29.05.2018

CFARS

Science Working Group –Site Suitability

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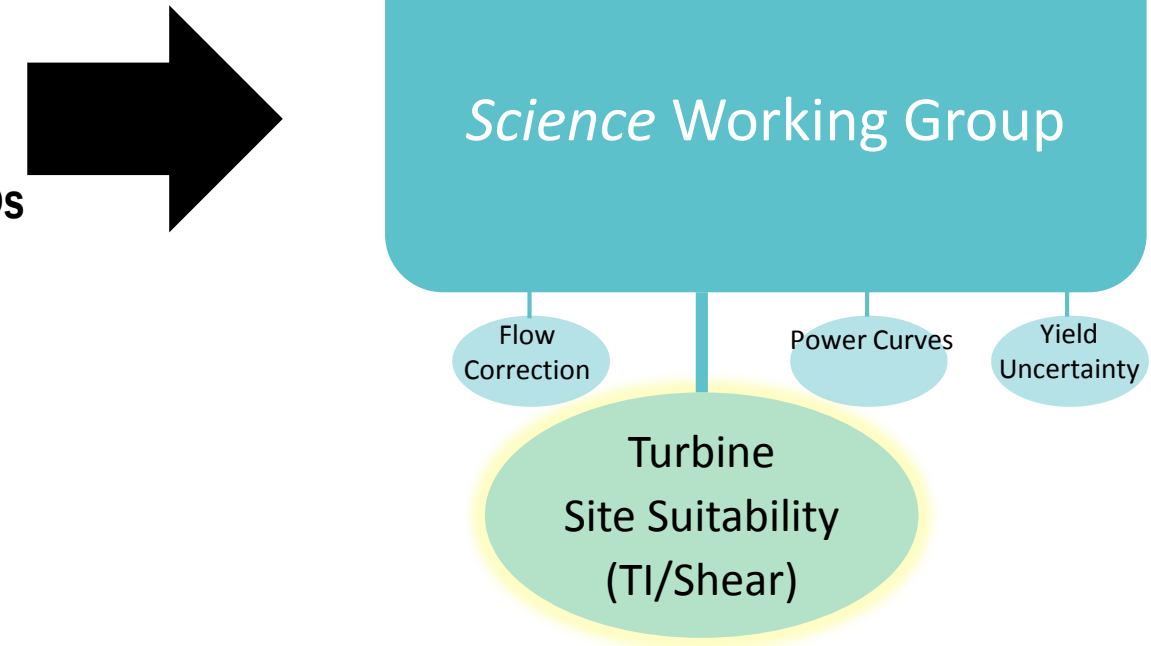
Motivation

CFARS

Increase Acceptance of RSDs



Mission: Increase RSD Acceptance for Site Suitability

Background - TI

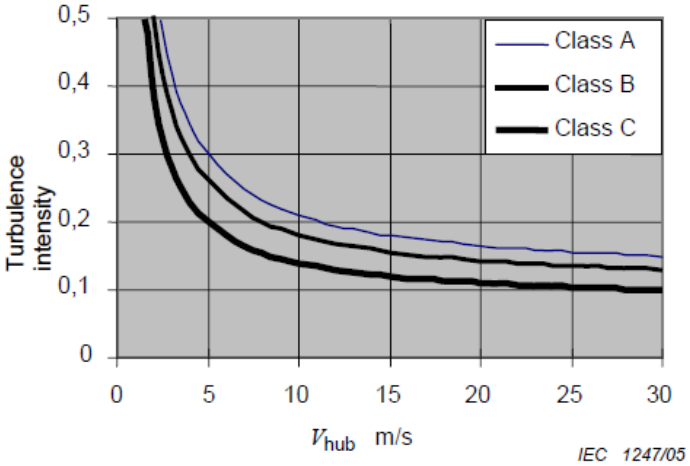
Turbulent wind → produce excessive turbine loads and fatigue

- Reduction in turbine performance and yield
- Increase O&M costs
- Decrease turbine lifespan

▲ Photograph: Raoul Dixon/North News & Pictures

IEC 61400-1 → standard wind turbine classification defined by wind speed & TI

- Accurate measurement of TI is mandatory as variation between turbine wind classes are small



Background - TI

Challenge:

- The industry is most familiar with cup or sonic anemometer TI measurements for turbine site suitability assessment – which are costly, fixed location, limited measurements by height

Solution:

- RSD provides viable option, however measures TI different than cup or sonic anemometers (volumetric vs. point)

Photo from Don Buchanan, NREL 19340

Photo by Jennifer Newman, NREL

Approach

RSD Corrected TI

RSD Raw TI

Research Question

What are the best RSD TI correction methods?

What is the relationship between RSD volumetric TI and turbine design parameters/ suitability?

Research Question

Convert RSD into cup measurement for use in current OEM fatigue models

Refine current OEM fatigue models to receive RSD directly

E.ON Preliminary Results

Average TI Comparisons

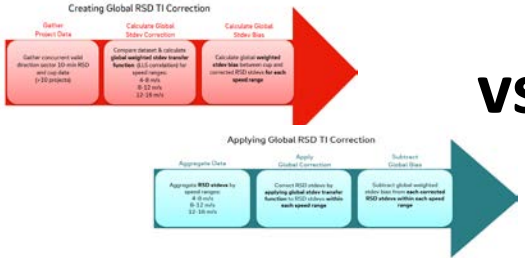
Lidar Raw vs. Thies Cup	13%
**Other Cup vs. Thies Cup	7%
Lidar Corrected vs. Thies Cup	2%
Thies Cup vs. Thies Cup	0%

*Thies Cup = Reference
**Wind Sensor & Vector
***7 Projects

The “Pitch” – Scoping CFARS RSD TI Project

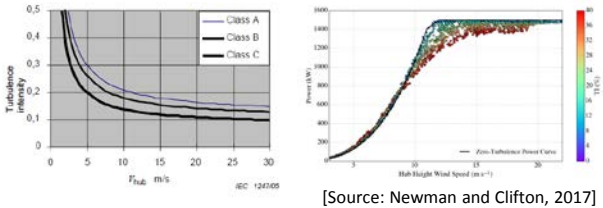
- **Define** the most appropriate **approach and methods**
- **Test** selected methods on numerous project datasets to **strengthen understanding** of best approach & methods
- **Align & Advocate** **data-driven recommendations** on acceptable RSD TI measurements & methods for site suitability assessment

RSD TI Correction



vs.

Impact of RSD on TI Curves & PCs



[Source: Newman and Clifton, 2017]

vs.

Other Ideas

Thank you!

Comments & Questions?

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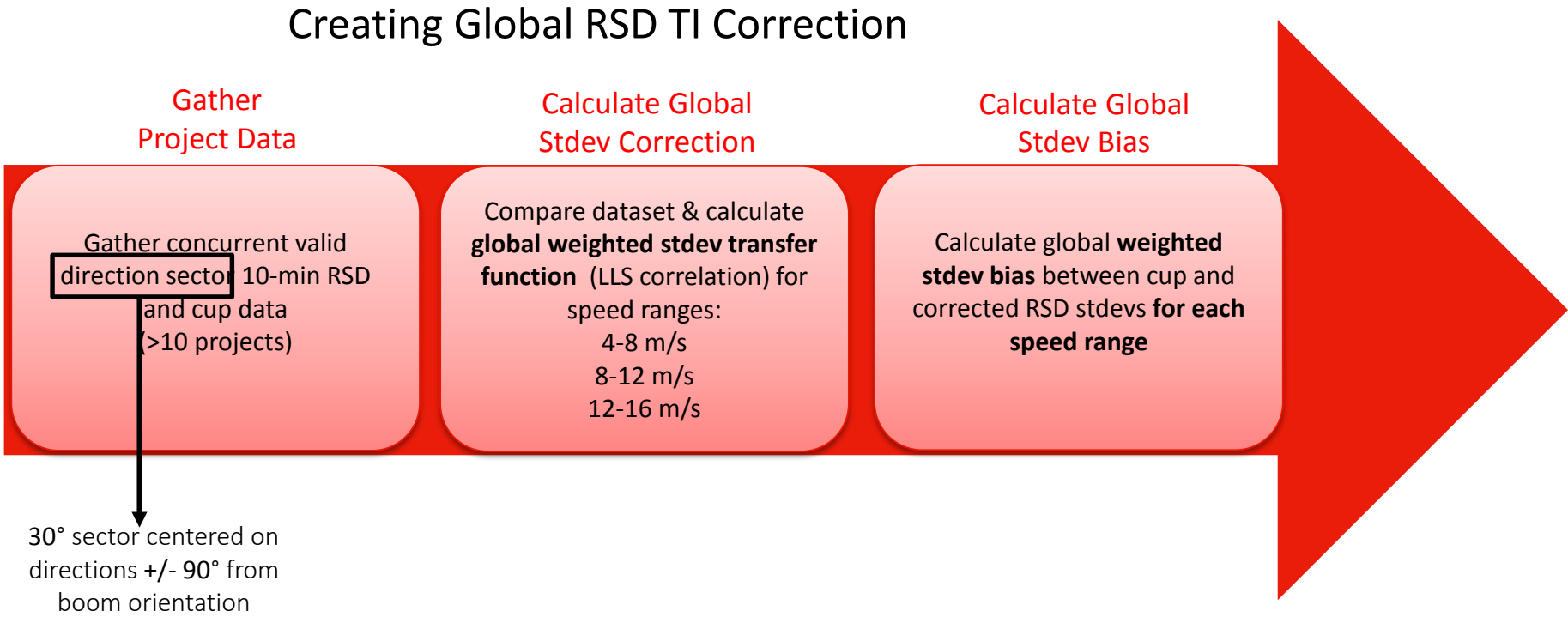
Extra Slides

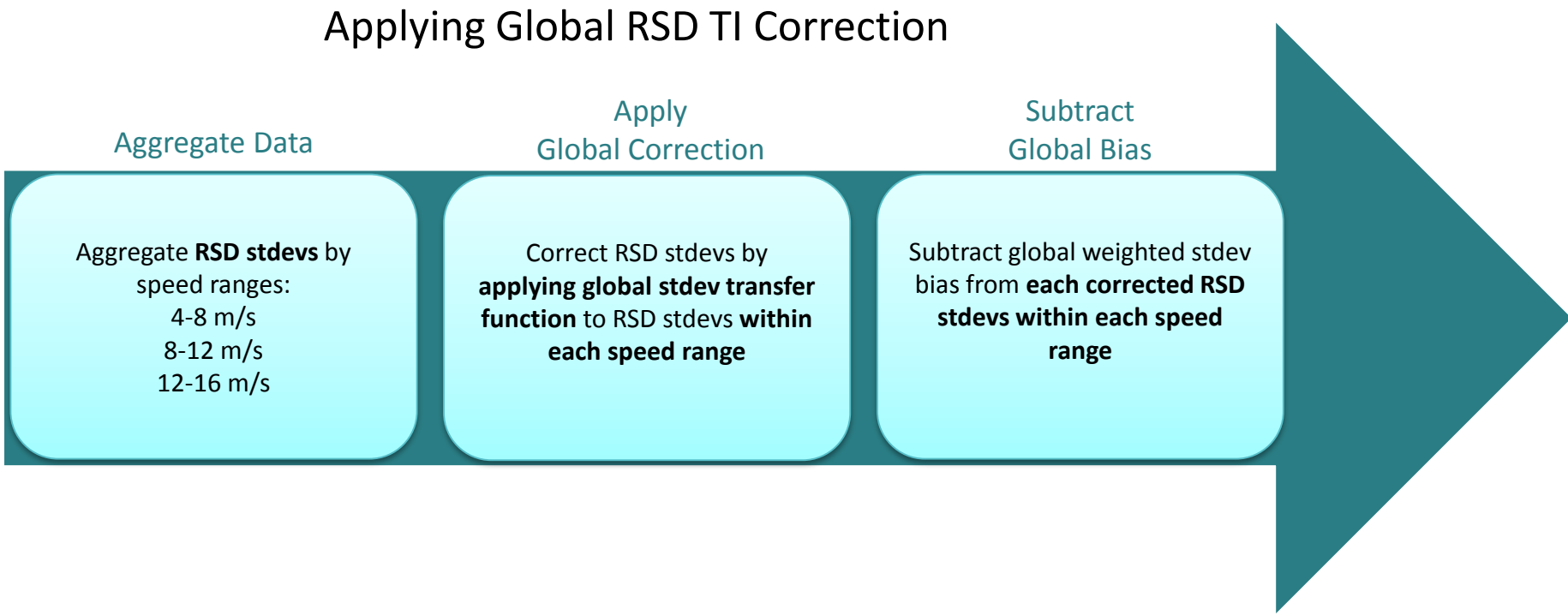
References

Newman, Jennifer F., and Andrew Clifton. "An error reduction algorithm to improve lidar turbulence estimates for wind energy." *Wind Energy Science* 2.1 (2017): 77.

E.ON Methods


Creating Global RSD TI Correction
Gather Project Data
Calculate Global Stdev Correction
Calculate Global Stdev Bias
Gather concurrent valid direction sector 10-min RSD and cup data (>10 projects)
Compare dataset & calculate **global weighted stdev transfer function** (LLS correlation) for speed ranges:
4-8 m/s
8-12 m/s
12-16 m/s
Calculate global **weighted stdev bias** between cup and corrected RSD stdevs **for each speed range**
30° sector centered on directions +/- 90° from boom orientation

E.ON Methods


Applying Global RSD TI Correction
Aggregate Data
Aggregate RSD stdevs by speed ranges:
4-8 m/s
8-12 m/s
12-16 m/s
Apply Global Correction
Correct RSD stdevs by applying global stdev transfer function to RSD stdevs within each speed range
Subtract Global Bias
Subtract global weighted stdev bias from each corrected RSD stdevs within each speed range

Preliminary Results

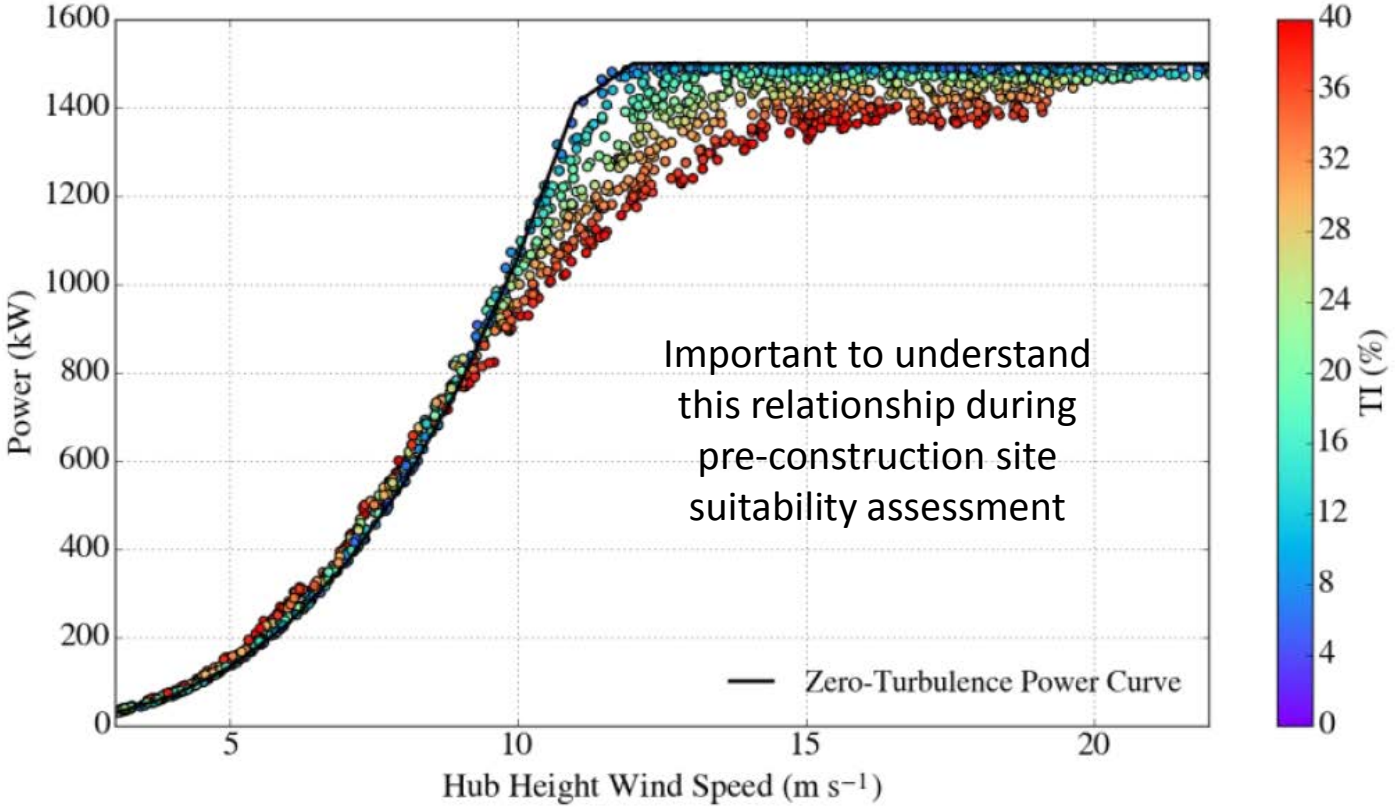
Turbulence Intensity Comparisons

Lidar Raw vs. Thies Cup	14%
Wind Sensor Cup vs. Thies Cup	13%
Lidar Corrected vs. Thies Cup	3%
Thies Cup vs. Thies Cup	0%

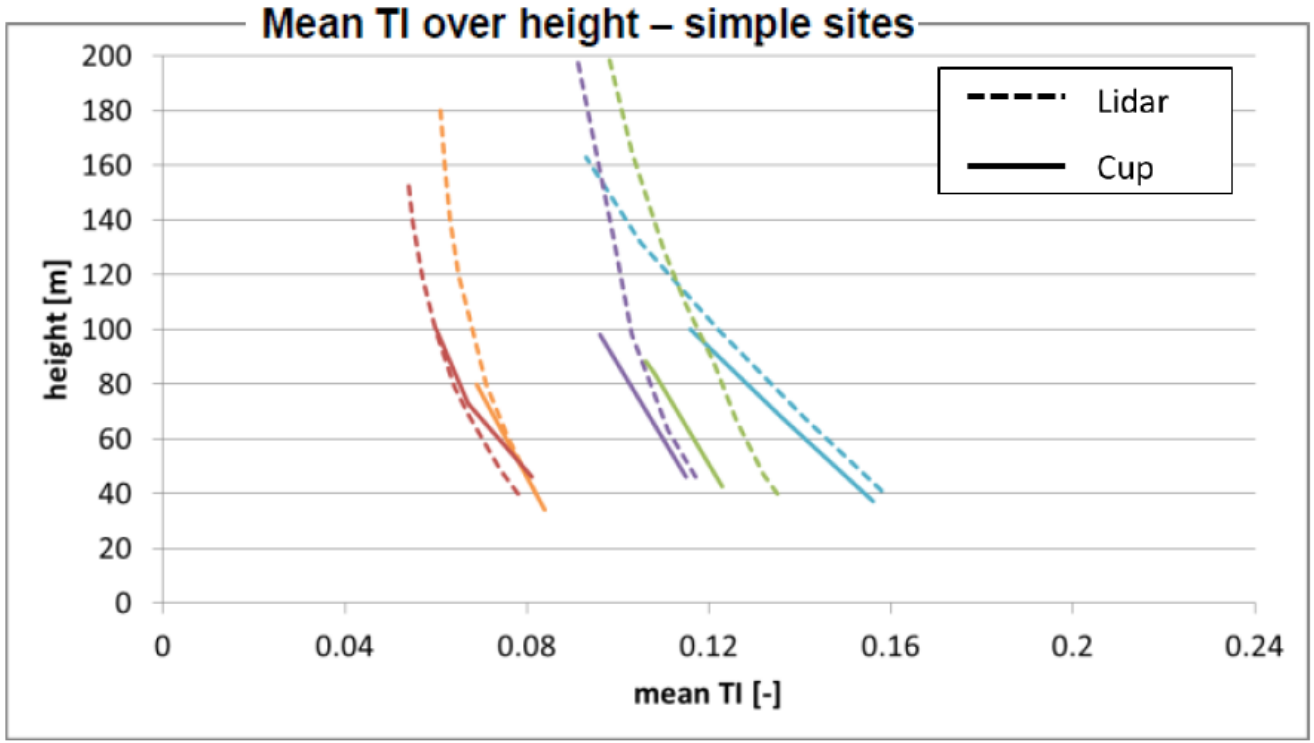
Lidar Raw vs. Thies Cup	11%
Lidar Corrected vs. Thies Cup	2%
Vector Cup vs. Thies Cup	0.30%
Thies Cup vs. Thies Cup	0%

* Thies Cup = Reference
** 7 Projects Total

Impact of TI on Turbine Power Curve



[Source: Newman and Clifton, 2017]



[Source: IFPEN EWEA, 2015]