

# Renewables

## Wind Project Services



Empowering Trust™

# About us

## Leaders in Global Services for Renewable Energy

UL is a trusted independent advisory, testing, inspection and certification body for a broad range of industries. In the renewable energy space, UL works to help manufacturers, developers, owners, investors, lenders, utilities and policy makers navigate the risk and complexity associated with renewable resources. We have become a trusted advisor by providing access to proven science and expert engineering, and by offering innovative solutions to meet the unique challenges of the renewable energy industry. We pride ourselves on being accessible, flexible and keenly responsive to the needs of our clients.

UL now delivers an even more extensive portfolio of renewable energy services, through the acquisitions of AWS Truepower (2016) and DEWI (2012). With offices in over 140 countries, a team of over 500 experts and 35 years of experience, we advise on wind and solar projects as well as battery and energy storage technologies, helping our clients make them safer, compliant and perform to the highest standards. Our goal is to empower trust in renewable energy throughout the project lifecycle and across the supply chain.

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UL OPERATES IN  
MORE THAN

**140**

COUNTRIES



**35+**

YEARS OF  
RENEWABLE  
ENERGY  
EXPERIENCE

**200,000+ MW**  
TOTAL MEGAWATTS ASSESSED

**500+** RENEWABLE  
ENERGY EXPERTS



**ADVISED 90%**

OF THE WIND INDUSTRY'S TOP PROJECT  
DEVELOPERS AND PLANT OWNERS



INDEPENDENT/OWNER'S  
ENGINEER FOR

**500+**

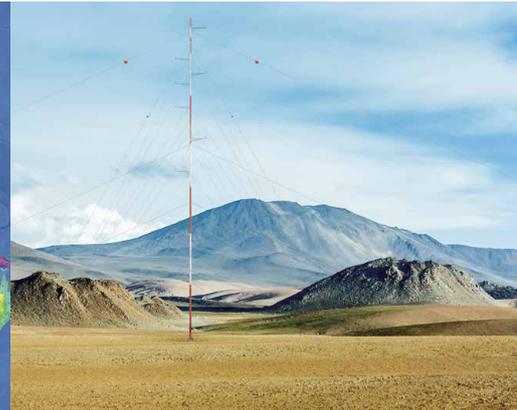
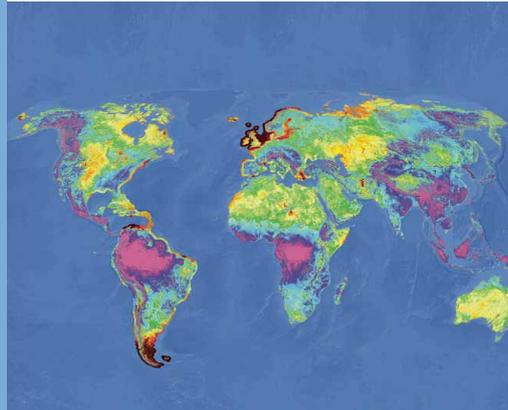
WIND AND SOLAR PROJECTS  
SINCE 2012

FORECAST PROVIDER FOR  
**70+ GIGAWATTS**  
OF INSTALLED RENEWABLE  
ENERGY PROJECTS



# Supporting projects throughout their lifecycle

Access to the top industry experts and tools is critical for project success. Our staff of engineers, meteorologists, and environmental specialists provide clients with comprehensive consulting services, independent engineering, technical advisory, and data and software solutions that span the entire project lifecycle. We work with clients as technical advisors, and we provide resource data, online services, and advanced software to support their teams. Our goal is to empower our customers to succeed.



## Feasibility

- Market Potential
- Site Prospecting and Wind Maps
- Site Feasibility and Assessment
- Wind Resource Potential
- Early-Stage Energy Estimates
- Field Assessment
- Early-Stage Plant Design
- Grid Integration Studies
- Regional Build-Out Scenarios
- Thermal Screening
- Environmental and Permitting Risks

## Development

- Measurement Campaign Design
- Met Tower Installation
- Remote Sensing Systems (Sodar and Lidar)
- Data Collection and QC
- Resource, Energy and Uncertainty Assessment
- Advanced Wind Flow Modeling and Visualization
- Turbine Selection and Suitability
- Turbine Layout and Cost Optimization
- Preliminary Road and Collection System Design and Costing
- O&M Strategy Development
- O&M Contractor Qualification and Selection
- EPC Qualification and Selection
- Contract Negotiations
- Financial Model Development
- Permitting Support
- Transmission Analysis
- Owner's Engineer



## Preconstruction and Financing

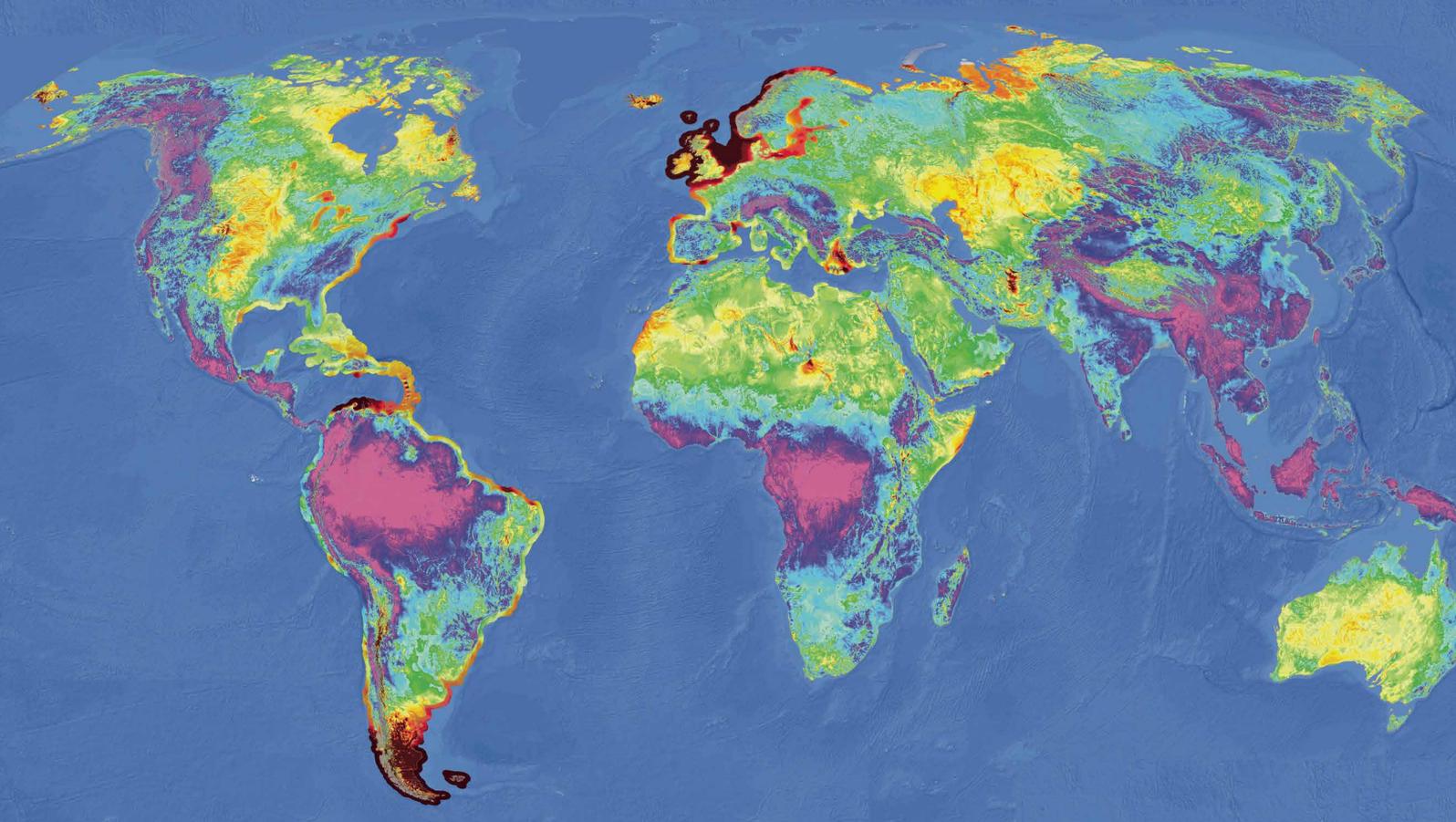
- Bankable Energy Production Reports
- Independent Engineer Reports for Financing
- Owner's Engineer
- Contract Review
- Civil and Electrical Review
- Turbine Technology Review
- Financial Model Review
- Review of Project Contractors and Capabilities
- Schedule and Construction Risk Review
- Curtailment Forecast
- Environmental Review
- Permitting Review

## Construction

- Construction Forecasting
- Construction Monitoring
- Progress Report Review
- Site Visits
- Schedule and Quality Review
- Drawdown Verification
- Substantial Completion Verification
- Factory Inspections

## Operations

- Operational Energy Assessment
- SCADA Data Review and Reporting
- Power Performance Measurement
- Plant Performance Analysis and Optimization
- Monthly Resource and Energy Reporting
- Real-Time Forecasting
- O&M Review and Optimization
- End-of-Warranty Inspection
- Curtailment Analysis
- Turbine and Component Inspections
- Lifetime Extension Analysis
- Power Performance Testing



## Feasibility

Whether you are a developer or investor looking for new opportunities, or a policy maker or power company wanting to know how best to incorporate renewables into your growth plans, we have the tools and expertise to help you succeed. We deliver reliable and detailed information about resources, siting opportunities and constraints, development potential, plant and technology characteristics, generation expansion scenarios, economic benefits and impacts, and many other factors.

Services:

- Market Potential
- Site Prospecting and Wind Maps
- Site Feasibility and Assessment
- Wind Resource Potential
- Early-Stage Energy Estimates
- Field Assessment
- Early-Stage Plant Design
- Grid Integration Studies
- Regional Build-Out Scenarios
- Thermal Screening
- Environmental and Permitting Risks

The world's only global, high-resolution (200 m) wind resource maps and data available for site prospecting.

Over 5000 preliminary wind assessment reports and 7000 datasets and maps delivered in over 80 countries since 2012.

Over 30 wind grid integration studies performed on four continents.

**LOCATION:** Mexico, Panama, Costa Rica, Colombia, Brazil, Uruguay, and Chile

## Site Screening for Wind & Solar Development Opportunities in Latin America for Celsia

Identified attractive wind and solar development opportunities in seven Latin American countries for Celsia. Assessed wind resource, capacity factor, and production availability as well as electrical line data and topography. Utilized and gave Celsia access to Windnavigator® maps and data sets, typical year time series data, and reports. Conducted a three-day workshop at Celsia's headquarters.

**LOCATION:** United States - Lower 48 States

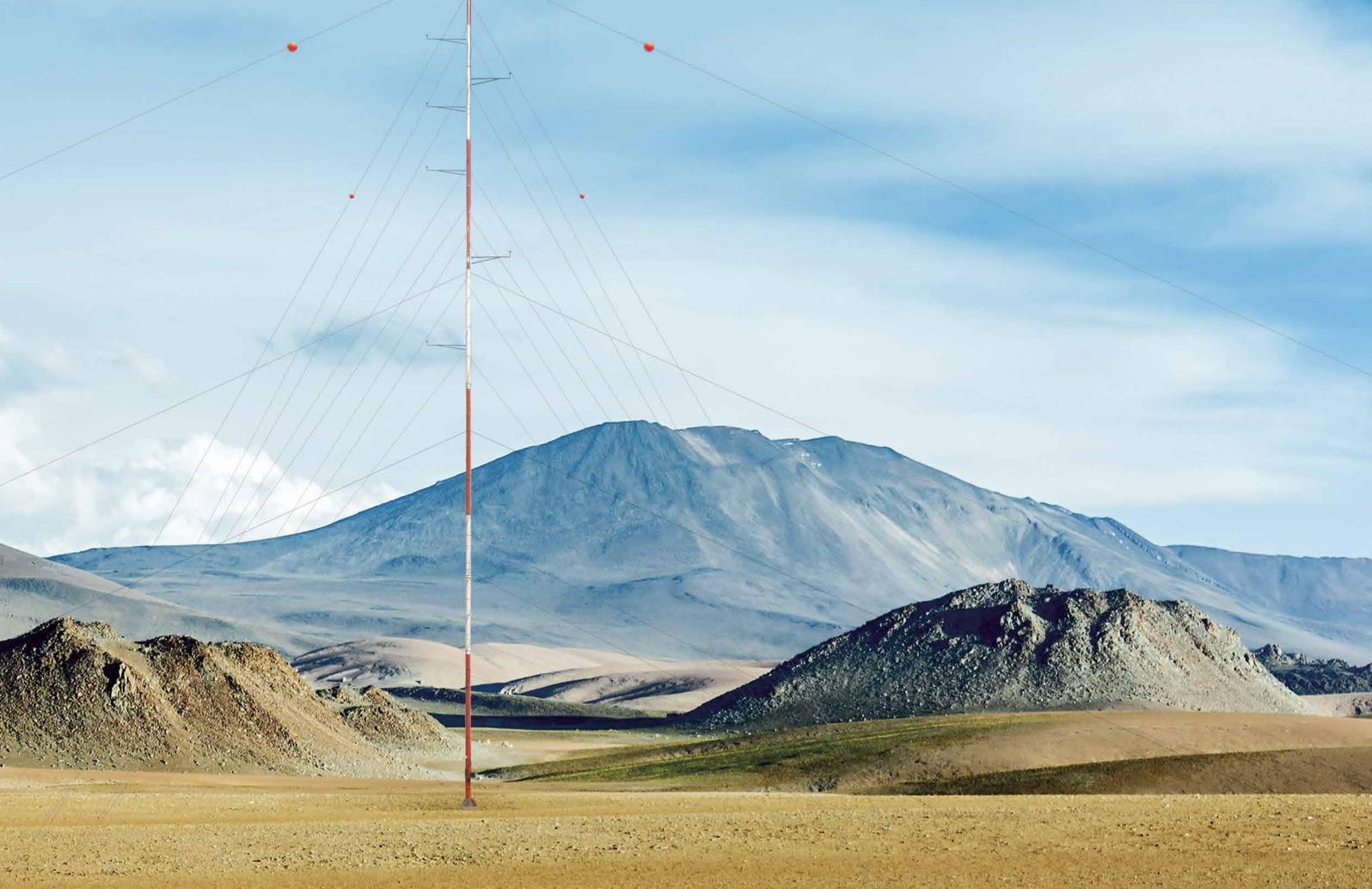
## Simulated Wind Energy to Support Economic Assessment of Renewable Energy

Identified 1400 GW of potential onshore and over 175 GW of potential offshore wind project sites meeting specified development criteria for the Electric Power Research Institute (EPRI). Used atmospheric models and wind resource maps to synthesize hourly generation data for every site, and aggregated the data by capacity factor and state. The data allowed EPRI to model a wide range of future economic-energy scenarios critical for decision making by the United States power industry.

**LOCATION:** India

## Identifying Project Locations in India

Assessed the wind energy potential of regions in India for a confidential developer to identify promising sites for further assessment and possible project development. Applied advanced computer models and practical resource assessment experience to produce high-resolution wind power and speed maps at hub height, digital elevation model, land cover, and gross capacity factor.



## Development

Over 30 years we have created a wide range of high-quality products and services to support the development of successful wind projects. We work with your team in the way that makes most sense for you – either as expert advisors or by providing resource data, online services, and advanced software. Either way, we help you achieve your goals.

### Services:

- Measurement Campaign Design
- Met Tower Installation
- Remote Sensing Systems (Sodar and Lidar)
- Data Collection and QC
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- Turbine Selection and Suitability
- Turbine Layout and Cost Optimization
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- EPC Qualification and Selection
- Contract Negotiations
- Financial Model Development
- Permitting Support
- Transmission Analysis
- Owner's Engineer

**LOCATION:** Chapada, Piauí, Brazil

720  
MW

## Advanced Wind Modeling to Assess Complex Wind Regime in Brazil

When Casa dos Ventos (CDV) needed a more accurate and comprehensive understanding of the wind resource at their large project site in Chapada, Brazil, they turned to us to apply our expertise in resource assessment, atmospheric science, and advanced wind flow models. CDV was developing 720 MW of projects within the 60x60 km area. Due to the complexity of the wind regime on this subtropical plateau, CDV had already installed about 35 meteorological towers. Even with this massive effort, they had significant questions about where to install turbines to maximize production, which could not be answered with conventional methods.

We provided high-resolution atmospheric modeling, expert interpretation and data analysis, and site visits to assess the wind resource. This helped CDV site additional towers where they offered the most value, and significantly reduced the uncertainty in energy production estimates. Subsequently we conducted a series of training sessions that reviewed our methodology and approach as well as the findings at CDV headquarters in Sao Paulo, Brazil. CDV used these results to achieve success in a wind energy auction in August 2013.

**LOCATION:** Wyoming, United States

3000  
MW

## Project Consultant for 3000 MW Wind Project in Wyoming

In 2008, Power Company of Wyoming LLC (PCW) approached us to consult for them on a proposed wind project in Wyoming, known as the Chokecherry and Sierra Madre Wind Energy Project (CCSM). Our assessment began with the creation of wind maps and conceptual turbine layouts to determine feasibility. Next we designed and executed a wind measurement campaign. This was a significant task due to the project size and the complexity of the terrain with the project boundary. Over 30 meteorological towers were sited and sodar was placed in over 25 locations. One hundred twenty-five years' worth of data was collected and analyzed. The data was used with advanced wind flow modeling to better understand complex wind phenomena at the site. All of this information was crucial in planning 1,000 turbines layouts, and it continues to inform turbine selection for this high-capacity-factor site.

We continue to support the CCSM project. Several energy studies have been performed, including energy production reports, hourly time-series data to determine load coincidence, and studies showing whether micrositing adjustments altered energy production and if so, to what degree. Once built, the CCSM project will be one of the largest wind farms in the world.



**LOCATION:** Texas and New Mexico, United States

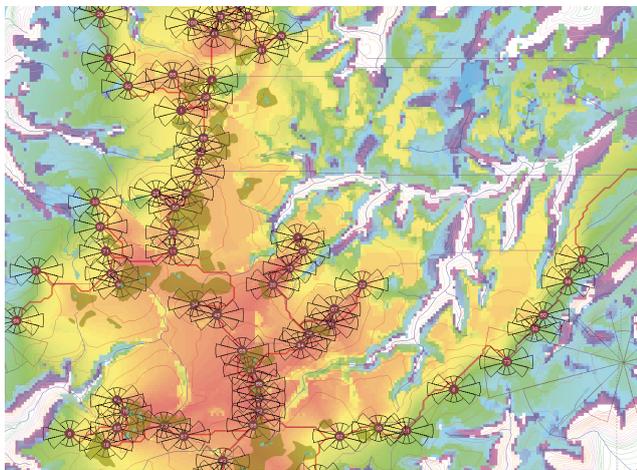
## Considering Balance of Plant Costs in Designing Wind Turbine Layouts

Designing the balance of plant (BOP: roads and electrical collection system) for a wind project is time consuming and expensive, and often occurs near the end of the development process when the plant layout is difficult to adjust. This can lead to missed opportunities for cost savings that could make a wind project more price-competitive.

Faced with this challenge, EDF Renewable Energy joined with UL (formerly, AWS Truepower) Mortensen, and Stanford University in a research study to demonstrate the capability of Openwind to reduce balance of plant costs and overall cost of energy in two EDF wind projects. We made modifications to Openwind to improve its BOP design and costing algorithms, and incorporated Mortensen's site-specific material and construction cost estimates.

For a recently built Texas plant, it was shown that through the use of Openwind's cost-of-energy optimization model, road costs could have been reduced by 15%, collection system costs by 7.8%, and total plant cost by 6.2%, compared to as-built. This would have lower the cost of energy by a substantial \$1.3/MWh. We also used this validated approach to inform the design of a project in New Mexico, which is currently under construction.

Openwind's cost of energy optimization tool allows developers to account for BOP costs much earlier in the development process, and to weigh them directly against energy production, producing a more competitive project design.

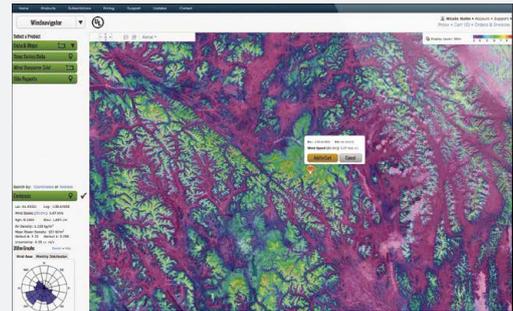


**Openwind is the only wind farm design tool capable of designing and costing roads and collection systems and optimizing for cost of energy.**

Our suite of software and data products supports the entire wind farm development process, from initial site prospecting to final design and energy estimation. We provide you with the tools your team needs to work on its own, as well as a platform to collaborate powerfully and efficiently with our experts.

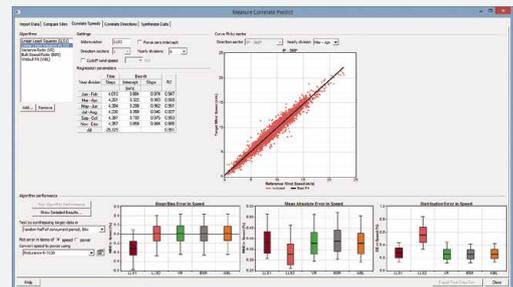
## Windnavigator

Windnavigator® is a web platform that allows you to view and access our high-resolution wind resource maps and data anywhere you have an Internet connection. Our clients use Windnavigator to prospect new wind development sites, browse global wind maps, query mean annual wind speeds at custom hub heights, and acquire wind statistics including Weibull values, wind roses and monthly diurnal distributions.



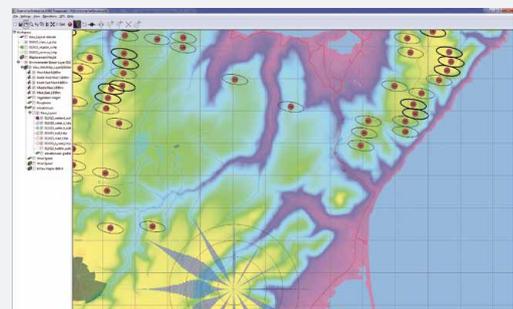
## Windographer

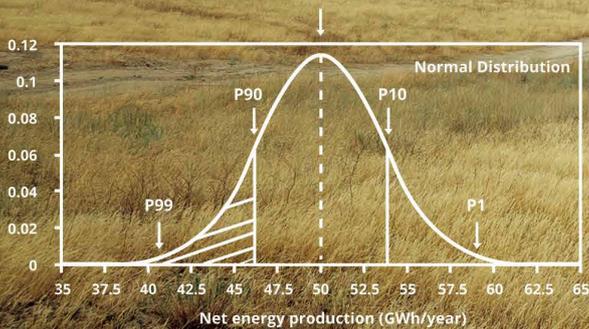
Windographer™ is the industry-leading software for analyzing wind resource data measured by met towers, sodar, and lidar. It quickly imports virtually every data format commonly encountered in the wind power industry, allows rapid quality control and statistical analyses including MCP, and exports to all wind flow models common to the wind power industry.



## Openwind

Openwind® software allows professional wind developers to design, analyze and optimize a wind project. Using an intuitive GIS interface, users can optimize for cost of energy, assess deep array wake impacts, define and analyze strategies for managed shut-down of turbines, uncertainty, and perform other advanced tasks.





## Preconstruction and Financing

We help make the critical financial close of a wind project as smooth and successful as possible. Our technical and commercial expertise, along with our understanding of the intricacies of project finance, make us the ideal partner for developers looking to raise capital. Our team of engineers and technical advisors will help you prepare your project for financing, mitigate risk, and help ensure it is technically sound and ready for construction. The approach we employ for our Independent Engineering (IE) reports has been thoroughly vetted with some of the world's top lead arrangers and lenders, so we know exactly what they are looking for, helping ensure a timely transaction.

### Services:

- Independent Engineer Reports for Financing
- Owner's Engineer
- Contract Review
- Civil and Electrical Review
- Turbine Technology Review
- Financial Model Review
- Review of Project Contractors and Capabilities
- Schedule and Construction Risk Review
- Curtailment Forecast
- Environmental Review
- Permitting Review

Bankable energy assessments throughout company history:

80,000 MW

**LOCATION:** Morocco

850+ MW

## Lenders Technical Due Diligence for 850 MW Portfolio Financing

In close relation with a bidding consortium, our company acted as independent technical advisor to lenders for Morocco's 850 MW national wind power tender. The project is spread across five sites around Morocco mixing simple and complex terrain, desert and temperate climates, from the north to the south of Morocco. In this capacity we performed: review of third-party energy yield assessments (EYAs), full independent EYAs and provided updated yield assumptions for the lender, technical review of the wind turbine technology, site suitability assessment including climate, wind conditions, review of specific load calculations, suitability to grid requirements, contract review including, TSA, BOP, O&M, PPA and project contracts, as well as assessment of the entire project contract structure, review of environmental impact studies. As a result, the bidding consortium was able to get necessary agreements with lenders for bidding on this tender.

**LOCATION:** France

128 MW

## Pre-finance Due Diligence for Six Projects

A major German bank hired our company to act as technical advisor for the financing of a wind farm portfolio located in France. Between 2014 and 2016, we evaluated six wind farm projects from the same developer, totaling 128 MW. We provided a detailed scope of review prior to project financing, covering contracts (EPC, TSA, O&M, PPA, grid connection, land lease), building permits and environmental assessment, turbine technology, project design (roads, foundations, electrical infrastructure), construction time schedule and inputs to the financial model. We subsequently supported our client during the construction phase of each project by providing a monthly review of construction reports, advising on compliance with budget and time schedule, analyzing change orders, providing review and validation of main contract invoices and confirming final acceptance of commissioning.

**LOCATION:** Texas, United States

## Bankable Energy Assessments for Several Wind Projects in Texas

Our typical project developer client seeks independent energy assessments multiple times through their development process. A confidential client sought our support for bankable energy assessment studies in Texas spanning the course of several years. The early results were needed to move the project through the client's internal approval process. Two years later, when they were seeking to secure project finance, we refined the analysis with the benefit of additional on-site data and improved inputs to the energy modeling process. Due to the nature of the project and site conditions, we conducted a more detailed analysis of the wake affects to further improve the accuracy of the energy projections. The project has since been financed and is operational.



**LOCATION:** Republic of Ireland

136.8  
MW

## Due Diligence to Support Construction Financing for Three Wind Projects

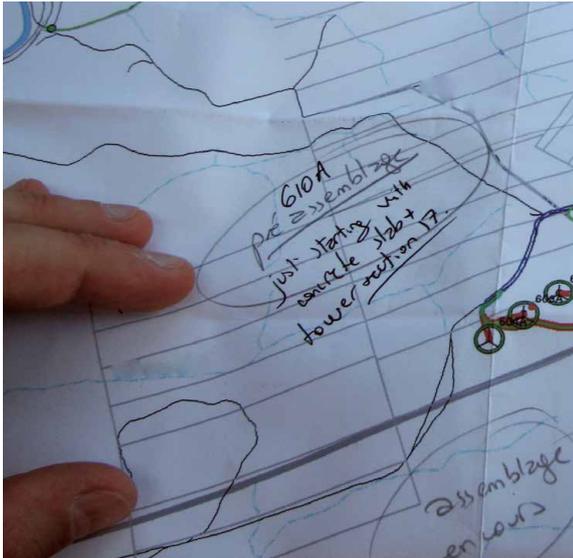
A due diligence was performed to support construction financing for three wind projects in the Republic of Ireland. The technical and commercial scope included independent verification and assessment of: balance of plant design, wind turbine technology, wind turbine site suitability, commercial agreements, curtailment, resource assessment and energy production, portfolio analysis, financial assessment, environmental legislation applicable to construction and operation, planning authority conditions for pre-construction, construction, operations and decommissioning, property and land rights documentation, equator principles, and construction monitoring.

**LOCATION:** Austria

207  
MW

## Technical Due Diligence to Support the Acquisition of a Portfolio in Austria

Contour Global hired us to provide full technical due diligence for the a wind porfolio they were looking to acquire in Austria. At Contour Global's request, our technical team reviewed the existing energy production reports for projects in development as well as all operating assets. We were asked to perform an analysis of the portfolio's operational data and prepare energy production reports. As part of this comprehensive analysis, our staff traveled to a number of project sites to inspect the balance of plant and review the potential risks associated with the operations and maintenance (O&M), as well as other key aspects on the projects. We also estimated future O&M costs, and provided CAPEX and OPEX (capital and operational expenditures) to the client. The resulting analysis and reports contributed to Contour Global's decision to acquire the 207 MW portfolio.

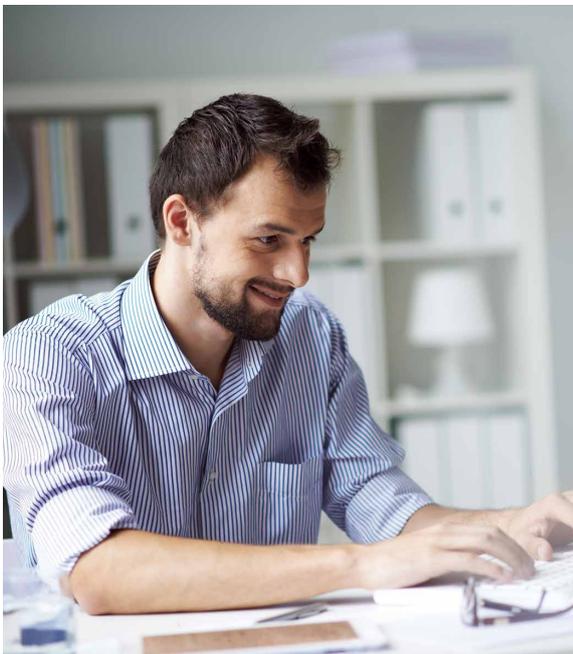


260  
MW

**LOCATION:** Andhra Pradesh and  
Madhya Pradesh, India

## Energy Yield Assessments to Support Ecoren Energy's Wind Development Activities in India

We supported the development of several wind farms throughout India, including Andhra Pradesh and Madhya Pradesh for Ecoren Energy India. For these projects our wind experts evaluated the proposed energy yield for a twenty-year period. Utilizing meteorological data from Ecoren's meteorological stations and our regional expertise, we conducted an assessment of the long-term wind resource. Ecoren has completed development on several of these projects and several more are underway.



150  
MW

**LOCATION:** Causapsal, Sainte-Marguerite-Marie and Sainte Florence, Quebec, Canada

## Energy Consultant and Independent Engineer for Wind Project in Quebec, Canada

The Vents du Kempt project retained us to act as the Independent Engineer and energy consultant for financing prior to construction. Vents du Kempt is a 101.05 MW wind plant located in the towns of Causapsal, Sainte-Marguerite-Marie and Sainte Florence, Quebec, which utilizes 43 Enercon E92 wind turbines. Our firm provided the Independent Engineering report prior to debt financing, which was provided by co-arrangers The Manufacturers Life Insurance Company and KfW IPEX-Bank GmbH as well as Caisse de Dépôt et Placement du Québec. We continued work on the project and provided construction monitoring through to commercial operation, which was reached in December of 2014. The project is jointly owned by Eolelectric Club, L.P. (51%) and Fiera Axium Infrastructure Canada, L.P. (49%).



## Construction

When your project moves into construction, we can help ensure that the construction process unfolds smoothly, on schedule and within budget. Whether you are looking for a desktop or onsite review of methods, documentation, schedule, or work quality, we can provide you with an independent progress assessment. In addition, our construction forecasting service can help you mitigate and manage weather delays. We can also review the technical aspects of construction and confirm compliance with the commercial closing requirements as defined by the credit or financing agreement and project documents.

Services:

- Construction Forecasting
- Construction Monitoring
- Progress Report Review
- Site Visits
- Schedule and Quality Review
- Drawdown Verification
- Substantial Completion Verification
- Factory Inspections



150  
MW

**LOCATION:** Oklahoma, United States

## Wind Forecasting Service to Facilitate Construction Activities

RES America Construction, Inc., contracted us to provide construction forecasts for a 150 MW wind farm located in Oklahoma. For a 3-month period, delivered twice-daily forecasts with a 72-hour (three-day) time horizon. Forecast parameters included wind speed, direction, and gust; temperature, precipitation, visibility, cloud cover, fog, and freezing rain, all for a height of 80 m above ground. Thanks in part to this service, construction was completed on time and the wind farm went into full operations in October 2014.

**LOCATION:** Kayseri Region, Turkey

82.5  
MW

## Pre-finance Due Diligence and Construction Monitoring of a Wind Farm

For a Spanish project developer, we analyzed and evaluated technical risks for an 82.5 MW wind farm with the following scope of work: turbine technology review, construction schedule, electrical and civil review, permits and licenses review, financial modeling / base case modeling, and major contracts review (TSA, O&M and BOP contracts).

150+  
MW

**LOCATION:** Mexico

## Construction Monitoring to Support Lenders

Upon the Notice to Proceed with Construction (after financing supported by our Independent Engineering report), we were engaged to conduct construction monitoring for this confidential 150+ MW wind project, located in Mexico. The monitoring included monthly site visits, drawdown verification, change order review, and completion certification, and was conducted on behalf of the lenders on the project.



# Operations

Manage expectations of operational plants and improve performance, including safe and reliable operations of wind projects beyond the original design life.

Services:

- Operational Energy Assessments
- Performance Analysis
- Plant Performance Optimization
- Remote Sensing / Lidar for Turbine Diagnostics
- Turbine Inspections
- Root Cause Analysis
- Lifetime Extension / Remaining Useful Life
- Loads Simulations
- Components Evaluation

**LOCATION:** France

22  
MW

## LIDAR-Based Measurement of Yaw Misalignment for Wind Project in France

Our company installed a nacelle-mounted LIDAR system to measure the degree of yaw misalignment for this 22 MW project in France. An optimization potential of 1.5% by correcting yaw misalignment in the wind project was identified. The project realized an increased AEP of 1.8% per turbine. Around 7000€ / year per turbine considering 80 € /MWh (for a 7.1° misaligned turbine).

**LOCATION:** Brazil

236  
MW

## Energy Assessments and SCADA Data Analyses for Brazil Wind Plant

Post-construction energy assessments with actual plant data were provided for a Brazilian wind plant of more than 70 MW, followed by an in-depth SCADA data analysis to diagnose existing underperformance issues and identify symptoms of damage in the main components of the wind turbines.

**LOCATION:** Canada

189  
MW

## Performance Analysis for Large Wind Developer in Canada

A confidential client wanted to obtain an in-depth evaluation of the performance of two wind farms in Canada and asked us to perform the analysis. In the first phase, based on the plants' SCADA data, we categorized wind turbine performance, identified and quantified sources of lost energy, and created a list of action items ranked by priority to correct and improve performance. One key finding was that the turbines were often in transitional states. Since then, the client has asked us to evaluate two additional projects in the same way.

**LOCATION:** California, United States

947  
MW

## Operational Assessment to Aid in Sale of One of the Largest Wind Projects in the United States

Terra-Gen Power announced that it would divest from the 947 MW Alta Wind project in Tehachapi Pass, California, USA, and sell it to NRG Yield. To support this transaction, we conducted an operational assessment to project future energy generation for Alta I-V. Relying on years of 10-minute SCADA data, we performed an in-depth investigation into plant operational issues, wake losses, and windiness corrections. Results showed that the initial energy production estimates had been too high. Our experts worked with Terra-Gen to determine a realistic best estimate of long-term energy yield. The sale was completed in August 2014.



**LOCATION:** Nebraska, United States

## Power Performance Measurement for Wind Project in Nebraska

More and more often for new plants, power performance tests are conducted to verify that the turbines are performing as they should. Such tests can even be a requirement for project financing and performance warranties. For a confidential client with a project in Nebraska, we tested three GE 1.5 MW wind turbines in accordance with IEC specifications. Initially, we completed a terrain and obstacle analysis, which led to a site calibration. Then we installed and commissioned the power measurement equipment on the three selected turbines and monitored their performance for three months. The conclusions were delivered in a comprehensive report to the client.



**LOCATION:** United States

69  
MW

## Operational Energy Production Assessment for Project Financing

Performed a detailed investigation of the performance of a wind project for a confidential client after a year of operation. Using SCADA data, benchmarking, and evaluating the project's operational reports, we provided the project owner with a better understanding of operational loss factors and identified areas of recoverable energy production for future operations. The results were used for project financing and considered in a portfolio benefit assessment.



155  
MW

**LOCATION:** Baja California, Mexico

## End-of-Warranty Inspection in Baja California

An end-of-warranty inspection was performed on a 155 MW wind farm in Baja California, Mexico. This work included general inspection, drive train inspection (gearbox and hydraulic actuators oil analyses, gearbox video-endoscopy, vibration analysis), blade inspections, switch-gear inspections (functional test, gas SF6 levels), yaw systems inspections and generator inspections. The work included an accredited acoustic test to comply with local regulations.

597  
MW

**LOCATION:** Spain

## Remaining Useful Life Calculations for Financial Recapitalization

A remaining useful life calculation was performed for a 597 MW project (comprised of 21 wind farms) for financial recapitalization. The project scope included probabilistic calculations for the main load stations (components) for all of the wind farms, as well as accredited wind turbine inspections for selected sample turbines for all wind farms. The probabilistic calculations were based on comprehensive uncertainty calculations and sensitivity factors per load station. The complete study contained a projection for OPEX and CAPEX beyond 20 years to ensure P50 life-values were met.

230  
MW

**LOCATION:** United Kingdom

## Remaining Useful Life for 17 Wind Farms for M&A Transaction

The lifetime extension potential was analyzed as part of a due diligence scope of work including performance assessment, contractual evaluations and technology reviews for 230 MW wind farm portfolio (17 projects) in the United Kingdom. The final report was redacted in English and Chinese and was considered by the buyer as crucial for the transaction.



## Technical Achievements and Advanced Studies

We pioneer solutions that overcome technical barriers. We are at the forefront of research in resource characterization, plant design, energy estimation and real-time forecasting. Look for more examples of our work in the Knowledge Center of our website.

## Study: Verifying Preconstruction Energy and Uncertainty Estimates

We were among the first to identify and close the gap between preconstruction wind energy estimates and actual production when we published our first backcast study in 2009. In 2012, we updated the study and implemented further improvements in our methods. This same transparency and drive for accuracy applies to all of our technical services.

## Offshore Wind: Moderating Impacts of Winter Natural Gas Price Spikes

Offshore wind has a strong coincidence with electricity demand profiles and produces maximum capacity factors during the winter. Our study demonstrating this powerful benefit was the winner of the 2014 AWEA Technology Award.

## Global Maps for Wind Site Prospecting

We were the first private company to apply mesoscale and microscale models to high-resolution, regional wind resource mapping. Today our detailed global maps remain the industry's leading site-prospecting tool. Through the web-based Windnavigator dashboard, these maps and associated wind roses and other data are available to our customers.

## Wind Flow Modeling Uncertainty

The uncertainty of wind resource and energy production estimates is a critical element in wind project financing. We developed a sophisticated uncertainty model, now in the Openwind software, that allows users to optimize the design of their monitoring campaign to minimize the uncertainty in future energy production.

## Environmental Losses

No stranger to severe environments, our company is at the forefront of research on associated energy losses in wind plant operations. Using 10-minute SCADA data from eighteen projects in sub-Arctic sites, we developed an icing-loss model that depends on turbine type and weather conditions.

## The Authoritative Reference on Wind Resource Assessment

"Wind Resource Assessment: A Practical Guide to Developing a Wind Project," published by Wiley in 2012, instantly became the authoritative reference on resource assessment methods for the global wind industry. This 280-page, peer-reviewed book provides guidance on how to achieve a high standard of resource measurement and analysis and addresses cutting-edge issues.



## Offshore

Our efforts have helped facilitate the growth of offshore wind markets globally. We have been active in the design and implementation of bankable wind resource and energy assessments and broad meteorological and ocean (metocean) studies to define reliable project design conditions. We integrate proven measurement and analytical methods with innovative observation techniques on fixed, floating and remote platforms. We leverage direct and remote sensing technologies for wind, wave, current, and atmospheric boundary layer characterization. Our pioneering wind and wake modeling capabilities, turbine technology assessments, and other technical evaluations quantify uncertainty and mitigate a project's technical risk.

### Services:

- Operational Energy Assessment
- O&M Assessment
- Commercial Contracts
- Off-Taker Agreement
- Curtailment
- Revenue Generation
- Future Up-Wind Build-Out Analysis
- Portfolio Effect Review
- Financial Modeling
- Turbine Technology Assessment & Track Record
- Maintenance Program Review
- Environmental Compliance

**LOCATION:** Europe

## Construction, Operations and Maintenance for European Offshore Wind Farms

As part of a strategy to further develop its services and offshore expertise, a leading renewable energy consultancy based in Japan engaged our company to provide a comprehensive overview on Europe's experience with the construction and operation of offshore wind farms. The assignment included the review of construction milestones and operational requirements in light of regulatory frameworks, as well as development and technology topics such as support structures, electrical connection and project management strategies. O&M issues such as required facilities, logistics, and the challenges imposed by offshore conditions complemented the work.

**LOCATION:** 50 miles from shore, United States

## Offshore Wind Resource Mapping to Facilitate Wind Energy Siting and Planning

The United States Department of Energy along with the National Renewable Energy Laboratory (NREL) contracted us to develop high-resolution (200 m) offshore wind maps of United States waters to facilitate wind energy siting and planning at the national, state, and project levels. The work has supported national policy development and the technical definition of build out potential. It has also supported the evaluation of selected BOEM Wind Resource Areas by NREL and others. The offshore wind mapping is inclusive of the Atlantic and Pacific coasts (including Hawaii), the Gulf of Mexico, and the Great Lakes. All mapping results, which include a variety of wind resource statistics at multiple heights, were independently validated by NREL.

**LOCATION:** Three miles southeast of Block Island, United States

## Project Meteorologist and Technical Advisor to Deepwater Wind

Project meteorologist and technical advisor for the first US offshore project to get full financing. Supported the metocean design input analysis for the project. Responsible for the wind resource monitoring program design and implementation, project meteorology, wind turbine assessment, project layout development, and energy production estimates.

**LOCATION:** Six miles from shore, United States

## Development Support for Cape Wind's Horseshoe Shoal Project

We have been instrumental in the technical support of the Cape Wind project from its inception. For the last fifteen years we have provided Cape Wind with services to support project feasibility, development, and pre-construction and financing activities. We conducted project meteorology, wind resource modeling, wind turbine layouts, energy production estimates, data analysis from offshore met masts, as well as visual assessments. The final energy production report was used to move the project to financing, including several recent iterations with varying turbine layout scenarios.

# We Help Renewable Energy Customers With:



## PROJECT DEVELOPMENT SUPPORT

Navigate project complexities in the earliest stages of development.

- Site Screening and Feasibility
- Turnkey Measurement Services (Met Masts and Remote Sensing)
- Resource Assessment
- Plant Design and Energy Assessment
- Technology Selection and Suitability
- Infrastructure and Balance of Plant
- Permitting Support and Environmental Assessment



## SOFTWARE AND DATA

Leverage the knowledge and expertise of our experts and enable your team to work independently.

- Windographer
- Openwind
- Windnavigator
- Wind Data Management
- Resource Maps
- Time Series Datasets
- Site Specific Reports



## ASSET MANAGEMENT

Manage expectations of operational plants and improve performance, including safe and reliable operations of wind projects beyond the original design life.

- Operational Energy Assessments
- Performance Analysis
- Plant Performance Optimization
- Remote Sensing / Lidar for Turbine Diagnostics
- Turbine Inspections
- Root Cause Analysis
- Lifetime Extension / Remaining Useful Life
- Loads Simulations
- Components Evaluation



## GRID SOLUTIONS

Understand renewable energy variability and the impact of weather-driven events:

- Real-Time Renewable Forecasting
- Grid Management and Planning Services
- Atmospheric Modeling and Applied Research



## ENERGY STORAGE SOLUTIONS

Address safety concerns for large battery systems for wind and solar integrators and OEMs.

- Testing and Certification
- Performance Testing
- Custom Research



## DUE DILIGENCE

Mitigate the risks associated with renewable energy project investment:

- Independent Engineering and Technical Advisory
- Pre-Construction, Operational and Repowering Projects
- Custom Support for Investors, M&A, Tax Equity
- Turbine Technology, Civil and Electrical Design Review
- Contracts Review
- Environmental Permitting Review
- Financial Model Review
- Construction Monitoring
- Owner's Engineer



## CERTIFICATION

Confirm compliance and provide assurance and confidence in wind technology.

- Certification of Turbines and Components
- Project Certification
- Grid Code Compliance
- Assessment of Construction and Foundations



## TESTING AND INSPECTION

Verify the safety, reliability, performance and compliance of wind turbines and components.

- Validation and Type Testing
- Mechanical Loads
- Power Performance Testing
- Electrical Characteristics
- Low Voltage Ride Through Testing



## CYBERSECURITY

Help validate and substantiate security claims, meet regulatory requirements and mitigate risks of cyber incidents.

- Training
- Custom Security Testing
- Penetration Testing
- Code Review
- Risk Analysis
- Gap Analysis



## RESEARCH AND ADVANCED STUDIES

Research in electrical safety, renewable resource characterization, plant design, energy estimation and real-time forecasting.

- Custom Research
- Market Studies

# Key Office Locations



## AFRICA

Johannesburg, SOUTH AFRICA

## ASIA PACIFIC

Beijing, CHINA

Suzhou, CHINA

Bangalore, INDIA

Ise, JAPAN

Tokyo, JAPAN

Seoul, KOREA

## EUROPE

Lyon, FRANCE

Bremen, GERMANY

Cuxhaven, GERMANY

Hamburg, GERMANY

Oldenburg, GERMANY

Wilhelmshaven, GERMANY

Milan, ITALY

Ansoain (Navarra), SPAIN

Barcelona, SPAIN

Izmir, TURKEY

London, UNITED KINGDOM

## LATIN AMERICA

Buenos Aires, ARGENTINA

São José dos Campos, BRAZIL

Rio de Janeiro, BRAZIL

Bogotá, COLOMBIA

Mexico City, MEXICO

## NORTH AMERICA

Albany, New York, UNITED STATES

Northbrook, Illinois, UNITED STATES

San Diego, California, UNITED STATES

San Jose, California, UNITED STATES



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