DNV GL – Turbine Power Performance in different regimes
PCWG at SSE, Glasgow, December 4th 2013

Richard Whiting, Global Head of Practice, Energy

Overview

- Data available
- Measured ws-ti matrices
- Observations from Round Robin dataset
- Conclusion

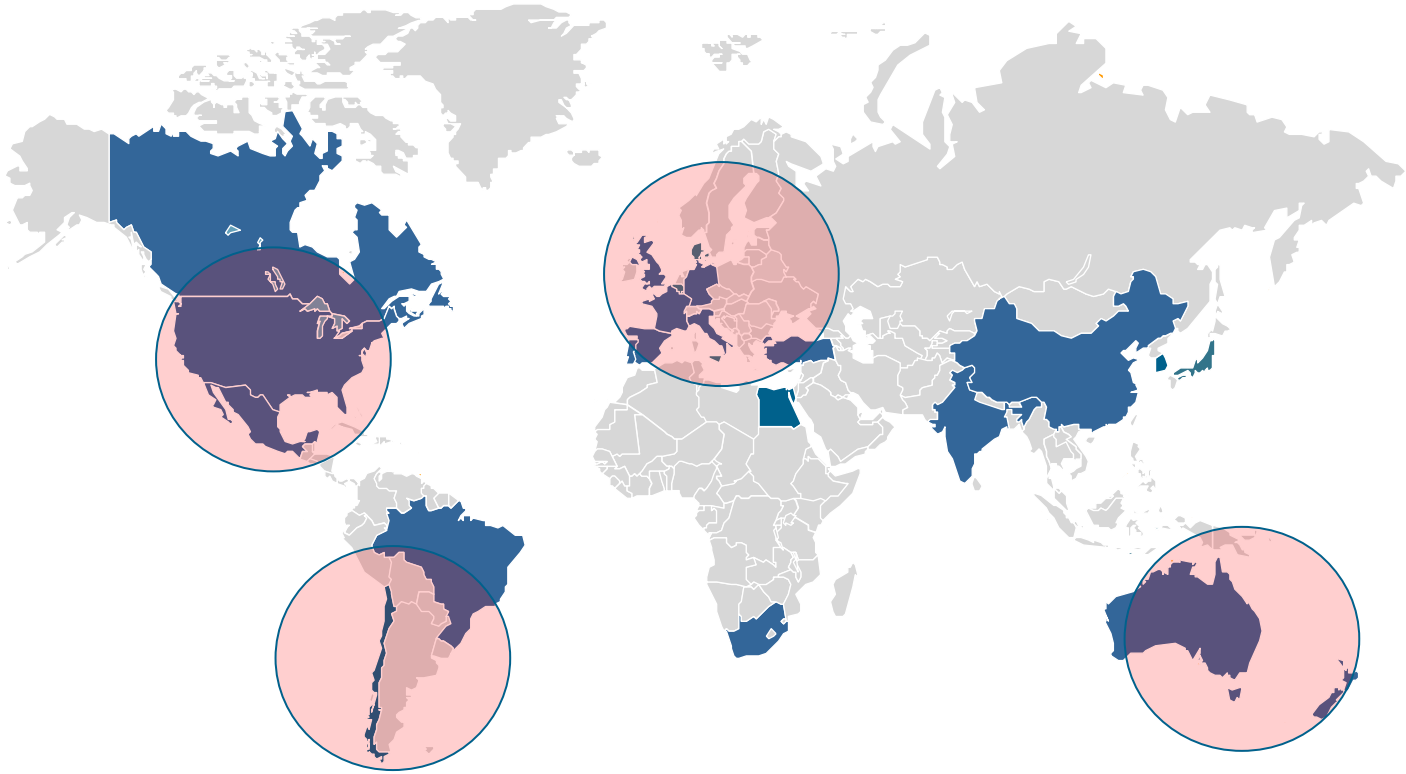
IEC power curve tests

Reviewed in detail 50+ PPTs and ws-TI matrices generated

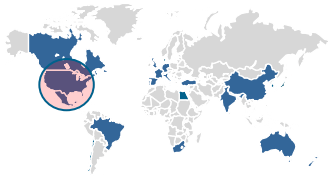
Grouped broadly by 4 regions

Plus RePower's matrix from previous meetings – location unspecified

Range of conditions

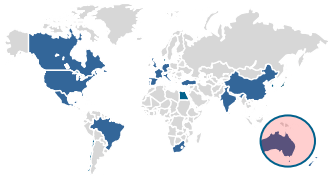


Region 1 - North America



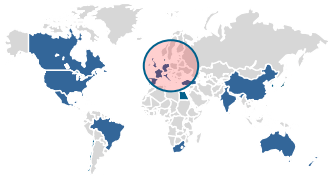
TI [%]	Wind Speed [m/s]																			
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
29%																					
27%																					
25%																					
23%																					
21%																					
19%																					
17%																					
15%																					
13%																					
11%																					
9%																					
7%																					
5%																					
3%																					
1%																					

Region 2 - Asia Pacific



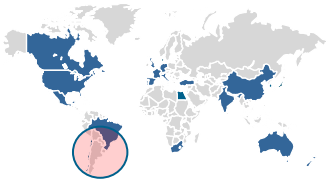
TI [%]	Wind Speed [m/s]																			
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
29%																					
27%																					
25%																					
23%																					
21%																					
19%																					
17%																					
15%																					
13%																					
11%																					
9%																					
7%																					
5%																					
3%																					
1%																					

Region 3 - Europe



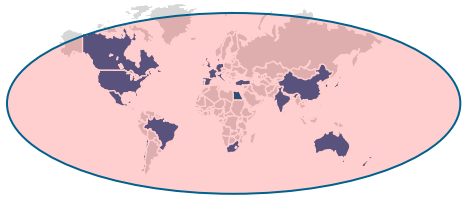
TI [%]	Wind Speed [m/s]																				
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
29%																					
27%																					
25%																					
23%																					
21%																					
19%																					
17%																					
15%																					
13%																					
11%																					
9%																					
7%																					
5%																					
3%																					
1%																					

Region 4 - S America

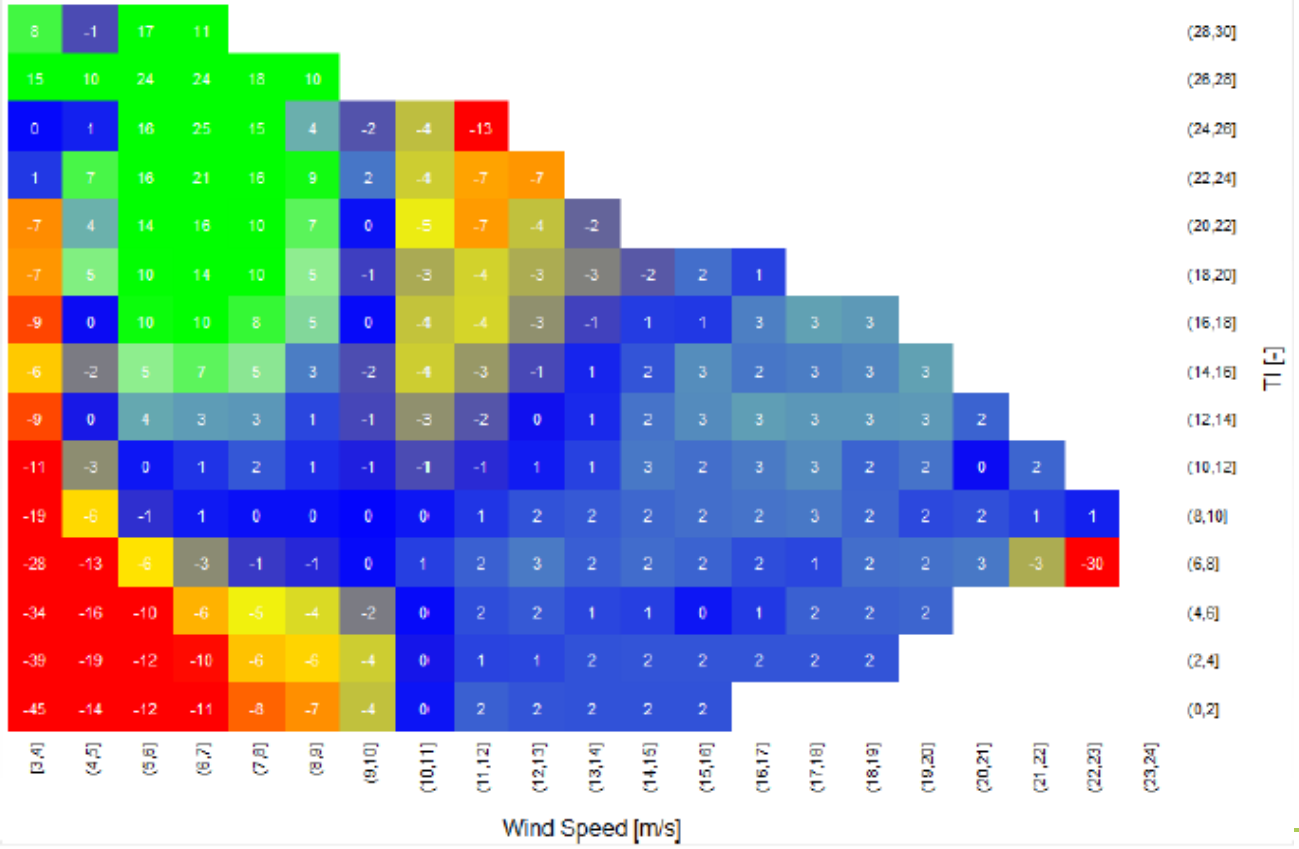


TI [%]	Wind Speed [m/s]																			
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
29%																					
27%																					
25%																					
23%																					
21%																					
19%																					
17%																					
15%																					
13%																					
11%																					
9%																					
7%																					
5%																					
3%																					
1%																					

Region X - RePower

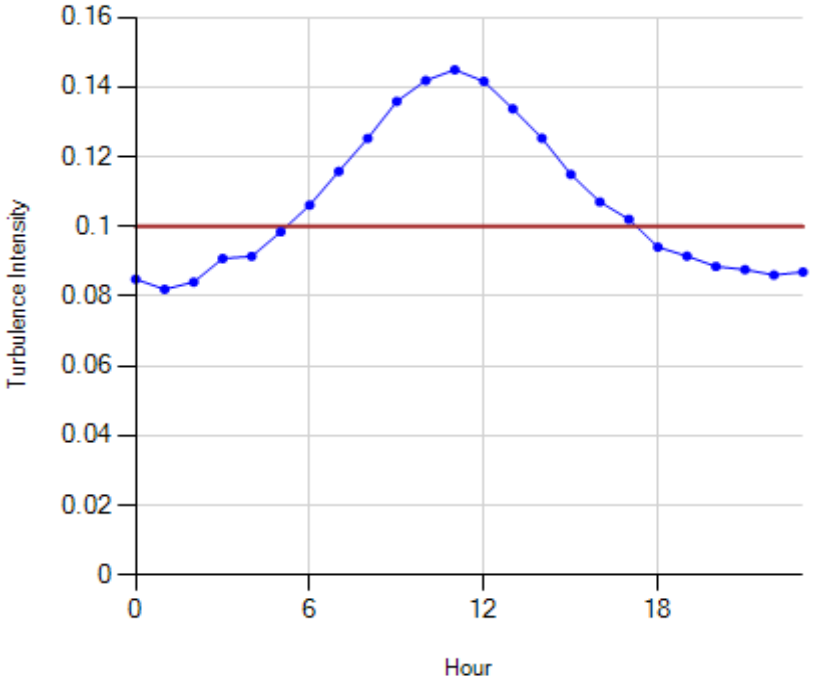


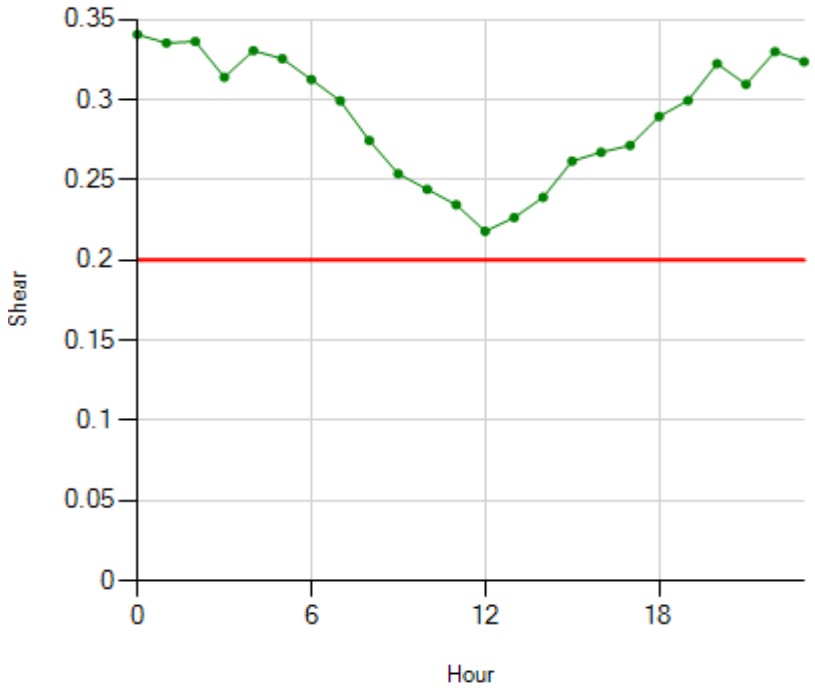
Yield Deviation – MM82 & MM92



Round Robin dataset 1 – Observations
Site Conditions

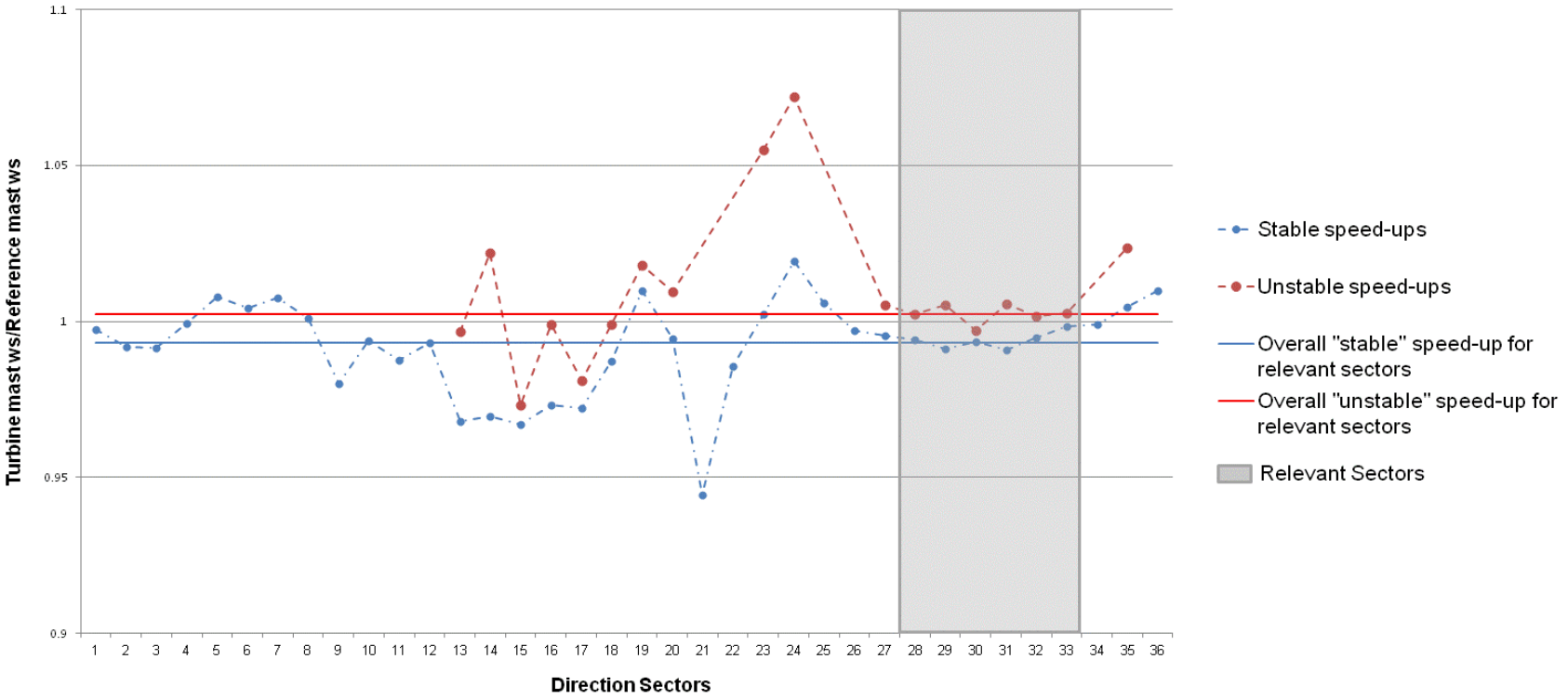
- We already know that data-set 1 site has high frequency of stable conditions characterised by low TI and high shear particularly during the night
- The frequency of these conditions also vary with seasons
- This will affect the **site calibration speed-ups**





Round Robin dataset 1 – Observations
Impact on site calibration

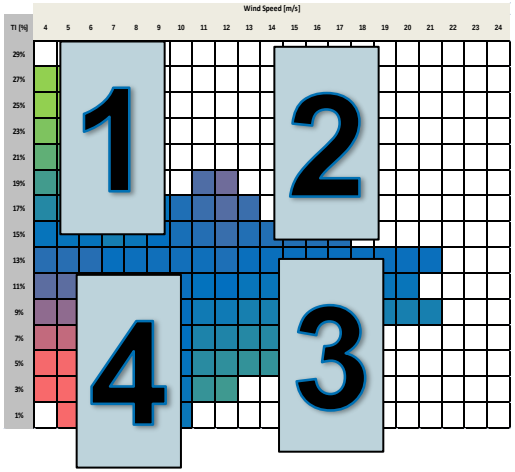
- Different atmospheric conditions will have different speed-ups
- Ratio of unstable conditions : stable conditions during site calibration – is this the same split as during measurements?
- Impact of differential stable/unstable speed ups could result in differences of order of **1% of wind speed => 2% in energy**



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

Thank you

Richard Whiting – Richard Whiting@gl-garradhassan.com

With Thanks to:
Ben Buxton
Simon Cox
Carla Ribeiro

TI adjusted Power Curve

- Shape is closer to measured PC