

Solar expertise you can trust in Latin America



Safety. Science. Transformation.™

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Table of contents

Introduction

Over the last ten years in Latin America (LATAM) and the Caribbean, the energy capacity of solar photovoltaics (PV) has increased more than 110 times, growing to more than 64.5 gigawatts in 2023.¹ In 2021, solar photovoltaic energy generation in the area reached more than 38 terawatt hours.² Brazil alone surpassed Germany and India to become the world's third largest solar market in 2023, behind only China and the U.S.³

The region is constructing more than four times the amount of solar capacity being built across Europe, and nearly seven times more than in India.⁴ And yet, solar power currently generates only 3 to 4% of the electricity produced across LATAM and the Caribbean. However nearly new 250 projects under construction could provide 19,429 megawatts of solar power capacity, so the region's solar power supply potential could jump 70%.⁵

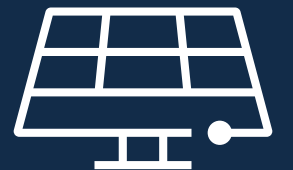
Countries in Latin America and the Caribbean have the largest solar power development pipeline outside Eastern Asia and North America, making the bloc a key renewable hot spot to track over the coming decade. Decisions made during project development are crucial to long-term success.

To meet this demand, energy producers working with UL Solutions have access to proven science, expert engineering and innovative services that address the unique challenges of solar energy production. The comprehensive portfolio for renewable energy from UL Solutions helps stakeholders plan, design, finance, build, invest, operate, maintain and manage solar projects throughout the lifecycle and across the value chain.



In 2023, the solar energy market in Latin America reached a value of approximately 16.60 gigawatts. The market is estimated to grow at a compound annual rate of 7.6% between 2024 and 2032, to reach a value of

32.10 gigawatts
in 2032⁶



We work with your team in the way that makes the most sense — either as a technical advisor or by providing access to resource data, online services and advanced software — enabling your team to do the work yourself.



Help you navigate project complexities in the earliest stages of development



Provide site screening and feasibility assistance, turnkey measurement services, resource assessments, plant design energy assessment guidance



Help with technology selection and suitability choices, infrastructure and balance of plant guidance, permitting support, and environmental assessment.

Partner with a company that has at its core a strong foothold in science to help guide you through the entire project lifecycle from site selection to construction inspection and battery storage studies to end-of-life equipment removal.





Site screening and feasibility

The first step in solar energy project development is identifying the best site with solar incidence. Selecting the right site for your project is a prerequisite for success. We use site screening tools, feasibility studies and field assessments to determine resource potential and identify new opportunities for solar energy development. These essential tools allow your team to mitigate risk and navigate complexities in the early phase of project development to help ensure long-term success.

We share our knowledge about the beneficial characteristics of sites being considered for power plant development with you through site visits, review of studies performed and analysis of planned technologies. We help you by providing access to proven science, expert engineering, the best available data and software, and a full range of innovative solutions.

Latin American countries have high solar irradiation levels, particularly in areas like the Atacama Desert in Chile and the Northeast region of Brazil. This natural potential makes solar energy an attractive option for electricity generation. Many LATAM governments have implemented policies to encourage the adoption of renewable energy, including solar. For example, Mexico's solar market has expanded quickly, thanks to energy reforms and competitive auctions for solar projects. Our strong relationships with governmental regulatory entities and expertise in standards development are useful to our customers who do not have the resources needed to focus on them.

Desktop site screening

We have developed tools to support fast and effective screening for solar project sites. When multiple sites are under consideration, the calculated cost of energy, load matching quality, and other factors play a part in rankings. Our comprehensive assessments provide developers with a better understanding of parcel value and help prioritize next steps. Using our solar resource maps and observational data; geographic information system (GIS) layers including land cover, land use, and development exclusions; and an understanding of your project objectives, we can help identify and assess your siting options.

Typically, the process considers the following factors:

- Solar resources
- Buildable area
- Transmission lines
- Important siting parameters

Field assessments

The initial desktop site screening is usually followed by site visits by our field engineers, who will work with your team to ground-truth the assumptions, obtain additional information, select places to install solar monitoring stations to characterize the resource, and address issues such as:

- Road and transmission access
- Potential visual and noise concerns
- Issues of cultural, environmental, historical or other community sensitivity
- Possible solar monitoring locations, including site coordinates, access and surroundings
- Cellular telephone service reliability for automated data downloading



Preliminary bankable energy assessment and optimization

Optimal plant design and accurate energy assessments are the key to realistic expectations for project performance and have a significant impact on project finance. We pride ourselves on being transparent, using calibrated energy assessment methods that have been validated against operational data. The foundation of our energy assessments includes high-resolution models, resource assessment campaign design, and rigorous measure-correlate-predict (MCP) analyses.

Globally, the cost of solar PV panels and associated systems has dropped significantly, making solar installations more affordable. But, a feasibility study is required to help you weigh the potential risks and rewards in developing a project before making large investments in monitoring and other project development activities.

A typical study will include some or all of the following elements:

- Preliminary resource assessment based on available resource maps and data
- Preliminary layout, turbine selection and energy production estimate
- Technical feasibility and technology options
- Potential environmental concerns such as visual and noise impact and threats to endangered species
- Regulatory requirements and challenges
- Interconnection options
- Potential challenges for community acceptance
- Cost and revenue projections and financial pro forma

Early-stage design and energy assessment

Using our satellite-based solar resource maps and time series data, we can develop a preliminary design for your

project and estimate its annual energy output quickly and efficiently.

Early-stage assessments of solar projects can serve several goals:

- Guide technology selection
- Gauge development potential
- Support permitting and community acceptance
- Support financial models and early-stage financing

Advanced design and energy assessment

Optimizing your solar plant design and accurately estimating its future production are essential to a successful outcome. Our methods and technical know-how are based on proven science, are transparent and proven, and have been validated against operational data.

Battery storage hybridization studies and software

We provide best-in-class, comprehensive advisory, due diligence and owner's engineering services to help you understand the evolving storage landscape. This includes technology risks, warranties, performance guarantees, contract reviews, resource planning and financial reviews, such as capital expenditures (CAPEX) and operations expenditures (OPEX) assessments, as well as augmentation strategies.

Our advisory services benefit anyone with a vested interest in understanding the key contributors to a plant's energy and economic loss profile and the specific actions to mitigate and manage those risks, improve energy yield and increase revenues. Performance and advisory services are for engineering, procurement, construction (EPC) companies; developers; investors; insurance providers; equipment suppliers; asset managers; operations and maintenance (O&M) managers; and plant owners.

Our services are highly customizable to better accommodate your analytical needs and specific requirements. Customers trust us to provide them with the following services:

Distributed energy generation resources, residential, commercial and industrial, and microgrids

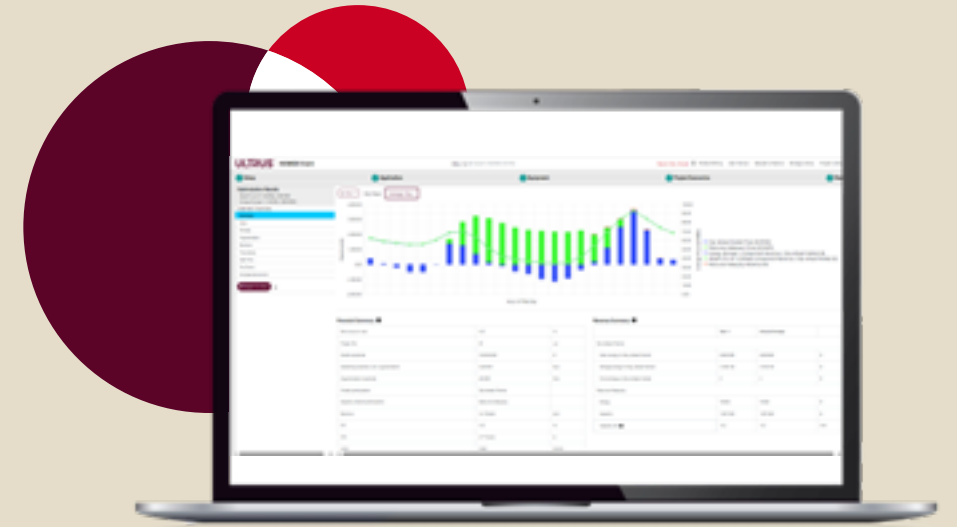
- Techno-economic optimization using HOMER Grid and HOMER Pro, our distributed generation and microgrid modeling tools
- System sizing and optimization
- Advanced sensitivity and reliability analysis
- Accurate tariff, incentive, resilience and demand response modeling
- Detailed, dynamic, multiyear and custom schedules

Storage energy models and economic analysis

- Preliminary site design, architecture and optimization
- Energy and capacity market simulation
- Solar and energy storage sizing and economic analysis
- Independent energy yield and energy model assessments
- DC versus AC inputs, shading, clipping, conversion efficiency and tracking
- Loss analysis including auxiliary load
- Grid and plant curtailment
- Battery augmentation planning and replacement strategies
- Equipment health, degradation, and risk analysis for modules, DC, trackers, inverters
- O&M oversight and improvement assessment

HOMER Front Hybrid Optimization, part of **ULTRUS™** software, is built on our trusted HOMER hybrid power optimization platform. HOMER Front Hybrid Optimization software provides a powerful online web application that helps you model and optimize the technical and economic performance of utility-scale battery energy storage systems (BESS), solar and wind— independently or as hybrid systems.

Utilizing the software's simple, intuitive interface and robust simulations, you get critical, actionable insights into maximizing multiple energy markets and revenue streams, and determining the most efficient system size, battery dispatch and augmentation strategies.



You can determine the winning system faster when you optimize essential aspects of your design with HOMER Front software, such as:

Sizing your system: Calculate the optimal size of energy storage, solar, wind and other components in utility-scale systems — whether as standalone, single energy resource systems or combined in hybrid systems.

Managing battery augmentation: Model battery lifetime, capacity degradation and augmentation or replacement strategies to minimize ongoing expenses and maximize revenue. Custom storage capability enables you to input details that replicate commercially available batteries.

Utilizing robust sensitivity analysis: De-risk your internal rate of return (IRR) by conducting a sensitivity analysis on key performance parameters that often fluctuate, such as solar irradiance or energy market prices. Screen project sites and evaluate site and system economic viability.

Comparing revenue streams for energy markets worldwide: Perform detailed, holistic modeling of most major electricity markets worldwide, including day-ahead, merchant,

wholesale or real-time energy markets down to a 15-minute interval. Evaluate power purchase agreements with time-of-delivery obligations, capacity markets and ancillary services such as frequency regulation. Stack and compare multiple revenue streams and dispatch strategies and calculate revenue possibilities. Select from all major monetary currencies and customize inputs for a specific country or region.

Product factory acceptance testing (manufacturer quality)

Safety in solar installations is essential for protecting individuals, ensuring compliance with legal requirements, maintaining system performance and fostering the sustainable growth of the solar industry. It is a critical consideration at every stage, from design and manufacturing to installation and operation.

Solar safety certification refers to the process by which solar energy products and systems, such as PV panels, inverters, mounting systems, and other related components, are evaluated and tested to ensure they meet specific safety standards and performance criteria.



Key aspects of solar safety certification

Photovoltaic modules are installed in extreme environments such as heavy snow, high winds or desert conditions. Installations such as these expose materials to stresses for which stakeholders need the reassurance of the long-term safety of the system. Standards are a way of reducing risk by introducing consistency to essential design features that address safety requirements.

PV modules

Our wide range of services for PV modules cover all types: crystalline, thin-film, building-integrated PV (BIPV) and concentrator PV. Solar products are tested against established safety and performance standards set by recognized standardization bodies. These standards may include electrical safety, fire safety, mechanical stability, and environmental durability, for example:

- UL 1703, the Standard for flat-plate photovoltaic modules and panels, primarily used in North America.
- IEC 61730, Safety qualification for PV modules, addressing electrical and mechanical safety, as well as fire hazards.
- IEC 61215, Reliability qualification for crystalline silicon terrestrial PV modules, focusing on long-term operation and environmental exposure

PV inverters and BESS converters

We provide inverter and converter testing and certification and evaluation services for compliance with a wide range of local, national and international standards to original equipment manufacturers.

We test power inverters, converters and power plant controllers (PPC) to the requirements of all key international standards, including:

- UL 1741, the Standard for Inverters, Converters, Controllers and Interconnection System Equipment for use with Distributed Energy Resources (DER)
- UL 62109, the Standard for Safety of Power Converters for Use in Photovoltaic Power Systems
- UL 1699B, the Standard for Photovoltaic (PV) DC Arc-Fault Circuit Protection
- IEC 62909, the standard for bi-directional grid connected power converters
- IEC 62109, the standard for safety of power converters for use in photovoltaic power systems
- IEC 62477, the standard for safety requirements for power electronic converter systems and equipment
- IEC 62920, the standard for photovoltaic power generating systems – EMC requirements and test methods for power conversion equipment

Certification Testing and Evaluation

Independent testing laboratories and certification bodies conduct rigorous testing and evaluation upon solar products to assess their compliance with the relevant standards. This includes testing for electrical safety, potential fire risks, mechanical loads (such as wind and snow), and resistance to environmental factors (like UV exposure and temperature fluctuations).

It is important to note that the specific steps and requirements can vary depending on the product category, the complexity of the product and the applicable safety standards.



Certification

After evaluation and testing, products that successfully comply with the applicable requirements are authorized to apply the UL Mark to their certified solar products.



Certification surveillance

Certification often involves not just a one-time test but also ongoing testing and inspection to ensure that products continue to be produced in compliance with the certification requirements. This may include factory inspections and periodic re-testing of products.



Consumer confidence

Third-party Certification provides consumers and businesses with confidence that the solar products they purchase are compliant with the applicable safety standards. It also helps to differentiate quality products in the market.

**Request for
certification**

**Certification
decision**

**Follow-up
services**

**Initial
evaluation**

**Factory
inspection**

**Product
testing**

**Test results
and analysis**

**Product
modifications**

**Market
surveillance**

A photograph of two professionals, a man and a woman, wearing safety glasses and high-visibility orange and yellow vests. They are standing on a construction site, looking down at a set of papers the man is holding. The background is slightly blurred, showing industrial equipment.

Due diligence for financing projects

Understanding and mitigating the risks associated with renewable energy projects is critical for developers, lenders and investors alike. As one of the world's leading and most experienced renewable energy technical advisors, we provide comprehensive, flexible and timely due diligence services for the solar industry to help you make sound investments in the future of solar energy in Latin America.

Our team of engineers and technical advisors will assist you in preparing your project for financing, mitigate risk and help ensure it is technically sound and ready for construction. As your independent engineer, our experts apply technical and commercial expertise to address project risks and propose mitigation, making financial close as smooth as possible. Our relationships with some of the world's leading arrangers and lenders combined with our technical experience and understanding of the intricacies of project finance to proactively evaluate projects make us an ideal partner.

Our standard areas of review on equity investments include:

- Energy review
- Data room audit and key risk analysis
- Technology review
- Contract review
- Review of technical inputs to the financial model
- Site visit
- Curtailment and revenue estimation
- O&M review and cost projection
- Future up-wind build-out analysis
- Company due diligence and staff interviews
- Portfolio review

Identifying and mitigating renewables investment risks

We support developers and lenders in their evaluation of technologies and projects for debt and equity investments. Our independent engineering (IE) reviews deliver objective information from a full scope of services needed to identify and mitigate the possible risks in solar projects. Our solid reputation and global bankability in the renewable energy industry has been built on experience, quality and transparency, and our track record reflects the trust that lenders have placed with us to help ensure project viability and profitability.

Technical and commercial expertise, along with our understanding of the intricacies involved in project finance, allows us to fully support developers looking to raise capital and lenders looking to finance energy projects. The approach we employ for our reports has been thoroughly vetted over time with some of the world's top lead arrangers and lenders, so we know exactly what they are looking for. We will guide you through the technical aspects of financing so your project can

secure the capital it needs to thrive. We offer a full scope of IE services for IE reports, but we can also tailor a scope to fit our clients' specific needs.

Independent engineering reports include:

- Contracts review
 - Power purchase and hedge agreements
 - Interconnection agreements
 - Turbine supply agreements
 - Balance of plant contracts
 - Schedule and scope of agreements
 - O&M and asset management contracts
 - Shared facilities and co-tenancy agreements
- Financial assessment
 - CAPEX review
 - Operating assumptions review
 - OPEX forecast



Construction supervision and inspection

During the construction and commissioning phases of a renewable energy project, we provide construction management and monitoring services to help ensure that project milestones are completed, the work conforms to the project design, quality controls are being met and potential delays or cost overruns are identified.

On-site visits to the project occur either on a monthly or milestone basis during the construction phase of the project. On-site reviews typically include:

- Review of final design for general compliance with contracts, and the progress of the design for compliance with the scheduled milestones
- Review of proposed work plans and quality control procedures
- Observe work in progress to determine that the project is proceeding according to the milestone schedule and design
- Consultations with the owner and contractor in advance of major inspections or important work phases
- Progress reports including budget and schedule variances and photos

Construction management

Our service includes full-time on-site monitoring by our staff lender's engineer whose primary role is to monitor the engineering, procurement and construction during a project's construction period. The on-site lender's engineer interfaces with all of the project construction stakeholders to provide feedback to the lender regarding construction conformance to the project design and schedule, reviews of work plans and quality control procedures, and provides consultations in advance of inspections and major work phases.

During the project start-up and testing phase, we provide independent assessments of performance guarantee satisfaction, initial operations, and completion of construction contracts. Services typically include:

- Review test procedures to confirm compliance
- Monitor data collection procedures
- Review loan requisition certificate and supporting documentation
- Prepare the engineering certificate for clients and lenders
- Witness performance testing
- Review test reports from contractor and owner
- Prepare final report/letter verifying the attainment of performance guarantees from contracts

We monitor the successful completion of each item, with a final on-site visit to verify that all items have been completed

Operational energy production and performance analysis

The installed base of operating solar plants continues to grow at a record pace. With this growth comes the opportunity to improve plant performance, the return on investment in operations and maintenance, and the accuracy and uncertainty of future operating energy estimates. Our analytical software tools and expertise will help you assess, optimize and manage solar asset performance.

Industry data indicate that solar assets are underperforming relative to pre-construction estimates, and a recent study found that solar projects underperformed their target production on average by 6.3%.

The good news is that a meaningful portion of this underperformance is attributable to addressable issues. We can help you assess, optimize and manage solar performance by

drawing on sophisticated analytical software tools and a team of experts to provide recommendations, including remediation actions and operational improvements.

Working with us means you benefit from our knowledge, experience and proprietary performance analysis software. **We can help you:**

- Confirm weather-adjusted under performance
- Provide actionable insights based on detailed loss attribution
- Identify recoverable losses and recommended remediation measures
- Monitor and validate remediation with ongoing reporting



Automated management of renewable energy assets



Renewable Asset Monitoring Platform (RAMP) Asset Analytics, part of **ULTRUS™** software from UL Solutions, is designed to provide customized solutions to owners, O&M directors, asset managers and technicians to manage their assets through monitoring, control, advanced analytics and insights.

We perform automatic monitoring and data validation, configure alarms, and provide in-depth analysis and reporting. The widgets available for measuring all kinds of KPIs make the platform totally configurable. With cloud and mobile access, your team can perform operations monitoring from any office or field location.

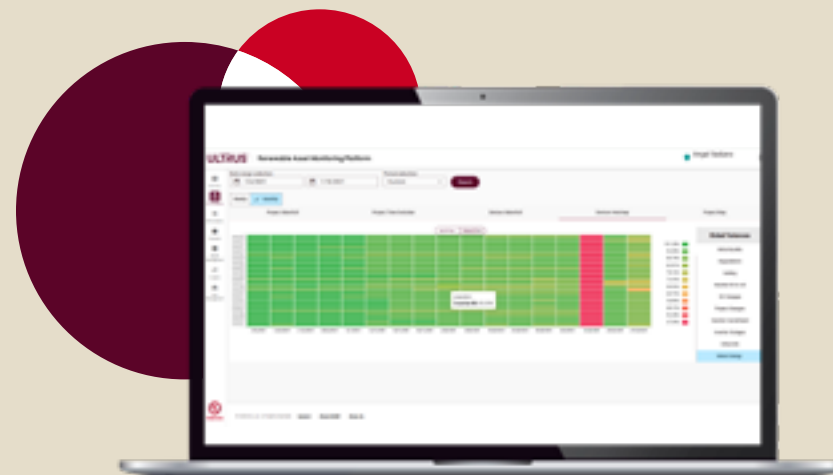
- Quantify system performance and recoverable energy losses: Understand how your plant is performing under all conditions and use deeper-dive analytics to improve energy production.
- Manage expectations: Improved tracking, maintenance prioritization practices, and performance improvement all allow for more realistic expectations on performance and return on investment.
- Identify KPIs: Translate your raw SCADA data into benchmarking metrics and related KPIs. From an independent evaluation of OEM metrics, to consistent owner-specific metrics that may be applied across a fleet of varying turbine types and models, we transform data into powerful asset management information.

Our RAMP Asset Analytics integrates seamlessly with industry-standard SCADA systems placing analytical tools to manage performance and availability in the hands of renewable plant operators.

Root cause analysis

You can manage expectations of operational plants and improve performance, including safe and reliable operations of wind projects beyond the original design life. Supporting the continued success of solar energy technology and facilities requires everything from energy assessments to diagnostic testing and root cause analysis (RCA). We have extensive experience working with manufacturers, operators, stakeholders and code authorities.

When installations are damaged, our qualified inspectors and structural and mechanical experts conduct an RCA to determine the reasons. Evaluating the pervasiveness of the causes across the complete solar project and clearly defining measures to mitigate the consequences is of critical importance. Our RCA processes are based on proven methodologies, including IEC 62740, that entail gathering all facts surrounding the incident and methodically reaching a conclusion.



Energy forecasting

We provide customized, location-specific renewable energy forecasting services for transmission system operators, asset owners and balancing authorities.

As an industry leader in operational assessments, we have developed and refined high quality methodologies for providing long term energy forecasts for operational solar plants. By using operational data, we can estimate future energy production more accurately than by using standard pre-construction methods alone. For investors, we provide bankable energy production reports based on operational data. These assessments provide a clear indication of normal operation and long-term energy projections with lower uncertainty than preconstruction assessments.

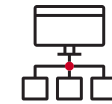
Our renewable generation forecasts and long-range analysis of variable renewable power help you manage grid operations, balance energy contribution from traditional and

renewable energy sources, and understand impacts on grid reliability, cost and operation.

Our forecasts — spanning minutes, hours, and weeks in advance — are tailored to meet the economic and reliability requirements that are required by your organization. Let us help you with short-term to long-range analyses of variable power from renewables impact grid reliability, cost and operations. Our forecasting solutions can conform to your requirements and meet your evolving grid challenges.

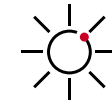
You can schedule solar power for sale, understand weather variables and extremes that influence energy production, understand the power output you should have received when a plant has been curtailed, or determine when to schedule construction activities and crane operations to avoid periods of hazardous weather conditions beyond safe operating conditions.

Our forecasting approach includes the following activities



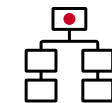
Input data

- Global and regional numerical weather prediction (NWP) model data
- Satellite data
- Nearby meteorological and sensor data



Ensemble of forecast methods

- Machine learning, statistical and physics-based models
- Solar-specific



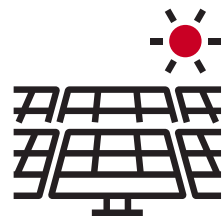
Optimized ensemble algorithm

- Machine learning algorithms weight individual forecasts according to historical performance and look-ahead time
- Produces composite forecasts based on best ensemble members for each look-ahead time



Power production models

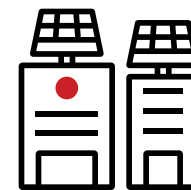
- Delivery of data to customers through primary and secondary delivery mechanisms
- Optional performance reports, monthly meetings, scope changes, and evolving ways to create, display and deliver results
- Translates met forecast to power forecast
- Statistical or physics-based
- Solar power forecast
- Delivery of data to customers through primary and secondary delivery mechanisms
- Optional performance reports, monthly meetings, scope changes, and evolving ways to create, display and deliver results



Power forecasting

Our power forecasting services predict future solar power production over the next several minutes out as far as the next several weeks. If you are an asset owner or utility responsible for scheduling or maximizing the profitability of solar power market transactions, or if you are a system operator or utility looking to maintain a reliable transmission grid, our technology experts can optimize and customize the power forecasting services to align exactly with your needs and requirements.

Forecasts are tuned to the exact location of the solar plants, and we will optimize the use of all the on-site measurement data available to us to enhance forecasting quality, but we can still produce highly valuable forecasts even when no on-site measurement data is available. Our suite of advanced statistical and machine learning models' forecasts is optimized for your application-specific needs.



Grid solutions and renewable simulations

We can model the atmosphere and its impact on the local, regional or global energy industry and estimate the potential generation from a planned solar plant. We can help you by:

- Simulating the existing, planned future or hypothetical wind and solar plant generation and variability on multiple time scales, spanning monthly generation to second-by-second generation.
- Creating synthetic power forecasts for the same plants to assist with optimal power scheduling approaches or to inform schedulers how predictable generation might be at plants prior to the plant's construction.
- Determining expected coincident generation from other existing or future centralized or distributed resources.
- Quantifying impacts from anthropogenic climate change on future increased variability or changes in wind and solar resources, wind and solar generation, changes in weather-driven events bringing icing, extreme winds, high or low temperatures, etc.

End-of-life: Equipment removal studies

When a project has reached its end-of-life, keeping your investment safe while removing equipment is critical. We can help you identify potential risks and complexities with our equipment removal advisory 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 environmental and jurisdictional concerns.

Developing good policies and effective plans for removing renewable energy equipment requires reliable and detailed information about resources, economic impact, and other factors. As an experienced renewable energy consultant, we can adapt services to suit your specific situation. Our offerings include providing an expert opinion, providing resource and energy data and using refined analysis tools to provide meaningful information to support removal decisions.

With a team of more than 500 experts and decades of experience, we have a proven track record of helping stakeholders mitigate risk and navigate complexities associated with solar energy technologies. We have:

- Assessed with more than 100 utility-scale solar projects since 2013
- More than 40 specialized solar engineers
- Independent/owner's engineer for more than 550 wind and solar projects since 2012
- Been the forecast provider for more than 70 gigawatts of centralized and distributed wind and solar generation capacity across the globe
- Evaluated 1.7 gigawatts of installed photovoltaic (PV) systems
- Performed more than 1,000 PV product evaluations annually



Solar energy expertise you can trust in Latin America

Solar energy plants require close attention to detail long before the plant becomes operational. UL Solutions has been working in the industry from the very beginning and can help you prepare for success by working alongside your team to help address these details and keep you moving forward.

Prior to project planning, identifying site locations and understanding site attributes are essential. Along with screening sites for the feasibility of either wind or solar use, detailed measurements and remote sensing help you identify unique needs and considerations to support efficiency and output.

However, when it comes time to officially plan and build your facility, our solar energy experts can remain an active part of your team to help ensure all considerations have been made.

From evaluating the need for new or upgraded infrastructure to considering plan designs, we can help you feel confident in your plans for the future while also demonstrating a commitment to reliability to all necessary stakeholders and authorities. Solar energy is our shared future in Latin America and around the world, and we remain committed to helping that future take shape safely and efficiently.





Endnotes

1. “Solar photovoltaic energy capacity in Latin America and the Caribbean from 2010 to 2023.” Statista.
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