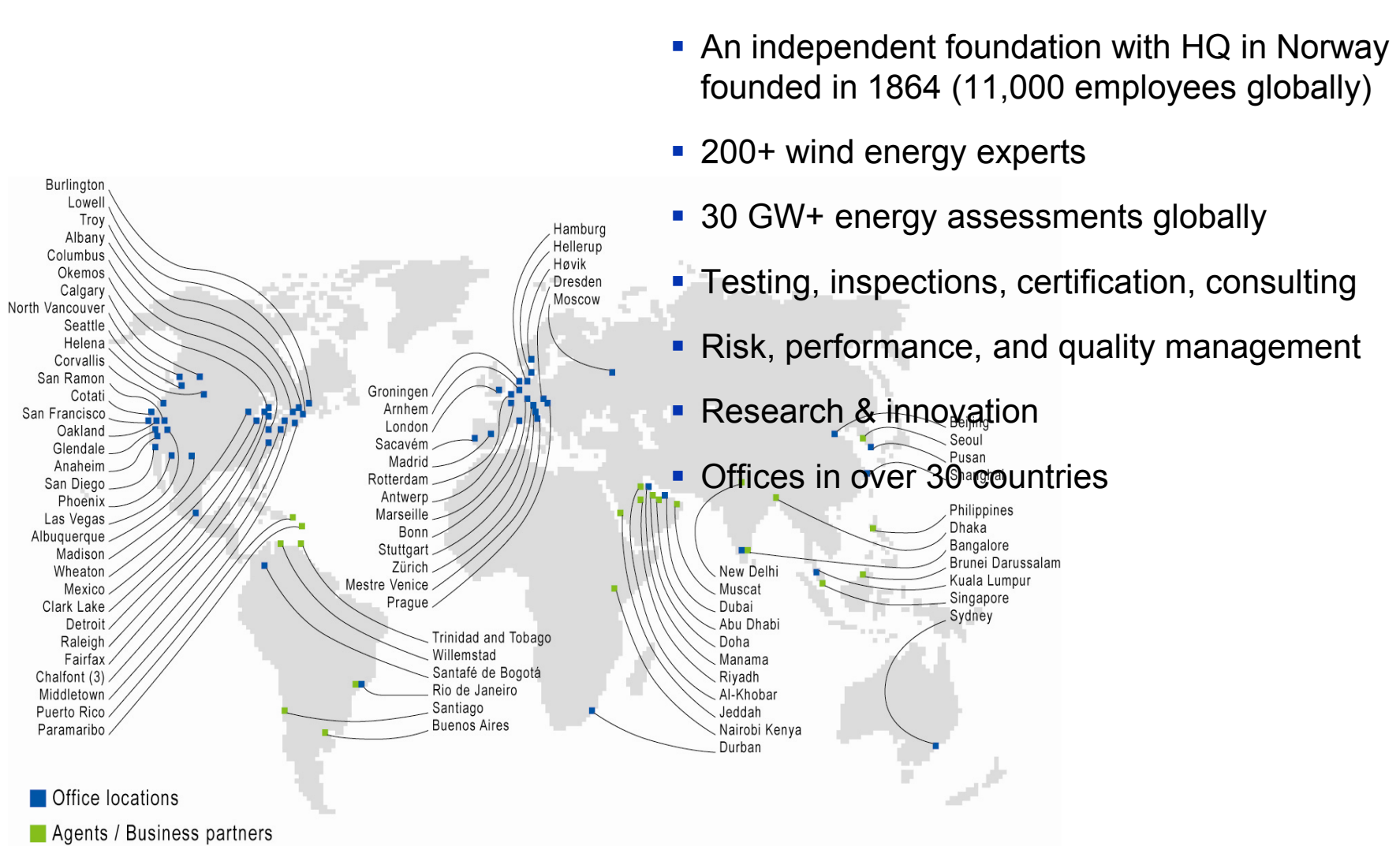




Optimization's Influence on Project Risk

Jake Frye
January 30, 2013





- An independent foundation with HQ in Norway founded in 1864 (11,000 employees globally)
- 200+ wind energy experts
- 30 GW+ energy assessments globally
- Testing, inspections, certification, consulting
- Risk, performance, and quality management
- Research & innovation
- Offices in over 30 countries

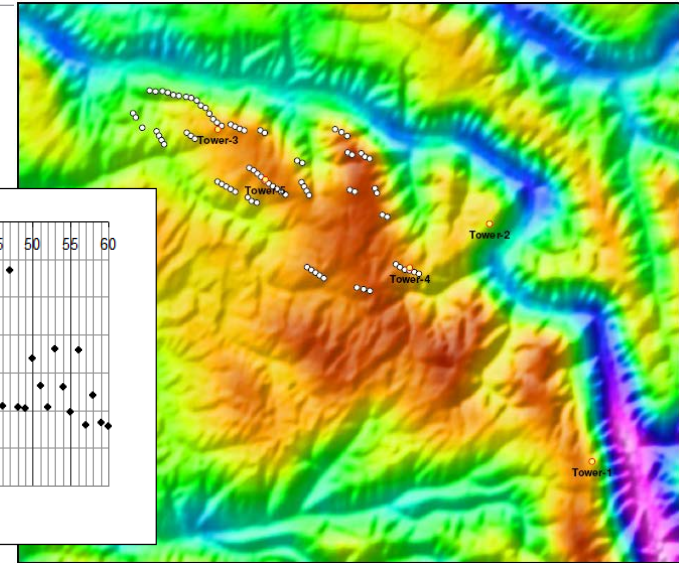
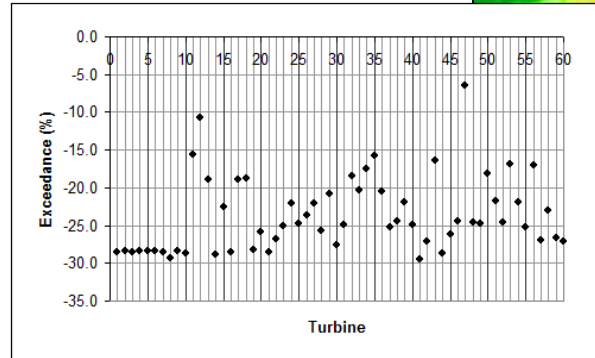
DNV KEMA and System Engineering Tools

- Site Suitability (loads analysis)

- In-house proprietary software

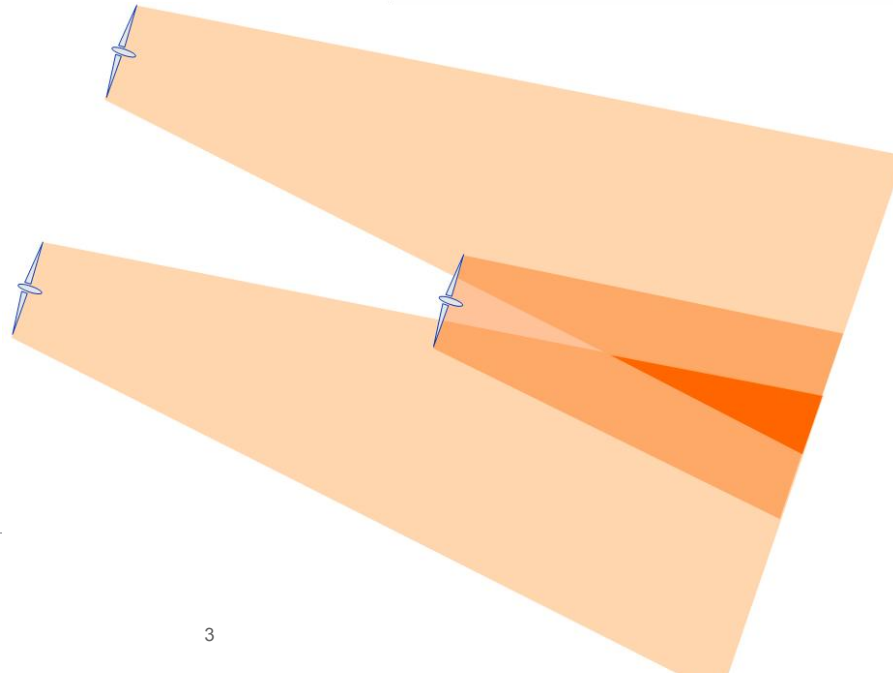
- Wind Flow Modelling

- WAsP & MS Micro3
- WindSim
- CFD



- Wake Loss Modelling

- Park (single turbine)
- Eddy Viscosity (single turbine)
- Different combination methods
 - Square root of sum of squares
 - Energy balance



What is an Optimized Layout?

Lowest Levelized Cost of Energy

- 1. Increase in wind energy across rotor
- 2. A decrease in loading
- 3. Increased turbine capacity

Technical Risks Low

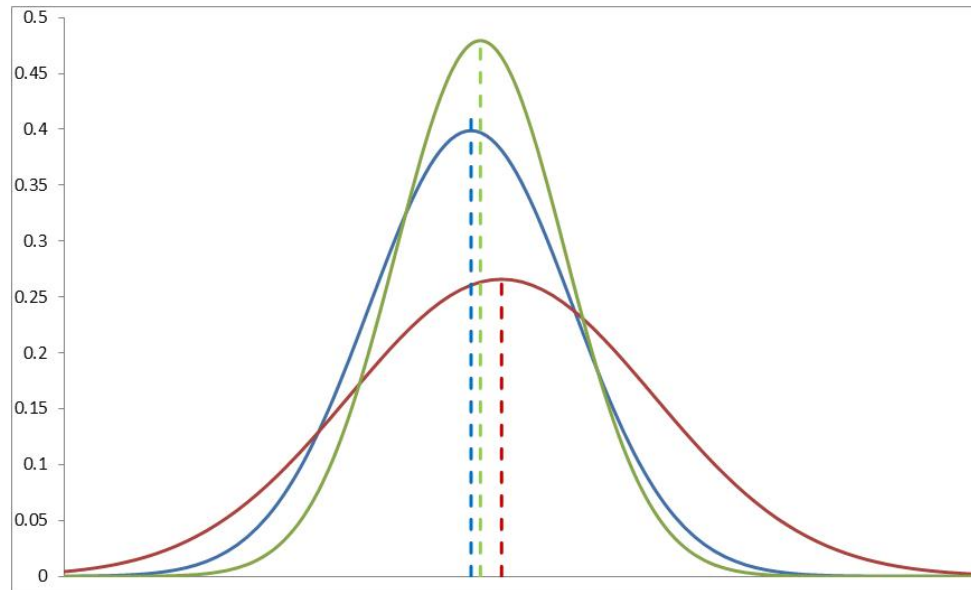
- A. Tight uncertainty bands
- B. Conservative assumptions
- C. Mitigation in place



How do you lower the perceived risk of new technology?

Lower Perceived Risk – Part 1

Quantify your uncertainties. And if possible, use those uncertainties as the basis of a probabilistic set of results so that a developer or investor can weigh their options based on their risk tolerance.



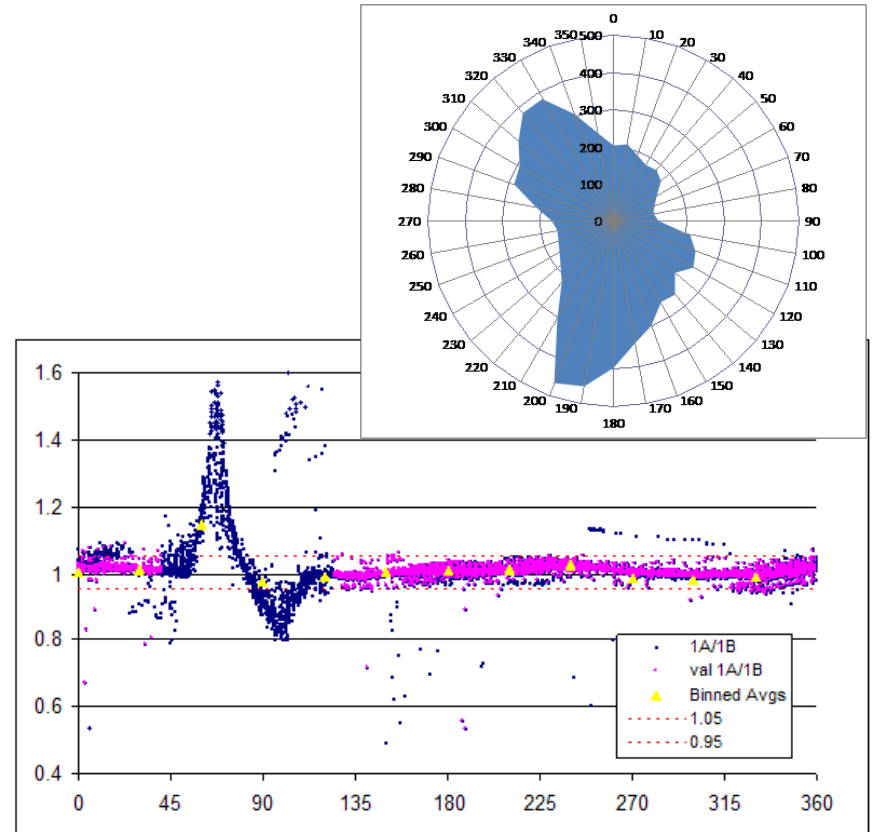
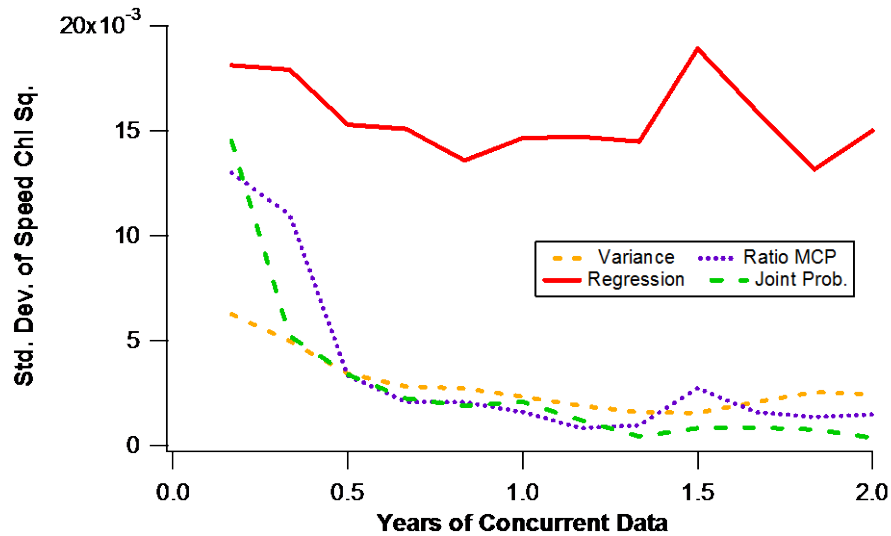
Lower Perceived Risk – Part 2

Include risk mitigation measures as inputs to the optimization process.



Lower Perceived Risk – Part 3

If at all possible allow for transparency in your methodology and process.



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