When it comes to the useful life of renewables, can 40 be the new 25?

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Executive summary

Historically, the useful lifespans of solar and wind facilities have been handicapped at 25 and 20 years, respectively. There is limited-to-no available data regarding large-scale systems with operational histories beyond 25 years in the existing body of scientific literature. This presents a bit of an empirical challenge for researchers. Namely, we don't know what we don't know. Scientists have not yet concretely established the projected useful life for a modern battery storage system, a relatively new entrant into the wholesale power market, but the conventional wisdom is that lithium-ion batteries have a lifespan of 7-10 years before they need to be either augmented or completely replaced.

In the ever-changing landscape of renewable asset development, financing, and tax reform, there is mounting pressure to extend the period of revenue generation by increasing the useful life of green energy projects. Assessing the overall value and long-term ownership benefits of a given technology is nearly impossible without first establishing an accurate determination of that technology's use life.

Evaluating a specific energy facility for its useful life requires complex multi-factor analysis. Such evaluations must take into account the qualifications and experience of the contractors and suppliers in question, the design and construction of the facility and associated equipment, the availability of replacement components, and all extant and proposed operations and maintenance plans.

As technical advisors, we review the following areas to evaluate the potential useful life for a renewable power facility:

- Site control and interconnection
- Site meteorological and geotechnical conditions
- Design specifications and criteria
- Equipment selections
- Experience and qualifications of the engineering, procurement, and construction and operations and maintenance contractor(s)
- Operations and maintenance plans and budget

If we want renewable assets to have longer useful lives, we need to give strategic consideration to all six of these aspects during the project planning and development phases and subject them to continued review throughout both the construction and operations phases as well.

Site factors

Site consideration primarily includes evaluation of the period during which an owner has site control, site access, and interconnection arrangements, as well as consideration of geotechnical characteristics for a project.

If a project company owns the property on which a specific project is built, these matters may become non-issues in assessing the long-term viability of a project. If facility operators' access to the property is dependent on easements or leases, we look for those agreements to be commensurate with the anticipated useful life of the project. Typically, real estate matters are ancillary to the review of a technical advisor or independent engineer, though the review is more straightforward if site control and access are not limiting factors.

Additionally, interconnection agreements typically adhere to a stated term with automatic renewals. If this is not the case, however, stakeholders should consider and plan to provide for interconnection corresponding to the anticipated operation of the project.

In determining useful life, it is also important to understand geotechnical and hydrological site factors, such as geological, soil, or seismic conditions that may impact or limit the design of the project. Similarly, for project sites prone to flooding or consisting of drainage problems, the aim should be to confirm (through review studies and conclusions) that the site's civil grading and, ultimately, the overall project design aligns with the long-term operating goals for the project.

Additional site-specific factors are those relating to meteorological conditions. These can include temperature, humidity, aerosols (e.g., sea spray and pollution), and the risk of any potential extreme weather events. Each of these meteorological factors affects the respective facility differently based on the site, technology, materials, and systems inherent to the specific equipment implemented.

System design, equipment, and construction

The methodology and quality of construction play a critical role in the longevity of a facility. As such, before evaluating useful life, we need to know the design basis and major components of the projects as a whole.

To help meet the intended useful life of a project, the design basis for the overall system or balance of a plant should reflect an appropriate design life in the engineering and construction contracts, and the qualifications and experience of the engineering and construction team should support their ability to design and construct high-quality facilities. Understanding and establishing appropriate construction quality standards, including requirements for quality monitoring and assurance in the field, is also critical.

Similarly, equipment supply contracts must support the intended useful life by supplying equipment that corresponds to the site's meteorological and geotechnical conditions and has warranties that meet industry-typical levels. Warranties for equipment that are longer than the industry-typical level or have additional negotiated provisions can support the extension of useful lives beyond the previously typical 25 years.

Solar

In evaluating solar facilities, we need to assess not just the design lives of individual racking, modules, and inverters and how they support the anticipated design life through historical failure mode analysis or warranties. We also need to couple those assessments with appropriate preventive and corrective maintenance reserves that assume useful lives beyond 25 years. Since the design life of most major solar equipment is between 25-30 years, this requires us to fundamentally shift how we look at individual solar components. Provisions for refurbishing inverters during years 17-22 and single-axis tracker batteries, when implemented every 10-15 years, are also necessary to reach useful lives beyond 25 years. The design of racking foundation piles must also be tailored to the site's corrosivity, frequency of flooding, and possible scour. Facility operators should also insist on industry-standard techniques and quality control reviews during construction to maximize the equipment's useful life. Poor installation or construction methods can significantly alter a solar project's useful life. Specifically, there should be thorough quality inspections for the foundations, racking installation, module installation, wire and cable management/installation, civil work (e.g., detention/retention system design), and monitoring systems. Proper module handling techniques for crystalline photovoltaic modules during delivery and installation can play a critical role in preventing micro-cracks that may not otherwise be visible and manifest several years into the life of a project resulting in accelerated degradation.

Wind

Wind facilities can take a number of proactive steps to extend their useful lives beyond current projections. Site-specific load assessments, typically produced by the turbine's original equipment manufacturer, can be updated to account for an increased operational lifespan. This will ensure that the existing fatigue life in the structural components (e.g., the tower, the foundation, the blades, the bolts) is already on the facility operator's radar and that these components are built to outlast extended operability projections, or, at least, that maintenance and replacement mitigations can be planned ahead of time. Foundation design can be altered to account for both potential increases in extreme loads and extended fatigue loading. Construction contracts for wind facilities should explicitly require extended foundation design life to accommodate projections for a longer overall lifespan. Plant designers can choose or design towers with extended lifetime usefulness in mind. During construction, well-executed and well-documented quality assurance and control programs can likewise increase the potential lifespan of a given wind power plant.

If facility operators want to extend plant productivity on the tail end, they can take proactive steps early on, like performing regular blade maintenance or swapping out components before they become a more serious problem. For example, if a facility replaces a failed gearbox in year 12, the main bearing can also be replaced proactively while the nacelle is already open. To extend the useful life of a wind facility, providers also need to invest in active turbine monitoring and intelligent sensor placement. Facility operators should budget up-front for the presumed operations and maintenance costs they will incur later in the life of the facility. Careful quality management of foundations, underground collection system installation, and even down-tower cable ties will not only reduce maintenance costs in the future, but also streamline the evaluation of useful life extensions.

Storage

As battery storage systems continue to gain popular attention, facility operators should give serious consideration both to the design architecture of the battery storage systems they employ and the initial use applications for those systems, especially contrasted with the technology's flexibility for future use. Battery life is quite often the limiting factor on a given technology's viability and longevity. In order to circumvent the potential limitations battery storage systems impose, facility operators need to design capacity augmentation strategies such as scheduled equipment additions and planned replacement of critical parts in order to meet the long-term needs of a given project.

To make life easier for themselves, renewable power facility operators should design around the very probable emergence of newer, more efficient technologies and the eventuality of integrating them into their battery storage systems. This is easier said than done, of course. Not knowing what technologies will be available in the future adds risk to relying on future augmentations for maintaining plant performance. But any future augmentation strategy is incomplete if it doesn't properly countenance the feasible integration of new technologies into the fold. For example, compatible battery racks with the correct form factor and operating parameters for an existing energy storage system might not be available in the future. That puts the onus on forward-thinking facility operators to build in more physical space for additional battery racks and to try to proactively design methods for integrating new components into old battery storage systems.

All energy storage systems have an annual cycle, that is an estimated number of times they will fully charge and fully discharge in a calendar year. But designers cannot determine the number of cycles an energy storage system will perform in a given year unless they have a clearly defined picture of the system's use cases. Any increase or decrease in a battery storage system's charge and discharge cycles is bound to alter its performance life greatly. Exceeding the number of anticipated cycles within a year will increase battery degradation and shorten the life of the energy storage system. Reducing the number of anticipated cycles, on the other hand, will decrease battery degradation and increase the useful life of the energy storage system. Therefore, if we want to get an accurate picture of an energy storage system's health (either to maintain or improve upon the system's level of efficiency) we need to evaluate its use cases on a yearly basis as part of that. In general, regardless of the technology, when selecting equipment for a project, facility operators need to consider a manufacturer's experience and the underlying components that make up a product. For example, leading manufacturers of central inverters or converters typically report a 20-year design basis for their products. Working with manufacturers to understand recommended maintenance, including long-term unit refurbishment options, can inform operational plans and major maintenance budgets. Manufacturers of key components can even provide expected failure data (including potential types of failure) to help facility operators understand the current and projected availability or scarcity of replacement parts, to help operators develop major maintenance reserves budgets if and when they need to replace components entirely.

Considerations and assumptions for long-term operation

O&M plans, operating budgets, and major maintenance reserve accounts are among the most significant factors that any useful life evaluation should incorporate. There must be adequate provisions to keep the project in top operating condition during the initial and middle years of operation. At a minimum, stakeholders should develop appropriate assumptions for:

- Planned/preventive maintenance
- Unplanned/corrective maintenance
- Maintenance reserves
- Availability
- Degradation for solar and storage projects

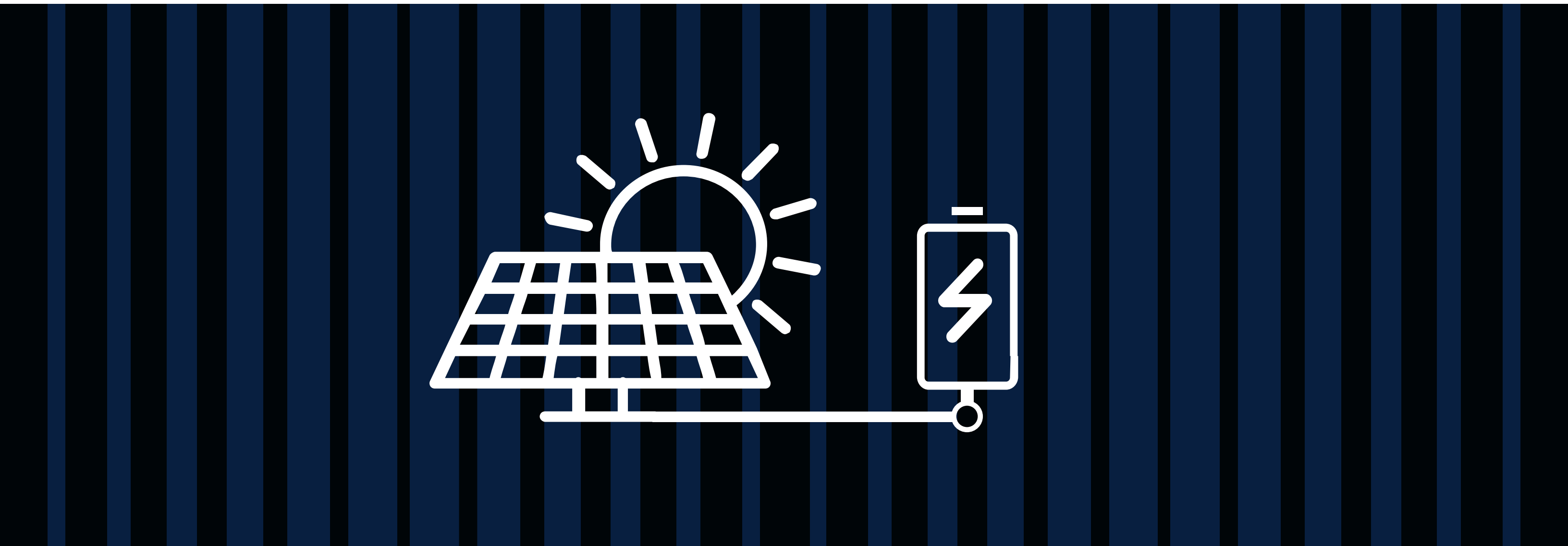
As facilities age, it is likely that the rate of component failures will increase commensurately and that the availability of replacement components may become more limited over time. Retrofitting facilities with new components may require design adjustments or additional costs in order to maintain the desired performance. Economic decisions regarding maintenance likely need to be made in the later years of operation for wind projects. For example, if a blade fails in year 26, finding a replacement may prove unreasonably difficult or cost-prohibitive, so decommissioning the turbine may be a better option. Considerations like this one should be reflected in project availability and thus energy production in the out years.

If any renewable power project wants to outlive historical projections, it needs to consider one (or all) of the following when drafting its financial pro forma:

- Increased O&M budget for corrective maintenance in the mid to late years of operation
- Reduced availability in late years of operation
- Increased degradation in late years of operation, specific to solar and storage
- A battery storage-specific augmentation strategy and budget to maintain the necessary capacity for the intended life of the project

In addition to those four specific recommendations, on a more general note, adhering to prudent industry practices, following manufacturer-recommended preventive maintenance guidelines, and responding diligently to unexpected issues are all essential for maximizing the useful life of a given asset.

Extending the useful life of a renewable project isn't impossible. In fact, it is eminently feasible. But if project operators want to outrun assumptions about the useful life of their facilities, they need to be diligent and deliberate about planning for the long term in the development and construction phases of projects. If they can do that, then they can add enormous overall value to renewable facilities and improve the long-term viability of a new generation of power plants and their useful lives. In the case of renewable technologies like wind and solar, the sky's the limit.



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Garrett Moran is a licensed professional engineer who specializes in wind turbine technology, loads, and controls. Garrett has led international teams focused on turbine technology design and testing, nonlinear aeroelastic loads tool development, and in-house wind turbine blade design. Garrett has supported the technical due diligence and financing for nearly 2GW of globally installed wind capacity and nearly 4GW of globally installed solar and storage capacity.

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Mark Reusser has more than five years of expertise in solar photovoltaics. He regularly performs due diligence for solar energy project owners and investors, as well as providing owner's engineering services. He has served as both an owner's engineering representative and an independent engineering representative for over two gigawatts' worth of solar photovoltaic projects. Mark developed his expertise in the field, performing independent engineering reviews for numerous utility-scale and distributed PV projects.

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Dave Doerner is an experienced solar energy industry professional offering a decade of experience as a design engineer and consultant in the renewable energy industry. He has served as an engineer for a solar energy firm that was responsible for the development, engineering, procurement, construction, operations, and maintenance of renewable projects. In his current role, he has performed technical due diligence for a variety of energy assets. Throughout his career, he has been responsible for certain design and quality aspects on over 550 MW of utility-scale solar installations worldwide and performed technical due diligence on over 1 GW of additional projects throughout the United States.

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