

# Renewables

## Solar Energy 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.



UL operates in more than  
**140**  
COUNTRIES

**200,000+ MW**  
*Total megawatts assessed*

**500+**  
RENEWABLE  
ENERGY EXPERTS

**35+** years of  
EXPERIENCE IN  
RENEWABLE ENERGY



**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



# 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



## OPERATIONAL 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 AND BANKABILITY

Mitigate the risks associated with renewable energy project investment:

- Independent Engineering
- 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



# Project Development Support

Identify potential risks and complexities at the earliest stages of development with UL's feasibility and development services. With a broad set of offerings that can be customized to individual project needs, we are able to assess feasibility and technical risk to help inform critical development decisions related to siting considerations, equipment selection, design, and environmental and jurisdictional concerns.

As an experienced renewable energy consultant, UL is able to adapt services to suit the client's specific stage of project development and situation. Our offerings include providing an expert opinion, providing resource and energy data and using refined analysis tools to provide meaningful information to support development decisions. Some of our standardized products and services include the following:

- Regional GIS Site Screening
- Individual Project Feasibility Assessment
- On-Site Solar Data Collection, Quality Control, and Validation
- Desktop Solar Resource Assessment and Typical Meteorological Year (TMY) with Modeled Solar Data
- Bankable Long-Term Resource Assessment Study and TMY with Measure-Correlate-Predict
- Equipment Recommendations and Verification
- Conceptual Project Design Drawings
- Project Configuration/Design Optimization
- Conceptual Design Review
- Energy Production Estimates
- Energy Yield Comparison for Multiple Designs

## On-Site Inspection and Construction Services

When your project moves into construction, UL can help ensure that the process unfolds smoothly, stays on schedule, and remains within budget. Our construction services include the following:

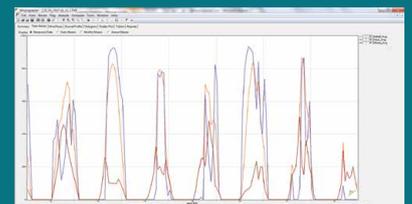
- Construction Forecasting
- Construction Monitoring
- Progress Report Review
- Feasibility Site Visits
- Schedule and Quality Review
- Drawdown Verification
- Substantial Completion Verification



# Software and Data

UL offers several software solutions to support solar project analysis. From solar resource maps for initial prospecting and site identification to data validation tools and 24-hour access to our online Solar Data Management platform, UL is committed to providing users with accessible and powerful software for solar project evaluation. Our services in this area include the following:

- Solar Resource Maps with Modeled Data—for initial prospecting
- Solar Data Management Dashboard—for resource data measurement validation and reporting
- Windographer—for resource data analysis and evaluation





UL has assessed  
**100+ UTILITY-SCALE  
SOLAR PROJECTS**  
since 2013





40+

SPECIALIZED

SOLAR ENGINEERS





## Operational Asset Management

As solar projects move into the operational phase, it is critical to evaluate and enhance their operational performance. Operational performance assessment leads to reduced uncertainty in future energy and revenue projections and can also reveal areas where project performance may be improved through strategic and attentive O&M activities. These services may be applied to an individual project or across a portfolio to support the valuation of operational assets and identify areas where performance may be improved.

- Operation Energy Assessments
- SCADA Data Review and Reporting
- Plant Performance Analysis and Optimization
- Monthly Resource and Energy Reporting
- O&M Review and Optimization
- Grid Curtailment Analysis
- Verification of Loss Factors
- Portfolio Benefit Analysis



# Due Diligence and Bankability

Investing in a renewable energy project or portfolio is a complex endeavor that requires an extensive evaluation effort.

## Independent Engineering

As a lenders' Independent Engineer, UL applies technical and commercial expertise to address project risks and propose mitigation, making financial close as smooth as possible. With extensive experience and a sound reputation as a Renewable Energy IE with some of the world's leading arrangers and lenders, UL combines technical experience with an understanding of the intricacies of project finance to proactively evaluate projects for financing.

## Project Overview

Site Layout  
Initial Site Visit

## Energy Production Report

Energy Production Report Summary  
Energy Loss Review

## Technology Review

Solar Site Suitability

## Balance of System Design Review

Foundation and Geotechnical Design Review  
Electrical Design Review

## Third-party curtailment and congestion summary

### Contracts Review

Power Purchase and Hedge Agreements  
Interconnection Agreements  
Equipment Supply Agreements  
EPC Contract/Balance of System Contracts  
EPC Performance Guarantee  
Schedule and Scope Agreements  
O&M and Asset Management Contracts  
Shared Facilities and Co-Tenancy Agreements

## Environmental and Permitting

### Financial Assessment

CAPEX Review  
Operating Assumptions Review  
OPEX Forecast

### Construction Monitoring

Progress Report Review  
Construction Drawdown Verification  
Construction Monitoring Site Visits

## Technical Advisory

Differently sized investments require different levels of review. UL offers guidance on the best path for due diligence, and identifies the critical risks. Our project evaluation strategies are adaptable for the specific nature and size of the project.

### Energy Resource

Pre-Construction Energy Production Estimate and P-Tables  
Operational Energy Production Estimate and P-Tables  
Third Party Review of Pre-construction Energy Estimate  
Review of Preliminary Layout  
Site Inspection and Review (Environmental, Jurisdictional, Other)

### Technology and System Design

Technology Review (Modules, Inverters, Mounting Structures and System Integration)  
Equipment Suitability Assessment Based on Climate Conditions  
Assessment of Extended Project Lifetime (Technical Failure Risk, Longevity, Contract Extension Review and O&M Projections)  
Balance of System (BOS) Design  
Civil and Geotechnical Review  
Electrical Design Review

### Warranty and O&M Review

EPC Contractor Agreement (Equipment Supply and Performance Guarantee)  
O&M Agreements  
OPEX Costs



*Investors/lenders engineer for*  
**500 wind and solar**  
**projects since 2012**





FORECAST PROVIDER FOR

70 gigawatts

of centralized and distributed  
wind and solar generation capacity  
across the world



# Grid Solutions

Our grid solutions group principally focuses on integrating large quantities of renewable energy into the power grid. As the renewable energy market grows, so does the importance of quantifying the impact of centralized and distributed solar technologies on our power infrastructure. Understanding power generation characteristics that result from solar variability across space and time is key to ensuring safe, reliable and economical operations.

UL applies its expertise in renewable energy to predict the variability of wind and solar energy sources and the resulting impact of weather-driven events on utility operations. Our strength is understanding the key drivers through advanced techniques in atmospheric modeling.

## **Forecasting for Energy Integration**

- Individual Plant Power Production Forecasting
- Services to Support Real-Time Dispatch Operations
- Minutes-, Hours-, Days-Ahead, Seasonal Power and Resource Forecasting
- Distributed Energy Resources (DER) Forecasting
- Solar Power Forecastability Studies
- Services to Support Emergency Management and Response
- Load Forecasting
- Forecasting for Energy Traders
- Dynamic Line Rating

## **Grid Management and Planning Services**

- Capacity Expansion Modeling and Infrastructure Planning
- Transmission and Distribution Planning and Investment
- Grid Reliability Sensitivity Studies
- High-Penetration Scenarios and Modeling for DER
- Optimization of Future Solar Plant Capacity
- Estimating Potential Solar Plant Capacity
- High Frequency, Sub-Hourly Power and Resource Profiles
- Load Coincidence Studies
- Smart and Micro-Grid Storage Optimization Studies
- Resource Mapping

## **Atmospheric Modeling and Applied Research**

- Modeling Plant Availability
- Occurrence and Energy Impact of Icing Events
- Synthetic Power and Resource Profiles
- Historical Plant or Geographic Region Forecasts
- Storage Planning, Capacity and Discharge on Renewables
- Advanced Forecasting Research
- Uses of Stochastic Data in Grid Operations



# Testing and Inspection

UL will handle the entire product evaluation process to applicable standards and deliver the required reports and certifications. If standards are not published, UL can assist in defining the requirements to achieve your objective. All products and components used in PV systems apply, including modules, inverters, racking and mounting system, trackers and all other balance of system (BOS).

## Performance

While safety standards are important, project developers, financiers, investors, banks and other stakeholder are also concerned about the performance of the products that make up a PV plant. UL performance testing services determine how a product performs in terms of output power, energy yield and long-term stability under certain stressors.

## Durability and Reliability

The ability to withstand a particular stress and maintain operation—and to continue to do so over time—is integral to product performance. While standards for PV reliability are not yet published, UL applies a methodology based on a sequence of well-known test elements combined with conditions specific to the intended installation site.

## Factory Inspections

Highest confidence in PV products is achieved when a PV product line is only tested and when the production facility is evaluated for reproducibility so that every item produced performs to specifications. Key elements of UL

Technical Factory Inspections include a quality audit, equipment calibration verification and observation of in-line testing during the site visit.

## Marketing Claim Verification

A manufacturer's claim of high performance or accuracy is often not trusted until independently verified. UL draws on its scientific acumen and testing experience to determine the accuracy of product marketing claims that allow our clients to differentiate themselves. The manufacturer may also choose to apply the UL Verified Mark on products and packaging and in advertising and communications.

## Product Field Evaluations

Uncertified products (i.e. modules, racking and wiring harnesses) that are discovered during project construction can result in delays by inspectors. UL can assist by evaluating the installed product and/or samples in the lab, and the evaluations may lead to approval by the appropriate authority.

## Global Market Access

While regulatory requirements for different markets may share some common elements, each country or region may have specific needs. UL takes an integrated and customized service approach to meet all of your product compliance needs. UL's global service package provides a complete compliance solution spanning the entire process across multiple regulations, enabling regional access or up to global market access.



# Certification

## Safety Certification

When an installed PV product fails it is imperative that it fail safely and does not create a shock or fire hazard. UL will evaluate PV products' construction to applicable safety standards and follow up with the necessary testing; a compliant result leads to certification and authorization to apply the UL Safety Mark.



Evaluated  
**1.7 GW**  
of installed  
PV systems

**1000+**  
*PV product  
evaluations  
annually*



## Standards

UL understands the challenges of introducing new technologies. We occupy a key leadership position in major international standards development and harmonization bodies, such as the IEC. At the same time, we are investing heavily in new standards development for innovative or enhanced balance of system (BOS) technologies, such as modules, inverters and converters.

UL is active on all National Electrical Code-making panels, and on various technical committees of the International Electrotechnical Commission (IEC) and the International Standardization Organization (ISO). Globally, UL plays a key role for the U.S. in the development of foreign standards and the harmonization of national and international standards. UL actively participates in the development of the International Code Council (ICC) building and fire codes. Our deep understanding of codes and standards provides active assistance to code authorities in resolving product acceptance issues and potential conflicts between codes and installation requirements to help keep PV projects on track.



# Research and Advanced Studies

UL is at the forefront of research in electrical safety, solar resource characterization, plant design, energy estimation and real-time forecasting.

## Research Commitment

Through our long-term commitment to research, we collaborate with industry stakeholders on the innovative technologies of tomorrow. Our close collaboration with renowned national and university laboratories and cutting-edge manufacturers allows us to rigorously evaluate new technologies in our research labs, and gives us a unique role to play in the ongoing technological evolution. Our expertise on greater PV safety, performance and quality are guiding the industry forward, creating increased acceptance, expanding markets and delivering a competitive advantage.

## Installer Training

The PV System Installation course provides critical knowledge of solar energy and systems applied to PV installations. It also focuses on gaining a full understanding of how to organize a successful PV installation project.

### Fire Resistance Testing of PV Panels

With funding from the U.S. Department of Energy, UL and the Solar Board for Codes and Standards (Solar ABCs) developed a test plan to investigate the fire resistance properties of PV panels supported on standoff mounted rack configurations. Rigorous testing revealed that the performance of a system (which includes PV modules on standoff mounted racks) exposed to fire or flame is not the same as that of a module alone. As a result of the testing, a new methodology was adopted by the UL 1703 Standard Technical Panel and was published October 25, 2013.

### The Cloud Tracker Project

For this project, UL developed a novel approach to modeling clouds and their impact on high-frequency (~one second) synthetic irradiance and power data for proposed solar PV. The approach combines a mesoscale Numerical Weather Prediction (NWP) model with a microscale model called the stochastic-kinematic irradiance estimation system (SKIES). The model simulates cloud movement and evolution that accounts for rapid ramps in solar irradiance and power generation. It also creates one-second solar irradiance and power production data at utility-scale and distributed PV

sites. The model was validated against high-frequency observations at 25 locations in Hawaii and is able to simulate solar irradiance fluctuations. In the Hawaii study, the modeled ramp distributions on time intervals (ranging from ~one second to one hour) agreed with observed ramp distributions. The modeled power spectral density (PSD) also had a shape and features similar to the observed PSD. SKIES can be used to support high PV penetration scenarios and grid operations under different market conditions, electrical system reliability studies and the application of storage to reduce cloud-induced ramps.

### PV Module Backsheets

The Department of Energy initiated the project "Physics of Reliability: Evaluating Design Insights for Component Technologies in Solar 2" (PREDICTS2), which began in 2015. The goal of this project was to identify predictive tests for degradation of PV module backsheets and to use that information to establish predictive models relative to PV module reliability. The predictive tests and models specify indoor/outdoor exposure and evaluation data acquisition criteria, variable selection and temporal duration/variation so as to be able to predict backsheet performance in various climatic zones.

# 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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