A Study on Wind Power Evolutions

Airborne Wind Energy Systems in a Future Wind Energy Market

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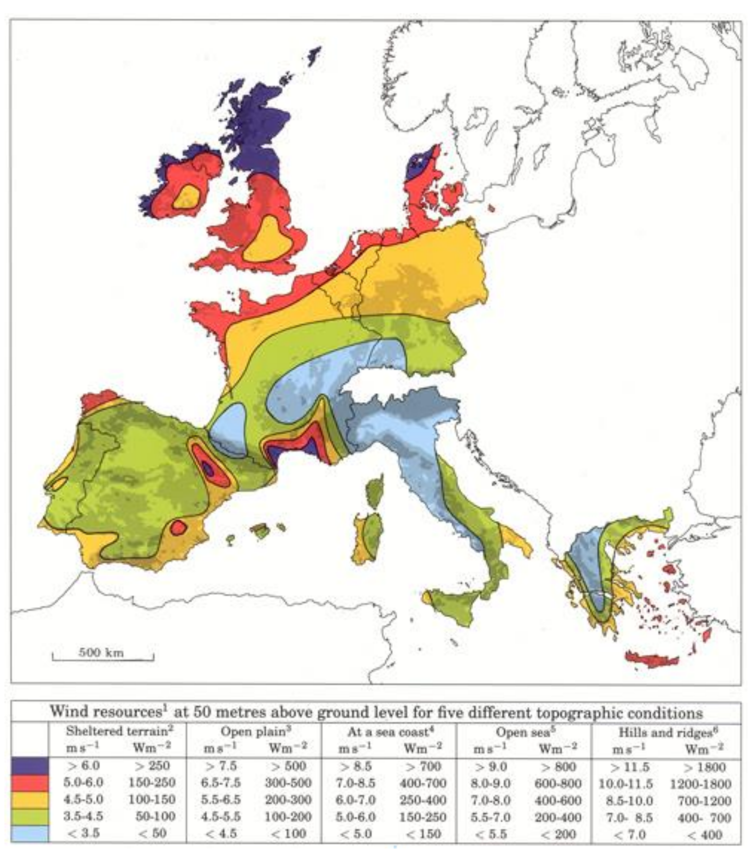
Context of the study

ENGIE France Renewable Energy (EFRE) develops, builds, finances, and operates ENGIE's renewable electricity generation assets in France (nearly 6,000 MW of installed capacity in 2017 [1]). In order to better understand future changes in wind power systems, **EFRE has commissioned a study to 4 students of the ENSE3 engineering school at Grenoble (France), under the supervision of researchers from Gipsa-lab and GAEL**. The study aims at providing some decision-making elements for EFRE positioning on low wind-speed turbines (LWT) and airborne wind energy systems (AWES) in France (100-page report , 160 references, 1000h). This poster shows some key information and reflections from the study.

Wind Energy challenges

Identified barriers and challenges facing power generation from traditional Horizontal Axis Wind Turbine (HAWT) :



Wind potential resource in Europe [2]

Availability of a proper site: onshore wind exposition, regulated distances and limitations, social acceptance, accessibility for transportation and distance to the grid strongly reduces wind farm potential sites.

Integration into the grid: Following the penetration rates of wind energy in the power grids, the variability of production poses growing balancing problems.

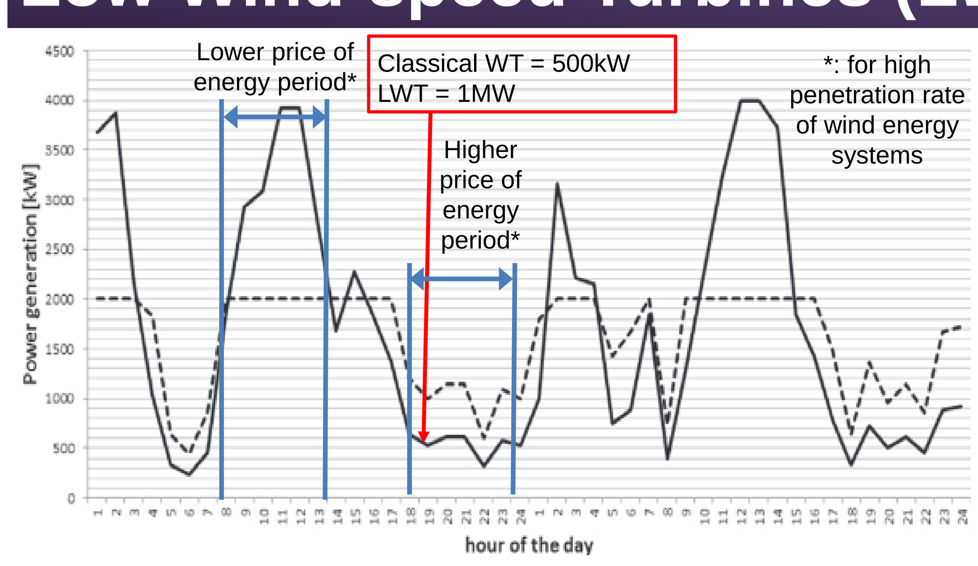
Offshore production imposes costs 1,5 to 2 times higher than onshore [3] and leads to uncertainties that discourages some manufacturers [4].

Legislative and regulatory issues can also have strong impact

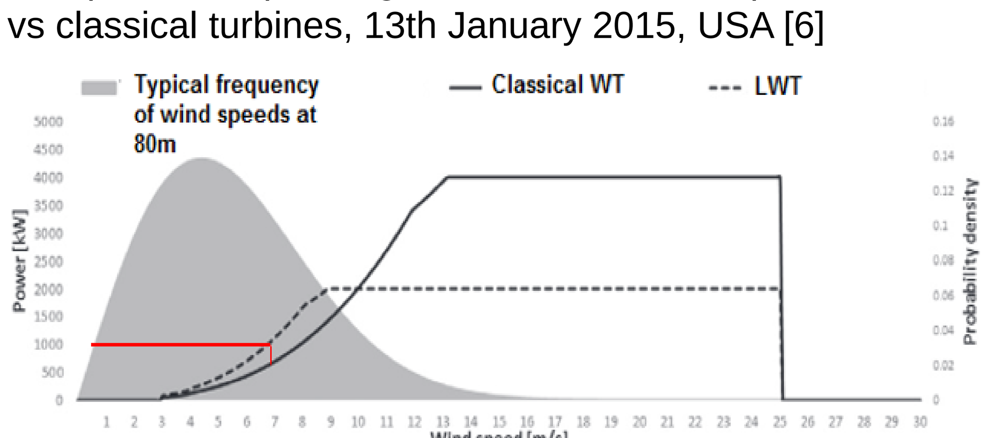
	AT	BE	BG	CY	CZ	DE	DK	EE	ES	FI	FR	GR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK
Complexity of administrative procedure		■						■	■	■	■	■				■	■			■			■	■				
Spatial and environmental planning	■	■	■			■		■		■	■		■			■	■	■		■	■	■	■		■	■		■
Cost of administrative procedure														■														
Duration of administrative procedure											■			■		■	■					■	■	■		■		

Reported Barriers Regarding the Administrative Process in Europe [5]

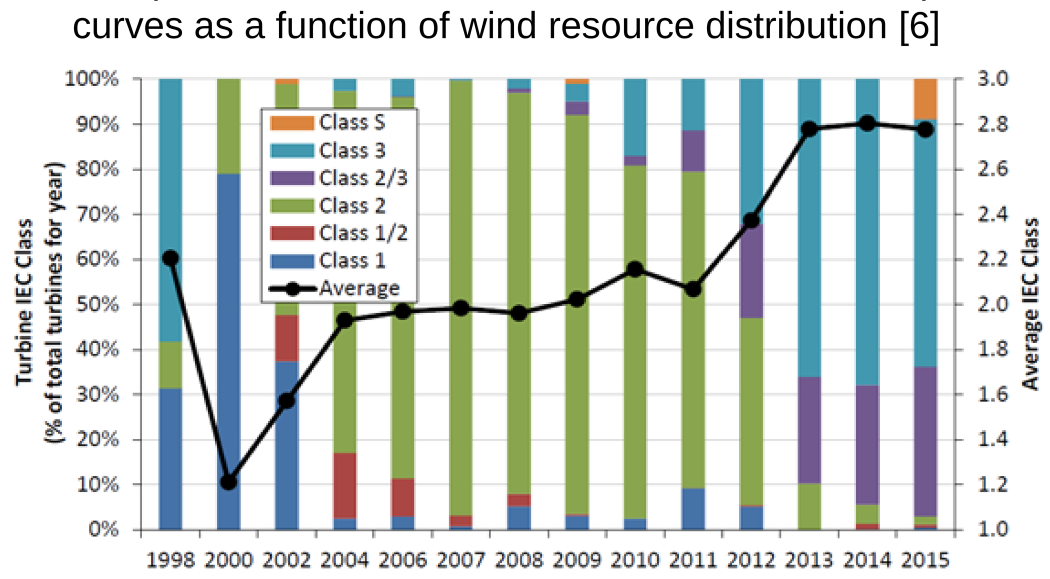
Low Wind-speed Turbines (LWT)



Comparison of power generation, low wind speed turbines vs classical turbines, 13th January 2015, USA [6]



Comparison between LWT and traditional HAWT's power curves as a function of wind resource distribution [6]



Classification of WT per IEC class in the USA [7]

Compared to a HAWT with the same cost, **LWT has smaller generator and bigger blades.** This leads to higher production when wind is lower and a constant but lower production at higher wind. This **smoothes the distribution of the production over the year**, with more production when less wind energy is available.

LWTs have now outclassed HAWTs in certain countries such as the USA.

Annual average wind seed at 50 m (m/s)	
Class I (High)	10
Class II (Medium)	8.5
Class III (Low)	7.5
Class IV (Very low)	6

Figure 3 : IEC 61400 wind classes, LWT are adapted for class III and IV wind

Some key points on AWES

Transportation and installation
The absence of mast, reduced size of the foundations and reduced size of the kite leads to highly simplify transportation and installation.

Availability of production
By changing altitude to harvest energy, AWES is a more flexible system than HAWT. One can choose to operate where wind is maximum or go to altitude where wind is lower when the maximum power is reached. Power curves can also be adapted to wind distribution by modifying independently the size of the kite and the size of the generator, like LWT.

Compacity of wind farm to reach utility scale
MW is a minimal scale in order to reach an energy density comparable to that of conventional wind farms [MWh/(km².year)]. Reducing the distance between AWES by sharing the same place at different altitudes has to be considered, as proposed in [8], [9].

Levelized Cost of Electricity (LCOE)

Cost compared to HAWT	AWES On-ground Generation	AWES On-board Generation
Mechanical Structure	- : no mast, less metal	- : no mast, less metal
Blades/wing	+ : complexity of flying system	++ : complexity of flying system and cable
Electrical system	+ : oversizing of the generator	+ : mass constraints of generators
Control, monitoring	+ : criticity of control and avionics	+ : criticity of control and avionics
Transport	- : easier to transport	- : easier to transport
Foundations, installation	- : less foundation, faster installation	- : less foundation, faster installation
Maintenance	+ : maintenance of flying part	++ : maintenance of flying part including generators

Only few studies have been found on the subject ([10], [11]): for on-ground system, expected **lower construction costs and higher maintenance costs** could lead to **intermediate LCOE.** More reliable forecasts about costs necessitates a higher maturity of the technology.

Conclusion of the study for AWES

Better access to sites: Easier transportation, potentially less visual, electromagnetic and acoustic impact (to be better investigated).

Better distribution and adaptation of energy production: Possibility to harvest at different altitude, wind resource more stable at high altitude and potentially adapted to a low wind-speed design.

Potentially better adapted to offshore condition in terms of cost of fabrication and installation costs, in particular when floating farms are needed.

Strong uncertainties on the final cost: Immaturity of the technology leads to significant costs uncertainties in key areas, especially regarding flying parts, lifespan and its maintenance.

Remaining issues identified in security, energy density and automatic take-off and landing.

References

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