Increasing the Profitability of Wind Energy in Icing Climates

as seen from a wind energy developer's point of view using input from EU's COST Action 727 - Measuring and Forecasting Atmospheric Icing on Structures and IEA's RD&D Wind, Task 19 – Wind Energy in Icing Climates

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Abstract – An analysis from a wind energy developer's point of view is presented regarding measures needed to utilize the full potential of wind energy in icing climates. The intended addressees are national energy administrations, researchers and industrial partners interested in expanding the potential for wind energy to such harsh environments. The work is based on input from developers, national and international wind energy research projects, current design standards and the international collaboration carried out in EU's COST Action 727 - Measuring and Forecasting Atmospheric Icing on Structures and IEA's RD&D Wind, Task 19 – Wind Energy in Icing Climates.

I. Introduction

The installed and forecasted future capacity of wind energy is rarely compared to the actual annual nuclear power production which was 2626 TWh, see ref. [1], in 2005. Data presented in a forecast from BTM, [2], as shown in Figure 1[1], indicate that wind's **energy**[2] production capacity may increase from today's 6% of nuclear to its equivalent in 2020.

A few years ago it was widely believed that offshore wind energy would take off and that an extended development of suitable locations on land therefore was not needed. Due to a significantly lower cost per kWh produced on land this is no longer considered to be the case. However, **iced up wind turbine blades** poses a significant challenge to wind turbine manufacturers as well as wind farm developers and owners in certain cold climate regions. The main reasons for their concern are:

- personal safety issues,
- loss of production and
- influence on the expected life of components.

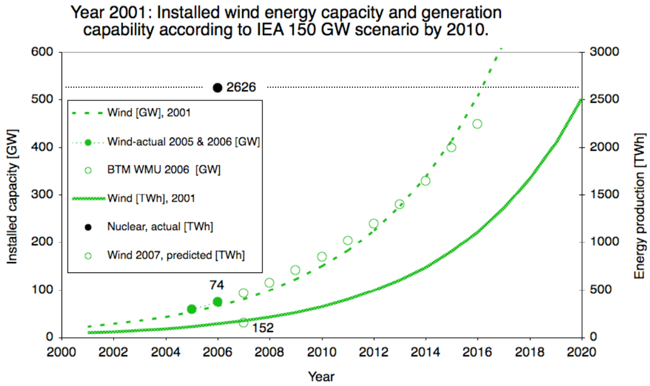

Figure 1: Forecasted (2007) installed capacity of wind energy and actual[3] (2005) production; 2626 TWh, from nuclear.

The adapted technology required to master wind energy in icing climates is currently lacking and the manufacturers are unlikely to pay much attention without market incentives. The main reason for this is that the previous buyer's market since two years has been replaced by a seller's ditto due to an overwhelmingly strong global demand for wind turbines. In spite of investing for a staggering growth, the listed manufacturers see an excellent opportunity window to increase their profit margins by

- utilizing economies-of-scale,
- improving efficiency,
- moving production to low cost countries and
- lowering the cost of capital employed by pre-charging customers.

The current backlogs for the major manufacturers are 1.5-2.5 years. Consequently, icing of wind turbines creates a more risky and not too overly interesting niche market.

The wind energy research community has addressed the issue of icing since the early 1990's. In spite of this, no commercial anti- or de-icing solutions currently exist for medium and severe icing conditions.

[1] The graph's original forecast from 2001 was based on a 150 GW scenario from IEA.

[2] In 2006, wind's installed **power** capacity was 20% (74 GW / 371 GW) of nuclear's, [1] and [2]. As wind's "optimum cost" capacity ratio is significantly lower than ditto for nuclear, wind's installed power can be viewed as less interesting than its energy production capability.

[3] The production from nuclear in 2006 was 2658 TWh, [1].

II. Background to the Current Situation

Icing of wind turbine blades causes problems listed in the introduction and the economic risk for an investor is consequently higher in icing climates in comparison with projects on the standard market. This is particularly true without proper means to remove ice from the blades as icing increases the economic risk and thereby may prevent or reduce the profitability of wind energy projects in affected areas. Figure 2 shows an example of an iced up blade.

Figure 2: An iced up blade of a wind turbine in Northern Finland. The rime ice is collected on the leading edge on the left. Photo: Timo Laakso, VTT.

A key industry issue is: Can wind turbine manufacturers really be expected to develop de-/anti-icing technologies when the demand for standard turbines is insatiable and the shortage of key components, [3], is a major concern, overshadowing most other issues?

This paper is written taking a wind energy developer's point of view and the Swedish company "Vindkompaniet" was chosen to serve as an example. It is, however, believed that the general results and conclusions herein are valid and of interest also to the other sponsors[4]. Figure 3 indicates the industry landscape. Players that have shown an interest in icing climates have been highlighted. As indicated in Figure 4, only one manufacturer, Enercon, has shown an interest in solving the icing issue.

While the market, technology wise, has been less farsighted than the research community, it has certainly succeeded in making some governments provide introductory measures and incentives like investment subsidies, feed-in tariffs, production tax credits, green certificates etc. These tools and measures are of little use as the technology required for utilizing wind energy in icing climates simply isn't readily available. Figure 5 shows some market niches compared to the current production capacity indicated by the horizontal line.

Figure 3: The developer Vindkompaniet's potential icing climate partners among interest organizations, manufacturers, in the research community, the government sector and among customers.

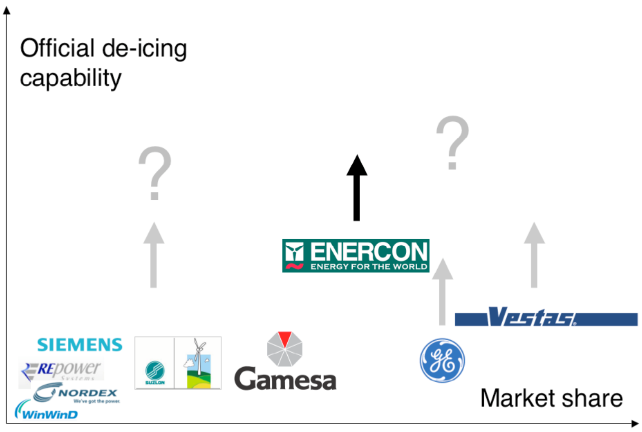

Figure 4: Official de-icing capability of selected manufacturers.

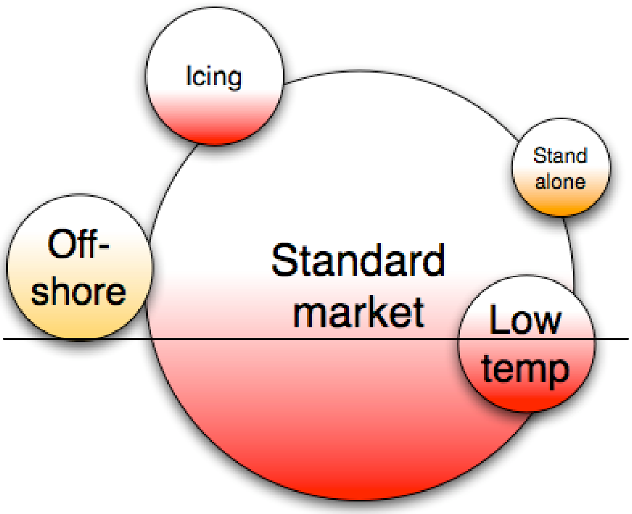

Figure 5: Wind energy market niches compared to the current production capacity.

[4] The sponsors of the work presented herein have been: the wind energy developer Vindkompaniet, the utilities Vattenfall and Skellefteå Kraft, [4], the Swedish Energy Administration (through COST Action 727, [5]) and its research advisory board Vindforsk II, [6].

III. Industry Incentives

If de-/anti-icing is needed for medium to severe icing conditions there is currently no solution available. It should be noted that the tools and measures proposed in Figure 6 are merely examples of actions that can be taken.

The bottom line is to increase the buyer's purchase power to get the necessary attention from an industry, which is growing rapidly in standard climates. It is believed that local sales organizations operating on markets where a large number of projects in icing climates might be sold may be able to get corporate attention. One example of the use of large purchase power was the recent round of bids to Hydro Quebec for 2000 MW of wind energy, of which some will be built in icing climates. Hydro Quebec's approach in this matter is such that the company will a) not own any wind farms, b) pass on favourable offers from manufacturers to developers, c) purchase the power produced at a fixed price, d) require no maintenance to be carried out during three winter months and e) penalize producers that are unable to periodically deliver a contracted amount of energy.

An alternative to the last requirement could have been to demand 95% technical availability including icing. It is, however, due to the inherent lack of adapted technology, questionable if any manufacturer would have been able to make an offer under such circumstances.

IEA's cold climate expert group in R&D Wind - Annex XIX, has published a State-of-the-Art report, [7], as well as recommendations for developers, [8]. Figure 6 shows an analysis of considerations to make regarding anti-/de-icing assuming a thorough understanding of the icing situation on the selected location. Examples of incentives and alternative players are also given. But do we really know how to ideally select locations in icing climates? The following chapter, based on work carried out by COST Action 727 provides an analysis of what is required to estimate the full potential of wind energy in icing climates.

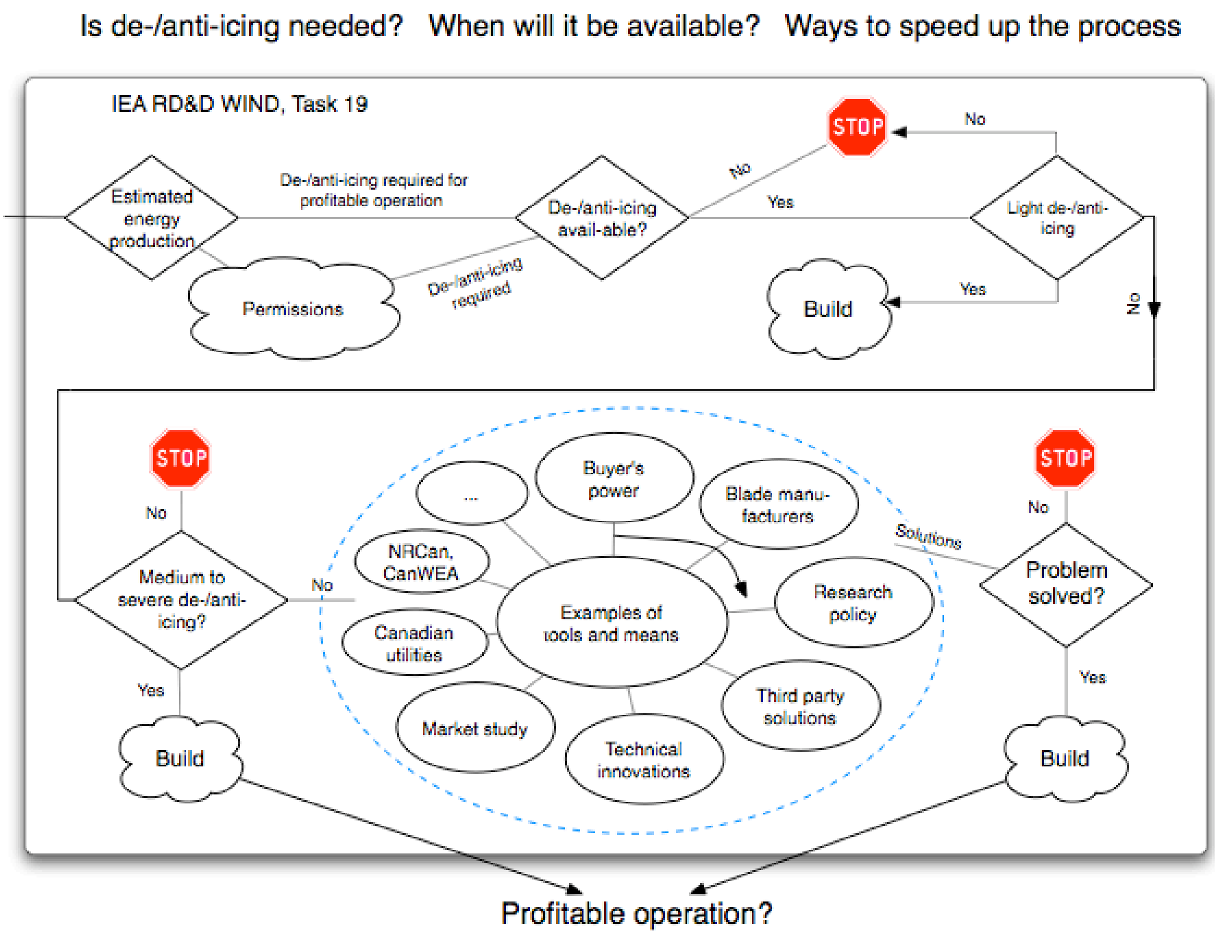

Figure 6: Considerations to be made regarding the need for anti-/de-icing equipment assuming a thorough[5] understanding of the icing situation on a selected site. Examples of tools and means to achieve de-/anti-icing capability are also shown.

[5] A thorough understanding of the icing situation requires the measures shown in Figure 7 to be taken.

IV. Estimating the Full Potential in Icing Conditions

The four main criteria governing the selection of sites, not considering icing are 3 times the wind speed and the grid connection cost. The wind speed, the grid connection cost and the conflicting interests are rather well known and/or easily accessible while icing introduces a whole new set of requirements. A sound utilization of wind energy in icing climates will require attention to be paid to fields shown in Figure 7. The targets of the analysis shown are to map the technical and net potential of wind energy in icing climates as well as to enable consistent energy assessment measurements to be carried out in such environments. The details can be found in COST Action 727 reports [9] and [10].

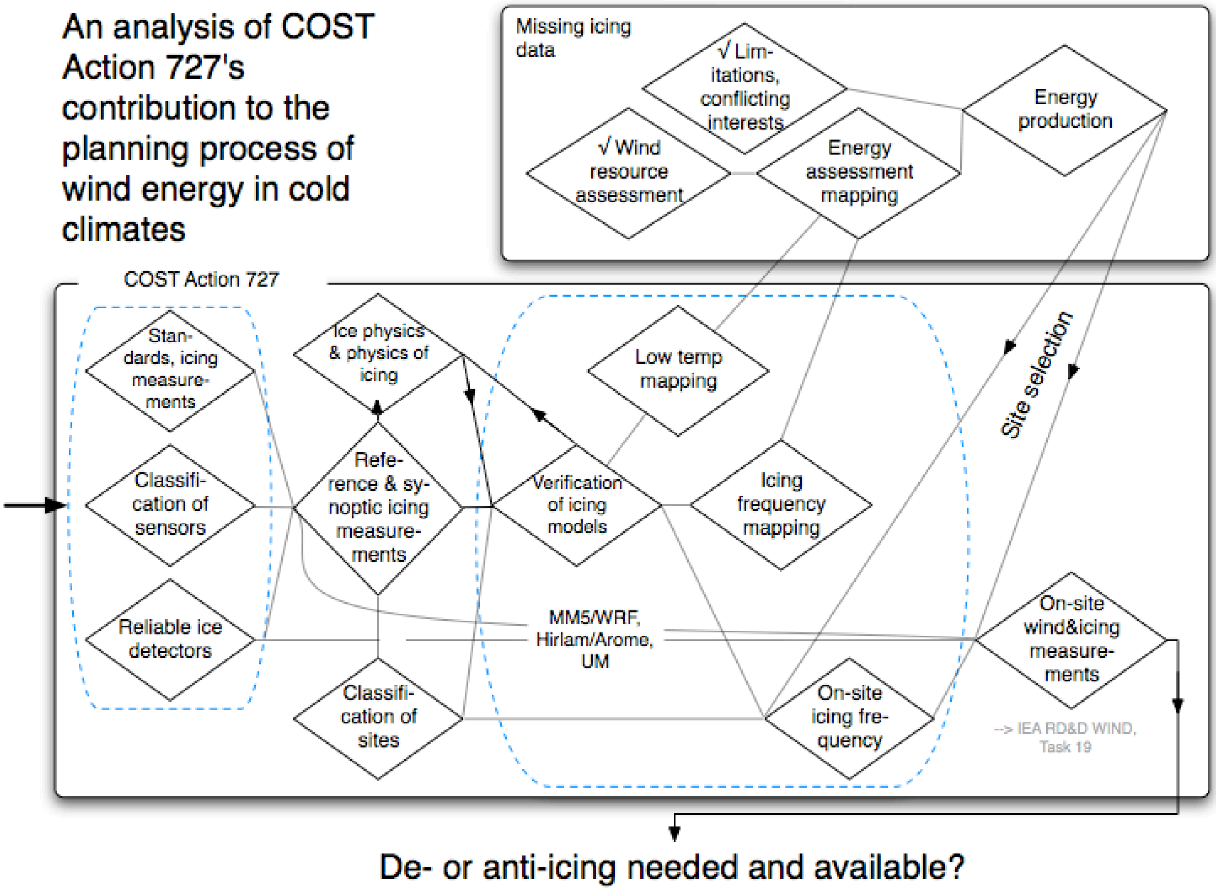

Figure 7: Measures needed to enable the full utilization of wind energy in icing climates.

V. Conclusions

A sound utilization of wind energy in icing climates requires a substantial and focused attention to the challenges listed above. This set of requirements is introduced at a time when manufacturers, due to the current high demand and shortage of main components, cannot be expected to solve such issues without additional external market incentives.

References

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