary, the vast majority of world wind turbines manufacturers have recently put on the market or announced new wind turbines models with potential high capacity factors on sites classified as adapted to IECIII class wind turbines [1], with an average annual wind speed from 6 m/s to a maximum of 7.5 m/s at hub height. This article demonstrates that those claims are realistic and that such new turbines models for this kind of sites open new opportunities for onshore wind development with specific advantages: more TWh delivered per GW and per year, higher penetration rates, new opportunities for wind developers, including farmers and cooperatives located in those light wind speed regions, lower competition for access to convenient sites, and specific advantages for grid operators: much more hours of operation per year at rated power and less GW of peak transmission capacity for given medium and long term targets in terms of TWh/year or penetration rates.

NEW WIND TURBINES MODELS WITH HIGH CAPACITY FACTORS FOR LIGHT WIND CONDITIONS (IECIII sites)

Figure 1 summarizes the equivalent annual full load hours ***Nh*** of 12 recent models of wind turbines proposed for IECIII sites, either already on the market or to be commercialized before the end of 2015 by 12 manufacturers based in Europe, North America or Asia. Models are characterized by their specific area ***Su***, the ratio between the swept area and the rated power, expressed in m2/kW. Annual production is calculated here from the "WindMatching Calculator" [2], considering a shape factor k = 2 (Rayleigh distribution) and 10 % wind farm losses. Average annual wind speeds are considered at hub height, which is between 90 to 140 m for this kind of wind turbines (here with diameters from 82 to 125 m and rated power from 1.5 to 3 MW) and IECIII sites.

The ratio **Nh** is clearly increasing with the ratio **Su**, and with a quasi linear progression at all considered average wind speeds **Vm** from 6 to 7.5 m/s at hub height.

Even at an average annual wind speed of 6 m/s at hub height, **Nh** values are very interesting for developers: from 2090 h/year for the wind turbine with the lower **Su** value (3 m2/kW) and up to 3040 h/year for the wind turbine with the higher **Su** value (5.1 m2/kW).

At 6.5 m/s at hub height, the corresponding **Nh** range is from 2470 to 3450 hours/years, at 7 m/s from 2830 to 3830 hours/years, and from 3180 to 4170 hours/year at 7.5 m/s.

Figure 2 summarizes the corresponding average annual capacity factors (**ACF**) values, based on the relationship:

ACF (%) = 100 * **Nh** / 8760   (with 8760 = 24*365 hours in a reference year)

Here also, **ACF** is increasing quasi linearly with **Su**, with a global range from 23.8 % to up to 47.7 %.

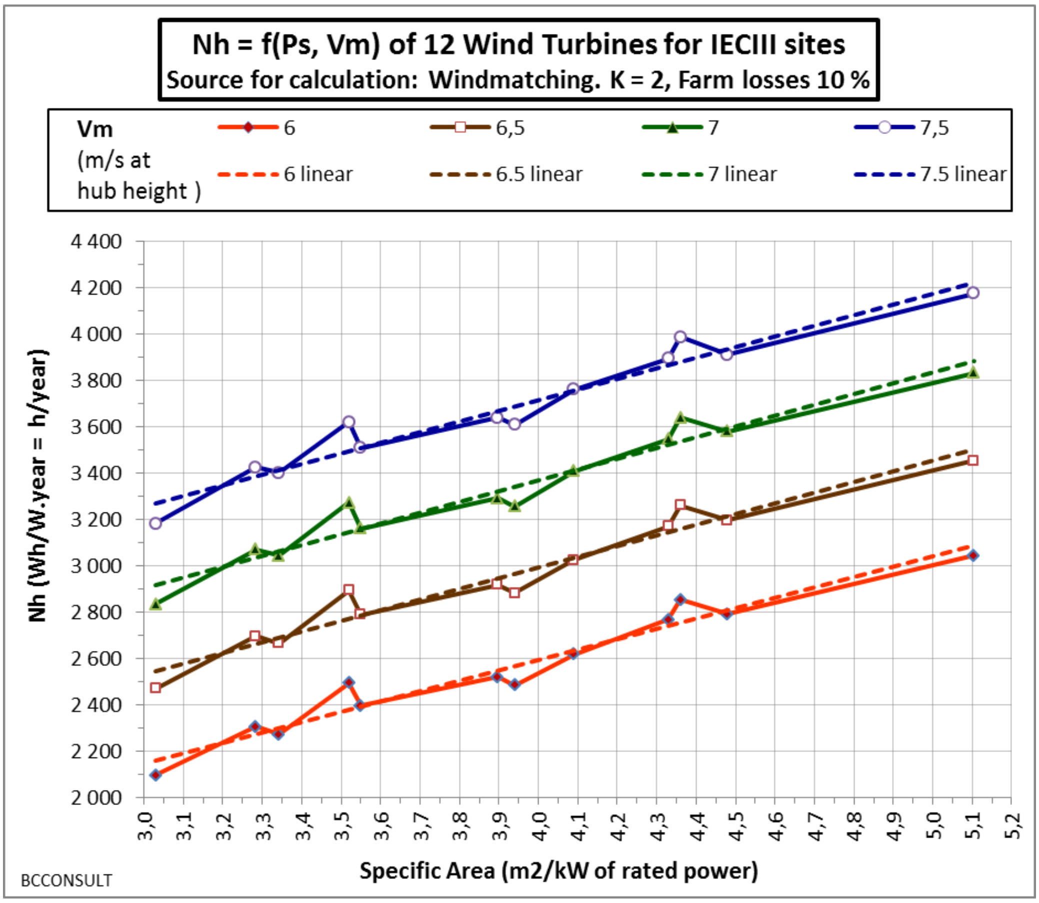

Figure 1: Yearly equivalent full load hours (**Nh**, hours/years) of 12 models of wind turbines for IECIII sites

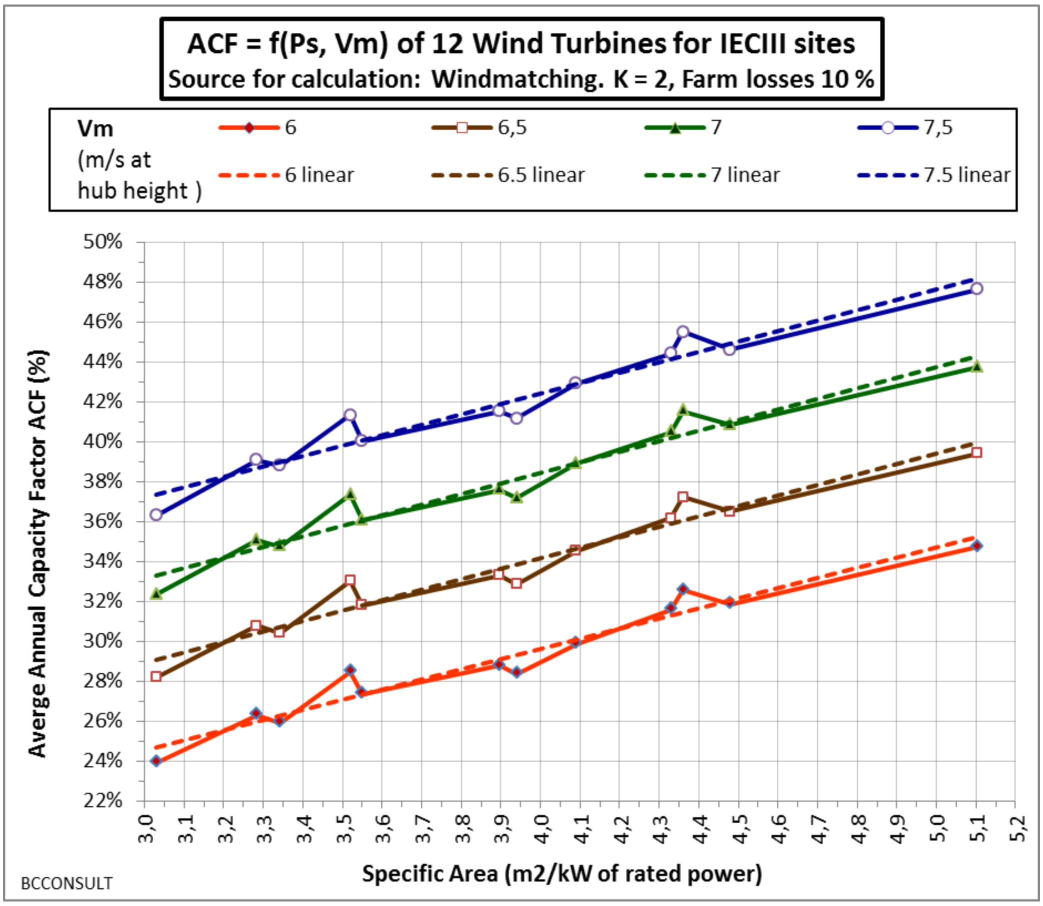

Figure 2: Average annual capacity factors (**ACF**, %) of 12 models of wind turbines for IECIII sites

INTERESTING ANNUAL SPECIFIC ENERGY YIELDS WITH LIGHT WIND CONDITIONS (IECIII sites)

Specific energy yield **Eys** (in kWh/m2 and per year) is the ratio between the annual production **Ey** (in kWh/year) and the swept area of the wind turbine **S** (in m2). Of course, it is linked to **Nh**, with the following relationship:

Eys = **Nh** * **P/S** = **Nh** * **Ps** = **Nh / Su**

where **Ps** = **P** / **S** is the specific power expressed in kW/m2 of swept area (ranging here from 0,196 to 0.33 kW/m2)

Figure 3 summarizes the specific energy yield **Eys** values corresponding to the twelve wind turbines models at different annual average wind speeds **Vm** at hub height, from 6 to 7.5 m/s

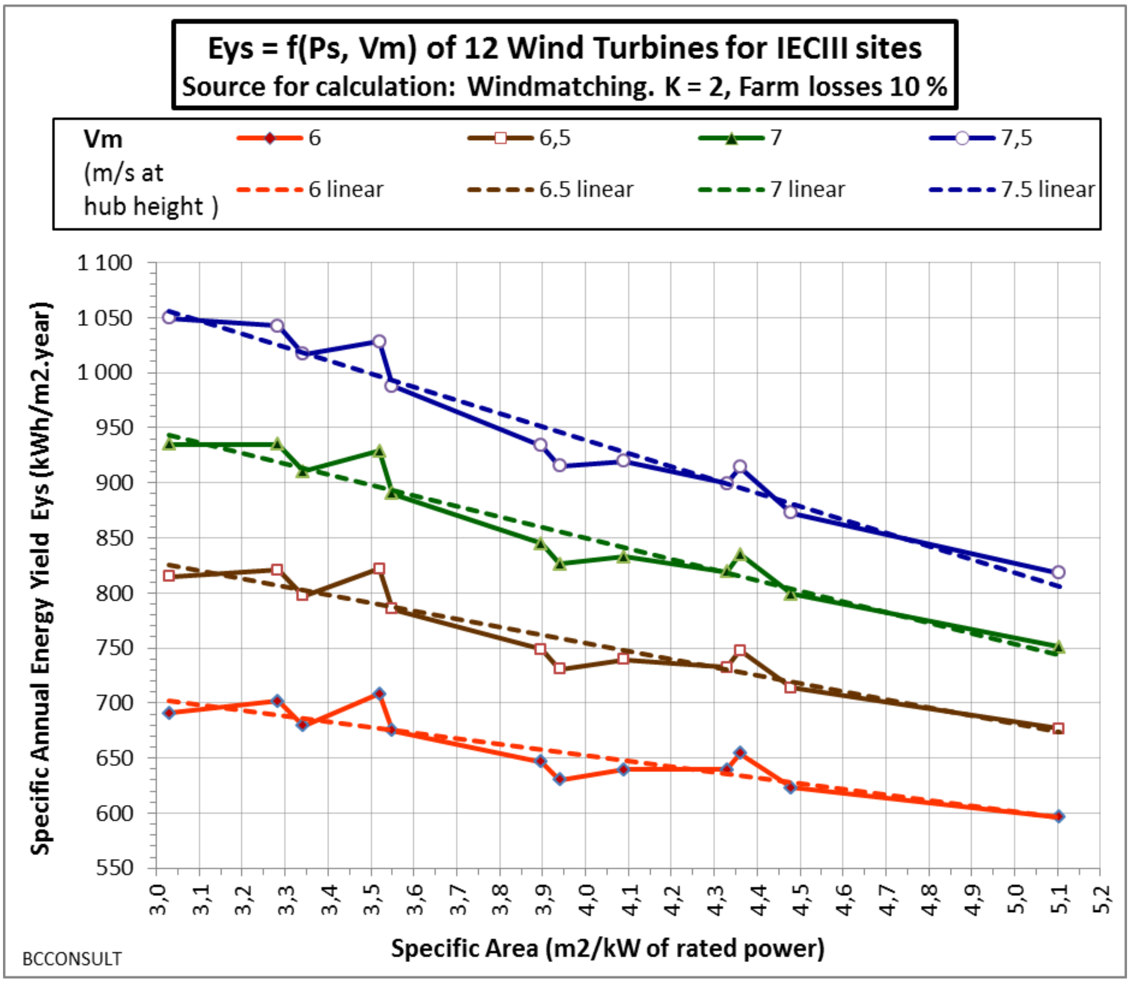

Figure 3: Specific Annual Energy Yield **Eys** (kWh/m2.year) of 12 models of wind turbines for IECIII sites

Of course, from the above relationship and as seen in figure 3, **Eys** is decreasing (quasi linearly) when the specific swept area **Su** of wind turbines is increasing.

The global range of **Eys** values is from 595 to 1050 kWh/m2.year. Those values are sufficient and correspond to a “good use” of each square meter of swept area even in light wind conditions.

Some advantages of those new models of wind turbines are qualitatively and briefly analyzed here, and further studies should be made to quantify them.

MORE TWhs AND HIGHER PENETRATION RATES PER INSTALLED GWs

High **Nh** values in light wind conditions with those new wind turbines models will deliver much more TWhs per year and per installed GW. Or for a specific target in GW in a country, more annual energy will be produced compared to assessments made with old models with lower specific area **Su**. At the end, energy targets and energy penetration rates will be easier to achieve.

MORE OPPORTUNITIES FOR LOCAL DEVELOPERS

Those new wind turbines models on high towers will allow to use new wind sites in regions and local communities which were considered either not sufficiently windy or not suited for wind turbines such as forests. This opens new opportunities for wind power developers, including local ones attached to local sites such as farmers and cooperatives of local investors.

LESS POTENTIAL OPPOSITION AND CONFLICTS FOR NEW WIND FARMS

Those new wind turbines models will allow to expand the national, regional and local areas where wind projects could be developed. Wind power development will need less and less to secure access to the "best windy spots" (corresponding to IECI and IECII classes) which are often in sensible areas for environment and landscape integration such as near the shores or on mountain ridges. So, potential local oppositions and conflicts should be lowered.

GRID OPERATORS WILL BENEFIT ALSO FROM THIS SILENT REVOLUTION

With higher average national, regional and local **Nh** and capacity factors values, adapting transport and distribution grids to large amounts of wind energy production will be easier and least costly: wind production would be easier to locate in areas of large electricity consumption, lowering transmission costs; and for a specific target in TWh/year, corresponding installed wind power in GW will be lower than with conventional wind turbines with low specific values **Su**. So, the required peak transmission capacity of the grid would be lower, a huge advantage both for existing grids to adapt and for new grids to develop specifically for wind power. And last but not least, the number of hours of operation of those new wind farms at rated power will be higher than with low and very low **Su** wind turbines, an advantage for grid management and offer-demand balance prevision and adjustments.

All those advantages need to be more specifically analyzed and the "bottom line" (profitability of wind farms using those new wind turbines on high and very high towers) should also be assessed. But the fact that the vast majority of tier 1 and tier 2 wind turbine manufacturers are proposing or will propose in a short delay such high specific areas wind turbines and the fact that some developers have already used them on IECIII class wind sites and within existing incentives and market conditions show that this "silent revolution" will be shortly recognized and will spread quickly and at large scale in many countries around the world.

REFERENCES:

[1] For the definition of IEC classes of wind turbines and corresponding quality of sites, see for example: Pramod Jain, "IEC Classification of Turbines: Selecting the right turbine for the site based on wind data", 2009, at: http://windwire.blogspot.fr/2009/05/iec-classification-of-turbines.html

[2] Access to the "WindMatching Calculator": http://www.windmatching.com/technical,calculator/