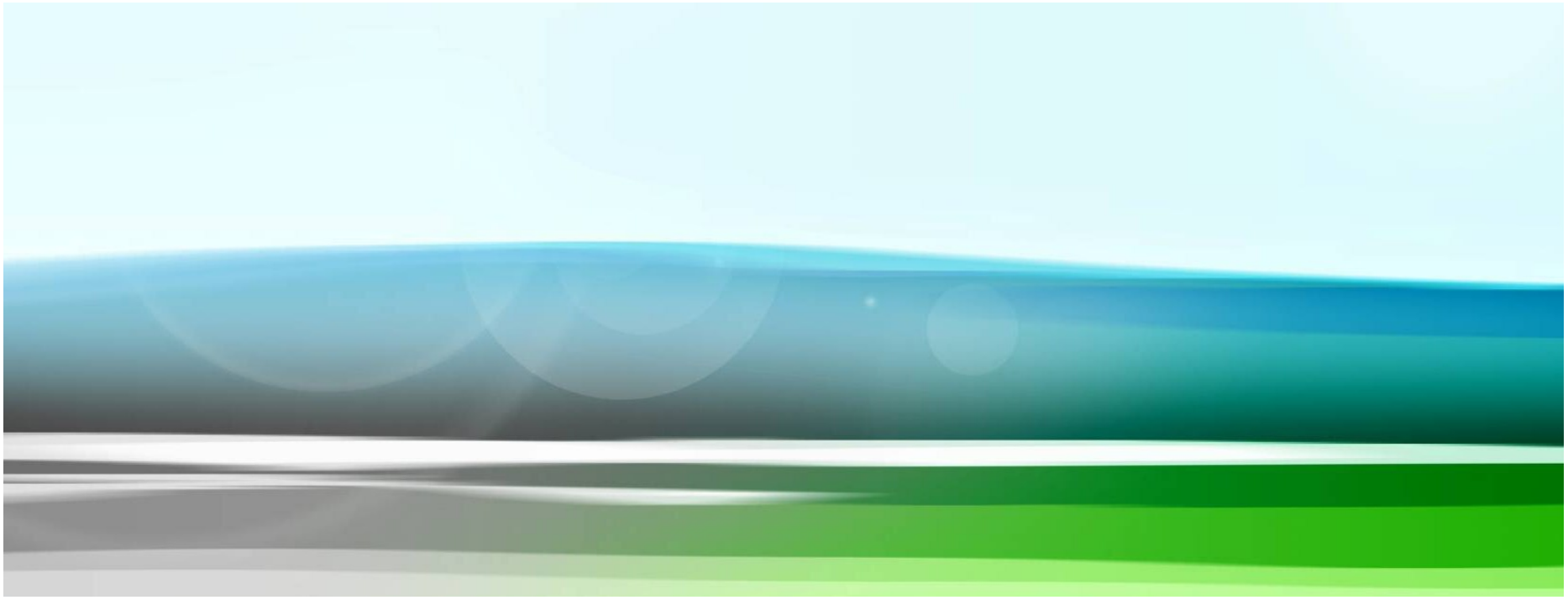


Systems engineering in wind energy at DNV

Some thoughts on the approach to wind turbine design, choice, and deployment

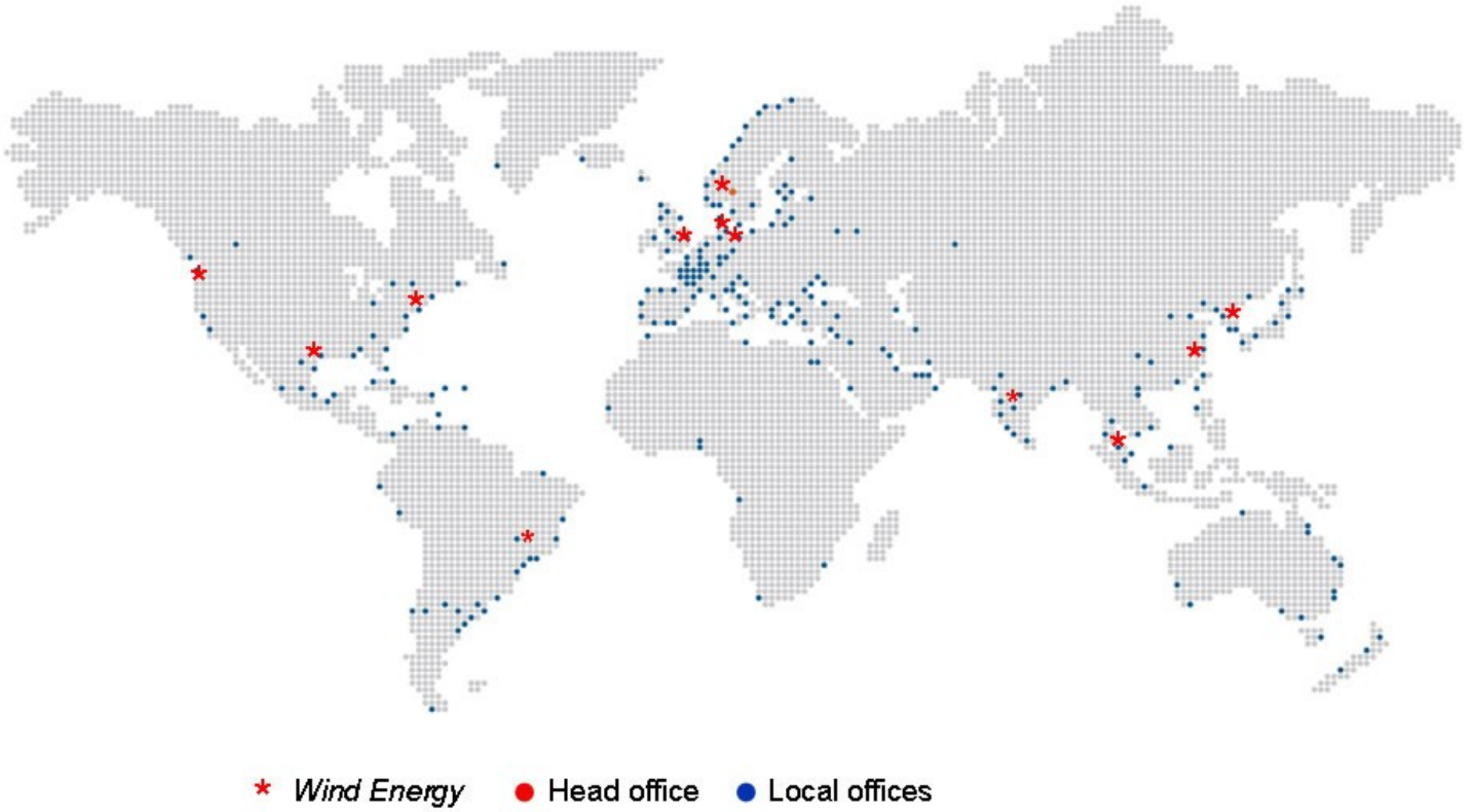
David Malcolm
14 December 2010

MANAGING RISK DNV

Overview

- One of the largest wind energy consulting and certification companies in the world
  - ~200 employees dedicated to wind
  - Many others technical specialists contributing to wind projects from other business units
  - Wind energy competence in offices in the Americas, Europe, and Asia

Wind energy expertise around the world



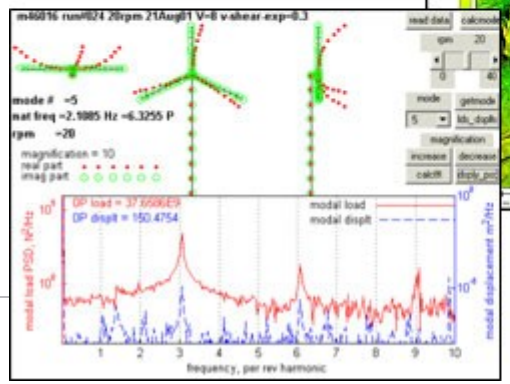
DNV Services to the Wind Industry

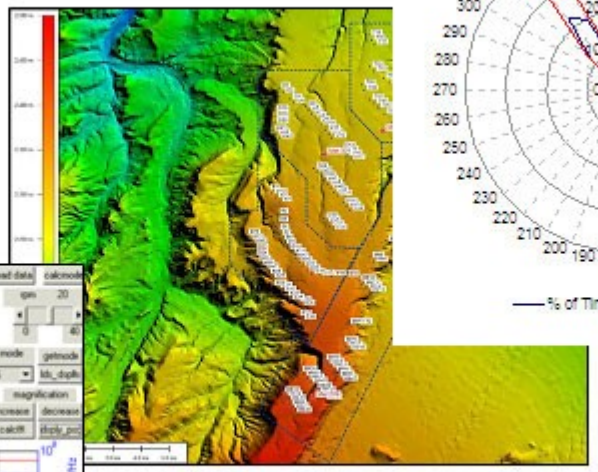
Advisory Services

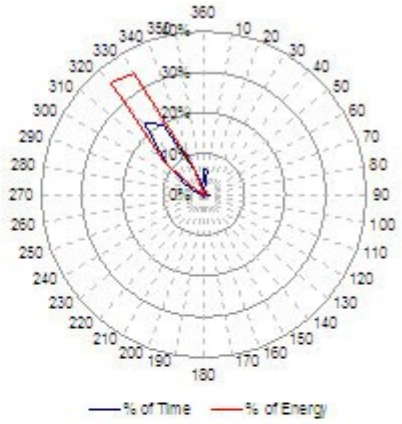
- Wind Resource Assessment
- Project Development Support
- Due Diligence
- Marine Advisory Services
- Asset Risk Management
- Health, Safety, and Environmental Risk Management
- Wind Turbine Technology
- Training and educational programs

Accredited Services

- Project Certification
- Type Certification
- Accredited Testing Services
  - Power Performance Testing
  - Loads Testing
  - Acoustic Testing





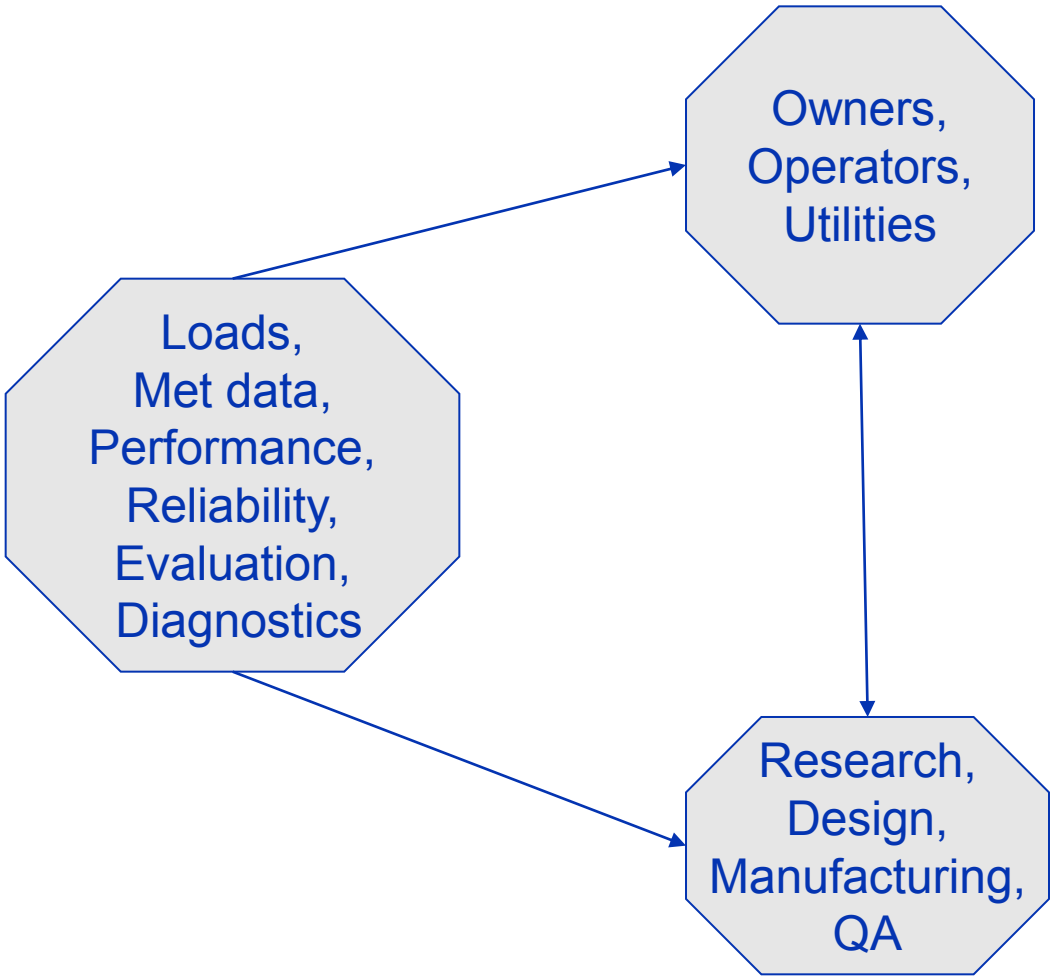


The holistic approach

- Some subjects / disciplines
  - Basic research
  - Resource assessment
  - Design and component testing
  - Quality assurance
  - Code development
  - Certification
  - Field loads measurements
  - Field health / condition monitoring
  - Client needs, COE
  - Utility needs – reliability, power quality, control
  - Operations & maintenance
  - Onshore / offshore applications
  - Transmission
  - Health and safety

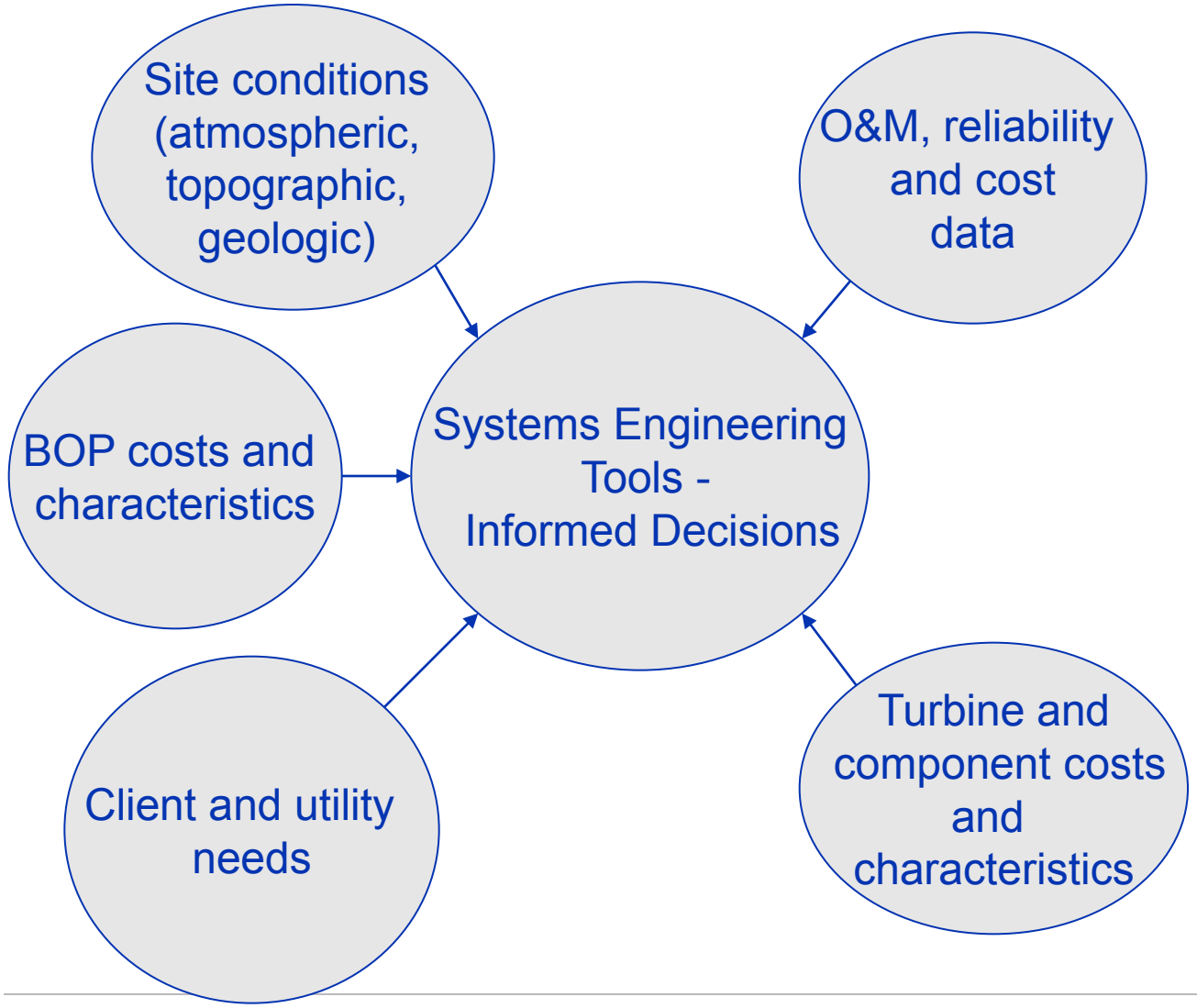
- As an industry matures, different groups and subject areas can become isolated.
- Communication between the groups and disciplines is essential.
- Analogies with the aviation industry.
  - Continuous monitoring enables immediate diagnostics – a spare part available at the next landing. FAA and similar agencies have access to data.
- Emphasis on
  - Condition monitoring & evaluation
  - Diagnostic tools
  - Feedback to manufacturer
  - Feedback to operator
  - Feedback to inform a systems engineering tool

Some relationships



- Example:
- If a blade breaks, the response needs to have information about the loading history, the maintenance log, the site conditions, data on similar blades, the manufacturing quality, etc.
- While this information need not be public, it must be collected and may be important to inform a systems engineering tool.

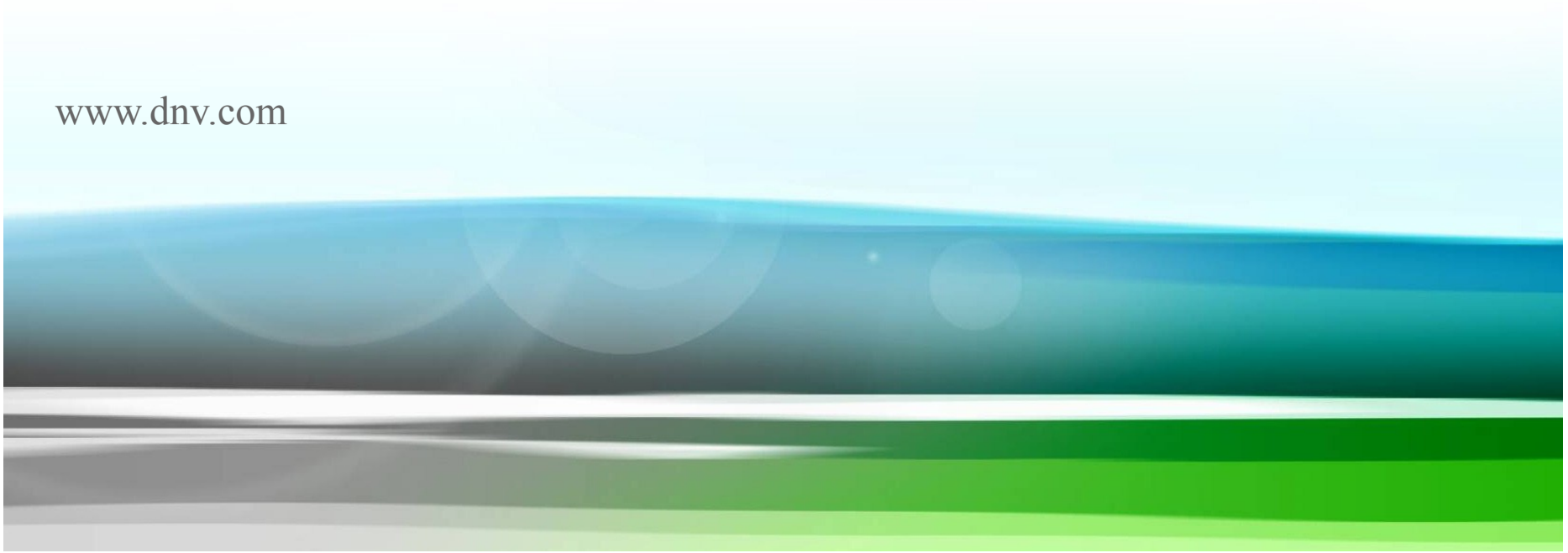
Good information and tools leads to better choices



- Good information is required for a client to choose the most appropriate turbine, or a manufacture to optimize a turbine configuration or product line,
- Tools to facilitate this process will help the industry.
- Separate tools are needed for onshore and offshore applications.

Safeguarding life, property and the environment

www.dnv.com



MANAGING RISK

DNV in the wind energy market

- 25 years in the wind industry
- 2nd largest wind technical advisory company in the world
- Global presence: long established in Europe and North America; expanding operations in Asia and South America
- Services address the whole value chain -from early phase wind energy assessment and project risk to asset risk management and marine operations.
- Leading certification agency in the industry
  - Market leader in project certification for offshore wind
  - Type certification for largest turbine manufacturers in the world
- Comprehensive engagement – DNV has played a role in the majority of the world's offshore wind projects and more than 75% of North America's onshore projects.
- DNV develops international rules and standards for the wind industry

Examples of Services Across the Entire Life Cycle

Offshore wind – three short facts