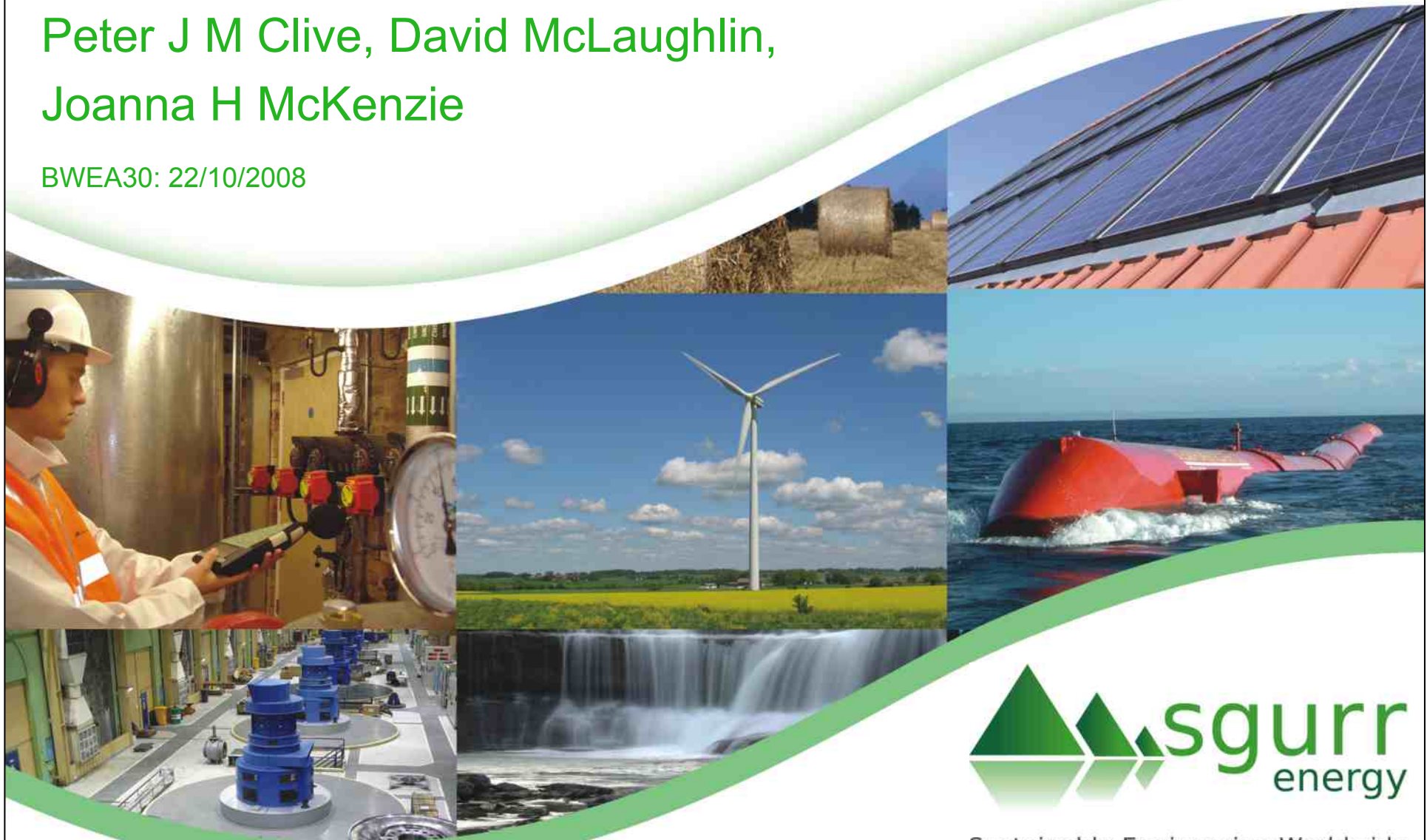




# Making the most of SCADA data: wind farm performance assessment

Peter J M Clive, David McLaughlin,  
Joanna H McKenzie

BWEA30: 22/10/2008



Sustainable Engineering Worldwide

# Introducing SgurrEnergy

- Leading independent engineering consultancy
- International
  - Based in Glasgow (Head Office), Beijing, Pune (India), Ireland, Canada & Wick



- Experienced
  - Over 80 professional staff
- Professional
  - ISO 9001 & 14001 certified
  - Progressing OHSAS 18001 registration



- Award Winning

Glasgow Business Award for International Activity 2007 &  
Best Business Achievement 2007 at



# Overview of Capability



Wind



Wave & tidal



Hydro



Solar



Bio-energy



Micro-generation



Project management



Noise & vibration

- Due diligence
- Lenders engineer
- Energy yields
- Technology audits & reviews
- Hybrid systems

- Technical advisor

# Experience

We have consulted on over 30,000 MW of renewable energy in over 20 countries covering both project development and due diligence

## Europe

- Belgium
- Estonia
- France
- Germany
- Greece
- Republic of Ireland
- Italy
- Malta
- The Netherlands
- Poland
- Portugal
- Spain
- Sweden
- GB & NI

## Asia

- China
- India
- Korea
- Philippines
- Turkey

## Africa

- Kenya
- South Africa

## Oceania

- New Zealand

## North America

- Canada
- USA

## South America

- Galapagos Islands



# OPERATIONAL WIND FARM DATA



# Introduction

- An operational wind farm typically generates vast quantities of data.
- The SCADA data contain information about every aspect of a wind farm, from power output and wind speed to any errors registered within the system.
- In general, the SCADA data are downloaded, however they are only used if some failure requires an analysis on a reactive bases.
- SCADA data may be effectively used to “tune” a wind farm, providing early warning of possible failures and optimising power output across many turbines in all conditions.

# “Performance monitoring”

- It is common for “condition monitoring” to be applied to a wind farm.
  - However, this involves the addition of extra instrumentation, involving wind farm down time, extra cost and potential warranty implications.
- As distinct from condition monitoring, performance monitoring uses existing instrumentation to analyse SCADA data from the wind farm.
  - No extra instrumentation, no down time, no cost.
  - Performance monitoring has the advantage of using data already routinely gathered.
- By making use of specially-designed software tools, a great deal of information may be gathered and analysed to provide a detailed look at the performance of the wind farm.

# Why monitor performance?

- To obtain maximum value from assets.
- To catch faults early, reducing the risk of catastrophic or downtime heavy failures.
- To prolong the life of all wind farm components.
- To plan for scheduled downtime based on real wind farm behaviour.

A wind farm is an asset – why leave its good performance to chance?

# PERFORMANCE MONITORING



# The possibilities of performance monitoring

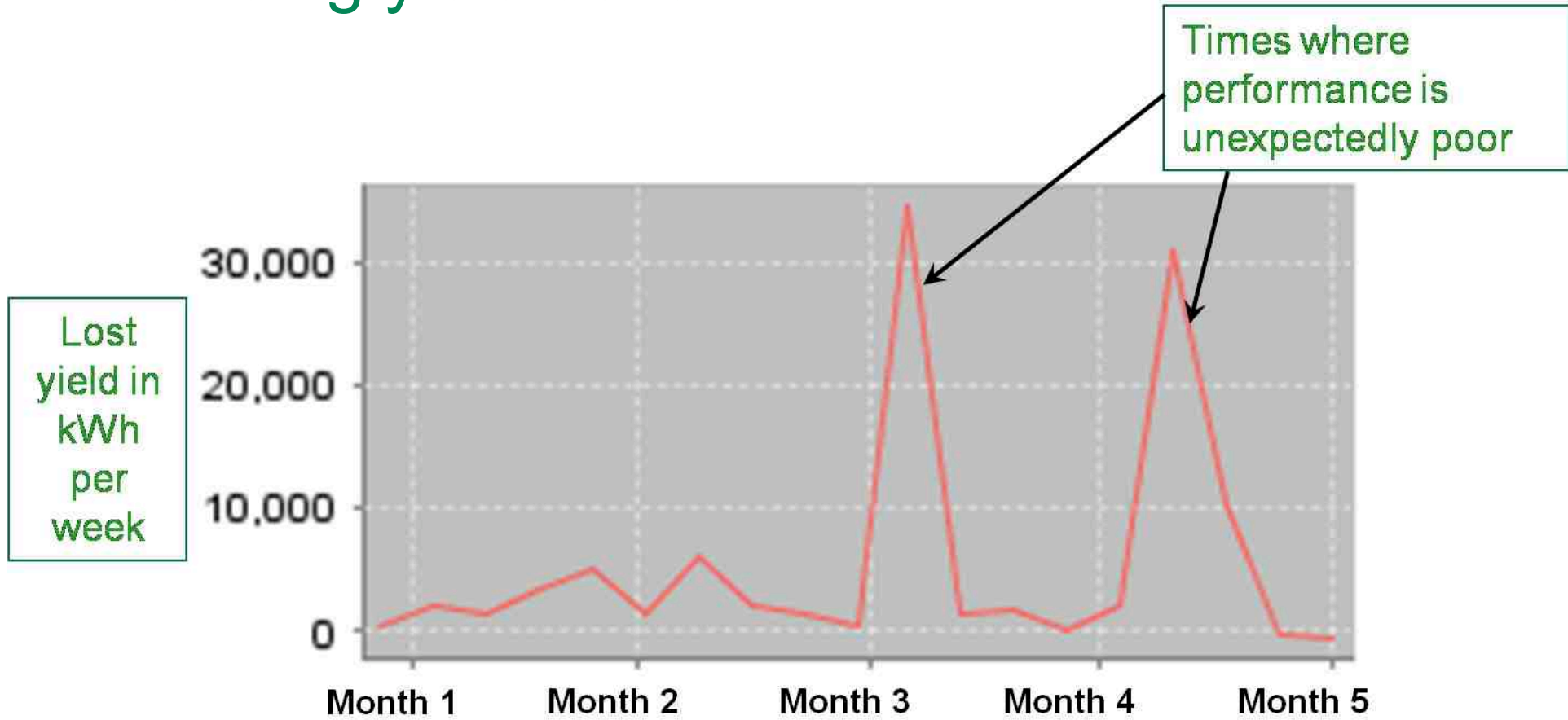
- Performance monitoring provides a snapshot of wind farm or turbine performance at a given time.
- It also allows behaviour to be trended over time.
- Important aspects of performance monitoring:
  - Trending yield deficit with time;
  - Power curve comparisons:
    - Compared to warranty
    - Compared to other turbines;
    - Compared to other times;
  - Met station data;
  - Error code analysis;
  - Performance metrics.
- Performance monitoring software provides easy access to all these.



# Quantifying power loss

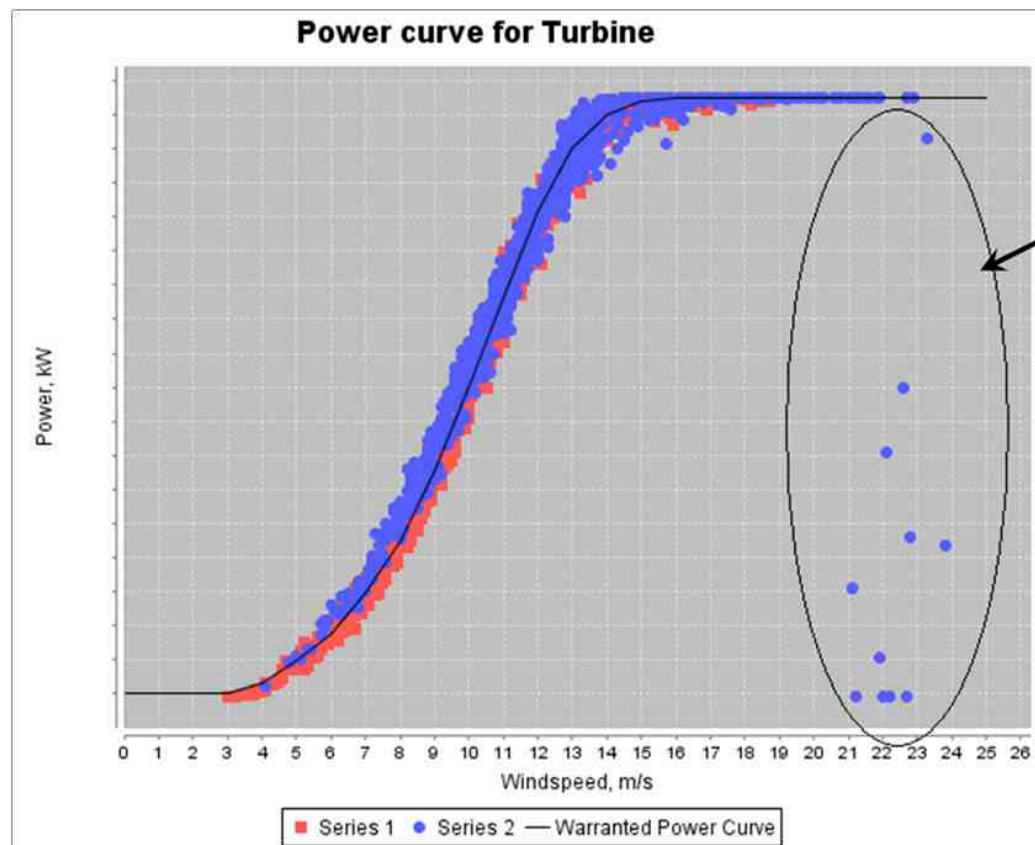
- “Lost yield” is a general term used to mean “power which would have been produced had the wind farm/turbine been operational”.
- Lost yield is tied to downtime, usually scheduled for maintenance.
- Performance monitoring software is not concerned solely with lost yield.
- Instead, we consider “yield deficit”:
  - This is the gap between the benchmark and operational performance.
  - In this way, performance monitoring focuses on opportunities for improvement while turbines are operational.
- Through a better understanding of the behaviour of a wind farm in a variety of conditions, it is also possible to schedule maintenance wisely, ensuring that the errors which impact most on power performance are fixed quickly.

# Trending yield deficit



# Power curve: winter 2006

- Power performance compared to warranted for 2 consecutive weeks in winter 2006



Points causing high lost yield

Partially hysteresis... but there may be another factor involved.

# What about the errors?

- Yield deficit occurring during two error codes:

Low oil level

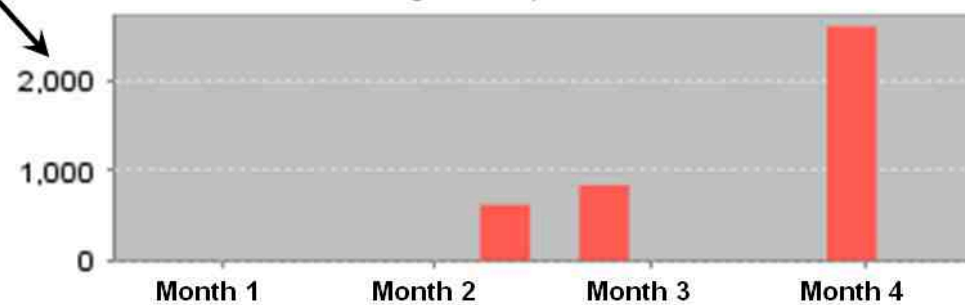
Note scale!

*Low oil-level, hydraulic*



High wind speed

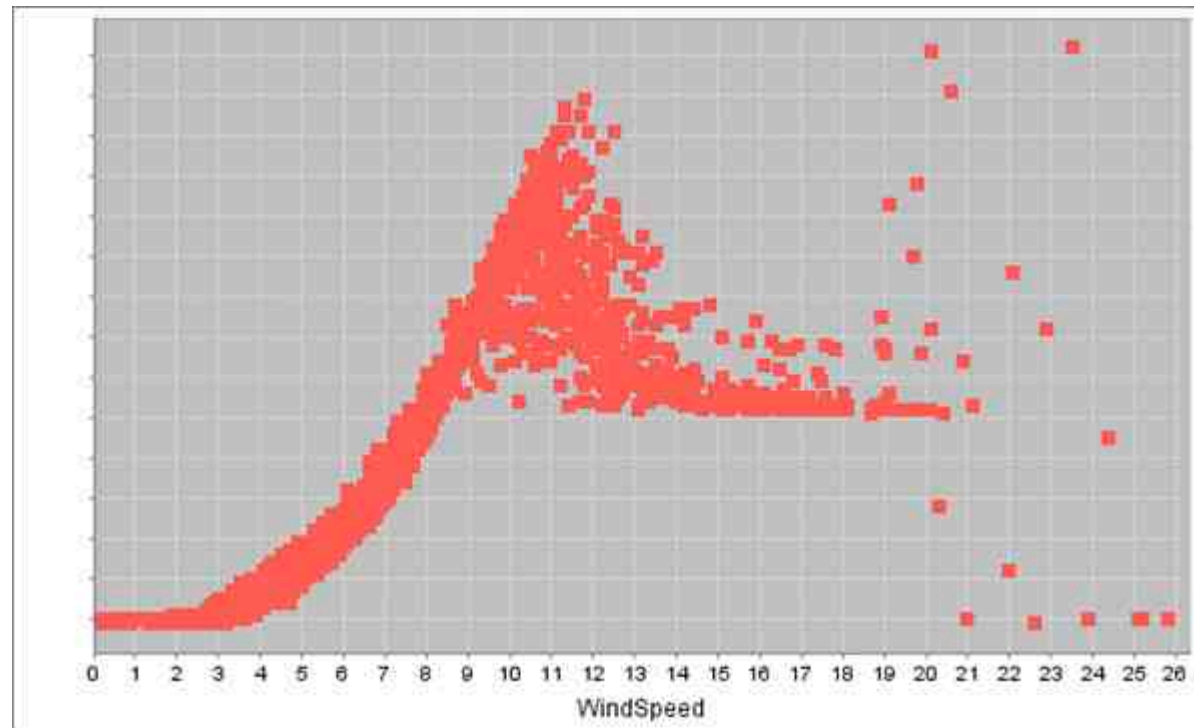
*High windspeed*



# So what was going on?

- This turbine was losing yield.
- From the power curve it was clear that most of the lost yield occurred at high wind speed.
- Some of the lost yield was due to high wind speed and hysteresis.
- The majority stemmed from a low oil level alarm
- During that alarm, the lost yield was consistently high. To some extent it followed the wind speed distribution.
- The alarm lasted 18 hours.
  
- Performance monitoring can highlight losses from subtle effects.
- What about more dramatic effects?

## A notable effect



- This wind farm was losing significant revenue due to this effect.
- By easily plotting the power curve, routine analysis could have identified this as soon as it started, saving a fortune.

# PERFORMANCE METRICS



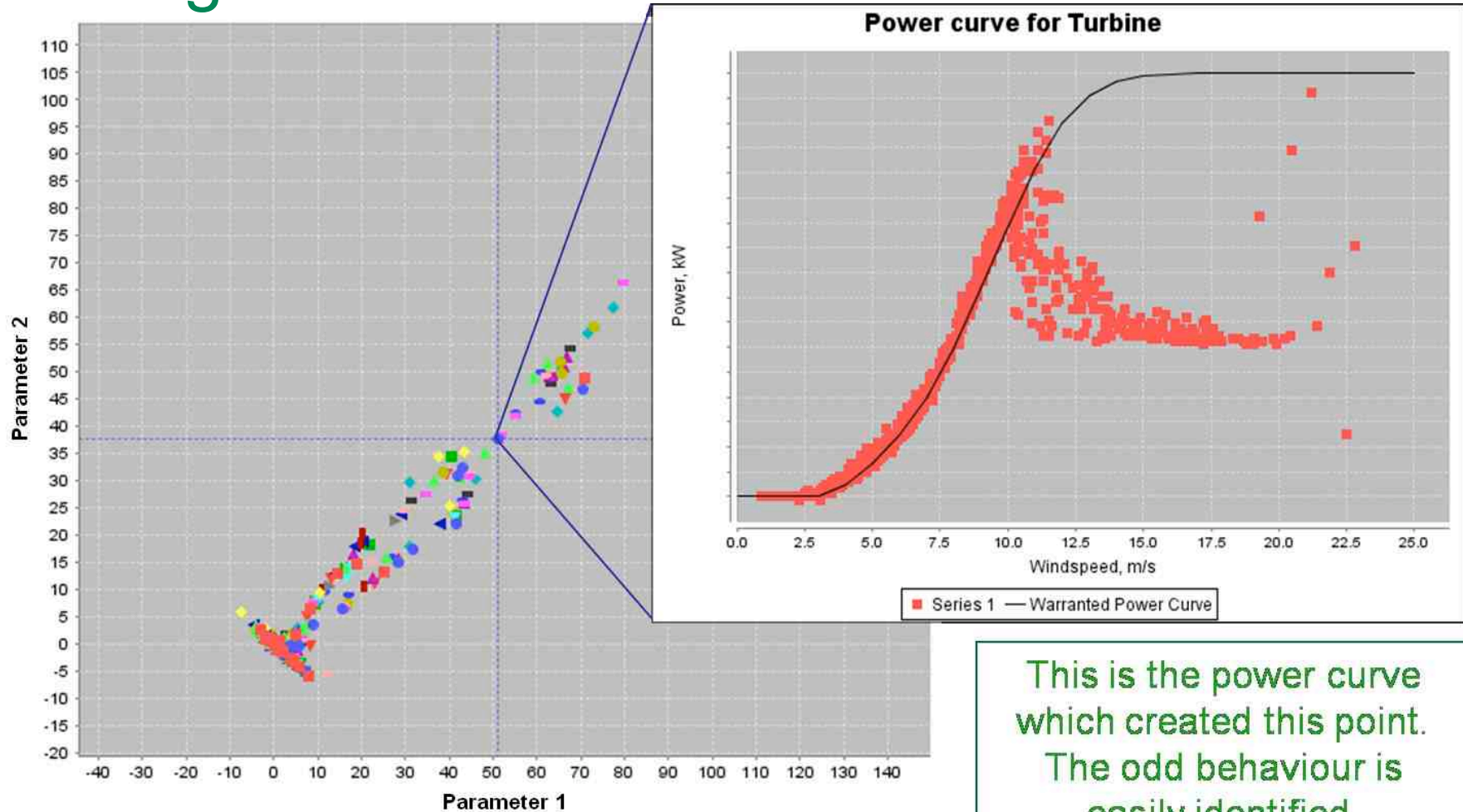
# More complex analyses

- So far, the plots shown have been fairly simple and direct representations of the data.
- With performance monitoring software, it is also possible to automate advanced analyses.
- With performance metrics, particular aspects of a turbine's performance may be highlighted on one graph, without the need for manual scrolling.
- This speeds the identification of any issues.

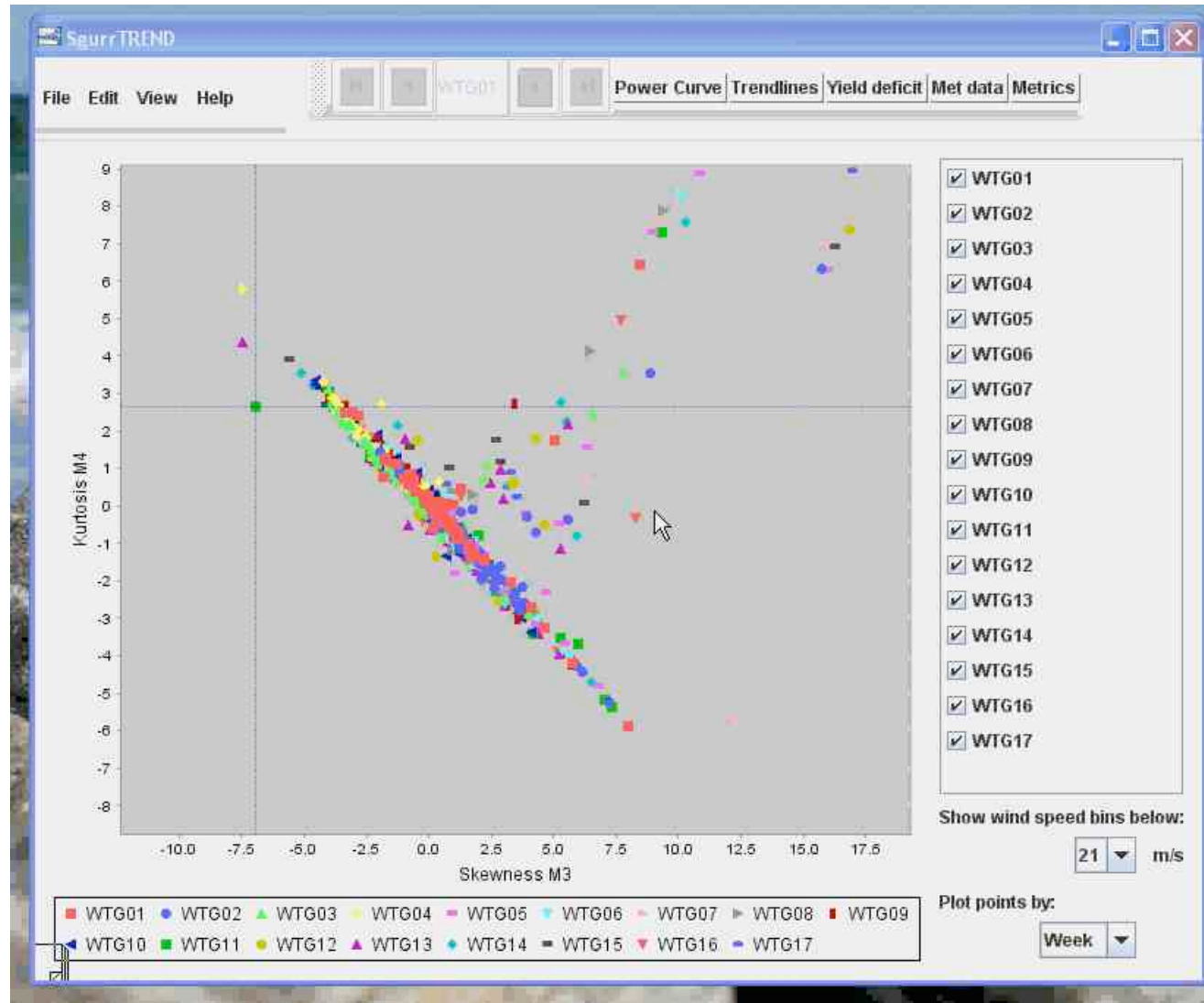
# Central moments

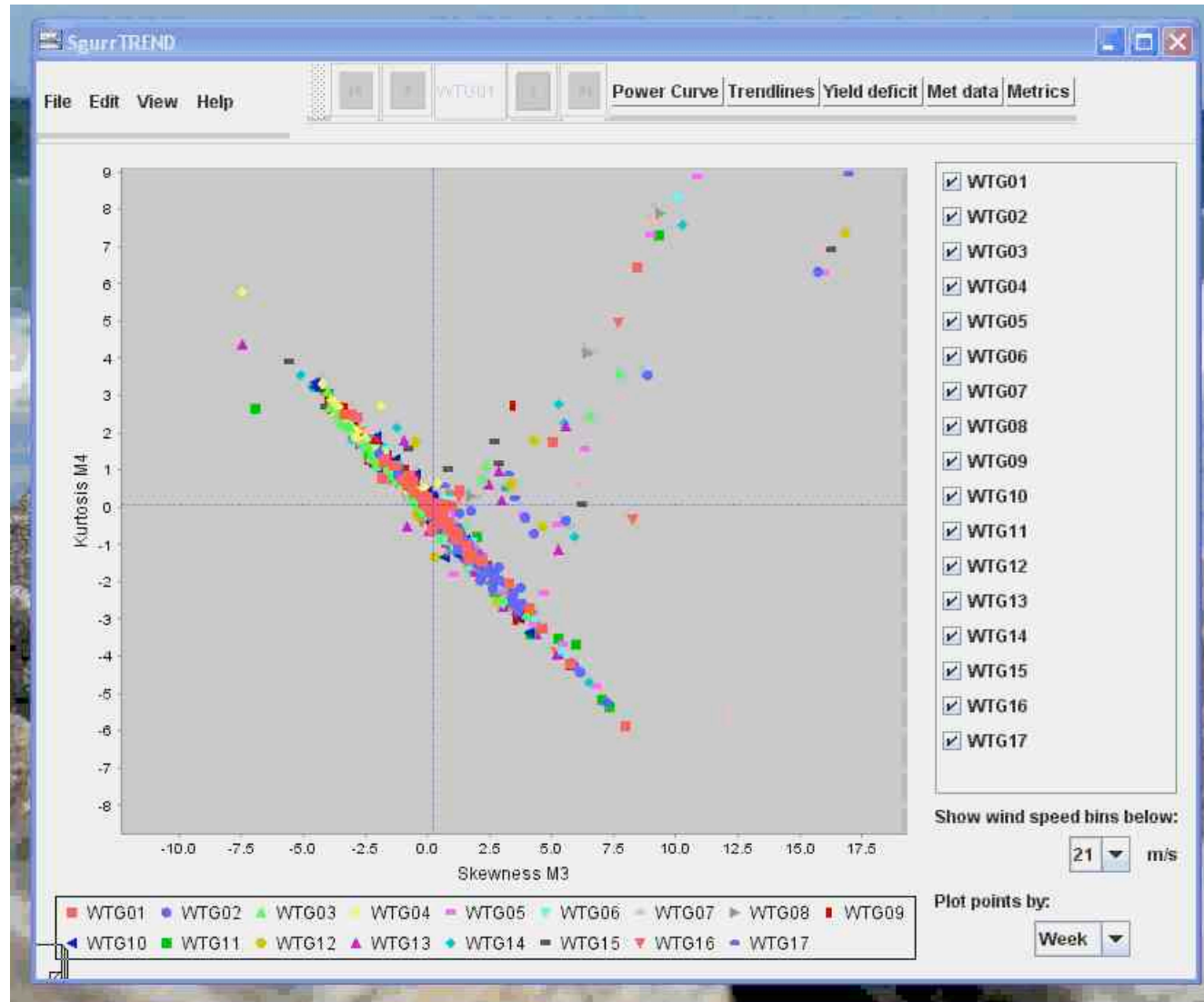
- Power curves often hide interesting features among the clutter.
- Plotting differences from the warranted power curve highlights the important features.
- Mean (1<sup>st</sup> moment) and standard deviation (2<sup>nd</sup> moment) of those differences tell a story.
- *Skewness* (3<sup>rd</sup> moment) and *kurtosis* (4<sup>th</sup> moment) may also quantify significant effects.
- Central moments are being explored.

# Plotting central moments



This is the power curve which created this point. The odd behaviour is easily identified.





# RESULTS AND CONCLUSION



# Performance monitoring summarised

- Performance monitoring is at its most powerful, and most useful, when:
  - It can be *automated*, reducing the time required for the analysis
  - It provides a variety of information sources
  - It can quickly indicate connections between data
  - It is interpreted by skilled and experienced personnel
- The fast identification of problems can save a great deal of lost income.
- An improvement of 3% could lead to £200,000 for a 50MW wind farm with a 30% capacity factor
  - A 1% improvement would be worth £60,000 in a year.

# Conclusions

- If you operate a wind farm, your SCADA system contains a wealth of information.
- This can be used in a productive way to ensure the wind farm output is optimised.
- By automating this process, performance monitoring software saves time on analysis procedures and can lead to either yield improvements or simply the avoidance of losses.
- Powerful performance metrics immediately highlight areas which require attention.
- This is a powerful field, and developing quickly.