ENERGY

Use of Manufactures Specific Inputs to Refine Energy Yield Predictions

PCWG mtg 7, RES Kings Langley

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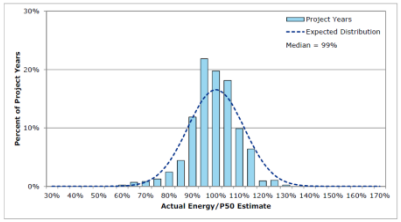
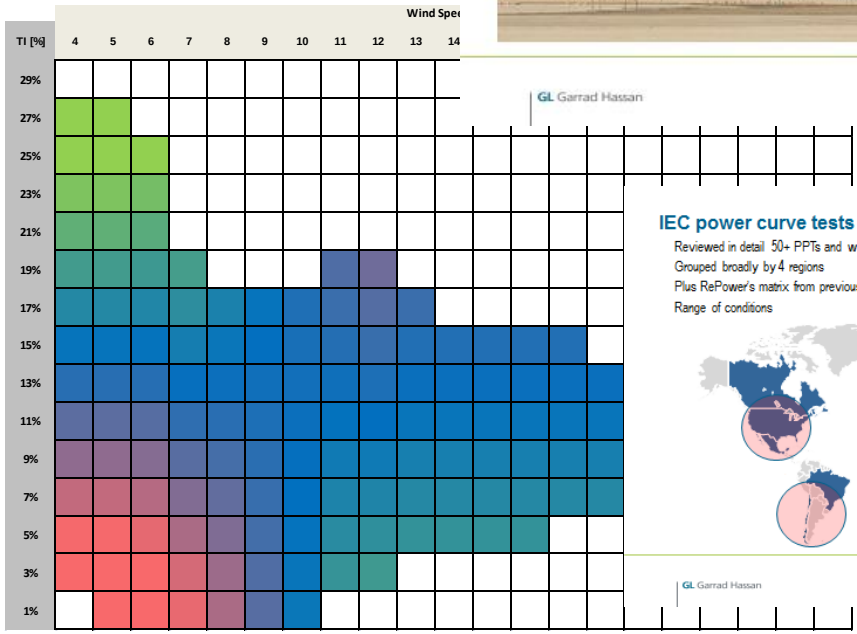
Outline

- DNV GL standard proxy matrix approach
- What information is often available?
- What do we need to improve on our standard approach?
  - Low, Medium and High resolution categories of data and information
- What can be done to make this data and information easier for manufactures to provide this? Would alternative data be more useful? (Discuss……)

DNV GL standard proxy matrix approach

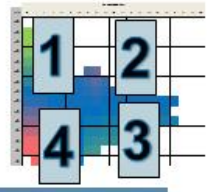
- WS-TI matrix, global with regional variations – as presented in Glasgow PCWG mtg
- Validated as part of DNV GL energy validations





Conclusions

- Similar trends globally – but magnitude and detail of trend varies
  - Need to understand nature of data making up the matrix and adapt
- Potential in TI models to model trends quadrant 1,2,3
- Quadrant 4, low TI, low-mid ws poorly modeled
- Requires empirical approach –
  - TI most dominant metric for simple model
- Manufactures can give more insight here



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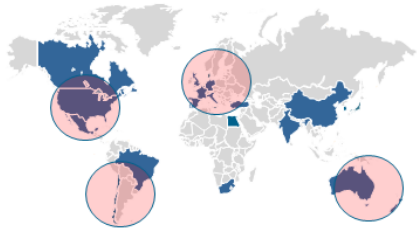
IEC power curve tests

Reviewed in detail 50+ PPTs and ws-TI matrices generated
Grouped broadly by 4 regions
Plus RePower's matrix from previous meetings – location unspecified
Range of conditions



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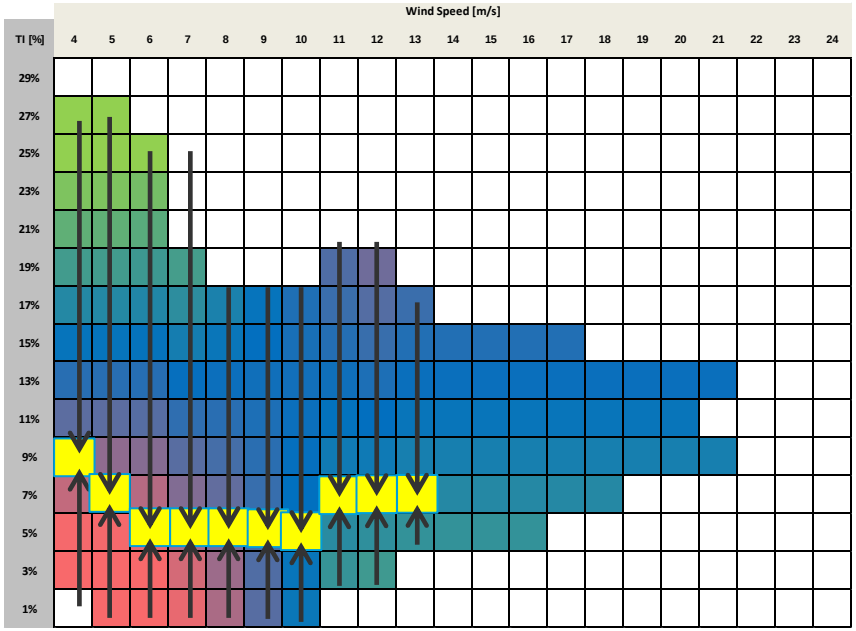
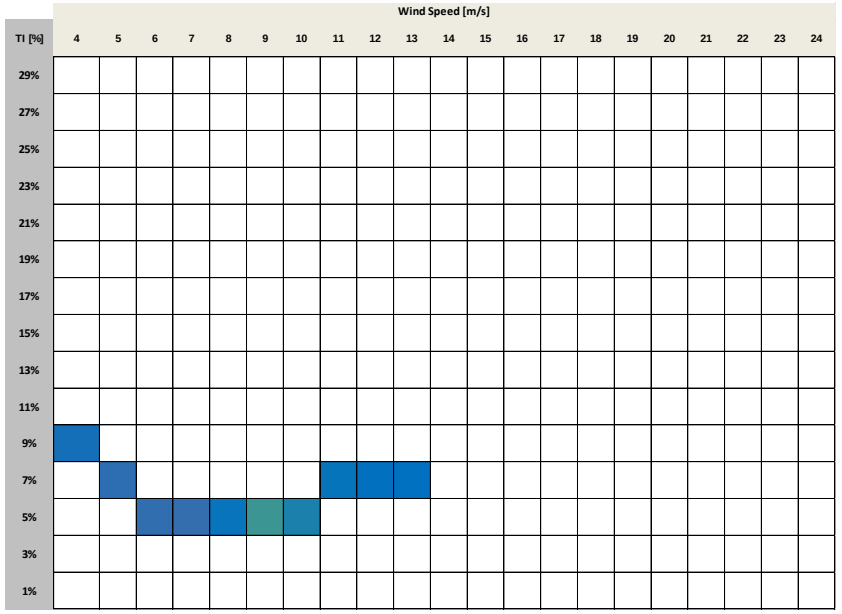
What information is often available?

- Site Specific Power Curves
- High / Med / Low TI Sales Power Curves
- High / Low TI Power curves based on single Power Performance Test

Site Specific Power Curve

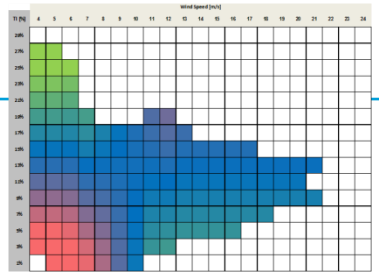
- When presented as power curve valid for a specific ws-ti profile on site, becomes equivalent to a single “thread” through the matrix, representing the TI distribution in each ws bin





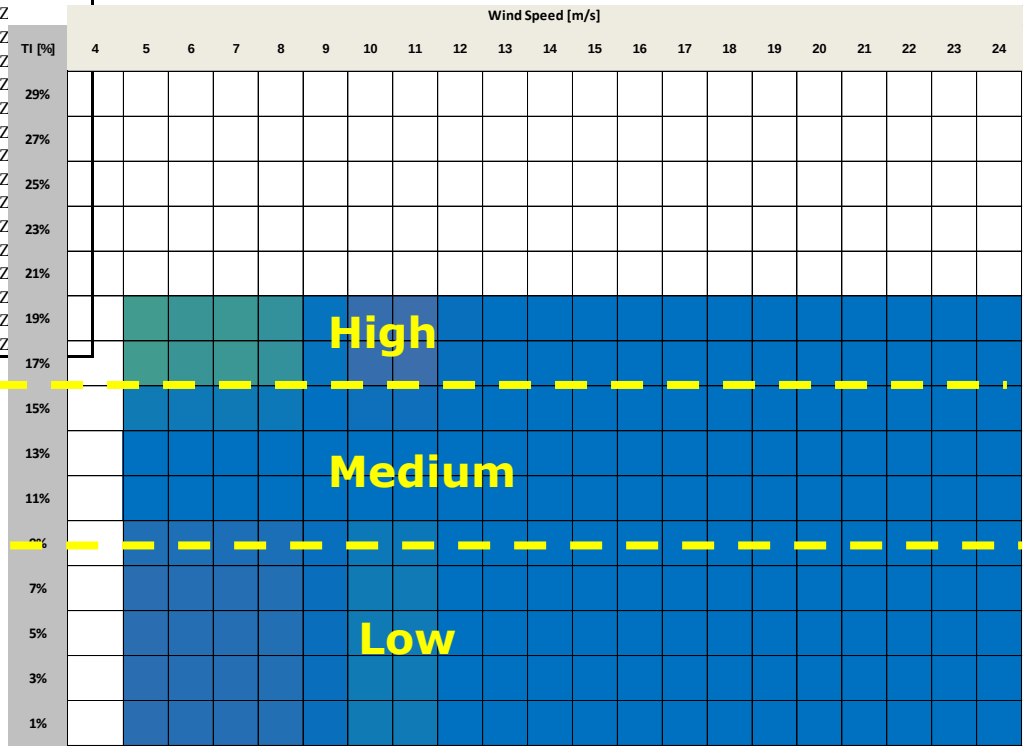
- Hard to verify or validate, but can be compared to matrix estimate by integrating across all TI within each ws bin

Low-Med-High TI Sales Power Curve

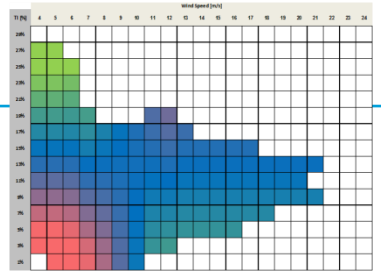


Hub height wind speed [m/s]	Low TI < 9%	10 % <= Med TI < 16 %	17 % <= Med TI < 20 %
3	0.0	0.0	0.0
4	XX.X	YY.Y	ZZ.Z
5	XXX.X	YYY.Y	ZZZ.Z
6	XXX.X	YYY.Y	ZZZ.Z
7	XXX.X	YYY.Y	ZZZ.Z
8	XXX.X	YYY.Y	ZZZ.Z
9	XXXX.X	YYYY.Y	ZZZZ.Z
10	XXXX.X	YYYY.Y	ZZZZ.Z
11	XXXX.X	YYYY.Y	ZZZZ
12	XXXX.X	YYYY.Y	ZZZZ
13	XXXX.X	YYYY.Y	ZZZZ
14	XXXX.X	YYYY.Y	ZZZZ
15	XXXX.X	YYYY.Y	ZZZZ
16	XXXX.X	YYYY.Y	ZZZZ
17	XXXX.X	YYYY.Y	ZZZZ
18	XXXX.X	YYYY.Y	ZZZZ
19	XXXX.X	YYYY.Y	ZZZZ
20	XXXX.X	YYYY.Y	ZZZZ
21	XXXX.X	YYYY.Y	ZZZZ
22	XXXX.X	YYYY.Y	ZZZZ
23	XXXX.X	YYYY.Y	ZZZZ
24	XXXX.X	YYYY.Y	ZZZZ
25	XXXX.X	YYYY.Y	ZZZZ

- Assumed distribution of TI within each ws bin for each low/med/high category
- Insensitive to site specific TI distribution

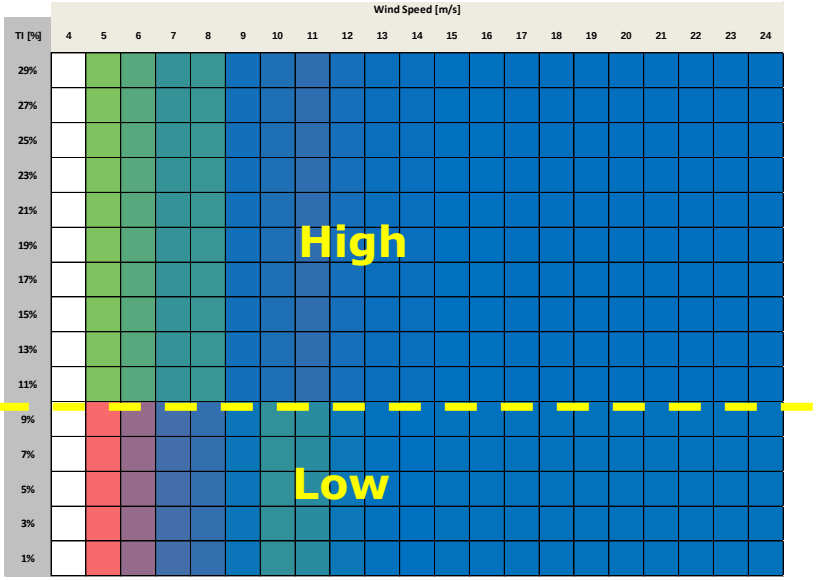


High-Low TI Power Curve from Measurements

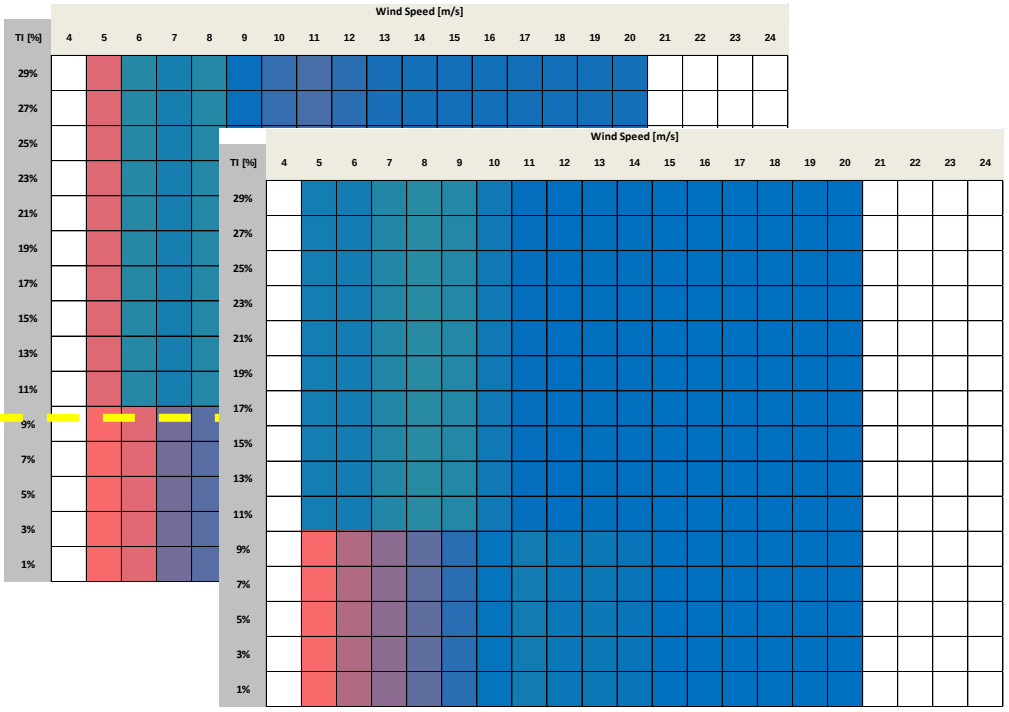


- Measurement based data shows basic broad trend

Derived from manufacture's high/low PC



Derived from DNV GL proxy matrix, using example site TI distribution measured from each ws bin

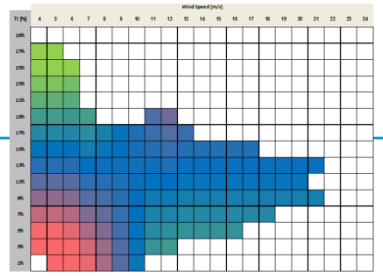


- Different site TI distribution,

  --> different high-low matrix

- Often based on a single test – very volatile results

DNV GL Proposed Data Requirements – High Res



- High Resolution:
- Individual Turbine Performance Matrixes, (similar to above), based on the raw data collected during multiple power performance tests.
  - Include standard deviation of production from warranted power curve in each WS-TI bin
  - No. points in each bin
  - Start & end date of tests, detail of measurement setup, filtering etc
  - Site location (could be approximate to maintain conf)
  - Minimum of 5 tests provided ; individual matrix for each test, and a combined matrix
  - Geographically diverse and seasonally representative spread of tests
  - Higher confidence if all individual matrices are similar ; substantial deviations will need explanation
- Aim to be used to replace consultant's own standard method, as lowest uncertainty option, with wide geographic applicability

DNV GL Proposed Data Requirements – Medium Res

- Medium Resolution:
  - Manufacturers to produce their own method for predicting the performance of turbines in specific wind conditions. The method should have the following attributes:
  - Be based on measured power performance test data with documented validation of the approach for a range of conditions
  - Be able to predict the variation in performance observed in consultants own internal database of power curve tests and analysis of operating wind farms in a range of conditions
  - Be warranted by the manufacture
- Expected use would be used in conjunction with consultant's own methodology, with some uncertainty benefit
- Inner-outer range based on measurements could fall into this category

DNV GL Proposed Data Requirements – Low Res

- Low Resolution:
  - Manufacturers to provide a set of power performance test results and background information to help inform and validate a turbine's performance. Information that would be required:
    - Results of at least 5 power performance tests from a minimum of 3 sites
    - Detailed description of any data filtering applied to the tests
    - Geographic description of the test locations
    - Additional metadata that will increase the usefulness of the tests include:
      - Start and end data of tests
      - Details of measurement set-up
    - Use of a "Low Resolution" information pack will be dependent how well the information aligns with consultant's own internal database of power performance tests for the region(s).
    - Less applicability "out-of-region"

Applicability across turbine models

- Once a data pack for given resolution has been established and accepted for one turbine model, additional effort required to extend applicability of findings to newer turbine models.
- Additional information would include comparison of smaller number of power curve tests showing similar response to environmental conditions
- Consideration of technical differences between turbine models in same family
- …….discuss!

Discussion
– How to make this data easy to be shared?
- Would alternative data be more useful?
- What do Manufactures want to see from us (the consultants)? How can we help!?

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