Built Robotics' AI Piling Solution drives piles autonomously

# Solar in the age of AI

**Words:** Erol Ahmed, Vice President of Communications, Built Robotics

From manual construction to autonomous jobsites, what will the future of solar look like?

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Picture this: a growing community needs 1 GW of new generation capacity. Today, selecting a site, securing permits, building, and connecting that capacity to the grid can take years, and that timeline can't keep pace with demand. Now imagine a future in which a project of that size could be delivered in about a year, roughly the time it took to build the Empire State Building. This is a hypothetical ambition, not a timetable demonstrated by a project or study.

Artificial intelligence (AI), robotics, automation, and edge computing are already reshaping how utility-scale solar gets built. This article explores their potential to improve the phases of project development and construction, specifically, but does not assess the potential for grid connection improvements.

The shift won't come from a single machine. It will come from connecting data, design, and equipment so each stage of a project feeds the next. Before getting to what that looks like, it's worth starting with the challenges pushing the industry toward these tools.

## A perennial priority: tools and labor

Research by Austan Goolsbee and Chad Syverson found that US construction productivity in 2020 was below its 1950 level. We wouldn't dig a trench today with wheelbarrows and shovels, nor should we be building with tools that haven't changed in decades.

Solar's bottleneck is rarely panels or capital. It's skilled labor. Utility-scale projects need crews who can survey, run pile drivers, and install trackers to tight tolerances, often far from where those workers live. Training them takes time, and keeping them is harder. Long days in heat, dust, and noise are difficult, and turnover means constant retraining.

Robotics addresses this from several directions. First, it stretches scarce expertise. One skilled operator supervising autonomous equipment can manage the work, which lets contractors build more megawatts with the people they have. Second, it takes workers out of the most hazardous tasks. Pile installation exposes crews to struck-by and caught-in-between incidents, heat stress, and repetitive strain. Doing parts of that work autonomously helps to lower injury exposure.

Third, technology changes who wants the job. A role that involves managing robots, reading site data, and troubleshooting software appeals to a generation that might never have considered construction. That's a recruiting pathway the industry hasn't had before. And once workers are on board, automation can

Erol Ahmed

improve their quality of life: less exposure to risk in temperatures of 105 °F, more predictable schedules, and skills that expand their opportunities. These jobs may be easier to fill and easier to keep.

## The technologies making it possible

Autonomy on a solar site depends on knowing exactly where a machine is and what's around it. Several technologies have matured enough

Real-time digital twins provide operators and contractors with a shared record for planning, production and analysis

Edge computing processes sensor data locally to support rapid decisions, including detecting people near robots

to make that reliable. Real-time kinematic global positioning system (RTK GPS) delivers centimeter-level positioning. Lidar and stereo cameras build a 3D picture of terrain, equipment, and people. Combining inputs from different sensors can help machines cope with changing site conditions. Their ability to operate in low light or dust depends on the equipment and its operating limits.

Edge computing ties it together. Solar sites are often remote, with limited connectivity, so a machine can't wait on a round trip to the cloud to decide its next move. Processing data on the machine itself means decisions happen in milliseconds, and only the data that matters gets sent back for analysis.

### Safety in physical AI

When software makes a mistake, you get a bad answer. When a hulking machine makes a mistake, someone can get hurt. That's why safety in physical AI has to be designed in layers.

The first layer is physical: barriers, safety signage, emergency stops, audible alarms, and warning lights that keep people and machines apart and make a machine's status obvious to anyone nearby.

The second is perception: AI and machine vision are trained to detect people and objects, and to slow or stop the machine before anything enters its working zone.

The third is remote monitoring, which keeps a human in the loop who can see what each machine is doing and intervene. No single layer is sufficient. Together they create redundancy, so a failure in one is caught by another.

The industry also needs shared rules. Open standards and industry consensus on how autonomous equipment is tested, certified, and operated will matter as much as any individual safety feature. They give owners, insurers, and regulators a common basis for trust, and they let machines from different vendors work the same site under the same expectations.

### The future jobsite: how it could work

Follow a project from the first survey to the first year of operation. This scenario brings together existing technologies and possible future developments to explore how a more connected jobsite could work.

**Survey.** It starts with data. Self-flying drones map the site while machine learning models analyze terrain, drainage, and historical weather. Smaller terrain robots carrying soil penetrometers cover the ground in a dense grid, collecting far more readings than a human crew could in the same amount of time. The result is a site carpeted with accurate data, not extrapolated from a handful of test locations.

That density pays off quickly: fewer unknowns mean contractors don't overspend on pre-drilling or bring in heavier equipment when simpler methods will do. On a large site spanning thousands of acres, that difference shows up directly in the bid. The same data helps developers pick locations best suited for solar based on weather patterns, sun exposure, and terrain. It can also record wildlife and habitat, so projects protect sensitive areas and route around them early instead of discovering them during construction.

**Design.** With detailed spatial data and the project's power requirements, AI can recommend the tracker system best suited to the site, then generate pile plans and power block locations within the software. Automated design software can speed up work on pile types, block layouts, and installation details. Because the design is tailored to the site rather than defaulting to generic, conservative solutions, it cuts material cost, installation time, and effort.

It also becomes the foundation of a living digital twin that updates as the project is built. That twin provides a single, current record of what was planned and what was actually installed.

**Piling.** Those plans load directly into autonomous pile drivers, such as Built Robotics' AI Piling Solution, which survey, distribute, and drive piles to high precision. According to Built Robotics, its system can install piles up to five times faster than traditional methods. Precision reduces rework against stringent tracker tolerances, and accurately driven piles let teams choose simpler assembly types. Complex terrain and varied pile types stop being a planning headache, because the machine handles each

AES's Maximo robot places solar modules onto tracker assemblies

pile as specified. Every pile's location and drive depth are captured in real time, feeding the digital twin.

**Trackers and modules.** Directly behind the pile driver, another set of robots installs tracker assemblies. And behind them, another places modules. Contractors can work with solutions from Luminous Robotics, Cosmic Robotics, AES, and XPanner, which offer different approaches for module installation.

**Sequencing is everything.** Each machine works from the same plan and reports what it actually did, so the next one knows exactly where every pile landed and can adjust before a small error compounds. On a conventional site, that handoff happens through paperwork, radio calls, and walk-downs. Here it happens through data.

**Operations.** Once the site is energized, smaller purpose-built robots take over operations & maintenance (O&M). Cleaning robots time washes to balance maintenance cost against panel efficiency. Vegetation management robots from companies like Swap Robotics and Renu Robotics keep growth in check. Sensors watch for fire risk and weather damage. Because these decisions run on data rather than fixed calendars, maintenance is scheduled on economics: enough to maximize energy capture, not so much that it erodes margin.

Taken together, this turns the jobsite into something closer to a factory: an AI-driven assembly line that handles the shifting, three-dimensional reality of outdoor terrain while capturing the efficiency of indoor manufacturing. Whether that comes from fleets of specialized machines from different vendors or from integrated, one-stop systems like those from Charge Robotics and Terabase remains to be seen. Both approaches will have a place.

The payoff is broad: less uncertainty, more resilient schedules, better information for planning and permitting, greater confidence in decisions, and consistent throughput. Repetitive, physically demanding work gets automated, and productivity rises without sacrificing installation accuracy.

### What's next

Plenty of companies are working on pieces of the autonomous solar jobsite. The harder work now is making the pieces fit. That starts with rethinking how sites are laid out and sequenced, so autonomous systems can run at full efficiency instead of being squeezed into workflows designed for manual crews. It also means working out how fleets from different manufacturers share data and coordinate on the same site: common data formats, shared site maps, and agreed rules for how machines yield to one another, built on the same open standards that will underpin safety.

No single company will build the future jobsite alone. But everyone working on it shares the same goal: build solar projects more safely and quickly to meet unprecedented energy demand. Working together could bring the industry closer to the ambition of delivering a 1 GW project in about a year. Achieving that would also require progress on grid connection, beyond the technologies discussed here.

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