

How to accelerate safer, more sustainable renewable energy deployment

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Entering the second half of the decade, renewable energy deployment globally is growing to keep pace with electricity demand growth and decarbonization imperatives. Solar and wind energy and battery energy storage systems are being deployed at significant rates across many geographies, driven by decreases in cost, technology improvements, regulatory support and growing demand. At the same time, deployment to date falls short of what is needed to align with ambitious decarbonization goals and net-zero targets.

Despite substantial progress, innovation and policy support, many roadblocks to faster, safer and more sustainable deployment persist. Challenges range from physical product safety and performance concerns to regulatory variance across geographies and markets, as well as grid interconnection delays. These hurdles slow the scale of renewable energy, which in turn delays progress toward a more sustainable future.

This e-book offers background on the state of renewable energy deployment and explores the key challenges that slow safer, more sustainable adoption. It also offers insight into strategies for stakeholders to navigate key complexities and advance efforts to continue progressing renewable energy projects forward.

The current state: The rapid growth of renewables continues

The data is real: Renewable energy generation is booming worldwide. Overall, renewables now provide 30% of the world's electricity globally.¹ Solar energy deployment, from the utility-scale to the residential level, has been the largest source of electricity generation growth in recent years. Annual solar capacity additions have grown for 20 years running, with 2024 poised to achieve another record.² Solar's dominance holds across many markets, including China, where renewable additions are growing most rapidly.³ China has deployed twice as much renewable energy as the rest of the world in recent years.⁴

Economics and technological improvements are major growth drivers, as are other factors like government subsidies. Manufacturing costs for solar cells, modules and other components have also dropped sharply. Similar dynamics are now at play for battery energy storage systems which, when paired with renewables, can make renewable assets more valuable by reducing curtailment and serving as backup sources for electricity delivery when needed.



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Progress toward decarbonization goals remains insufficient

Despite considerable progress, the world is still not on track to meet most national or international decarbonization targets, whether for 2030 or 2050.

Global greenhouse gas emissions remain at record highs and could drive up to 3.1°C of global warming, the high end in a range of estimates provided in the United Nations Environment Programme's (UNEP's) Emissions Gap Report 2024.⁵ Other estimates, including those from the International Energy Association's World Energy Outlook 2024,⁶ are less pessimistic. Still, current emissions reductions and renewable energy deployment rates are not in line with holding warming at or below 1.5°C or 2°C, according to many decarbonization targets, such as those originally enshrined as part of the 2015 Paris Accords.⁷

The reasons for the progress and deployment gap include the fact that coal use – buoyed by China and India, which represent 60% of consumption – is still at an all-time high.⁸ Similarly, natural gas is still the top fuel source for electricity generation in the U.S., accounting for about 40% of generation.⁹ Even as wind and solar energy comprised 13% of global electricity generation in 2023, up from 3% in 2013, this growth has not been enough to offset growing demand and decarbonize existing levels of the necessary global power supply.¹⁰ It's a difficult task: low-carbon energy must not only decarbonize existing power supply but also meet myriad new demand growth.

Against this backdrop, it's worth analyzing the means to accelerate safer, more sustainable renewable energy implementation. Proactivity is key. While renewables scale to drive decarbonization, safety and performance risks can be amplified and new hazards, whether in design, production or operations, can emerge.

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Roadblocks to scaling safer, more sustainable renewable energy

Stakeholders across renewable energy development, operation and regulation face multiple hurdles to manage and mitigate. Potential issues related to safety and performance factor into each stage of development and operation. The ability to recognize, prepare for and act against these challenges can help reduce project delays, enhance efficiencies, improve financing terms and build trust with regulators, investors, and other stakeholders.

Safety and performance remain paramount – amid technological innovation, market shifts and pace of adoption, stakeholders cannot afford to sacrifice safety and performance for speed. Safety and substantiated performance underpin long-term sustainability and the success of the energy transition.

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Other challenges include:



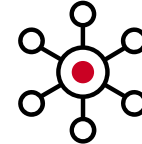
Bankability

Successful deployment depends on de-risking projects to promote bankability. Bankability – i.e., access to affordable financing – hinges on understanding the uncertainties inherent to project development as fully as possible. For developers and investors, the ability to secure or provide financing depends on risk assessments that account for and price the impact of potential issues. These assessments can help demonstrate that development plans accurately account for known risks and developers have made their best efforts to mitigate them. Assessing safety and performance under a range of potential operating conditions across markets and in a manner responsive to regulatory changes can help unlock capital and expedite renewable energy growth.



The cost of capital

Macroeconomic conditions can significantly influence the viability of renewable projects. Higher interest rates raise project costs, as the expense of new development is typically higher than maintaining or upgrading existing assets. Wood Mackenzie estimates that a 2% increase in interest rates raises the cost of energy produced by a modal renewables project close to 20%, compared to roughly 10% for other types of power plants.¹¹ When interest rates are high, subsidies can help support development but may not offset additional costs from higher rates.



Interconnection

The viability of many projects depends on their ability to connect with the power grid. Whether and how quickly projects can secure interconnection depends on the availability and capacity of local infrastructure, like transmission lines, substations and other complicating factors. Interconnection queues in the U.S., for instance, are logjammed. Per the Lawrence Berkeley National Laboratory:

“The typical duration from connection request to commercial operation increased from <2 years for projects built in 2000-2007 to over 4 years for those built in 2018-2023 (with a median of 5 years for projects built in 2023).”¹²

The International Energy Association (IEA) has also called out interconnection as a significant challenge for renewable energy:

“Lagging efforts to integrate renewables into global power grids threaten to sap the benefits of the wind and solar surge, the International Energy Agency warns ...They see delays jeopardizing up to 15% of solar PV and wind generation in 2030 ...”¹³



Supply chain bottlenecks

From tariffs to raw material shortages and the concentration of production or processing capacity in specific geographies, supply chain issues create uncertainties for renewable energy stakeholders. Efforts to scale domestic manufacturing for batteries and solar components and systems in the U.S. and Europe may offer opportunities to reduce supply chain bottlenecks but are still in their initial stages. And the success of these new industries is not guaranteed; in 2024, both new entrants¹⁴ and large incumbents¹⁵ have gone out of business. Disruptions, like transformer shortages, can affect timely project development while other factors, such as tariffs on imports, can impede it.



Regulatory variability and compliance hurdles

In the U.S., the Inflation Reduction Act (IRA) has driven significant investment in new renewable energy projects. While that's good news, it also increases project volumes and contributes to the interconnection backlog in queues. Further, when directives, rules, subsidies, tax credits or permitting requirements differ across markets, which is often the case, it can complicate project development and introduce added compliance difficulties for project developers and other stakeholders.





The path forward

Expanding renewable energy offers a major opportunity to accelerate decarbonization and increase electricity access and affordability. Participating in the renewable energy economy also offers financial prospects for many stakeholders, including project developers, grid operators or component and system manufacturers. The challenges that can hinder progress require proactive de-risking and mitigation strategies. To this end, there are **some key questions stakeholders should consider**:

1. How can renewable developers and operators pre-empt risks that may derail projects?
2. How can stakeholders navigate regulatory variance, whether in the subsidies available across different regions or interconnection requirements between markets?
3. How can stakeholders across the value chain stay informed about the latest innovations or changes to testing and certification that may help reduce risks or require new processes?

At UL Solutions, we have more than a century of expertise and experience helping stakeholders navigate these types of questions, with testing and certification services for countless products, including many renewable energy technologies and products. We partner with stakeholders across the stages of renewable energy manufacturing, development, deployment and operation with services designed to address challenges in the following categories:

The importance of safety and performance testing for renewable energy technologies

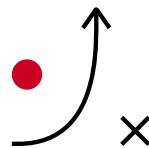
UL Solutions helps manufacturers and OEMs test and certify products to relevant safety and performance standards and certifications for various requirements. This helps stakeholders provide more accurate, transparent information about potential performance and reliability, which strengthens trust between manufacturers, OEMs, buyers and project investors. Insofar as testing and certification play a foundational role in de-risking renewable energy technologies, they also help investors make determinations about the bankability of projects, which is key to project success and safer, more sustainable renewable energy deployment.



Product performance evaluations and testing and certification

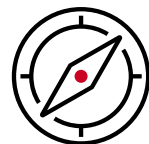
We offer product evaluations and compliance testing to help manufacturers and operators assess safety and performance and demonstrate compliance with relevant standards.

- For example, we offer testing and certification for technologies like wind turbine blades, both to standards developed by UL Solutions Standards and Engagement, like UL 6141, the Standard for Wind Turbines Permitting Entry of Personnel, and other international and national standards, like International Electrotechnical Commission (IEC) 61400 series.¹⁶
- We also offer testing and certification for solar energy technologies, including assessments of efficiency, energy output and durability to relevant standards like UL 1741, Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources, and IEC 61730, a series of standards for photovoltaic (PV) module safety qualification.



Field evaluations to identify recurring risks

We offer services to gather and analyze data from testing, certification and field evaluations to help manufacturers and developers identify recurring issues and risks. This can help inform design and development plans and identify updates that can help mitigate issues in manufacturing, compliance and more.



Pilot testing and field trials

We also offer pilot testing and field trial services with industry partners to assess the practical application of new industry standards as they arise, helping our customers navigate shifting standard, certification and code frameworks.

De-risking projects to promote bankability

Evaluating renewable energy project risks in the planning and development stages helps build consensus and trust between stakeholders involved in development, financing and operation. Thorough articulation and risk mitigation help promote safety, improve performance and support timely interconnection, all of which can also improve bankability. Services like engineering reports, bankability assessments, and reliability validations across solar, wind and storage technologies can help developers and operators secure attractive financing terms, driving deployment.

Services and software UL Solutions offers to help developers and other stakeholders de-risk projects include:

Bankability, reliability reports, and renewable energy rating services

We conduct safety tests and offer durability ratings for renewable technology components to assess the quality and lifecycle of assets and evaluate potential performance issues. These services can help inform investor decisions regarding bankability and financing terms.

Independent engineering reports

These reports evaluate project risks holistically, from equipment performance to overall site safety, which can also help inform investor decisions.

Software tools

We offer advanced software tools to help de-risk renewable energy projects and cancellation risks across the development lifecycle, ranging from site identification to permitting. Examples of these software tools and their potential uses are listed to the right.



Independent model verification and validation services¹⁷

Our model verification and validation services help manufacturers and developers anticipate regulatory and compliance gaps during development phases to help avoid costlier challenges and delays in the future.

ULTRUS™ Windnavigator Resource Data and Maps¹⁸

Windnavigator Resource Data and Maps, part of ULTRUS™ software,¹⁹ can help project developers conduct project development activities with maps and datasets that enable analysis and prospecting of greenfield sites.

ULTRUS™ HOMER® Front²⁰

ULTRUS™ HOMER® Front supports ongoing management of renewable energy and battery energy storage assets, including compliance tracking, performance analytics and environmental impact reporting, which can be needed for regulatory requirements.

Addressing other emergent challenges

As power grid infrastructure digitizes and more renewable energy and distributed energy assets connect to electrical infrastructure, other challenges, like cybersecurity, can emerge or escalate. Each new grid-connected device that is managed with software and connected to other devices can represent a new target for cyber threats. Proactively addressing these risks helps preserve and maintain trust with customers, industry partners and other stakeholders.

We offer testing and certification under standards and series of standards like UL 2900-1, the Standard for Software Cybersecurity for Network-Connectable Products, Part 1: General Requirements, UL 2941, the Standard for Cybersecurity of Distributed Energy and Inverter-based Resources, and ISA/IEC 62443, an international series of standards developed by the International Electrotechnical Commission (IEC) for cybersecurity in industrial automation and control systems (IACS). Compliance with these standards can help address cyber threats in industrial environments.

Testing and certification can also help address interconnection challenges. Certification to standards like UL 1741, the Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources, and supplemental tests like UL 1741 Supplement A (SA) and Supplement B (SB) can help stakeholders test and certify inverters and other utility interconnected equipment to assess the compatibility of grid support functions with key requirements to promote safer, more sustainable grid interconnection.²¹

Navigating regulatory complexity

As regulations and requirements for emergent challenges evolve, working with third parties that actively track industry shifts can help stakeholders stay ahead of the curve.

At UL Solutions, we prioritize participation in working groups and on industry boards to maintain an informed perspective on how various industries, including renewable energy, are evolving and help customers navigate diverse regulatory landscapes. Our expertise supports global customers who often operate across markets, may want to enter new ones and need to harmonize their approach to compliance across various standards.

The range of standard-setting bodies and boards we participate in includes working with UL Standards and Engagement (ULSE) and other bodies such as the International Electrotechnical Commission (IEC), the American National Standards Institute (ANSI), the Solar Energy Industries Association (SEIA), the American Wind Energy Association (AWEA) and many other global trade associations. Our level of engagement across these groups and industries helps us keep customers up to date on industry evolutions that can impact many facets of their businesses and future development plans.

Summary

Safety science is our superpower, and testing and certification form the foundation for safer, more sustainable renewable energy development. We offer services and software tools to help de-risk renewable project development, promote efforts to demonstrate bankability and help stakeholders navigate emergent challenges. Combined with our active participation in standards panels and other technical committees, we refine our offerings and build expertise to turn challenges to competitive advantages.

Connect with us to learn more and advance safer, more sustainable renewable energy deployment.

[CONTACT US](#)



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