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# Reducing investor risk & increasing productivity with new accurate offshore wind farm radar tool

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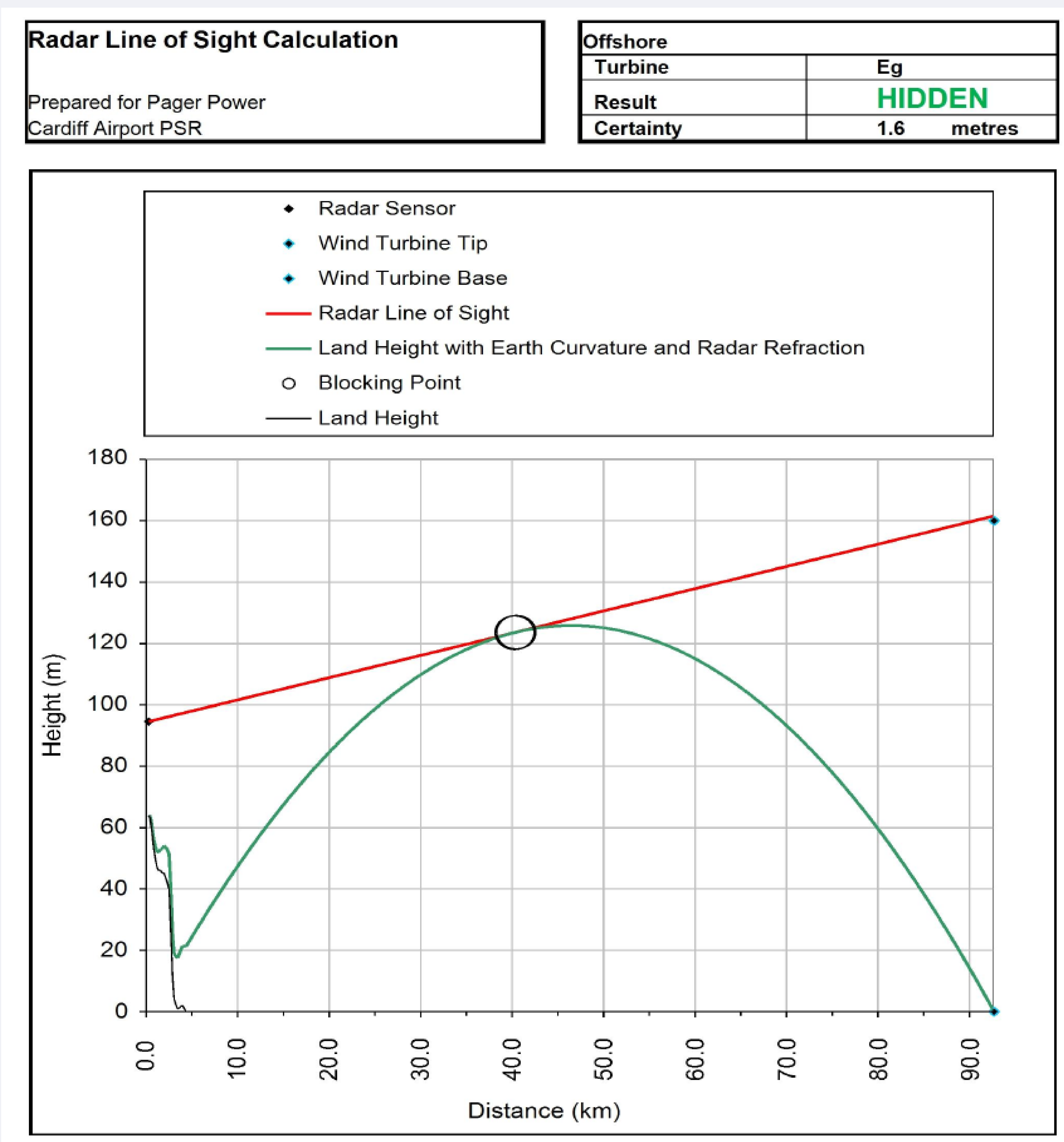
## Wind Turbine Risk

Wind farm development risks can be classified as delays, cost increases or inability to operate. Radar regularly causes all of these in many parts of the world. In some cases these risks are not fully understood by the wind farm developer. In extreme cases this can result in wind farms being built which cannot subsequently be operated.

## Background

Wind turbines can affect aeronautical, marine, meteorological and military radar. This means that offshore projects are delayed; have unplanned mitigation costs and are sometimes stopped entirely. Gigawatts of wind development have been adversely affected by radar in Germany, France, Czech Republic, Belgium, Netherlands, Sweden, Ireland, United Kingdom, United States, Canada, South Africa and other countries. The radar impact of wind farms has to be assessed to determine whether the wind development will be acceptable and whether some form of technical mitigation solution is required. Any uncertainties in the radar assessment process result in increased investor risk and reduced developer productivity.

## Abstract




Radar operators often have the power to block wind farm proposals. This normally occurs via written objection responses to planning/permitting authorities and additional correspondence with wind farm developers. For a wind development to be deemed to be acceptable the radar operator has to be satisfied that either (a) there will be no unacceptable impact (b) the development is outside the radar's safeguarded area or (c) there is a satisfactory mitigation solution. There are often time consuming negotiations regarding the likely technical and operational impacts as well as the suitability, availability and cost of mitigation solutions not to mention who takes on the responsibility for any residual risk.

Assessment of impact can occur in a number of ways but the most common assessments are Radar Line of Sight calculations that account for terrain, earth curvature and refraction and Radar Detectability calculations that take into account additional factors such as diffraction, radar power and sensitivity. All calculations account for the vertical path profile between the radar and the wind turbine. This profile is normally derived from a digital terrain model (DTM) or digital surface model (DSM). Accuracy and reliability depends on (a) vertical accuracy of the DTM/DSM; (b) post spacing of the DTM/DSM; (c) accounting for waves; (d) accounting for tidal variations; (e) the effect of beaches {sometimes exposed and sometimes covered by water}; (f) accounting for buildings, structures and vegetation; (g) abnormal meteorological conditions and (h) computing algorithms used to generate the profile from the available data.

The author's company has a range of online assessment tools that developers can use themselves to assess the impact of wind turbines on radar systems. There is a project, supported by the European Regional Development Fund, to significantly enhance accuracy and confidence in the results of the tool – specifically for offshore wind turbines. The project started in September 2014 and will end by March 2015. Existing wind turbine radar assessment tools do not account for varying sea state which affects radar propagation. By accounting for varying sea state, beaches, onshore vegetation and structures radar assessments become increasingly accurate and reliable.

## Example

The example Radar Line of Sight Calculation to the left shows the visibility of a fictitious 145 metre high offshore wind turbine to the radar at Cardiff Airport. This calculation shows that the radar's view of the wind turbine is limited by the sea – <u>assuming that there are no waves and that the sea is at mean sea level</u>.

In actual fact the radio path passes over the Bristol Channel which has some of the largest tidal variations in the world. At Avonmouth the difference between high and low tide frequently exceeds 10 metres. In this particular example the wind turbine is completely hidden from the radar when the sea is at mean sea level but becomes visible to the radar at low tide.

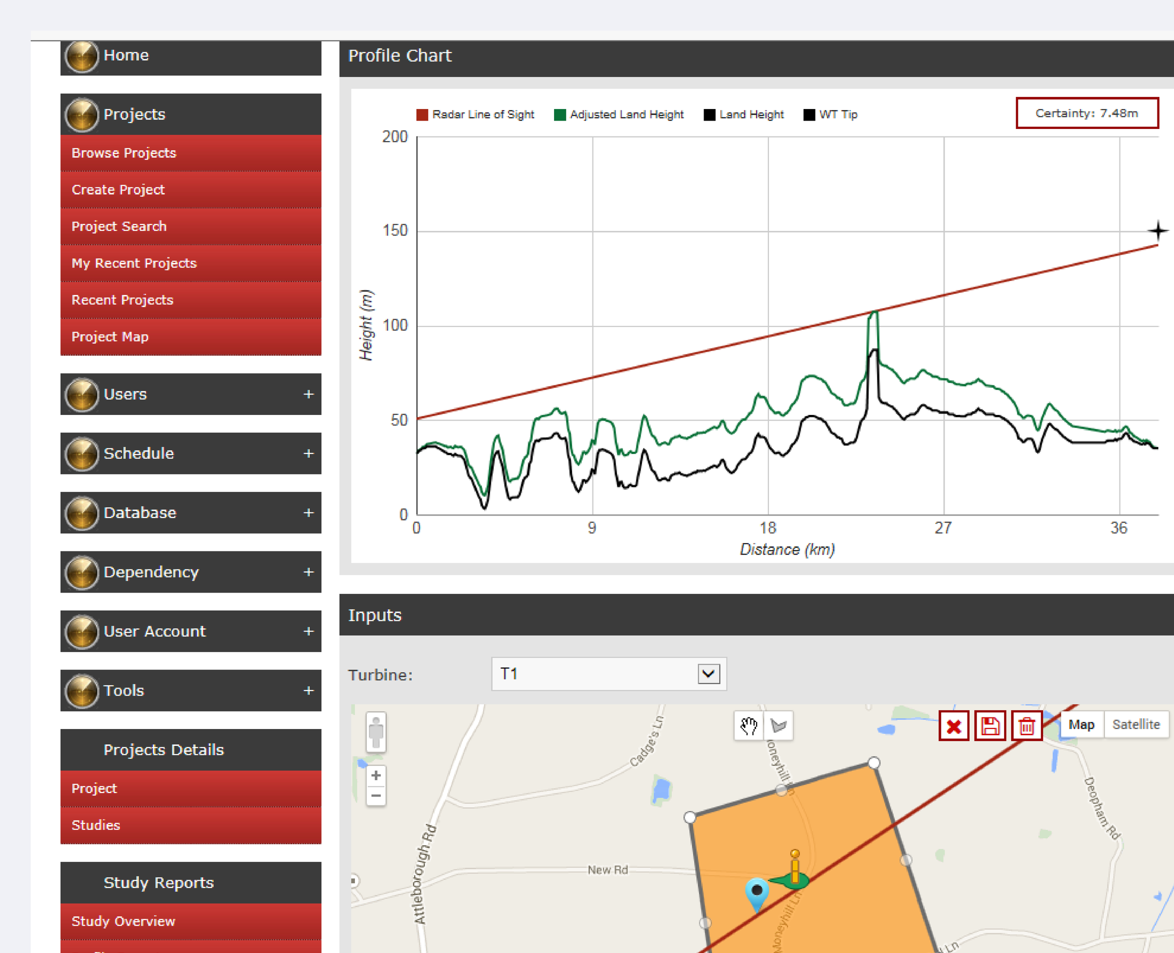
It is clear that failing to account for wave and tidal effects could lead to inaccurate results where the blocking point between radar and wind turbine occurs at sea.

## Software Development

The Pager Power online system has been developed further so that changes to the land or sea profile between radar and wind turbine can easily be made. The system has been developed so that changes can be made easily and the change data is stored to enable easy verification and auditing. On land it may be necessary to add additional height to account for the shielding effects of forestry or buildings.

Conversely on sea paths it will usually be necessary to remove height to account for low tides occurring at the blocking point between radar and wind turbine.

Additional research and development work has been undertaken specifically on accounting for atmospheric refraction and further enhancing the interpolation algorithms used for determining actual terrain height from digital terrain data.




## Conclusions

Failing to account for wave and tidal effects does lead to inaccurate predictions of wind turbine effects on radar.

The research and development undertaken mean that radar impact assessments for offshore wind developments can now be undertaken more accurately – particularly where there is a significant tidal range at the radar blocking point. There is ongoing research and development work which will further increase this accuracy.

Use of these increasingly accurate assessment will significantly reduce the three main areas of risk to wind developments. These are the risks of failing to generate completely, delays to commencement of operation and (often unexpected) radar mitigation costs.

## References

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