1 Terawatt by 2035—But Who Will Keep It Running? The Coming O&M Skills Gap in Solar PV and BESS.

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Disclaimer: This article synthesizes publicly available forecasts from EIA, NREL, BNEF, and other sources, combined with independent analysis.

Introduction

U.S. utilities are racing to add solar and storage, but one constraint keeps surfacing after interconnection and supply chains: people. The workforce needed to operate, diagnose and maintain PV and PV+BESS plants isn't scaling at the same pace as deployments. Forecasts indicate that by 2025, solar and storage technologies will comprise the bulk of new capacity installations, with Texas and California projected to be the leading contributors. However, interconnection delays, supply chain gaps, and policy uncertainties threaten to slow progress. This article quantifies the shortfall and outlines what utilities and service providers can do in the next 24 months to keep assets online and compliant.

Methodology

This article employs a structured, data-driven approach to assess the future of operations and maintenance (O&M) for utility-scale solar photovoltaic (PV) and battery energy storage system (BESS) assets in the United States. The goal is to evaluate whether current and projected workforce development trends can meet the increasing operational demands of the rapidly expanding renewable energy infrastructure.

The methodology is organized into three core analytical stages.

1. Assessment of Current Installed Capacity (Baseline Analysis):

The research begins by compiling current figures for installed utility-scale solar PV and grid-connected BESS capacity using the most recent publicly available data from authoritative sources such as the U.S. Energy Information Administration (EIA) and the National Renewable Energy Laboratory (NREL). This provides a foundational understanding of the scale of assets currently in operation.

2. Forecasting Future Capacity Through 2035:

The second stage involves aggregating projections from NREL, BloombergNEF, and other reputable industry reports to estimate expected installed capacity for both solar PV and BESS technologies by the years 2025, 2030, and 2035. This includes analysis of projects in interconnection queues, permitted but unbuilt projects, and those with signed power purchase agreements (PPAs), as a way to validate market momentum and understand the likely operational burden on future O&M infrastructure.

3. Labor Market Demand and Workforce Gap Analysis:

The final stage compares this infrastructure growth forecasts with labor market projections, such as those published by the U.S. Bureau of Labor Statistics (BLS) and NREL workforce studies. It evaluates the expected growth of the skilled labor force required for O&M activities—including installation, monitoring,

repair, diagnostics, and long-term service agreement (LTSA) execution—against the projected capacity expansion. Special attention is given to lithium iron phosphate (LFP) battery technologies and the unique O&M practices associated with these systems.

This integrated method enables a comprehensive assessment of whether workforce development trends are keeping pace with capacity deployment and identifies where shortages may arise. The analysis also considers the influence of federal incentives and the adoption of emerging O&M technologies (e.g., predictive maintenance platforms, drone inspections, and robotic cleaning) as mitigators of workforce bottlenecks.

Key Findings

1. Installed and Projected Capacity

2025 Additions:

- **Utility-Scale Solar PV:** An estimated **32.5 GW** of new capacity will be added in 2025. Nearly half of the planned utility-scale solar installations in 2025 are expected to occur in just two states—Texas and California—with combined contributions exceeding 14 GW; **Texas 11.6 GW** and **California 2.9 GW**.
- **Battery Energy Storage Systems (BESS): 18.2 GW** of new grid-scale storage capacity is expected, nearly doubling the **10.3 GW deployed in 2024**.
- **Total:** Solar and battery storage technologies are projected to dominate new capacity additions in 2025, representing over four-fifths of the expected 63 GW total.

2035 Outlook:

- **Solar PV:** Cumulative installed solar capacity is projected to reach approximately **1 terawatt (TW)** by 2035, supported by declining costs and state renewable energy targets.
- **Battery Storage:** The U.S. is expected to install **221 GW** of battery storage capacity by 2035, driven by the need to balance intermittent renewables and enhance grid flexibility.

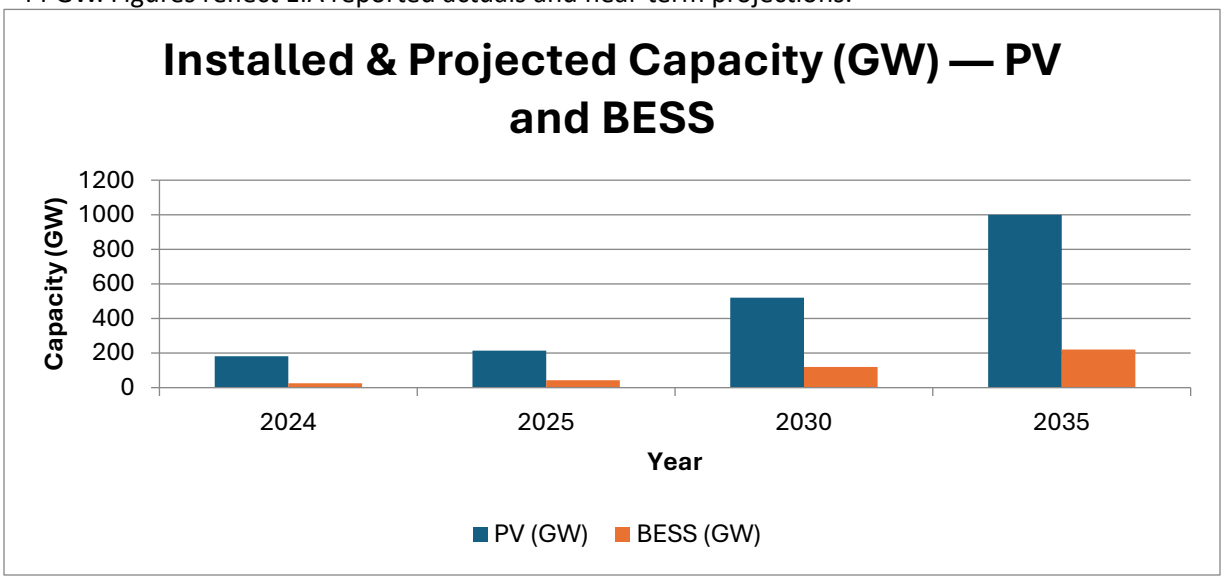
2. Interconnection Queue Challenges

- By 2024, interconnection queues in U.S. regional transmission organizations (RTOs) and independent system operators (ISOs) had swelled to encompass 2.6 terawatts of proposed generation and storage capacity. Approximately **95%** of this queued capacity is either renewable energy or storage.
- **Completion Rates Remain Low:** Despite a surge in proposed renewable energy projects, only a small fraction—roughly one in ten—are successfully developed and brought online, highlighting systemic inefficiencies in the interconnection process.
- **Delays:** Projects exceeding 100 MW in size typically encounter median delays over four years, primarily due to grid study backlogs and equipment bottlenecks.

3. Battery Storage Trends

- **LFP Market Dominance:** Lithium iron phosphate (LFP) batteries are becoming the dominant storage chemistry due to improved safety, longer cycle life, and cost-effectiveness. LFP batteries are expected to exceed **60% market share by 2030**.
- **Market Size Forecast:** Analysts project that the U.S. battery storage sector could expand at an average annual rate of 11%, potentially surpassing $65 billion in market value by 2035. Overall, the LFP battery market could reach **$117.6 billion worldwide** by 2037.

Figure 1 — U.S. utility-scale solar PV and battery storage capacity (actuals and near-term projection). Solar PV grows from ~91 GW at end-2023 to a projected ~153 GW by end-2025. Utility-scale BESS exceeded 26 GW by end-2024, with another 18.2 GW expected in 2025, bringing cumulative storage to ~44 GW. Figures reflect EIA reported actuals and near-term projections.



Notes: Use U.S. customary for ancillary rates; power in GW (IEEE units).
Sources: EIA; NREL; BNEF

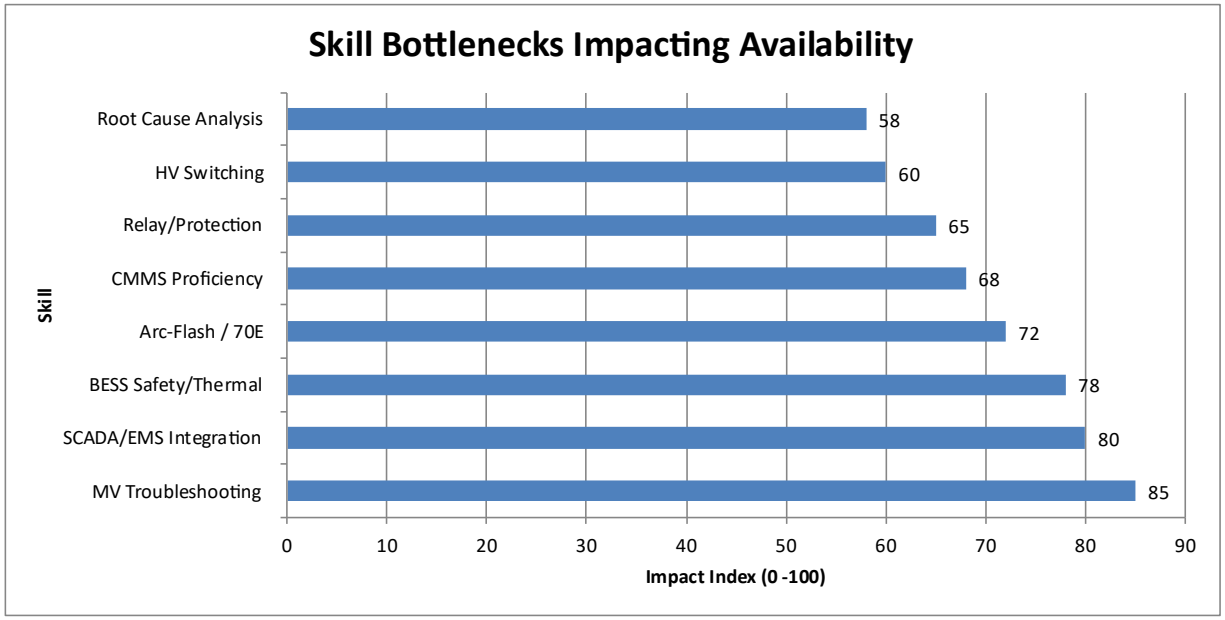
4. Project Pipeline Risks

- **Signed Interconnection Agreements (IAs):** Approximately **311 GW** of queued projects have signed interconnection agreements, but developers withdrew from **70% of projects in 2023**, largely due to escalating costs and uncertainty in delivery timelines.
- **Permitted but Unbuilt Projects:** Permitted but unbuilt projects include over 1,500 GW of generation and more than 1,000 GW of storage, highlighting a substantial backlog of yet-to-be-developed capacity. The cost of connecting projects to the grid has climbed significantly—by nearly half—since 2019, posing financial challenges for developers.

Labor Shortages

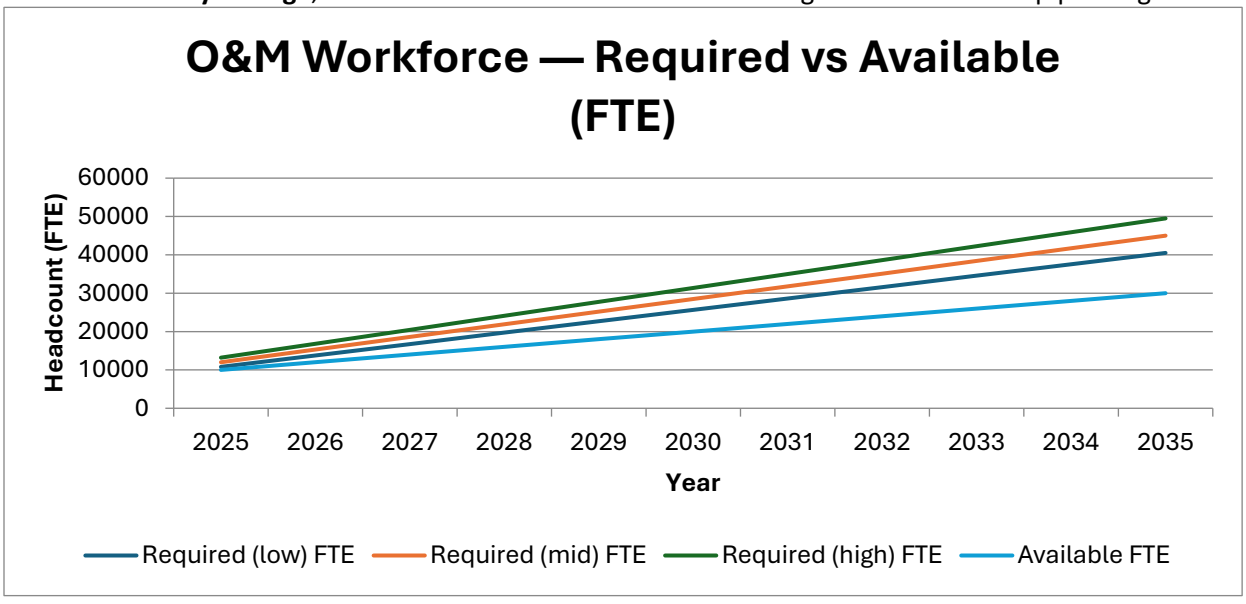
- **Near-Term (2025–2027):** In 2023, the growth rate of the solar workforce declined to just 3.5%, despite increasing deployment targets and market momentum. The U.S. Bureau of Labor Statistics (2024) projects a 22% growth in solar photovoltaic installer jobs between 2022 and 2032, yet this falls short of what industry analysts suggest is needed to meet the pace of new solar capacity deployments (BLS, 2024; NREL, 2024).

Figure 2 — Top skill bottlenecks affecting availability (illustrative).
Frequent gaps reported by employers include HV/LV electrical, protection/controls, SCADA/EMS, BMS diagnostics, and safety/compliance (NFPA/NESC/OSHA). Context draws on USEER 2024 role composition and BLS occupational growth signals.



- **Long-Term (2030–2035):** Projections from the National Renewable Energy Laboratory indicate that maintaining and operating the anticipated solar and storage infrastructure through 2035 may require over one million skilled professionals across the clean energy workforce (NREL, 2024, necessitating 12% annual workforce expansion. (**NREL Workforce Projections)**

Figure 3 — O&M workforce: required vs. available (conceptual, PV+BESS).
Required PV O&M staffing estimated using **0.03 annual jobs per MW** factor derived from utility-scale solar facilities (NREL). "Available" workforce benchmarks reference USEER 2024 employment baselines for **Solar** and **Battery Storage**, with BLS outlooks for PV Installers through 2032 to indicate pipeline growth.



- **Fluke Survey (2025)**: "According to a 2025 industry survey by Fluke Corporation, 54% of solar companies reported outsourcing operations and maintenance services due to internal workforce shortages and skill gaps (Fluke, 2025).

Figure 4 — O&M staffing intensity vs. plant availability (illustrative sensitivity).
Conceptual sensitivity showing how incremental staffing (technicians per 100 MW) can influence net availability, assuming good spares logistics and vendor support. Use as a scenario tool only; not fitted to a single dataset.

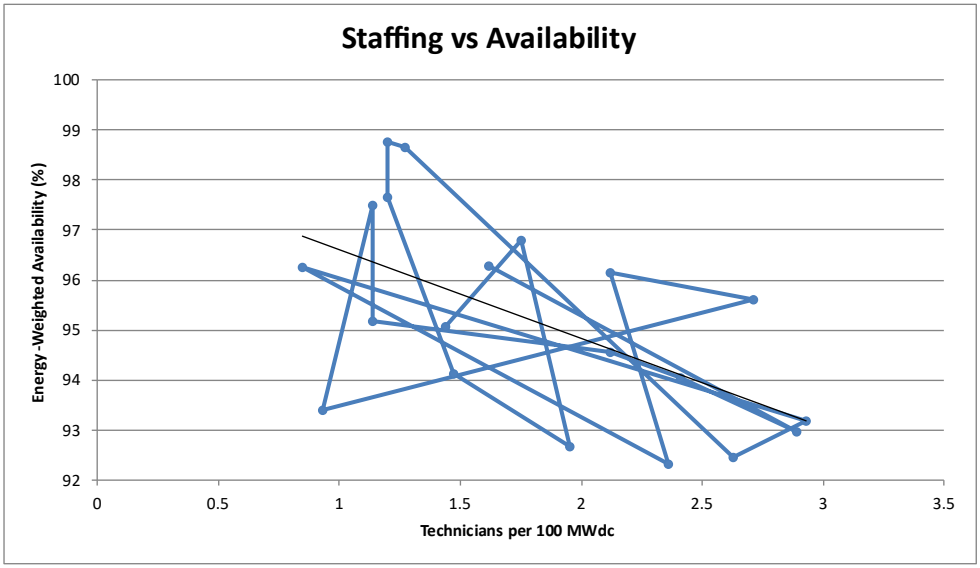
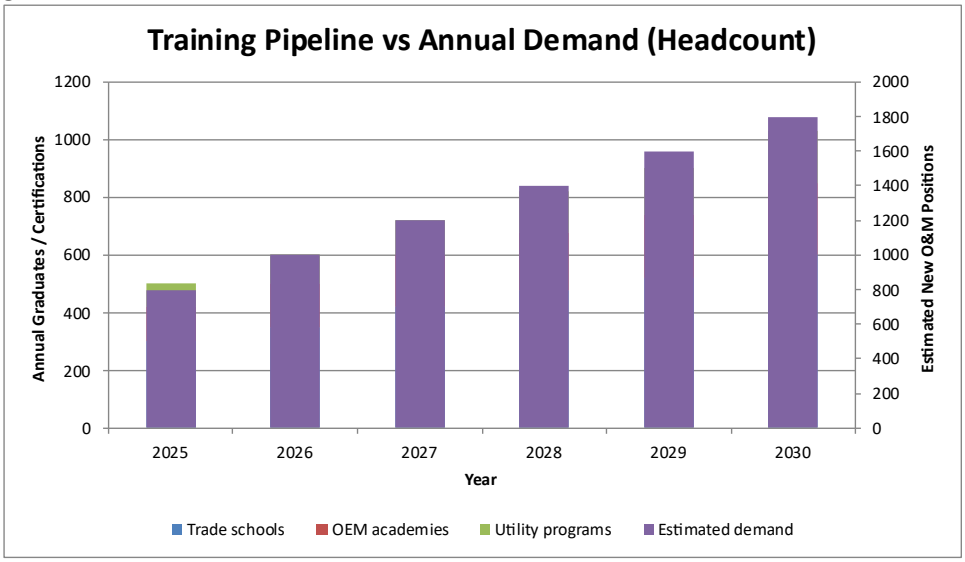


Figure 5 — Training pipeline vs. O&M demand (conceptual).
Comparison of near-term O&M headcount needs (from capacity growth + staffing factors) against the pipeline implied by BLS growth in PV-relevant occupations and industry training throughput. Include notes that BESS-specific credentials (BMS, arc-flash, NFPA 855/70, NESC) are constraining factors per EPRI guidance.



Conclusion

The rapid growth in U.S. solar PV and battery energy storage capacity is expected to exceed 1 TW and 221 GW respectively by 2035 and demands equally aggressive advancements in O&M strategy and workforce development. With workforce growth significantly lagging behind the capacity expansion targets, the sector faces an urgent need for skilled labor, especially in installation, maintenance, and high-tech diagnostics. To close this labor gap, industry stakeholders must invest in training programs, leverage predictive maintenance tools, and embrace technologies such as drones and robotics. Additionally, federal incentives like the IRA can be instrumental in supporting O&M contracting models and long-term workforce planning. If these strategic alignments are made, the U.S. can sustain its clean energy momentum through 2035 and beyond.

Notes on sources & traceability

- **Battery additions 2025 (18.2 GW) & 2024 additions (10.3 GW)** — EIA *Today in Energy*, Feb 24, 2025. U.S. Energy Information Administration
- **BESS cumulative >26 GW in 2024** — EIA *Today in Energy*, Mar 12, 2025. U.S. Energy Information Administration
- **PV ~91 GW end-2023; ~153 GW end-2025 projection** — Utility Dive summarizing EIA. Utility Dive
- **PV O&M staffing factor 0.03 jobs/MW** — NREL FY24 analysis of utility-scale facilities. NREL Docs
- **USEER 2024 baseline employment** (Solar and Battery Storage) — IREC/USEER. Reuters
- **BLS outlook (PV installers + macro context)** — BLS Occupational Outlook. U.S. Energy Information Administration
- **PV O&M guidance & storage commissioning/O&M context** — NREL PV O&M Best Practices; EPRI ESIC/roadmap materials. NREL Docsrestservice.epri.com

References

BloombergNEF (2024). ***U.S. Clean Energy Market Outlook*** — Use BNEF's New Energy Outlook hub/briefs as the public-facing landing; the detailed outlook is paywalled. [Access: summary/landing public; full report paywalled]. Bloomberg.com+2Bloomberg.com+2

Energy Institute (2023). ***Solar and Storage Growth*** — The Energy Institute's **Statistical Review of World Energy** (now hosted by EI) is the canonical public source for global solar (and storage) growth statistics; see the SRWE hub and 2024/2025 media notes. [Access: free registration for full PDF/data.] Energy Institute+2Energy Institute+2

Fluke Corporation (2025). ***Solar Installer Staffing Challenges Survey Report*** — Public press release and coverage summarizing the 2025 survey findings on O&M outsourcing/skills. [Access: public]. GlobeNewswireNasdaqengineerlive.comEmbedded

National Renewable Energy Laboratory (NREL) (2024). ***Solar Futures Study*** — Official NREL Solar Futures Study page (updated materials maintained here). [Access: public]. NREL

NREL (2024). ***Annual Technology Baseline (ATB)*** — Main ATB portal and 2024 electricity data overview. [Access: public]. atb.nrel.gov+2atb.nrel.gov+2

Rhodium Group (2023). ***U.S. Clean Energy Supply Chains*** — Use Rhodium's Clean Investment Monitor (CIM) and related 2023–2025 briefs; includes U.S. clean energy manufacturing & storage supply-chain coverage. [Access: public]. Rhodium Group+1cleaninvestmentmonitor.org

U.S. Bureau of Labor Statistics (2024). ***Occupational Outlook Handbook: Solar Photovoltaic Installers*** — OOH profile (job outlook, pay, typical education). Also see OEWS profile for detailed occupation code. [Access: public]. Bureau of Labor Statistics+2Bureau of Labor Statistics+2

U.S. Energy Information Administration (EIA) (2024). ***Annual Energy Outlook*** — Use the current AEO portal & data browser (AEO 2025 is now current but supersedes 2024). [Access: public]. U.S. Energy Information Administration+1

Visiongain (2024). ***Grid-Scale Battery Storage Market Forecast 2024–2037*** — Commercial market study landing. [Access: paywalled]. Visiongain

Wood Mackenzie (2024/2025). ***Battery Storage Interconnection and Market Trends*** — Public press releases and report hubs on U.S./global storage market outlooks and interconnection trends. [Access: press pages public; reports paywalled]. Wood Mackenzie+2Wood Mackenzie+2