Constraints to growth: supply chain risks facing renewables

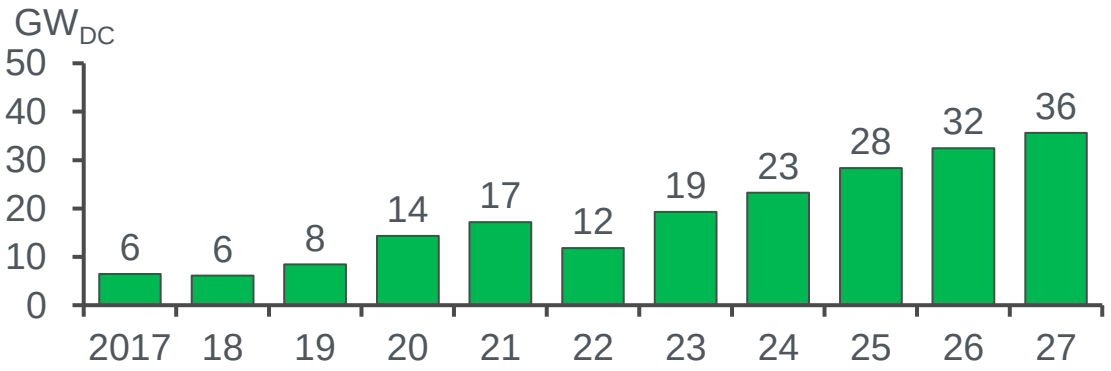
Presentation

June 28, 2023

These materials are intended to supplement a discussion with L.E.K. Consulting.
These perspectives will, therefore, only be meaningful to those in attendance.

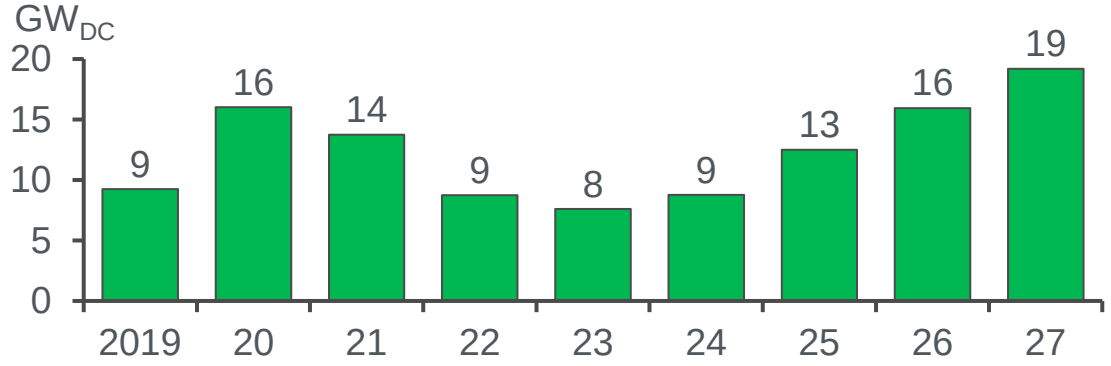
With the passage of the IRA, renewables installations are forecast to grow at a rapid rate

U.S. utility-scale solar capacity additions (2017-27)

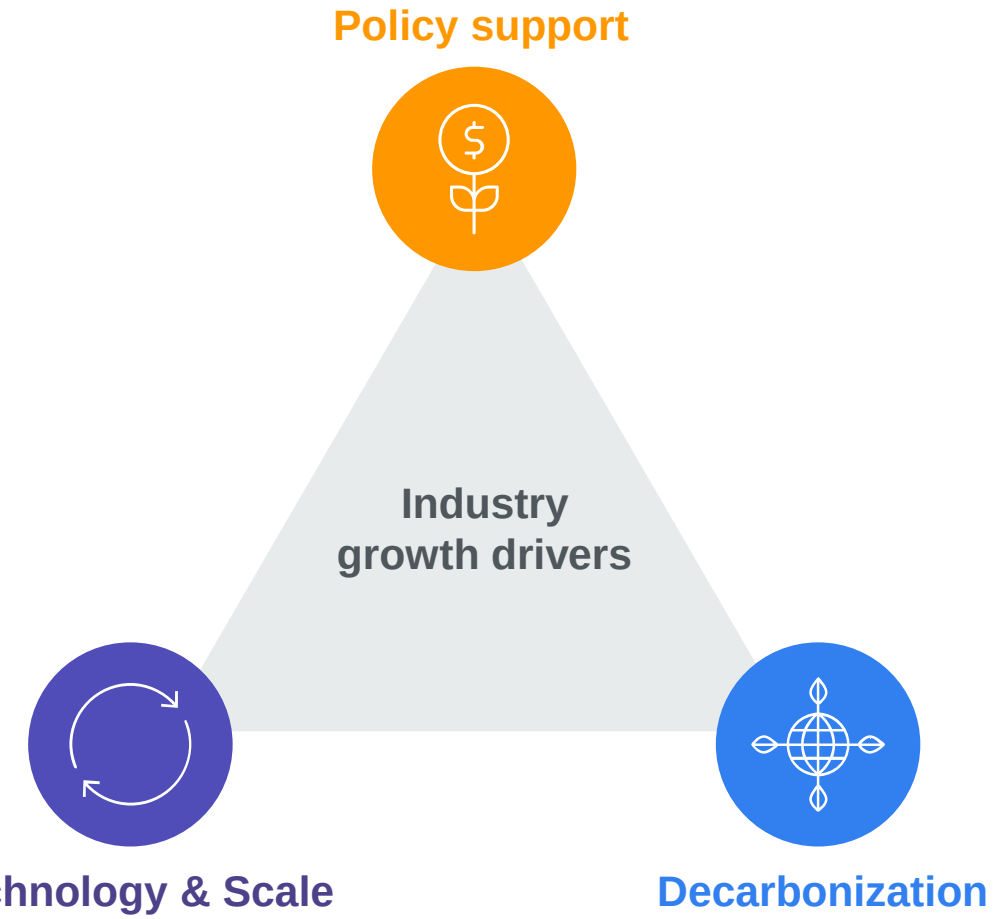


CAGR
(17-22) (22-27)
13% 27%

U.S. wind capacity additions (2019-27)



CAGR
(19-22) (22-27)
-2% 26%



Source: SEIA; Wood Mackenzie; LBNL; L.E.K. research and analysis

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But is an unconstrained demand view a reasonable assumption?

Potential constraints moderating growth

1. **Interconnection queues**
2. **Labor availability**
3. **Critical equipment shortages**

What's real?	*What's not?*	*What's the impact?*

Source: L.E.K. research and analysis

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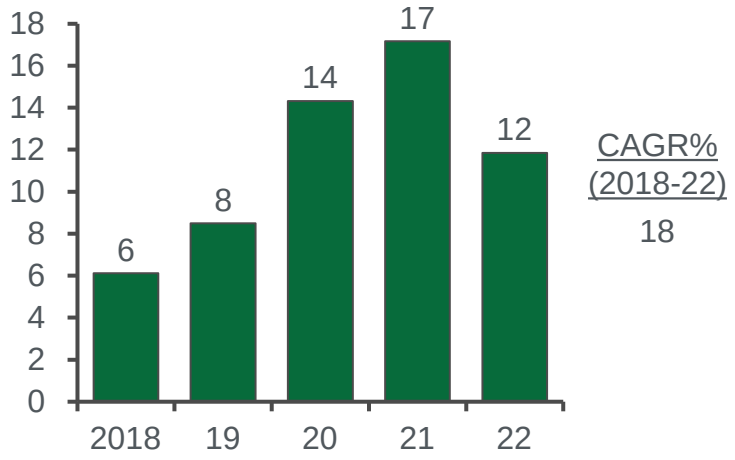
Taking solar as an example, despite a challenged '22, historical dynamics & IRA are supporting growth, but there is a shift in focus on if there is enough capacity [to serve demand] versus a cost-centric mindset

Historical growth

- Supported by declining costs and demand for low-carbon generation
- Issues from tariff circumvention and UFLPA*
- 2023 has shown rebound

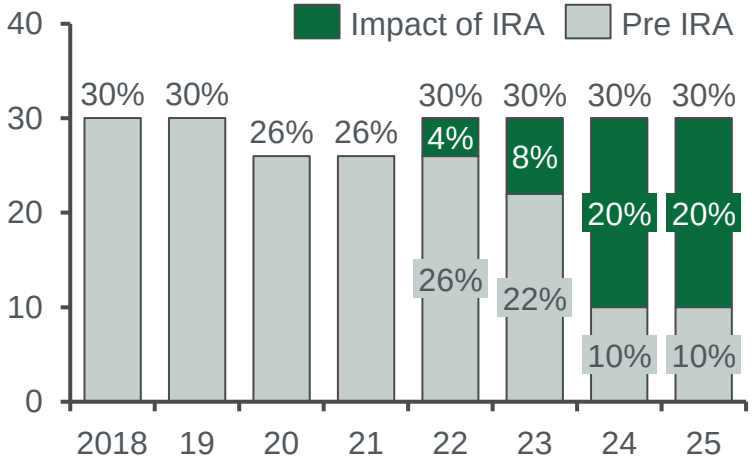
U.S. utility-scale solar new capacity additions (2018-22)
GW_{DC}



IRA expected to be key driver

- 30% investment tax credit or 2.6 cent per kWh through to 2032,
- Domestic content requirements

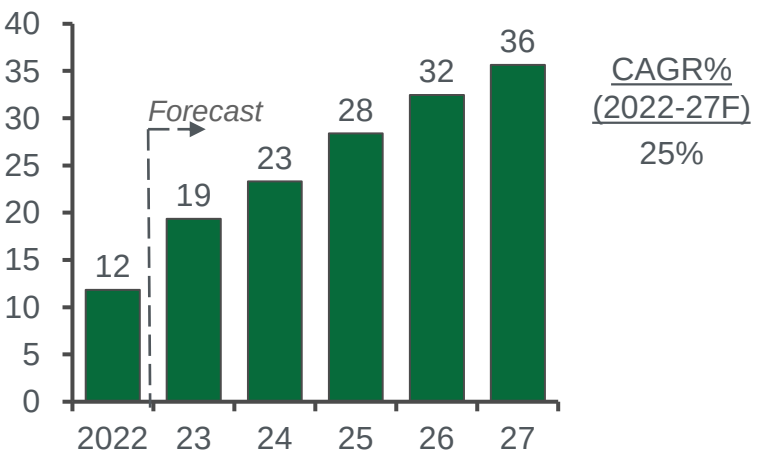
Federal ITC for customer-owned residential solar (2018-27F)
Tax credit as percent of solar investment cost



Forecast growth

- Similar tailwinds to historical
- Manufacturing capacity may be more important than costs versus the historical dynamics

U.S. utility-scale solar new capacity additions (2022-27F)
GW_{DC}



Note: * Uyghur Forced Labor Prevention Act
Source: SEIA; L.E.K. research and analysis

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Interconnection queues have surged and duration has increased from 25 to 35 months

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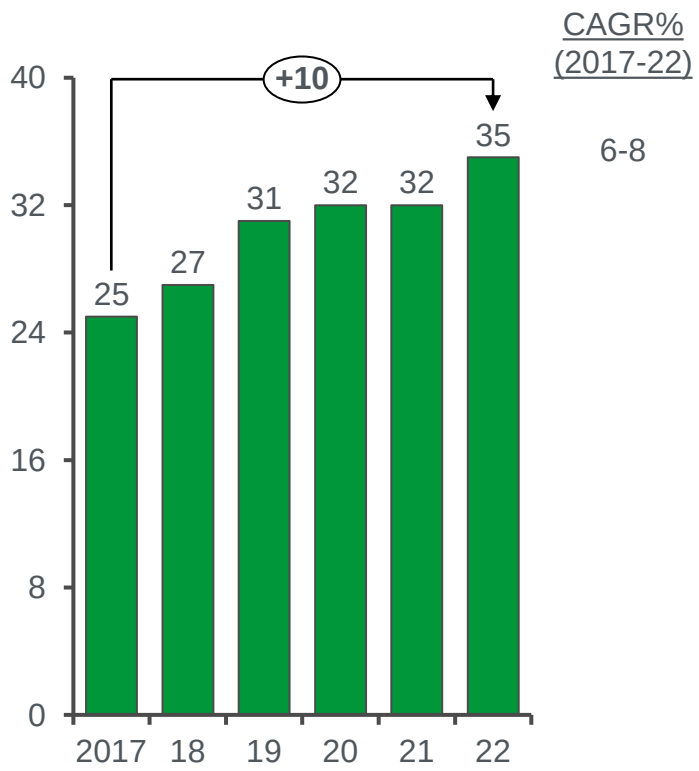
Interconnection queues | *Labor availability* | *Critical equipment shortage*

Total solar capacity in interconnection queue (2017-22)
GW_{DC}

Median duration of solar projects from interconnect request to interconnect agreement (2017-2022)
Months



Source: LBNL; L.E.K. research and analysis

- Interconnection queues have doubled in past 2 years
- Between 2000-17, ~72% of proposed projects were withdrawn from interconnection queues

"… 4 or 5 developers put in a project for the same site, and the queue works on a first come first served basis. There are a lot of projects which get withdrawn because of this…"

Senior VP, EPC

- Despite the high cancellation rate; approvals have grown at x2 the rate of the queue, but at the same time duration in queue is growing

Analysis of the inflated interconnection backlog suggests a limited impact to 2023 and 2024 installations

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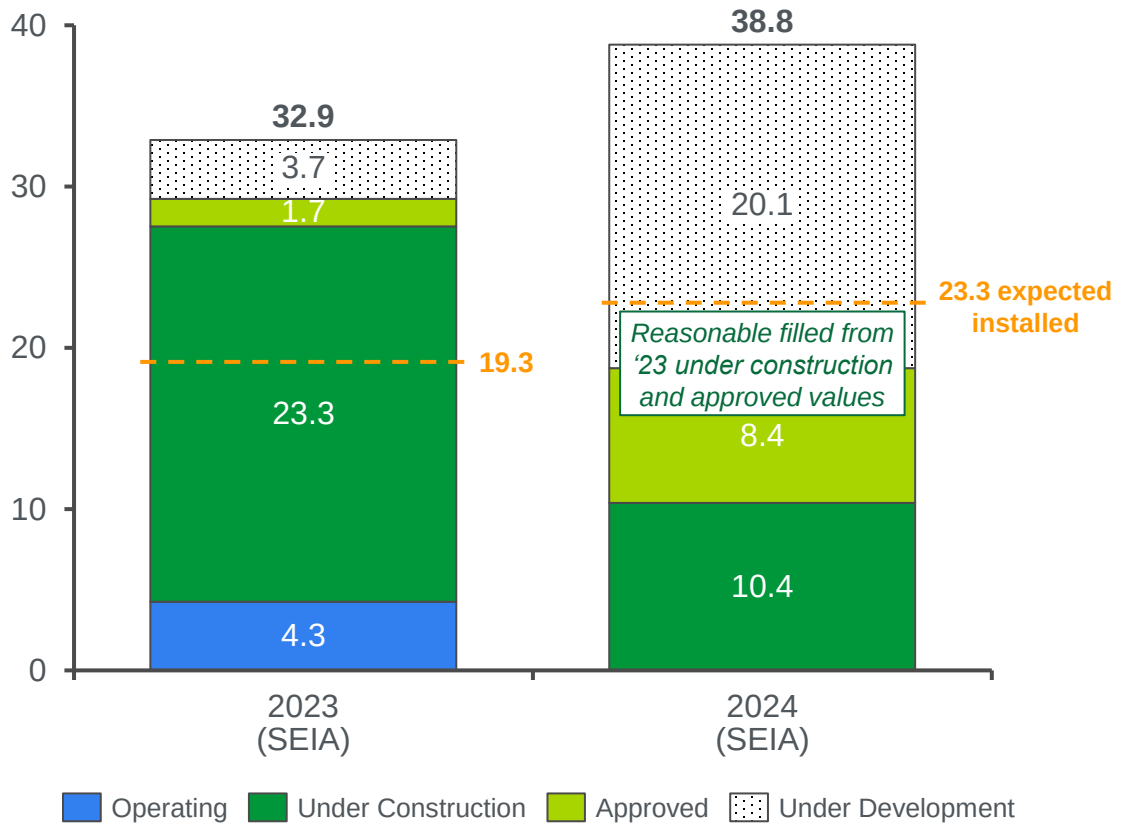
Interconnection queues | *Labor availability* | *Critical equipment shortage*

U.S. active solar capacity by study phase and expected capacity forecast (2023-24F)
GWdc



Source: SEIA; Lawrence Berkeley National Laboratory; L.E.K. research and analysis

- ~42.6 GWdc capacity additions forecast over 2023-24 (orange line)
- ~47.8 GWdc are operating, under construction, or approved
  - No projects that are in pre-planning or pending approval require approval to meet the SEIA's forecast
  - >50% of "under development" projects are pending approval; site preparation could be underway
- Additional resources being added to increase approval rates

"… The approval rates should increase in the future, no one wants to further delay these opportunities and more resources are being added to help get more projects through the queue..."

Solar project manager, EPC

"…No one wants to be perceived as a bottleneck, so they're working through it, but suspect that to an extent, it will always be an issue…"

Executive, Developer

- Many cite the bigger challenge is transmission capacity required for new projects
  - Sites close to existing transmission infrastructure have already been taken
  - More transmission investment is needed to avoid postponement and higher costs of planned projects

EPC labor shortages have presented challenges for developers, but companies are managing by expanding the list of EPCs used and companies cite the long project timelines provide flexibility to find EPC labor

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Interconnection queues | **Labor availability** | Critical equipment shortage

There is a labor shortage at EPCs

- 89% of solar firms reported difficulties finding qualified applicants in 2021, and given the age of the workforce (25% over 55) and projected demand growth, the labor shortage is expected to worsen

"… The first holistic problem is that there are just not enough skilled workers to perform all of the work …"

Executive, EPC

"… We know it's a problem, and there is regionality element to this, in some areas of the country, we still have resources in Texas and California that we can pull from….:

Senior VP, EPC

Projects can find EPCs to complete projects, but are expanding their vendor lists

- The market for EPCs is fragmented, and while the top tier EPCs are at capacity, there are still smaller EPCs available, making delays unlikely

"… Solar development has grown past the capacity of the large, tier 1 EPCs, but there are smaller EPCs out there. These tier 2 and tier 3 EPCs are less sophisticated and less equipped to handle unanticipated things, but you won't often see developers wait. Not saying it won't happen, but the sooner you can get the project online the better …"

Development Manager, Leading US Solar Developer

There is time to find EPCs within the solar project timeline

- Given that it takes at least two years to get through the interconnection queue, developers & EPCs have time
- EPCs are more efficient plus are developing training centers, planning for new staff, and training the coal industry

"… Developers generally submit the interconnection proposal without an EPC firm and then hire a consulting firm that finds the EPC. So, they don't need an EPC initially, but they'll be ready to go by the time the interconnection queue delays are solved …"

Former executive, Asset Owner

"… We're looking into high schools to find people and train them up, and also looking at those who are currently working in coal to reskill them. We have avenues to be able to source more labor…"

Executive, Asset Owner

Source: Renewable Energy World; Solar Builder; Interstate Renewable Energy Council; L.E.K. research and analysis

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Transformer lead times are a critical issue today and beginning to impact marginal projects

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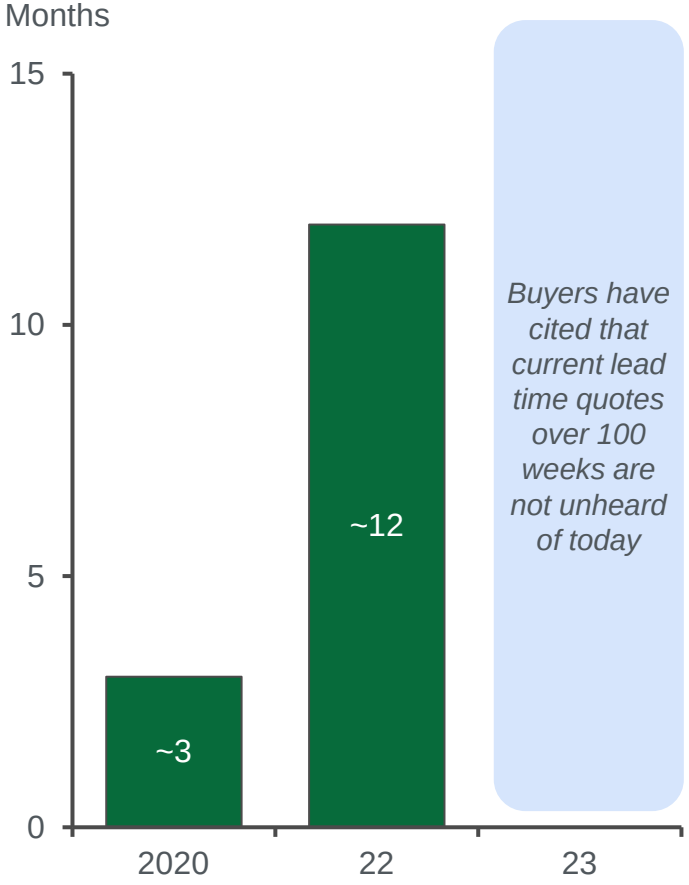
Interconnection queues | *Labor availability* | **Critical equipment shortage**

U.S. average transformer lead time (2020, 22)
Months



Source: APPA; T&D World; L.E.K. research and analysis

- Lead times are not expected to be a significant bottleneck for new capacity until lead time exceeds construction time (~18-24 months)
- Aging power grid, ongoing supply chain issues, and growing demand for renewable installations are key drivers of the issue

"… Solar projects require a lot more transformers compared to a traditional coal plant, you need many dotted around the site which leads to higher demand and longer lead times…"

Senior VP, EPC

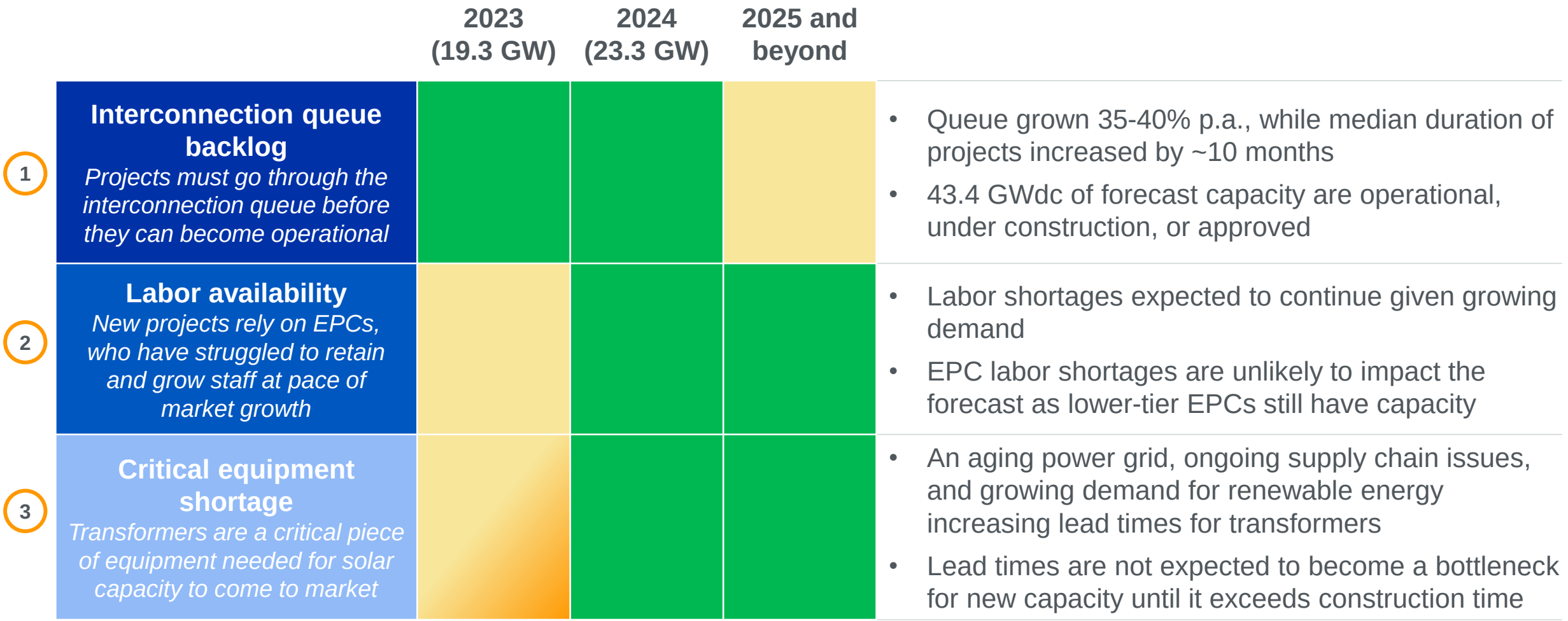
- Lead times rose from ~3 months in 2020 to ~12 months in 2022; some utilities reported lead times of ~3 years
  - Small-scale solar developers with lower buying power are more likely to see longer lead times
  - Historically this has not been a critical issue, but tightness in 2023 may push marginal projects into 2024
  - Some projects are expected to be delayed or canceled due to transformer lead times and achieving the SEIA forecast is in question – though disruption is not at the same magnitude of the 2022 issues
- Some market participants believe that lead times will decrease

"… There was a demand shock in 2022, but I think after next year transformer manufacturers will be better prepared to provide the market with transformers. They're working three shifts a day, and I expect lead times to come down …"

Project Manager, Engineering Company

Labor availability & equipment shortages may pose some risk to reaching near-term potential with project delays a possibility; longer-term the queue, without further intervention, may become an issue at 30+GW

Summary

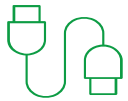


While the risk outlook appears manageable, one final risk to consider: the lack of interregional transmission lines

Transmission congestion is the next key bottleneck

- Transmission miles being built has declined over time and insufficient transmission lines have become a major “bottleneck” in deploying renewable resources

Transmission connection times are rapidly increasing



- ~950GW of solar capacity is currently seeking transmission access with typical duration from connection request to commercial operation at 5 years in 2022 (up from <2 years between 2000-2007)

Considerable investment is required

- To achieve 100% clean electricity by 2035, a total of 91,000 miles of new transmission lines required within the next 13 years

Value can be unlocked for developers, EPCs and consumers

- Many regional and interregional transmission links have significant potential economic value and expanding transmissions could save >$300B in power system costs for consumers and allow additional renewable projects to be onboarded

Source: L.E.K. research and analysis; LBNL

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Thank you

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