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Electric Power & Natural Gas Practice

Build together: Rethinking solar project delivery

Limited engineering and construction capacity could challenge America's ability to quickly grow renewables. To win in an undersupplied market, renewables players can rethink project delivery.

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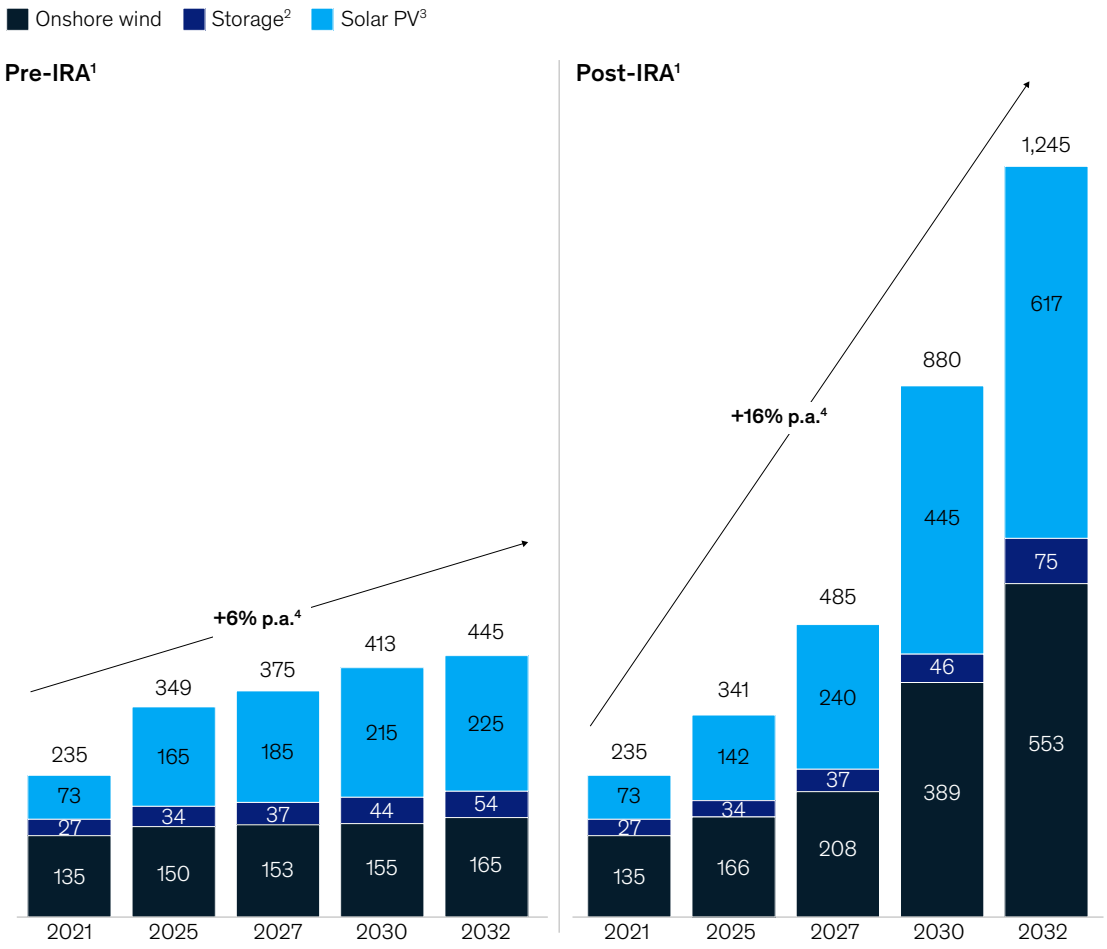
The passage of the Inflation Reduction Act (IRA) supports the growth of US renewables at an unprecedented pace. Solar, storage, and onshore wind capacity could reach more than 1,240 gigawatts (GW) over the next decade, growing 2.7 times faster than projected before the IRA took effect (Exhibit 1). The IRA is expected to stimulate domestic manufacturing of modules, subcomponents, inverters, trackers, and more, which could alleviate material shortages that had previously restricted project installation.

However, the solar industry faces significant construction and labor shortages that could worsen over the next three to five years. As solar projects grow in number and size, demand for engineering,

Exhibit 1

The projected capacity of solar, storage, and onshore wind has almost tripled, thanks to the Inflation Reduction Act.

Projections of US installed solar and wind capacity, gigawatts



[1]Inflation Reduction Act.
[2]Includes lithium ion and existing hydro-pumped storage.
[3]Photovoltaics.
[4]Per annum.
Source: Inflation Reduction Act of 2022; McKinsey Power Solutions

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procurement, and construction companies (EPCs) and for the labor and materials required to build projects is expected to increase rapidly. Based on McKinsey analysis, EPC capacity to serve utility-scale solar projects would have to almost triple to meet the anticipated demand of approximately 50 GW installed in 2027.

These market dynamics produce strong incentives to rethink traditional industry practices and unlock more-efficient project delivery. The size of the prize for successful collaboration has never been bigger: US renewables could attract an estimated $700 to $800 billion in capital investments to build onshore wind and solar projects through 2030. To capture this value, solar project owners, developers, and EPCs should establish new approaches to partnerships, risk ownership and contracting, workforce development, and digital and technology adoption. The energy transition will depend on it.

An undersupplied market persists as bottlenecks shift

To stimulate solar project development, the IRA extends old incentives and provides new ones. Chief among them are the revamped Investment Tax Credit (ITC), which offers a 30 percent tax credit on solar project capital cost, and the alternative Production Tax Credit (PTC), worth an estimated 2.75 cents per kilowatt-hour produced.[1] The IRA also created a new production tax credit that can be applied to domestically manufactured solar modules and subcomponents, including cells, wafers, polysilicon, and polymeric backsheets.[2]

However, despite these incentives, the solar industry still faces five critical challenges: EPC and labor shortages, limited access to land and permits, inflation and commodity price volatility, interconnection costs and timelines, and supply chain constraints. These are the main bottlenecks that make it difficult to deliver projects at a competitive cost and schedule, and they could potentially limit the rate at which the United States is able to grow its renewables to meet the economic incentives in the IRA.

— *EPC and labor shortages.* The IRA puts pressure on already constricted markets for EPCs and labor, which have not kept pace with rapid renewables growth. Moreover, demand for engineering and construction talent is growing in other industries, such as broadband, transportation, semiconductors, and public infrastructure, with support from federal legislation including the 2021 Bipartisan Infrastructure Law and the 2022 CHIPS and Science Act.[3] To expand capacity, solar EPCs must compete with higher-margin industries for engineering and construction talent. What's more, solar projects are often installed in rural areas where the overall labor pool is smaller to begin with, putting even more pressure on solar EPCs to ramp up their workforce development.

— *Limited access to land and permits.* Securing the land and approvals to install solar is a challenge for early-stage developers. A 100-MW solar project can require more than 500 acres of land, and interconnection and topographical constraints further limit the land available. Permitting is managed by local governments, producing a patchwork of different requirements and regulations that developers must navigate. In addition, permits can be difficult to obtain without community support.

— *Inflation and commodity price volatility.* Historically, solar module pricing has trended down as the technology has improved. However, the solar industry has not escaped recent inflationary pressures, and commodities such as steel, aluminum, and copper—which are used in modules, trackers, inverters, and bulk materials—have experienced record price volatility in the past 36 months. Going forward, pricing trends could be more uncertain because of geopolitical dynamics, commodity price volatility, and the challenges of rebalancing supply and

[1] Utility-scale projects can receive potential add-on tax credits for using domestic materials or for basing themselves in communities tied to traditional energy resources, such as former coal, oil, and natural-gas sites; see "Renewable electricity production credit amounts for calendar year 2022," Internal Revenue Service (IRS), November 10, 2022.
[2] "The Inflation Reduction Act," US Environmental Protection Agency, updated April 17, 2023.
[3] Garo Hovnanian, Adi Kumar, and Ryan Luby, "Will a labor crunch derail plans to upgrade US infrastructure?," McKinsey, October 17, 2022; "Semiconductor fabs: Construction challenges in the United States," McKinsey, January 27, 2023.

demand amid the diversification of solar panel manufacturing.

— *Interconnection costs and timelines.* Until an interconnection agreement is signed, grid connection can be one of the most uncertain costs for a renewables project. Additionally, in many regions, the interconnection process has become longer and more expensive. On average, US projects spend almost three years in interconnection queues, according to Lawrence Berkeley National Laboratory.[4] To reduce the number of speculative projects in queues, some independent system operators (ISOs) have implemented administrative fees that force developers to make larger bets on projects before reaching an interconnection agreement.

— *Supply chain constraints.* The IRA creates incentives for the US solar market to transition toward a more localized supply chain. US panel manufacturers could begin producing at scale within the next one to three years, relieving recent module availability challenges. However, the shortage of domestically manufactured wafers and solar cells is expected to persist, leaving panel manufacturers and their customers dependent on an international supply chain for these critical subcomponents. Other inputs, such as inverters, trackers, and racking, face an uncertain cost outlook, but significant shortages are not expected.

Many of these challenges have been ongoing, but a recent McKinsey survey suggests that they have shifted in order of priority.[5] Today, EPC and labor shortages are a top challenge for renewables players, overtaking other obstacles such as limited access to land and permits, inflation and commodity price volatility, and interconnection (Exhibit 2).

EPCs could remain in short supply for the next three to five years as the industry attempts to almost triple in size to build new utility-scale solar projects. This undersupplied market has given EPCs leverage to negotiate more favorable pricing and reduce

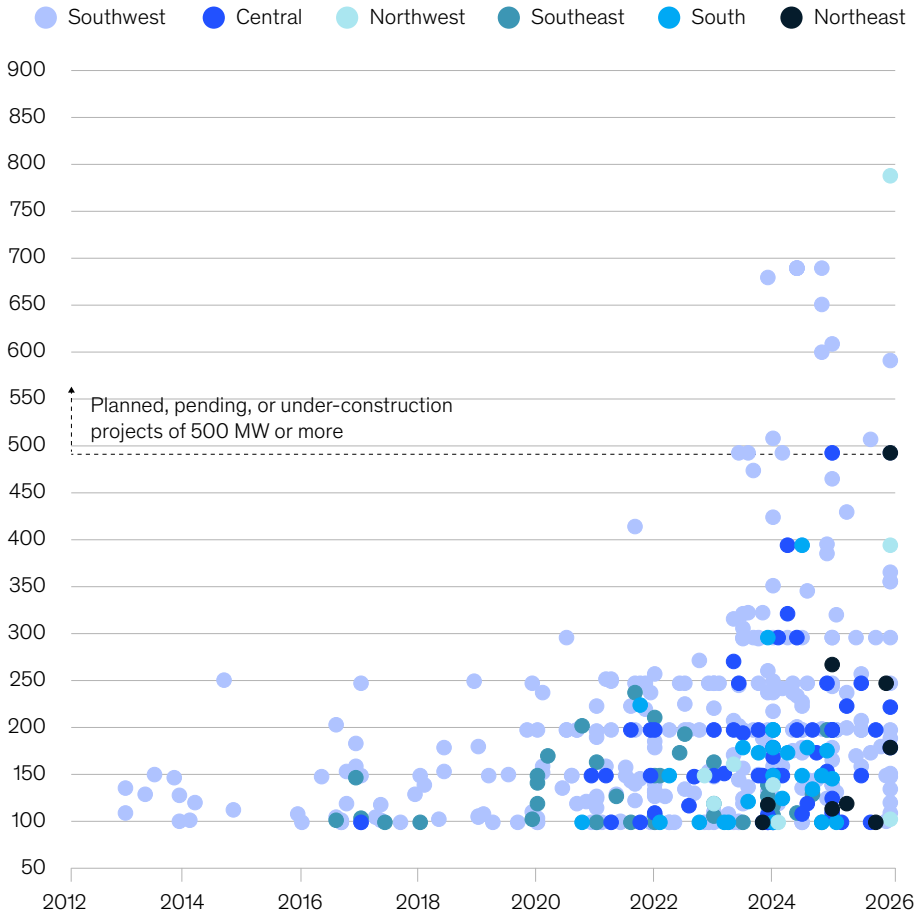
[4] Will Gorman et al., "Queued up: Characteristics of power plants seeking transmission interconnection as of the end of 2021," Lawrence Berkeley National Laboratory, April 2022.
[5] McKinsey Utility, Developer, and EPC Survey, December 2022.

Today, EPC and labor shortages are a top challenge for renewables players.

Exhibit 2

Utility-scale solar projects are expected to increase in number and size, driving high demand for qualified construction companies.

US utility-scale solar projects of more than 100 MW, by region[1]



Number of utility-scale solar projects in previous 12 months (Jan-Dec)

2	5	4	2	19	8	8	16	28	51	41[2]	98[2]	98[2]	52[2]

[1]South = Alabama, Arkansas, Louisiana, Mississippi, Tennessee; Southwest = Arizona, California, Colorado, New Mexico, Nevada, Oklahoma, Texas, Utah; Northwest = Oregon, Washington, Idaho; Central = Iowa, Illinois, Indiana, Michigan, Minnesota, Ohio, Wisconsin; Southeast = Florida, Georgia, North Carolina, South Carolina, Virginia; Northeast = Delaware, Maine, New Hampshire, New York, Pennsylvania.
[2]Pending, planned or under-construction projects include 242 projects: 45 pending regulatory approval, 69 planned for installation but without initiated regulatory approvals, 32 with regulatory approval received but not under construction, 6 with construction complete but not yet in commercial operation, and 90 under construction.
Source: EIA Monthly Electric Generator Inventory, March 2023

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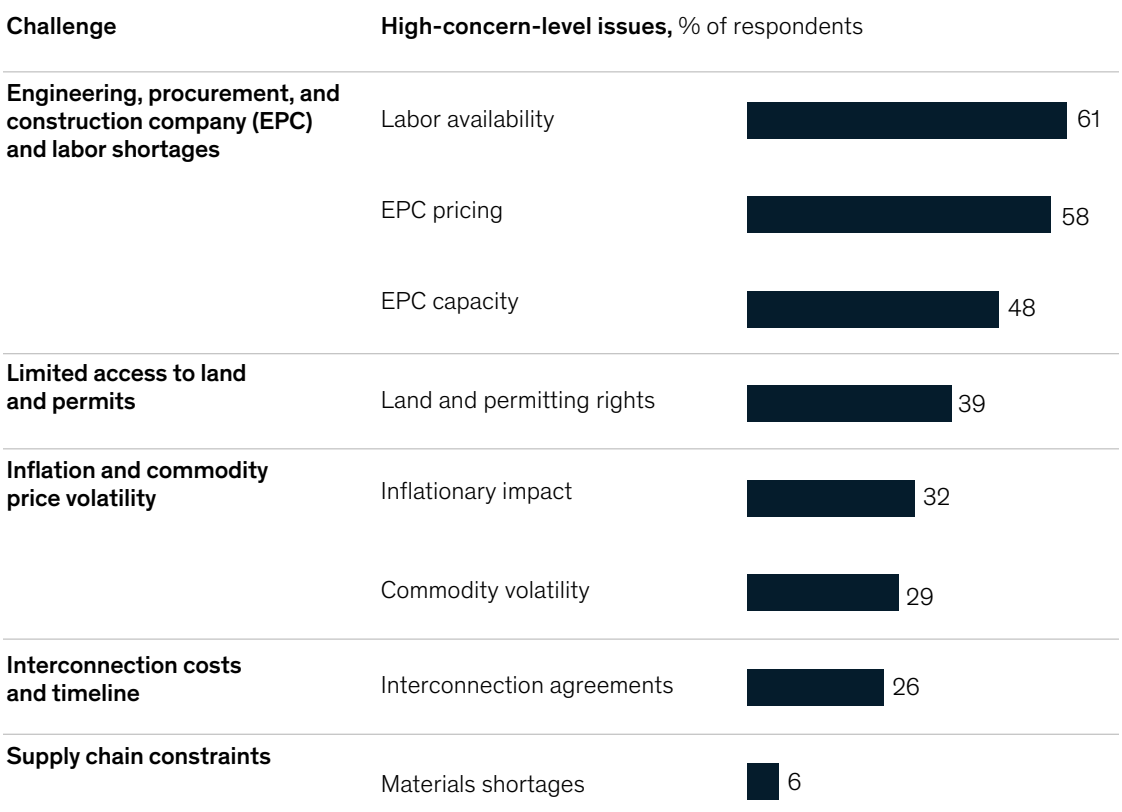
their liability when materials or labor shortages cause schedule or cost overruns. At the same time, owners are struggling to secure EPC capacity and absorb risk from procurement uncertainty. Although some developers have established EPC partners, others—such as utilities that are just beginning to self-develop renewables—have arrived late to the matchmaking and need to catch up on solar-project-delivery capabilities. In this constricted environment, project pipelines are at stake, along with a seat at the table amid growing demand for renewables. More than a dozen megaprojects of more than 500 megawatts (MW) each—enough to power the equivalent of more than 150,000 American homes—are already in the pipeline for 2023–26 (Exhibit 3).

Capacity isn't the only challenge. Because solar construction is relatively simple, efficiency and consistency in installation are critical to preserving margins. There is already a significant performance gap, with smaller players' productivity lagging behind that of market leaders that have a dozen or more years of experience in the solar industry. And as project sizes grow, there is a shortage of EPCs

Exhibit 3

Engineering, procurement, and construction company and labor shortages are a top challenge for developers and utilities.



Note: High concern level = concern levels of 6–8, as rated by respondents.
Source: McKinsey Utility, Developer, and EPC Survey, Dec 2022, n = 42

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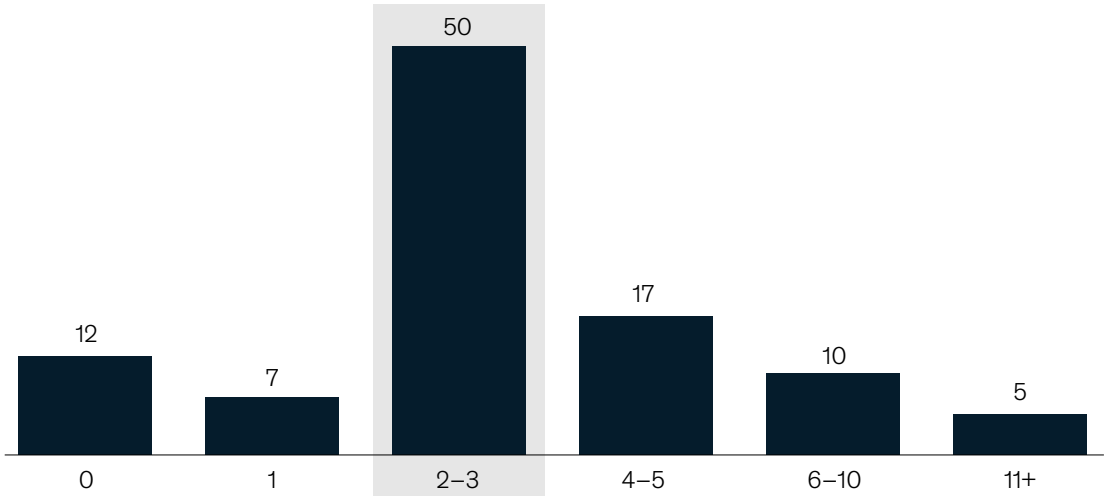
Exhibit 4

Leading solar players have established an average of two to three partnerships each to achieve a broad array of benefits.

Number of partnerships per solar player, % of companies



Source: McKinsey Utility, Developer, and EPC Survey, Dec 2022, n = 42

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that can achieve high productivity and deliver cost-efficient projects at greater scale.

Rethinking solar project delivery

In the coming years, collaboration will be a major theme in renewables, achieved through new approaches to strategic partnerships, risk ownership and contracting, workforce development, and digital and technology adoption. Established EPCs and developers can form tighter partnerships, such as by facilitating more integration between their respective engineering teams or promoting transparency on pricing and risk. And those without committed partners might entertain new options; for example, a utility developer might invest in building the capabilities of a regional contractor to install solar at scale.

Bold ambitions such as these could shift the market away from traditional contracting structures in which EPCs are treated purely as service providers that are compensated for delivering each project. Instead, owners and EPCs could pursue portfolio partnerships in which both sides have incentives to tackle supply chain and labor constraints together, unlocking additional value to be shared between them.

Partnerships

Partnerships have been a winning strategy in the solar industry for many years. Today, leading developers have locked in capacity with two or three core EPC partners on average, bringing benefits to both sides (Exhibit 4). The idea of a partnership extends beyond simply establishing a select set of

EPCs that bid on or are awarded work on a project-by-project basis. They can range from nonbinding relationship-based commitments to formal master service agreements with bilateral contractual commitments. All partnership arrangements share common objectives, such as increased visibility and joint planning of project pipelines, early engineering involvement and continuous improvement of designs, and collaborative workforce attraction and development programs.

Forming partnerships will continue to be a winning strategy in solar project delivery, but the landscape of partnerships is expected to change going forward. First, the industry could shift to include a broader set of stakeholders vying for committed partners. Second, new approaches to joint business growth and capability building could deepen partnerships and promote collaboration across larger and longer-term project portfolios.

Expanding the industry. Incumbents will expand their businesses to take advantage of IRA tailwinds, but rapid market growth also opens the door for other players to build a presence in renewables. For example, it has become potentially more attractive for regulated utilities to self-develop renewables, since they could not efficiently monetize the Solar Investment Tax Credit but can take full advantage of the alternative Solar Production Tax Credit created by the IRA. New types of EPCs could also enter renewables. A few large, diversified EPCs that serve other industries have begun expanding into solar. And as owners look for available talent pools to get projects in the ground, local or regional contractors could also be reskilled to install solar projects.

Shifting to portfolio partnerships. Contracting across a larger pipeline of projects can create flexibility to reallocate labor and materials to the projects that are ready to go. Shifting from one-off projects to larger pipelines also helps align incentives for partners to support each other's growth and productivity improvements over time. For example, to establish a multiyear solar portfolio, a utility developer might contract an EPC that currently serves the developer's other transmission assets but has ambitions to expand into renewables. The utility could procure equipment in-house—such as panels, inverters, trackers, and racking—to manage long lead times and leverage economies of scale across multiple projects while the EPC focuses on building the labor and technical skills to install solar. Greater cost transparency could allow the utility to monitor efficiency gains over time and set realistic expectations for the first few projects. The project load could also ramp up in stages, allowing the EPC to streamline the installation process and implement learnings on future projects.

Co-investing in growth and capability building. Players along the solar value chain can deepen partnerships through joint capability building and capacity expansion. For instance, a developer could co-invest with an EPC to build a workforce-training center to address the shortage of construction labor. The developer could use its community ties to assist with talent attraction, securing a skilled workforce to install its renewables projects. Meanwhile, the EPC could implement a training program that is compatible with the intended project pipeline and offer consistent, localized work to program graduates by collaborating with the developer on an efficient installation process and project sequencing. Joining forces with local government, unions, or a community trade school could also strengthen the partnership.

Risk ownership and contracting

EPC availability has become a tighter bottleneck on project pipelines, pushing owners to engage EPCs earlier, consider less-experienced players, and absorb greater pricing risk for labor and materials. Stakeholders, including the owner, developer, EPC, and suppliers, can shift their contracting approach to reduce disruptions to their agreements and promote more-efficient project delivery. These stakeholders can revisit the allocation of responsibilities and risk, as well as engaging in more collaborative contracting.

Adapting to new responsibilities. The line between the responsibilities of the EPC and those of the developer is already blurring as some developers

have shifted away from turnkey contracts. Our survey and interviews with industry experts indicate that an increasing number of owners are expanding in-house procurement capabilities over the next five years. Developers are already delivering projects with engineering, procurement, and construction management (EPCM) and project management contractor (PMC) models that enable more owner oversight and control, and some utilities are expected to follow suit.

Revisiting the allocation of risk. Risk ownership is another aspect of contracts that is ripe for revision. Recent contracts with EPCs have tended to shift more risk onto the project owner. However, instead of taking an adversarial approach to risk ownership, stakeholders can work together to align incentives so that both parties are mitigating risks that could lead to cost or schedule overruns. For example, project partners could set aside a common incentive pool that grows or shrinks based on overall project performance and negotiate allocation percentages as part of contracting. As suppliers or EPCs take on additional project risk, the project owner's percentage would decrease to compensate them. In another model, the contractor that carries the risk for materials and labor could receive progressive incentive payments for achieving costs or schedule below a predefined target. In such progressive incentive schemes, the contractor retains a higher percentage of the cost savings as the total cost savings increase (for example, 30 percent of the first $100,000 in cost savings, 35 percent of the next $100,000, and so on). This system can motivate the contractor to exceed targets and capture incremental savings beyond the low-hanging fruit.

Embracing collaborative contracting. Collaborative contracting could be a solution to anticipate demand, align on capacity for future projects, and unlock mutual growth. In other capital-intensive industries, collaborative contracting pilots have improved both costs and schedules by 15 to 20 percent versus traditional contracts, according to prior McKinsey research.[6] The right level of collaboration will depend on the nature of the partnership. For example, in aligned-incentives arrangements, cost and schedule overruns and underruns are shared. In integrated project delivery models, partners shape project scope, validate cost and schedule estimates together, and both share risk and profits. Stakeholders might operate under a single contract and a joint management structure that guides the execution of project.[7]

Contracting with newer players. Collaborative contracting is also beneficial in a market with newer, less-experienced players attracted by the rapid growth of renewables. Project owners who make significant bets on emerging EPCs could agree on a more "open book" approach with visibility into the underlying costs of delivering projects. Owners could monitor improvements over time and help structure contracts so that both the EPC and its workforce are rewarded for efficiency gains. Developers who scale their own in-house or joint capabilities, such as building late-stage engineering and design capabilities, can also reshape project delivery. For instance, moving away from a complete reliance on turnkey solutions could give developers flexibility to build projects with new contractors.

Workforce development

The labor shortage has affected numerous sectors of the US economy, and renewables have not escaped the crunch. More than 92 percent of employers in the electricity generation sector are having difficulty hiring construction workers.[8] The rapid growth of renewables has led to many players competing for the same talent pools, and because solar installation has lower margins, it can be difficult to compete with rising wages in adjacent industries.[9]

To increase productivity—which is a main source of competitive differentiation in solar—effective training and talent retention are critical. A renewed approach to workforce development can help secure access to labor, enable high productivity and continuous improvement, and reduce unexpected changes in project schedules and costs.

[6] "Collaborative contracting: Moving from pilot to scale-up," McKinsey, January 17, 2020.
[7] Ibid.
[8] *United States energy & employment report 2022*, US Department of Energy, June 2022.
[9] "Will a labor crunch derail plans to upgrade US infrastructure?," October 17, 2022.

Attracting talent. Talent attraction is the first step in growing the construction and engineering workforce. Solar project design and installation can provide jobs in rural parts of the country, but local people need to know those jobs exist. EPCs can partner with trade schools and local high schools to recruit new entrants to the workforce. In addition, dedicated efforts to attract historically underrepresented demographics would help expand workforce participation and make the growing industry more inclusive. Currently, 88 percent of the US construction workforce is White, and 89 percent is male.[10] Targeted career events, scholarships, and early-career mentorship and internship programs can help open paths for women and minorities to participate in the sector. To differentiate from other industries that are drawing from the same talent pool, solar EPCs should emphasize the mission-driven aspect of their work.

Training talent. Training programs can help new employees build the skills to work safely on jobsites and increase productivity. EPCs and project owners can collaborate on workforce development and ensure that localized training efforts are matched to a real pipeline of projects. Project owners can shift to a proactive approach, shaping talent development efforts around their needs. For example, to maximize efficient project delivery, an owner could co-invest in a training facility with a committed EPC partner and help tailor the curriculum to the owner's project pipeline, whether that be standardizing the module installation process or piloting new materials such as easy-install trackers.

Improving the employment pipeline. Once the trained workforce is in place, a consistent local pipeline of projects is critical for talent retention and productivity gains. Project owners and developers can help EPCs keep employees on a steady payroll. For example, a utility can sequence projects within its territory to ensure that the same workforce can service one after another. Project developers can also look for opportunities to standardize certain materials and designs across projects. In addition, productivity gains should be shared between contract parties. EPCs that achieve higher efficiency on later projects could be rewarded, with the initial baseline agreed on up front. Stipulations can also be made to ensure that every project meets the IRA's new prevailing wage and apprenticeship requirements.

Digital and technology adoption

Adoption of digital software and technology has been slow in solar construction. Although some leading solar EPCs are beginning to pilot digital solutions and next-generation equipment in solar, widespread adoption remains elusive. However, project pipelines are growing quickly, and the additional value at stake has pushed solar companies to look for innovations that increase overall solar construction capacity. Such digital and technology solutions can help EPCs reduce costs, increase productivity, and track progress throughout project planning and construction.

Adopting digital solutions. A range of digital tools can help align project plans with reality on the ground. Generative scheduling uses advanced analytics to efficiently allocate labor, equipment, and materials during construction planning. Such tools generate hundreds of thousands of schedule and resource configurations. The programs then evaluate these configurations based on predicted schedule and cost outcomes. In other capital-intensive industries, generative scheduling has improved materials staging and distribution, increased equipment utilization, and alleviated labor constraints through better work sequencing. Remote monitoring can also benefit solar project construction. For example, drone-enabled digital twins can check construction progress against the schedule and flag any deviations from a project's design. Catching and correcting issues early can increase project quality and minimize costly rework. Some project tracking tools can not only forecast the schedule based on progress but can also test alternative scenarios and suggest adjustments to optimize future resource allocation.

[10] "Labor force statistics from the Current Population Survey," US Bureau of Labor Statistics, accessed March 10, 2022.

Achieving greater efficiency through technology. Novel technologies have the potential to transform project engineering and construction, alleviating the labor shortage by allowing existing workers to become more efficient. For example, the latest solar tracker technologies are reducing the need for extensive earthworks on undulating terrain and enabling quicker and easier installation. Modular or preassembled solar components have also been tested in the field and are well positioned to scale. And automated earthworks equipment, which reduces labor time, is on the horizon. Start-up digital players and leading construction equipment manufacturers are testing autonomous bulldozers, excavators, and pile drivers with their partners. EPCs that adopt such technologies have the potential to capture higher margins from efficiency gains, and owners who create opportunities to pilot new equipment and materials on their projects can share in those benefits.

Strong tailwinds from the IRA have made certain market constraints facing US renewables more challenging, but the tailwinds also present a major opportunity for stakeholders to resolve EPC and labor shortages collaboratively. In a market that is expanding fast enough for both incumbents and emerging players to grow, owners can engage with EPCs in win–win partnerships that reach beyond adversarial contract negotiations to capture the growth opportunity. Our net-zero future depends on it.

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