Introduction

PCWG
20 March 2015

10th Meeting Agenda

09.40 – 10.00 “Introduction” (Peter Stuart) – (RES)

- Review of PCWG 2015 Road Map
- Overview of Analysis Tool

10.00 – 11.00 PCWG Analysis Tool Introduction/Training - Alex Clerc (RES)

11.15 – 13.00 Data Sharing Initiative Dry Run (Dress Rehearsal) – Introduced by Joe Kane (RES)

13.45 – 15.15 Design of Data Sharing Initiative Discussion:

- Aggregated Data Sharing Initiative Dry Run Results Presentation
- What do we want to achieve?
- What information will be exchanged? What are the timelines?
- Feedback/thoughts from “Dry Run”

15.15 – 15.45 Nacelle Mounted Lidar in Complex Terrain (Paul Lawson DNV GL)

15.45 – 16.00 Wrap Up

PCWG 2015 Road Map Reminder

Power Curve Working Group 2015 Roadmap (Draft)

Background: Reasons For Action

- **Real world wind conditions** are composed of both inner range and outer range wind conditions:
  - **Inner range conditions** refers to moderate shear and moderate turbulence.
  - **Outer range conditions** refers to high turbulence, low turbulence, high shear, low shear etc.

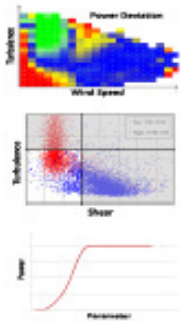
- **Outer range conditions are relatively frequent** and therefore the calculation of turbine power output in outer range conditions is an important consideration in wind energy resource assessment.
- There are **no industry consensus methods** for predicting wind turbine power output in outer range conditions for the purposes of resource assessment.
- **Power performance tests and associated warranties** are **normally limited to** a relatively narrow range of idealised conditions i.e. **inner range conditions.**

Current Wind Industry State

- There are no industry consensus methods for predicting wind turbine power output in outer range conditions for the purposes of resource assessment.
- Power performance tests and associated warranties are normally limited to a relatively narrow range of idealised conditions i.e. inner range conditions.
- The lack of a validated industry consensus methods for predicting power output in outer range conditions (for resource assessment applications) increases the risk perceived by wind energy investors.
- The failure to consider outer range conditions in power performance tests increases the risk perceived by wind energy investors.

Target Wind Industry State

- Well document and validated consensus methods for predicting wind turbine power output in outer range conditions for the purposes of resource assessment.
- Open source benchmarks (e.g. Excel examples) available for all validated consensus methods.
- Open source tools (which comply with benchmarks) available for all validated consensus methods.
- Power performance tests routinely make some consideration of outer range conditions.
- Harmonised communication of power curve information so that corrections for outer range conditions can be unambiguously applied.
- Consensus methods embedded in real world resource assessment industry practice. Reduced resource assessment risk perceived by wind energy investors.
- Reduced power performance risk perceived by wind energy investors.



Reasons for gap between current and target

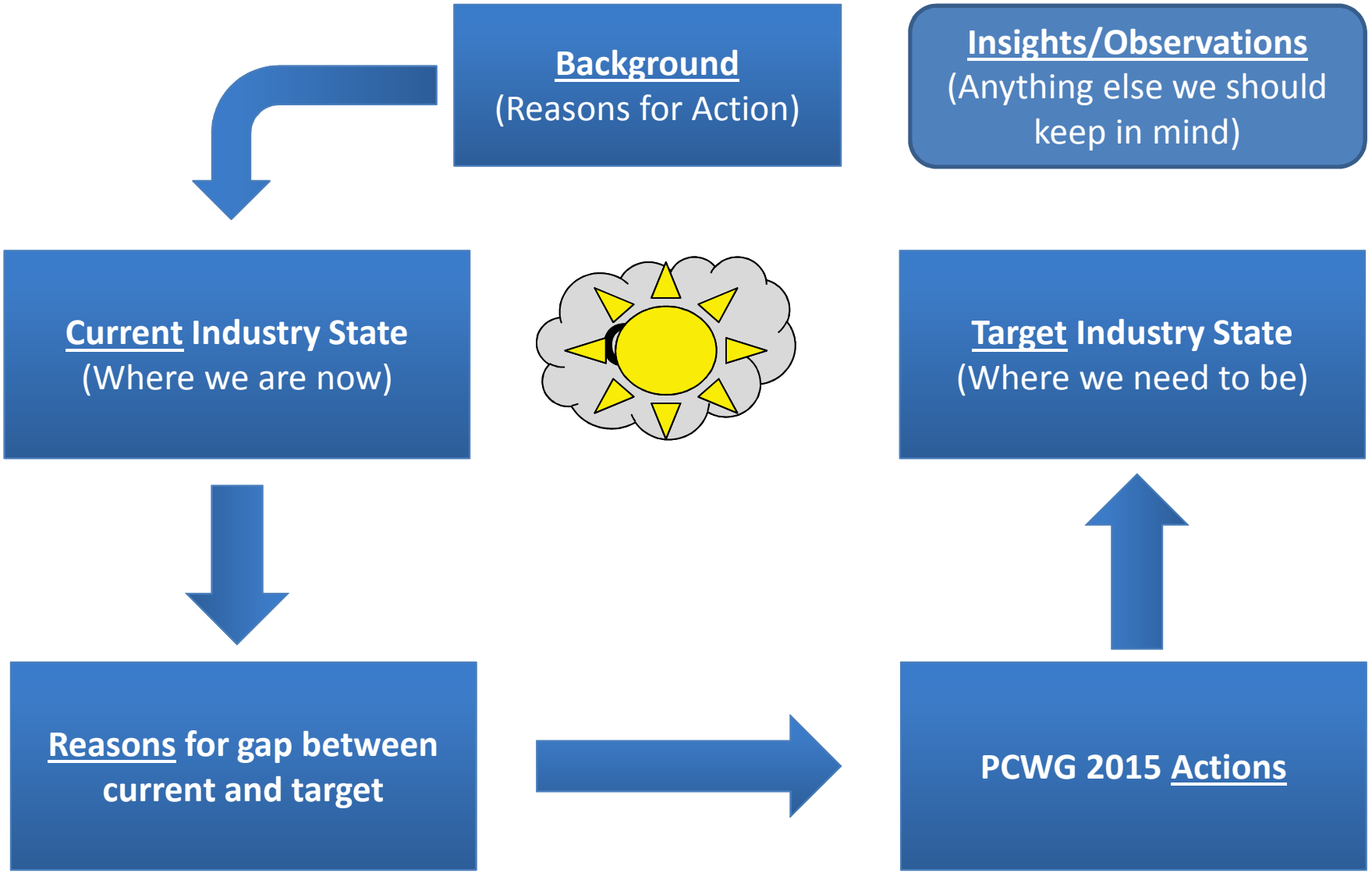
- REWS and turbulence renormalisation methods are helpful, but do not fully solve the problem.
- There are no industry standard tools for applying existing methods for modelling power output in outer range conditions.
- Several empirical (proxy) methods are available which tie observed turbine performance to key (frequently measured) parameters such as turbulence intensity and lower rotor shear exponent. However, there is a lack of industry consensus regarding which proxy methods are best.
- Minimal data sharing between key stakeholders.
- Current power curve documentation can make the application of corrections for outer range conditions difficult e.g. it can be hard to tell if a power curve is defined for hub wind speed, rotor equivalent wind speed or both.

PCWG 2015 Actions

- Define trial methods and validate them (including new and novel methods) e.g. REWS, RAWS, site/conditions specific power curves, turbulence renormalisation, power deviation matrix, production by height, modified turbulence renormalisation method.
- Implement PCWG data sharing initiate to provide a platform for developing and validating trial correction methods.
- Develop open source benchmarks (e.g. Excel examples) for applying trial methods so that methods are well understood. Where appropriate perform round robin exercises to develop consensus understanding:
  - Power Curve Deviation Matrix Round Robin
  - Rotor Equivalent Wind Speed Considering Inflow Round Robin
- Develop open source python tools so that trial methods can be applied to many datasets efficiently:
  - Power Curve Deviation Matrix Implemented
  - Rotor Equivalent Wind Speed Considering Inflow Implemented
- Promote application of Inner/Outer range concept for power performance tests by sharing experiences.
- Develop a document to harmonise the communication of power curve information
- Develop a requirements document for site specific power curves from a developer/consultant (required outputs) and manufacturer (required inputs) perspective.

Brief Introduction to A3 Report Format

- **The PCWG 2015 Road Map will use the A3 Report Format.**



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PCWG Data Sharing Initiative Concept

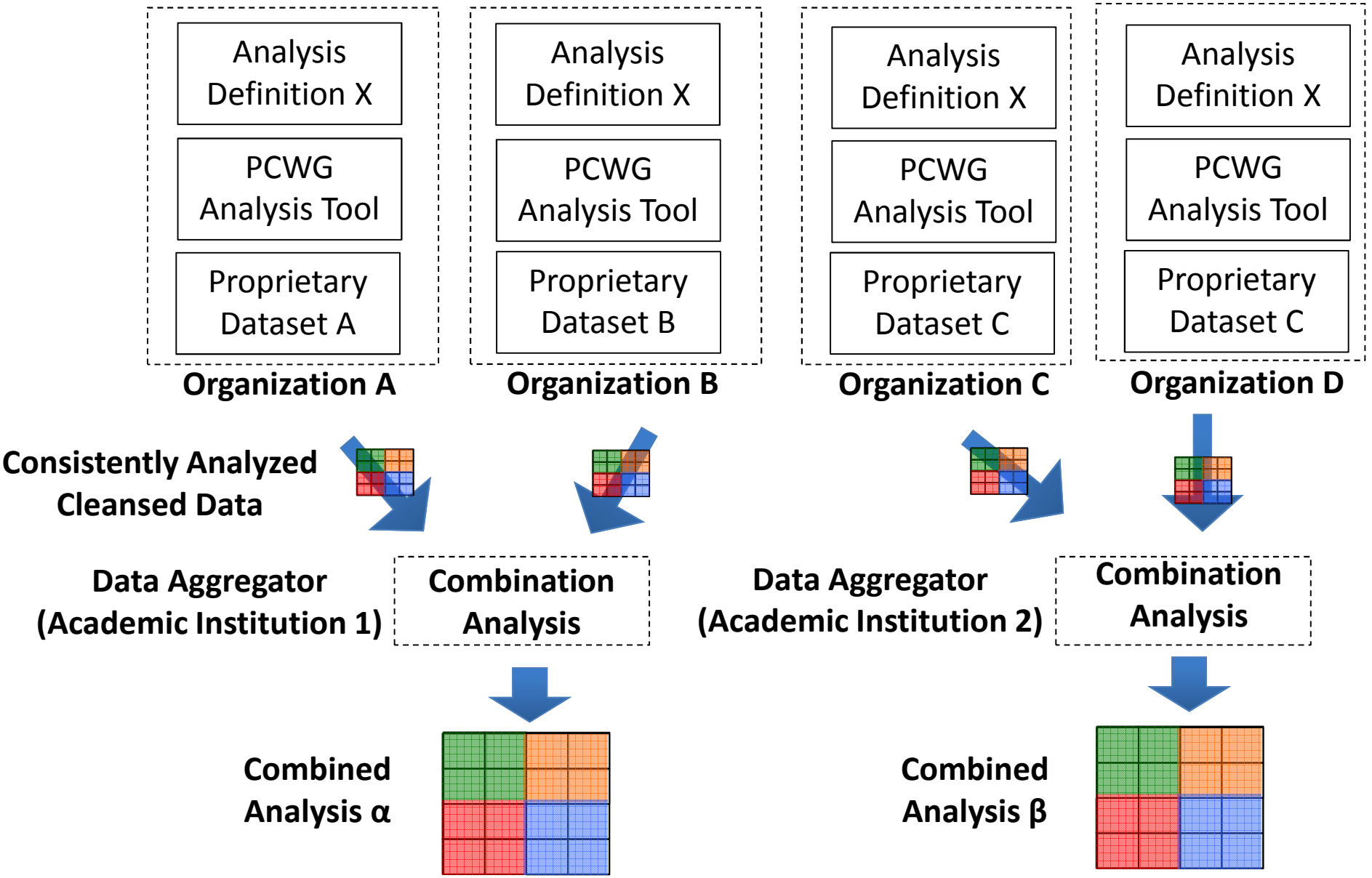
PCWG Data Combination Initiative: What?

- A new innovative industry collaborative exercise based on data aggregation across organizational boundaries.
- The exercise will seek to unlock the potential of data that already exists for the benefit of the whole industry,

Why?

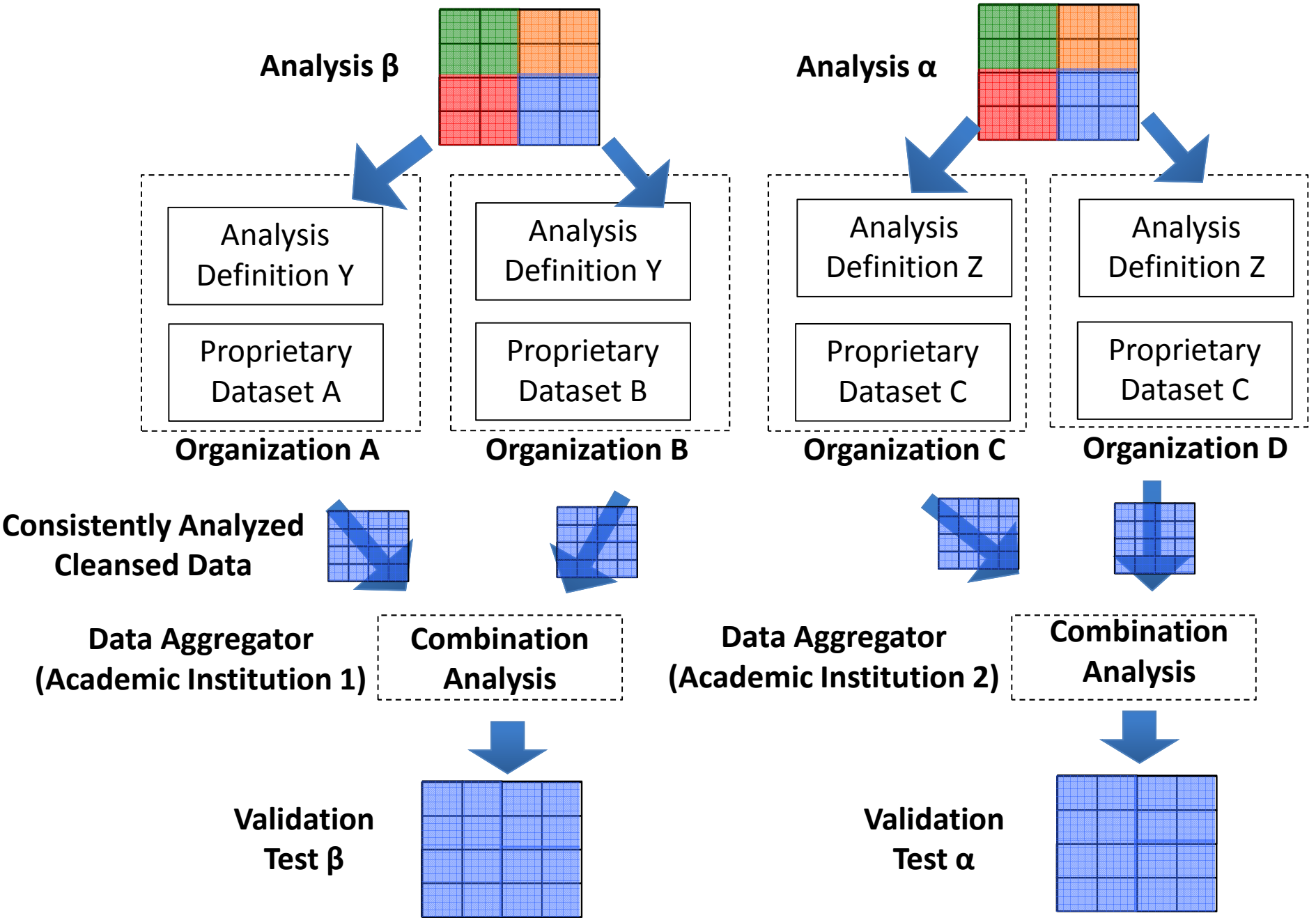
- Aggregation of information across organization boundaries offers the potential for a step change in industry understanding of turbine performance.
- The initiative aims to deliver an effective and practical parameterization of real world turbine performance to an entire industry.
- It will deliver a strong message to the investment community that wind energy is serious about improving its value proposition.

How? Part A Data Aggregation



* 'Cleansed Data' means that all commercially sensitive information is removed e.g. site, machine, site wind speed etc.

How? Part B Training Independent Test

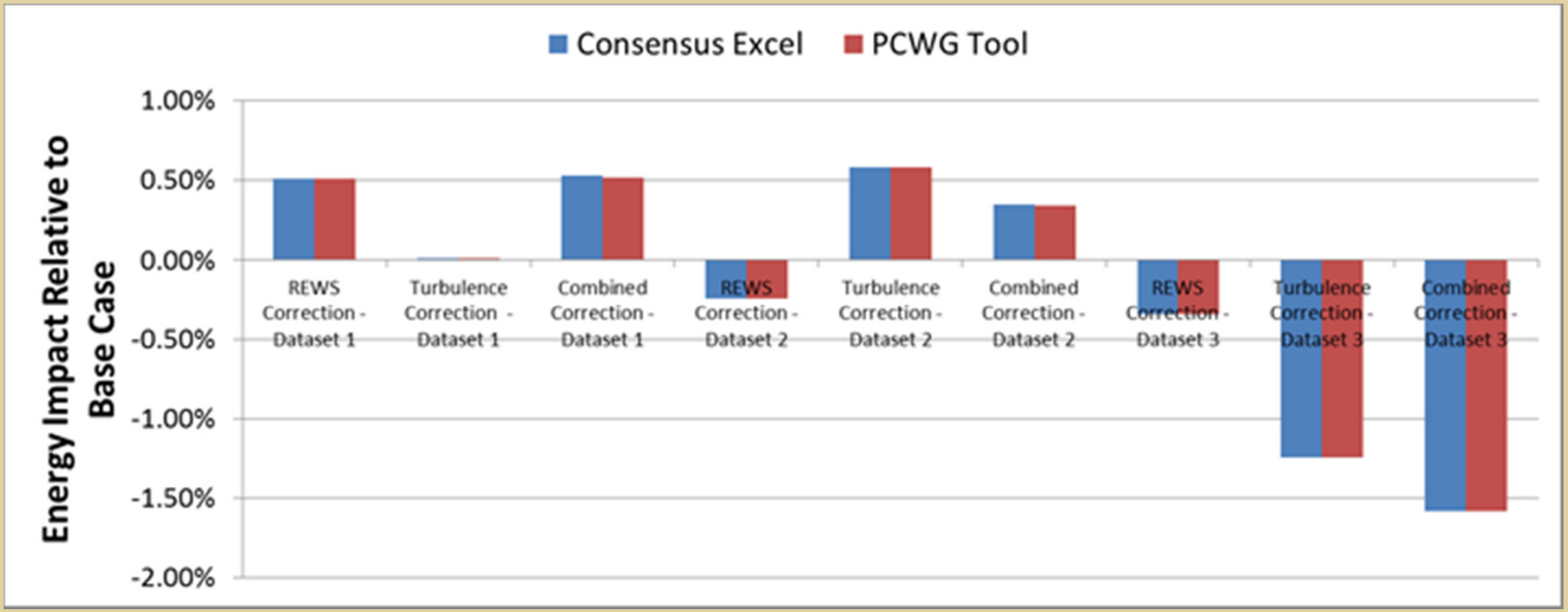


PCWG Open Source Tool

Purpose/Vision of PCWG Open Source Analysis Tool

- Provide an Open Source Tool to perform IEC Compliant Power Performance Analysis
- Facilitate the work of the PCWG e.g. the PCWG Data Sharing Initiative.
- Open Source: Demonstrate IEC (+other) methods implemented in open source code.
- PCWG is a work in progress, but already it can do a lot!

PCWG Analysis Tool Benchmark vs Round Robin Results



PCWG Open Source Analysis Tool

- The latest release of the (**Version 0.5.3**) of the PCWG Open Source Analysis tool is now available to download.

- The code is provided without warranty under the terms of the MIT software license (see attached for more details). The tool itself can be downloaded at: https://sourceforge.net/projects/pcwg/files

- The tool has been benchmarked against the Excel Consensus Analysis of the working group Round Robin Exercises.

- The tool is open source and working group members are encouraged to contribute. Those interested can access the project source code on GitHub: https://github.com/peterdougstuart/PCWG

- Detailed introduction to tool presented by Alex Clerc during March PCWG Meeting in Hamburg (see