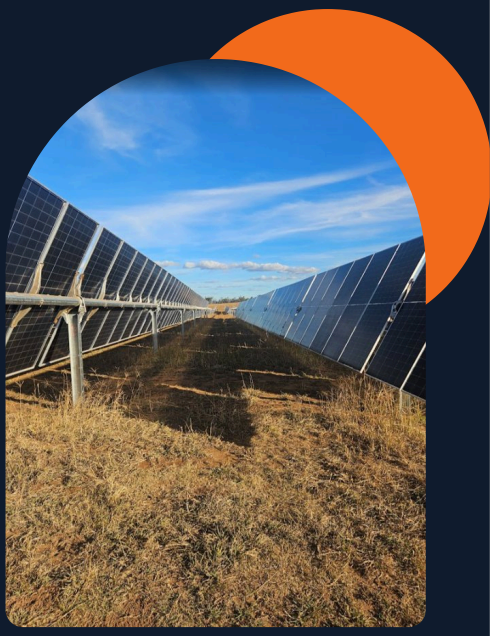
From Paper to Power

Digitising utility-scale solar construction for decarbonisation



Jenna Connellan
CEO and Co-Founder, Surya
jconnellan@rishitech.co

White paper, 14 October 2026
With contributions from Australian customers

8,420
labour hours saved on a 300 MW reference project

28.1
hours saved per MW

$2,390
estimated saving per MW

84%
reduction in direct work-hours

Modelled estimates from a time-and-motion assessment.

Abstract

Australia's decarbonisation targets require rapid growth in utility-scale solar, yet construction productivity has not kept pace. Despite a strong project pipeline, delivery is constrained by fragmented, paper-based workflows, limited real-time visibility and manual reconciliation across construction, logistics and quality processes. These inefficiencies contribute to schedule delays, rework and higher balance-of-plant and operating costs, creating a barrier to ultra-low-cost solar.

This white paper examines the principal bottlenecks in utility-scale solar construction and where targeted digitalisation can unlock material efficiency gains. Construction has lagged other sectors in adopting digital and automation-ready tools, leaving project data fragmented, difficult to validate and poorly suited to emerging automation technologies.

The case study considers a representative utility-scale solar reference project of approximately 300 MW with an 18-month construction programme. A time-and-motion assessment compares baseline practices with digital workflows for project planning, progress recording and reporting, inventory management and quality control. The analysis indicates potential savings of approximately 8,420 labour hours, or 28.1 hours per MW, worth approximately $2,390 per MW at $85 per hour. Benefits are concentrated in inventory management (39%), avoided delays and broader impacts (20%) and quality control (19%), followed by project planning and forecasting (12%) and progress recording and reporting (10%). The findings also show how structured construction data can support robotics-assisted workflows and future expansion into DC electrical, battery energy storage system (BESS), and operations and maintenance scopes.

The time-and-motion criteria, and the estimated durations with and without digital intervention, were calculated from institutional solar installation knowledge. They were tested with our Australian customer base, whose site teams execute solar construction every day, and adjusted where feedback was provided. The paper was prepared by Surya, the provider of the platform assessed.

1. Introduction

> Australia must rapidly increase renewable generation. Technology costs have fallen, but project delivery remains constrained by construction productivity.

Australia's energy transition requires an unprecedented scale-up of utility-scale solar. Much of the discussion about renewable deployment focuses on generation technology, financing, planning approvals and grid connection. Less attention is paid to construction productivity, which is becoming a critical bottleneck.

This paper examines whether construction digitalisation can improve installation productivity, reduce costs and create a foundation for future automation and robotics-assisted construction.

2. Australia's Solar Construction Challenge

> Large deployment targets, labour shortages, remote locations and fragmented workflows are slowing project delivery.

2.1 Scale of the challenge

AEMO's 2026 Integrated System Plan (ISP) indicates that approximately 28 GW of new grid-scale solar capacity is required in the National Electricity Market (NEM) by 2035.[1] Together with Western Australia's decarbonisation demands, close to 38 GW of new renewable capacity is required across the country in the next decade.[2,3] These figures are before considering the potential AI data-centre boom in Australia. Deployment is running below the pace these pathways imply: Australia is installing about 1.4 GW a year against a pipeline of 24 GW across 100 projects over the next five years.[4] A strong pipeline alone will not close the gap. Projects must also move through procurement, construction, commissioning and grid connection more efficiently.

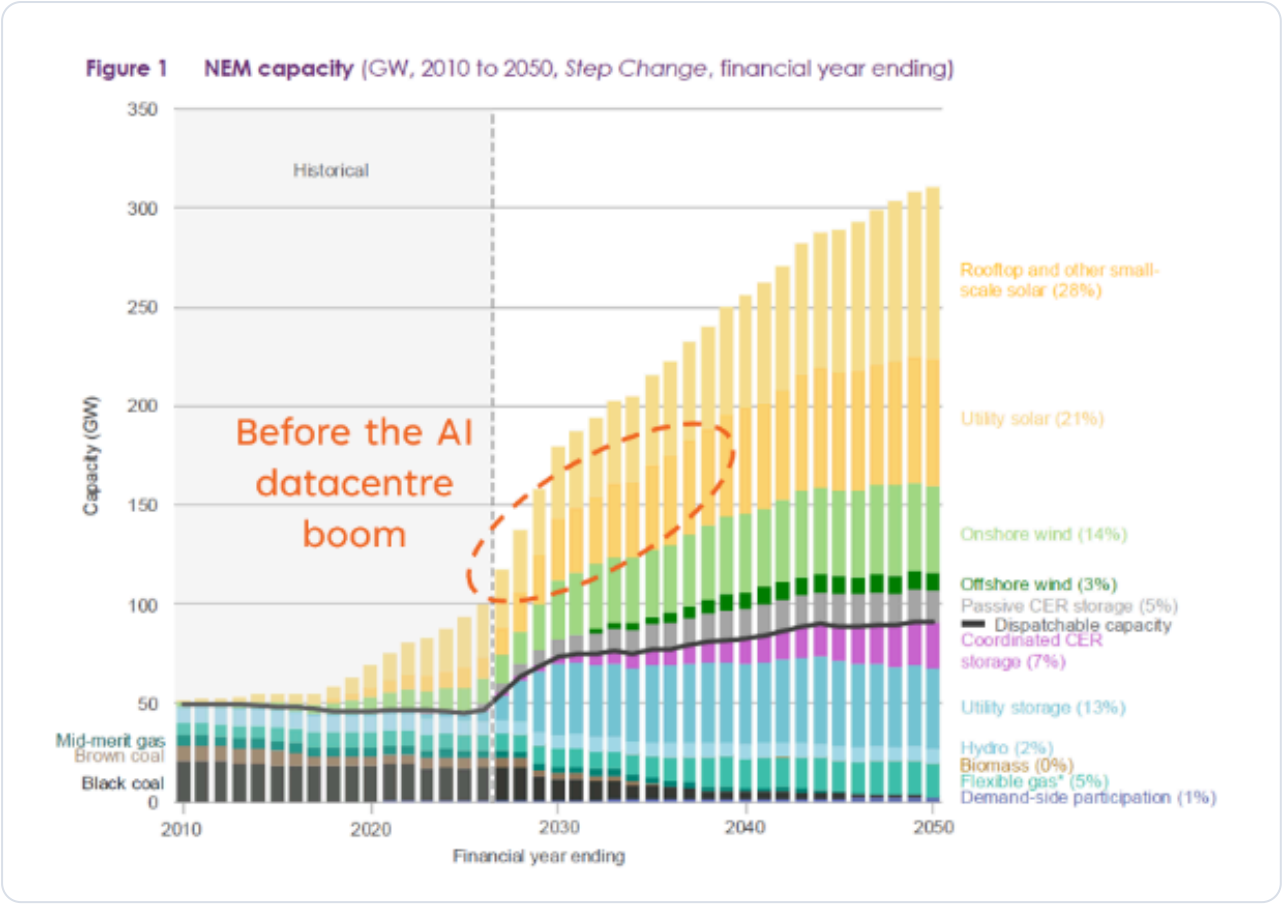


Figure 1. AEMO's 2026 ISP projection of NEM capacity to 2050 under the Step Change scenario. The annotation was added by the author.

Source: AEMO 2026 ISP.[1]

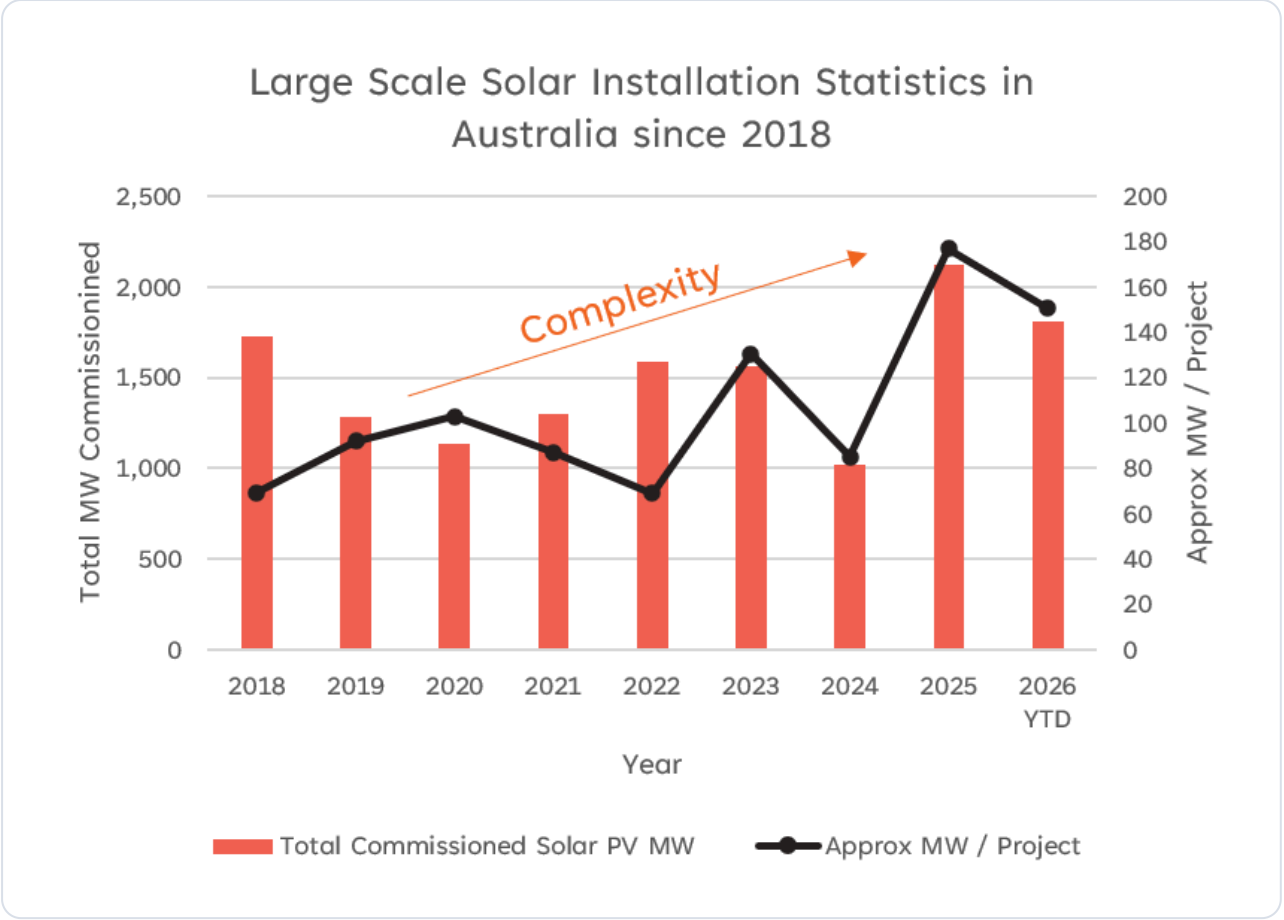


Figure 2. Large-scale solar installed in Australia since 2018: capacity commissioned each year (bars) and approximate average project size (line). Larger projects bring greater complexity.

Source: author's calculations from AEMO NEM Generation Information, July 2026.[4]

2.2 Labour constraints

Utility-scale solar delivery depends on a workforce already under pressure from competing infrastructure programs. Skilled labour shortages, limited engineering, procurement and construction (EPC) capacity and the remote location of many projects increase mobilisation costs, constrain supervision and make consistent execution difficult. These pressures are expected to intensify as solar, wind, transmission, transport, data-centre and public-infrastructure projects compete for similar capabilities.[5,6,7]

Solar construction is particularly exposed because projects need large workforces for relatively short periods in regional locations where the labour pool is limited.[8] As projects grow and demand for solar rises, fewer EPCs have the experience and systems required to maintain high productivity at scale. Workforce turnover increases the importance of repeatable processes, reliable handovers and consistent digital records.[9]

In Australia, EPC contractors and industry bodies report that skilled-labour shortages are already contributing to project delays, cost pressure and execution risk.[10] Incentives and regulatory frameworks that differ across the states add further pressure.[11]

McKinsey's analysis of renewable project delivery identifies labour and EPC capacity constraints as material risks to the sector.[8] Internationally, EPC capacity to serve utility-scale projects would have to almost triple to meet anticipated near-term demand.[8] Broader construction research points to weak long-term productivity growth,[9] and forecasts point to an Australian construction labour shortfall of approximately 300,000 workers by mid-2027.[12] Together, these findings reinforce the need to increase the output of the existing workforce rather than relying solely on workforce expansion.[9]

3. Why Solar Construction Remains Inefficient

> Many solar projects still rely on spreadsheets, paper records, PDFs and disconnected software systems. The result is delayed reporting, poor visibility and rework.

3.1 Construction as a digitalisation laggard

Global construction labour productivity grew by only 10% between 2000 and 2022, compared with 57% across all industries.[9] Only 42% of construction businesses report that site teams primarily have access to real-time project data, while 25% still rely primarily on paper-based systems.[12]

Deloitte's Digital Capability Index found that only 16% of construction businesses have advanced digital capability, while 84% remain at developing or intermediate stages. 37% identified a lack of digital skills as the largest barrier to adoption.[12]

Construction remains one of the least digitised major industries.[9] For utility-scale solar this matters because project outcomes depend on coordinating repeated installation activities across large sites, with multiple stakeholders executing different scopes of work and making decisions based on different challenges, while keeping control of materials, quality records and schedule performance. Many digital tools are also used to reproduce existing processes rather than redesign how work is planned, executed and

verified.[9] The opportunity is not simply to digitise documents but to create connected workflows that reduce duplicate entry, make exceptions visible and enable timely decisions.

3.2 Traditional construction workflows

Traditional solar construction sites remain heavily dependent on printed drawings, marked-up plans, spreadsheets, PDFs and messaging applications. Visual aids can make repetitive field activities easier to execute, but the information they contain is often disconnected from the systems used for planning, reporting and close-out.

Progress is commonly recorded by colouring drawings or updating spreadsheet representations of array layouts. Separate workbooks track deliveries, storage locations, damaged materials, inspections, defects and completion status. Information is then reconciled manually into reports for project leaders and clients, often after the data has become stale.

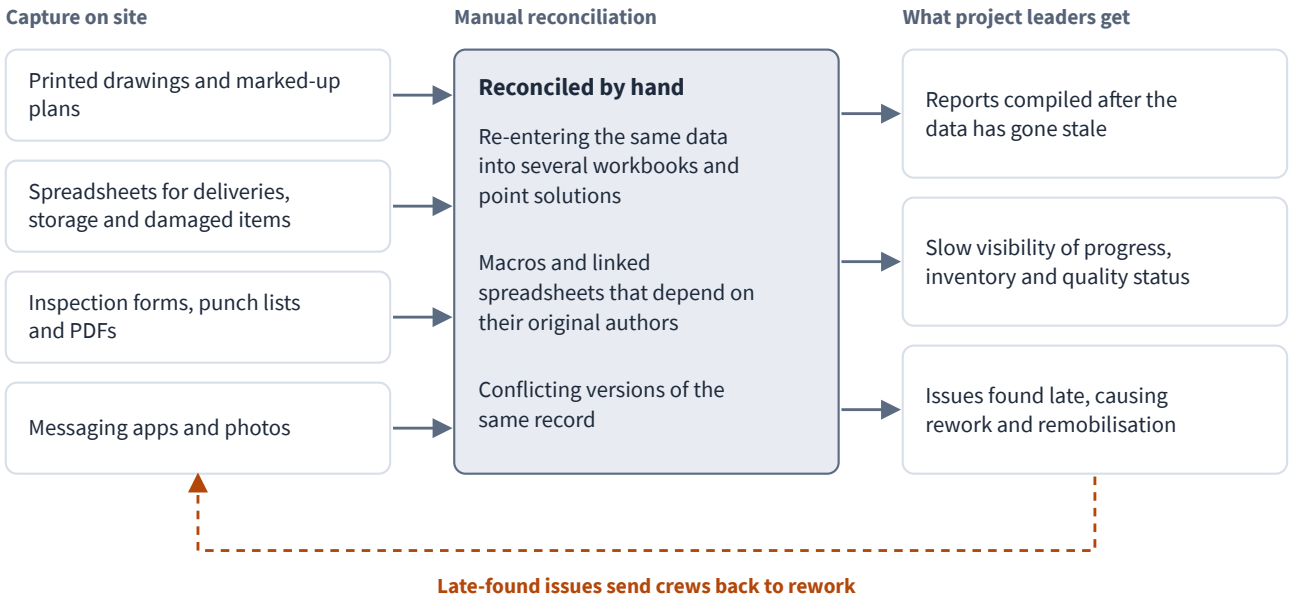


Figure 3. Traditional construction workflow. Information moves from drawings, spreadsheets and messages into manual reconciliation, so project leaders see it late and issues surface as rework.

Some teams build complex networks of formulas and macros across multiple workbooks. These systems can work well while their original authors maintain them, but they are difficult to govern, transfer and adapt.

When staff change or project conditions differ, manual workarounds multiply and trust in the data declines.

Point solutions can also increase the burden on field teams. A supervisor may have to enter similar information into several applications that do not exchange data reliably. Effective digitalisation therefore requires an integrated, field-ready platform, robust data governance and deliberate change management.[9] Site teams adopt new tools only when they are trustworthy, faster than the process they replace and clearly support construction delivery.

3.3 Fragmented data

A construction manager may need to move between multiple systems to understand the status of a single workfront:

Project schedule | Inventory systems | QA systems | Progress reports | Workforce information

When these sources are disconnected, teams spend time searching for information, reconciling conflicting records and re-entering data. The result is slower issue resolution, weaker forecasting, lower labour productivity and a higher risk of delay or rework.

The volume and velocity of data that site teams must handle keep increasing, but individuals' capacity to process it does not. Digital workflows should therefore reduce cognitive and administrative load by presenting validated, role-relevant information at the point of work. Industry research reports that construction businesses use a median of six data environments and point solutions, contributing to data inaccuracies, training complexity and higher operating costs.[12]

Our Australian market research drew on structured interviews with individuals from Tier-1 and Tier-2 EPCs and construction contracting companies in Australia between December 2025 and March 2026. The research identified an industry need for mobile-enabled productivity tracking software. It also highlighted the value of being able to record information from within the solar array so that stakeholders can view it from anywhere.

4. Case Study Methodology

> A utility-scale solar project was analysed using a time-and-motion approach that examined project planning, reporting, inventory management and quality control activities.

The case study compared baseline construction activities with digitised workflows enabled by a digital-twin-based construction management platform. The assessment focused on labour time, process steps, data handovers and avoidable delays.

4.1 Project

The assessment was based on a representative utility-scale solar reference project of approximately 300 MW with an 18-month construction programme. Customers drew on their experience of similarly sized projects in the ANZ region and normalised their results to a 300 MW project for consistency. All reference projects were executed in the last 2 years.

The projects assume a consistent tracker-structure technology and a similar delivery model. A head contractor, or EPC contractor, engages a subcontractor on site who delivers the vast majority of the work. The subcontractors were Surya's customers: they executed the work on site and reported up the value chain, while the EPCs mainly provided management oversight.

The analysis does not cover cable trenching, DC cabling or battery energy storage system (BESS) construction. Surya is pursuing these scopes next on its product roadmap, because they offer comparable opportunities for efficiency improvement and for a digital twin that spans every construction process end to end (see Section 8).

4.2 Scope

The evaluation covered four workflow groups:

- Project planning and forecasting
- Progress recording and reporting
- Inventory management
- Quality control

4.3 Time-and-motion assessment

Baseline activities were mapped and compared with the equivalent digitised workflows. Savings were estimated from changes in task duration, frequency, handovers and avoidable rework. Each estimate compares the effort required with and without Surya over an 18-month (approximately 78-week) construction programme, assuming eight-hour days and five-day weeks. Financial estimates assume $85 per labour hour as a conservative estimate across multiple site stakeholder roles, which would include associated labour overhead costs. The estimates were reviewed with site teams from Australian subcontractors and adjusted where they provided feedback. Results are presented per megawatt and on a 300 MW-equivalent basis.

4.4 Limitations and disclosure

- The results are modelled estimates for a representative 300 MW reference project, based on institutional knowledge and validated with two customers.
- A 25% allowance for avoided delays and broader impacts was assumed based on customer feedback.
- The analysis covers mechanical installation on tracker-based projects only.

5. Digitalisation Approach

> A digital twin environment integrated construction progress, logistics and quality management into one structured data environment.

The approach centred on a shared, map-based project environment that connected field activity with structured asset data. The platform was evaluated as an enabling system for construction delivery rather than as a standalone software product.

5.1 The digital twin as the foundation

The digital twin established a geo-referenced representation of the site and its construction assets. This allowed progress, materials and quality records to be associated with specific locations and work packages, creating a consistent data model across the project lifecycle.

Site representation | Geo-referenced assets | Structured construction data

5.2 Key digital workflows

Construction progress

- Real-time progress recording
- Automated forecasting

Logistics and inventory

- Receiving
- Tracking
- Reconciliation

Quality control

- Geo-located inspections
- Punch list management
- Automated reporting

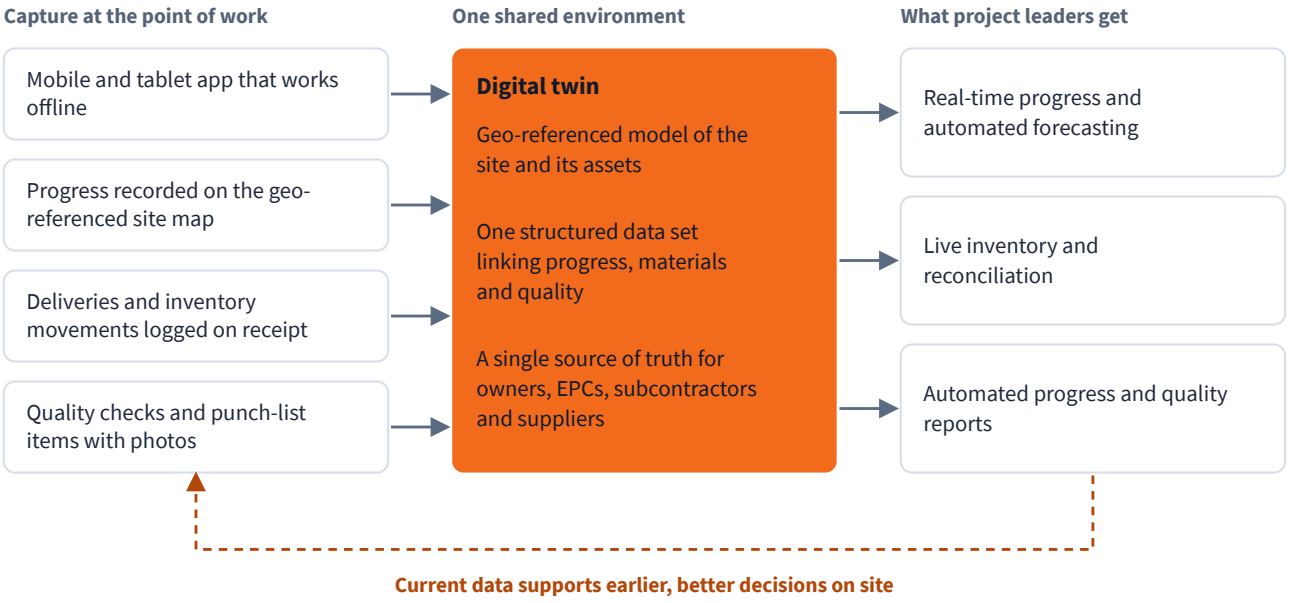


Figure 4. Digital construction workflow. Field capture feeds a shared digital twin, which gives project leaders current progress, inventory and quality information.

Figure 5. Screenshot from one of the digitised reference projects in progress.

Figure 6. Block view from another customer's project, which identified productivity gains.

5.3 Collaboration and a single source of truth

Shared project data can improve collaboration among owners, developers, EPCs, subcontractors and suppliers by making progress, constraints and responsibilities visible.[8] This matters most in a capacity-constrained market, where clearer risk ownership and faster issue resolution can support more effective commercial relationships.

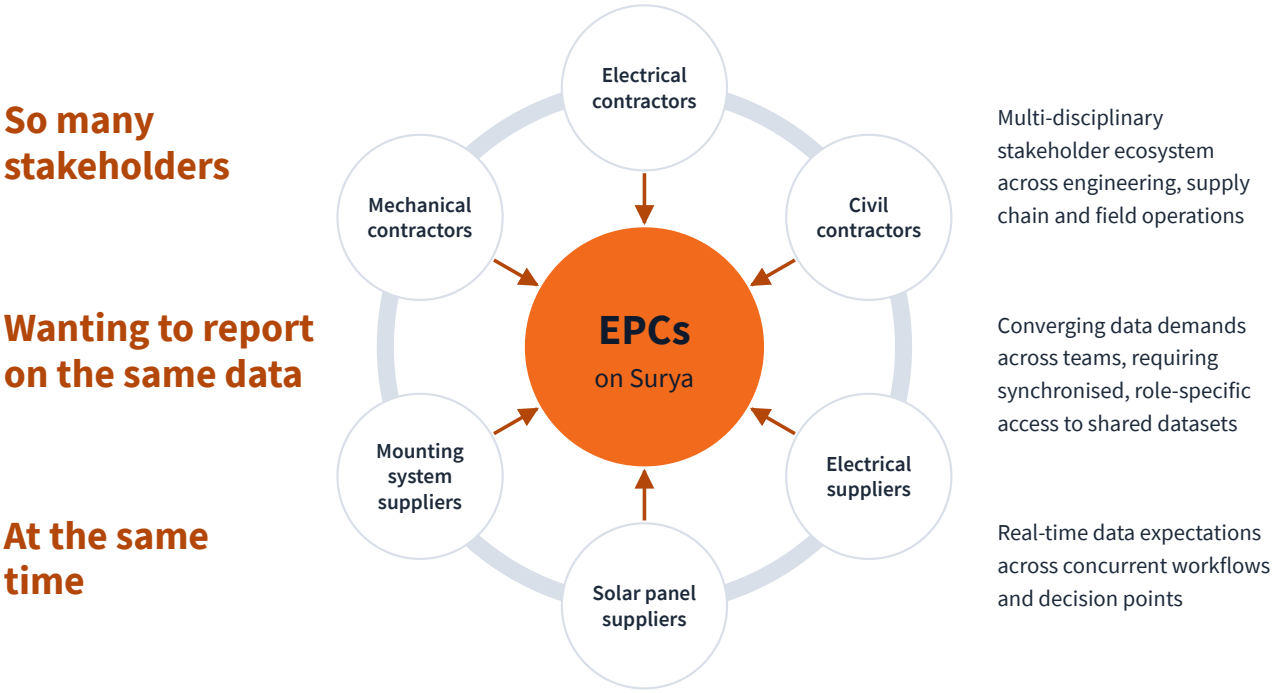


Figure 7. Australian solar sites involve many stakeholders who must make decisions, and report on the same data, at the same time to deliver on time and in full. As complexity grows, so does the number of stakeholders and the risk of inconsistent information.

Other site processes, including health and safety, workforce sign-on and sign-off, plant location and access control, could also benefit from integration into a common environment. These functions were outside the scope of this study, but reducing the number of systems field teams use may bring further efficiency and data-quality benefits.

Successful collaboration depends on transparent information, appropriate access controls and agreed responsibilities for data quality. Digital platforms can support these conditions, but technology alone does not resolve contractual or organisational misalignment.

6. Results

The analysis indicates total savings of approximately 8,420 labour hours on a 300 MW reference project, or 28.1 hours per MW, concentrated in inventory management. At $85 per

> hour, total estimated savings are approximately $716,000, or $2,390 per MW.

6.1 Labour savings

Direct savings were estimated for 11 activities across project planning, progress management, inventory management and quality control, using the assumptions in Section 4.3. Total savings combine approximately 6,735 hours of direct work-hour savings with an estimated 1,684 hours from avoided delays and broader impacts.

Table 1. Summary of estimated labour savings

Metric	Estimated result
Effort without Surya	Approximately 8,045 hours
Effort with Surya	Approximately 1,311 hours
Direct work-hour savings	Approximately 6,735 hours (84% reduction)
Avoided delays and broader impacts (estimated at 25% of direct savings)	Approximately 1,684 hours
Total labour hours saved	**Approximately 8,420 hours**
Labour hours saved per MW	Approximately 28.1 hours per MW
Reference project basis	300 MW, 18-month construction programme

These estimates are directionally consistent with industry research linking stronger digital capability to improved schedule, budget and bid outcomes. [12]

6.2 Drivers of improvement

Inventory management accounts for 39% of total estimated savings, followed by avoided delays and broader impacts (20%) and quality control (19%). Inventory planning (1,507 hours) and inventory receiving (1,100 hours) are the two largest individual activities.

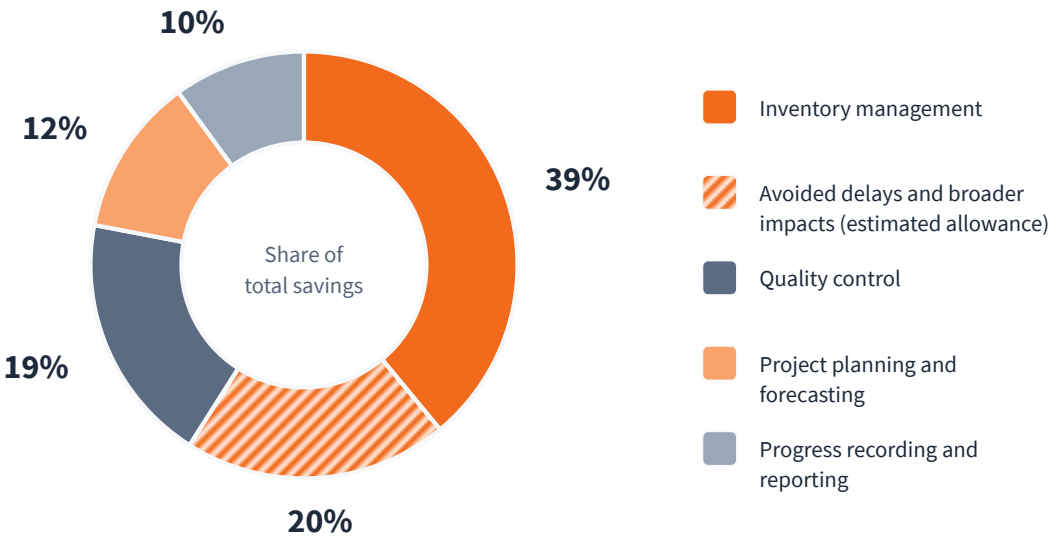


Figure 8. Share of total estimated savings by category. The hatched slice is an estimated allowance rather than a directly measured saving.

Avoided delays and broader impacts are a conservative allowance of 25% on top of direct work-hour savings. Customers described these impacts as significant, but they were not measured directly. The allowance covers:

- Lost time from demobilising, remobilising and reassigning contractors because of material availability, access constraints or changing site conditions
- Delays and additional costs from urgent, last-minute component orders when shortages are identified late in the build
- Time lost to repeated back-and-forth communication to confirm which blocks are ready for commissioning after mechanical build QC
- Other delays or inefficiencies that result when construction and project managers make decisions without accurate, real-time data on inventory, construction progress or QC status

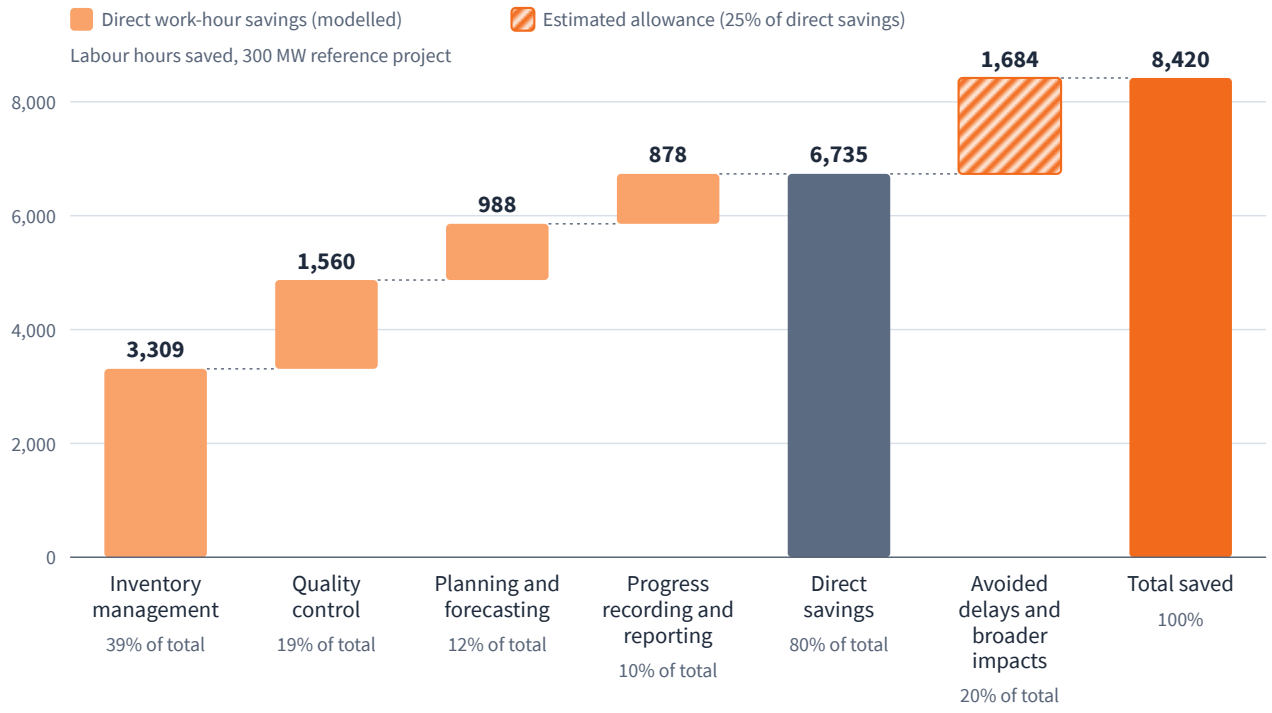


Figure 9. Inventory management and quality control together account for 58% of total savings. The rest comes from project planning, reporting and avoided delays. The hatched bar is an estimated allowance, not a directly measured saving.

Table 2 shows the direct savings for each activity, grouped by workflow. Component distribution maps are grouped with project planning and forecasting. Percentages are rounded and may not sum exactly to 100%.

Table 2. Direct labour savings by activity over the 18-month programme

Activity	Without Surya (h)	With Surya (h)	Saved (h)	Share of direct savings
Project planning and forecasting	**1,032**	**44**	**988**	**14.7%**
Project planning and forecasting	240	40	200	3.0%
Component distribution maps	480	4	476	7.1%
Progress forecasting and resource allocation	312	0	312	4.6%
Progress recording and reporting	**975**	**97.5**	**877.5**	**13.0%**
Construction progress recording	585	97.5	487.5	7.2%
Construction progress reporting	390	0	390	5.8%
Inventory management	**3,776**	**467**	**3,309**	**49.1%**
Inventory planning	1,640	133	1,507	22.4%
Inventory receiving	1,200	100	1,100	16.3%
Ongoing inventory management	936	234	702	10.4%
Quality control	**2,262**	**702**	**1,560**	**23.2%**
Quality control checks and field recording	1,365	585	780	11.6%
Punch list management	273	117	156	2.3%

Activity	Without Surya (h)	With Surya (h)	Saved (h)	Share of direct savings
Quality control documentation	624	0	624	9.3%
Total direct savings	**8,045**	**1,310.5**	**6,734.5**	**100%**

6.3 Financial benefits

All dollar figures are in 2026 Australian dollars. At an assumed labour rate of $85 per hour, direct work-hour savings are worth approximately $572,000, or $1,910 per MW. Including the allowance for avoided delays and broader impacts, total estimated savings are approximately $716,000, or $2,390 per MW. These savings come from reduced remobilisation and rework, lower administrative effort and faster close-out.

6.4 Qualitative benefits

In addition to measurable labour savings, integrated digital workflows can improve:

Decision-making | Visibility | Traceability | Quality outcomes | Predictability of project delivery

These benefits arise from earlier identification of constraints, clearer accountability and a common view of current site conditions. More advanced scheduling, remote monitoring and scenario testing may extend these gains,[8] but they should be evaluated separately from the measured workflows in this study.

Customers also reported benefits outside the activities assessed. Because they could easily calculate the material used and the quantity still required, Surya helped them avoid component shortages that would have caused delays. They also valued being able to overlay the progress of different activities in each block. This shows how efficiently different teams are working and lets productivity issues be addressed before they become expensive.

7. Preparing the Industry for Automation and Robotics

> Automation requires trusted, structured and connected datasets. Digitalisation is therefore a prerequisite to robotics-assisted solar construction.

Robotics, autonomous equipment, computer vision and AI are increasingly discussed as solutions to construction productivity constraints. However, these technologies depend on accurate, structured and timely information about asset locations, work status, materials, quality requirements and site conditions.

Where project information remains distributed across PDFs, spreadsheets, paper records and manual reconciliations, automation systems cannot reliably interpret the work environment or verify outcomes. Digitalisation is therefore not the destination. It is the foundation on which higher-order automation can be built.

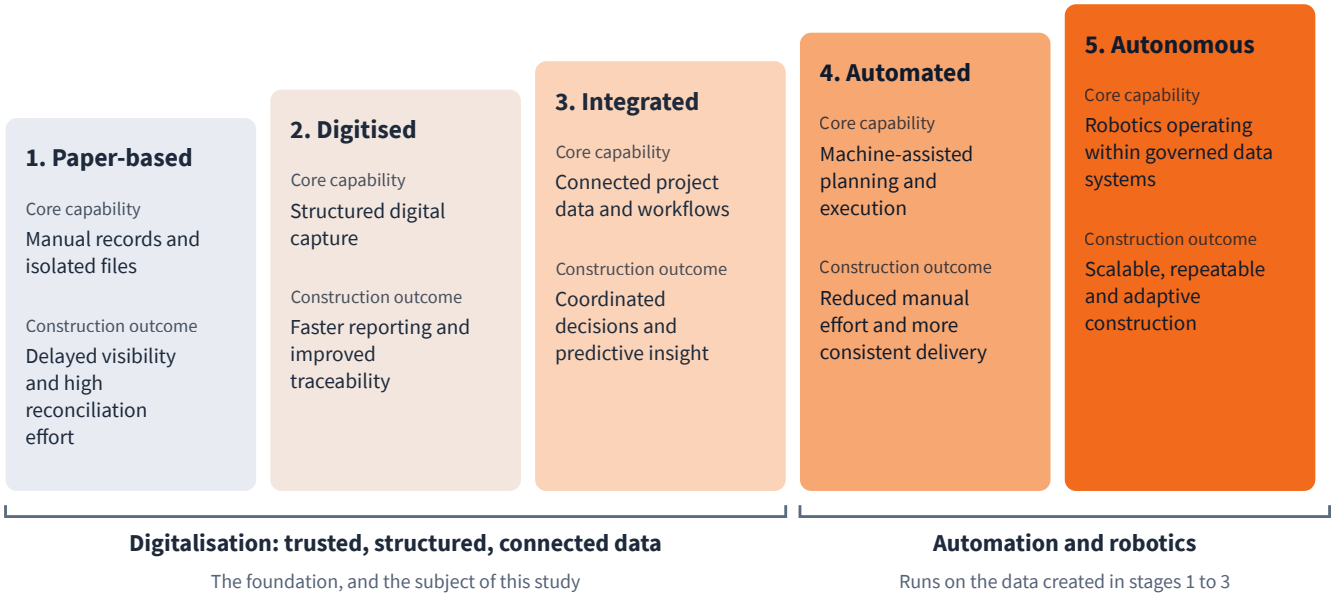


Figure 10. Digitalisation-to-robotics maturity model. Each stage depends on the structured, trusted data created in the stages before it.
Source: author's framework.

Reported adoption trends suggest strong interest in both digital twins and robotics. Deloitte's research indicates current adoption of 26% for digital twins and 25% for robotics or automated systems, with a further 37% and 40% respectively planning adoption. [12]

8. Beyond Mechanical Installation

> The same principles can extend to DC electrical installation, BESS deployment and ongoing operations and maintenance.

The workflows assessed in this study relate primarily to mechanical construction. The same data principles could be extended to adjacent scopes, but the benefits have not yet been validated through this case study.

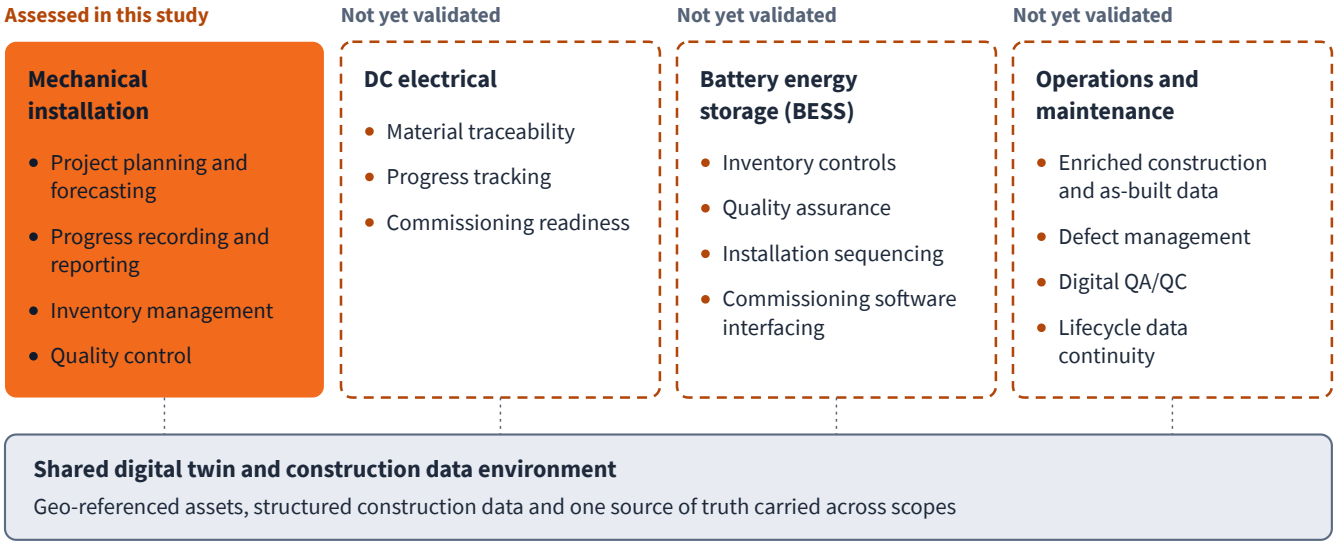


Figure 11. Future extension of the digital twin across mechanical, electrical, BESS, and operations and maintenance scopes.

8.1 DC electrical

Extending geo-referenced work tracking to cable installation, terminations, testing and commissioning could improve material traceability, progress visibility and readiness for energisation.

8.2 Battery energy storage systems (BESS)

BESS construction introduces additional requirements for equipment traceability, installation sequencing, quality assurance and commissioning interfaces. A shared data environment may reduce handover friction across these activities.

8.3 Operations and maintenance

Construction data can retain value after handover when asset records, inspections, defects and corrective actions remain connected to the digital twin. Reusing an established data environment may reduce the cost of creating and maintaining operational records.

9. Conclusions

> Construction productivity is becoming a defining factor in renewable energy deployment. Digitalisation can reduce cost, risk and schedule pressure while supporting future innovation.

Australia's challenge is not only to develop renewable generation, but to deliver the required infrastructure at the speed and cost the energy transition demands.

This case study indicates that integrated digital construction workflows can reduce administrative effort, improve productivity, strengthen traceability and lower project risk. They can also create the structured datasets required for more advanced analytics, automation and robotics.

Digitalisation should therefore be treated as a construction-performance capability rather than a standalone software initiative. Its value depends on practical field adoption, reliable data, integration with project governance and evidence that benefits are repeatable across different projects and delivery models.

The results here are modelled estimates, and Section 4.4 explains the limitations.

References

1 Australian Energy Market Operator (AEMO), *2026 Integrated System Plan (ISP)*. aemo.com.au/energy-systems/major-publications/integrated-system-plan-isp/2026-integrated-system-plan-isp. Accessed September 2026.

2 Australian Renewable Energy Agency (ARENA), *ARENA announces $45 million for Pilbara Solar Innovation Hub*. arena.gov.au/news/arena-announces-45-million-for-pilbara-solar-innovation-hub. Accessed February 2026.

3 Government of Western Australia, *Whole of System Plan Report*, November 2020. wa.gov.au/system/files/2020-11/Whole of System Plan_Report.pdf. Accessed September 2026.

4 AEMO, *NEM Generation Information*, July 2026 (author's calculations). AEMO NEM Generation Information, July 2026 (xlsx).

5 PwC Australia, *Solving the EPC equation for utility-scale solar developments*. pwc.com.au/energy-transition/solving-the-epc-equation-for-utility-scale-solar-developments.html. Accessed February 2026.

6 Clean Energy Council, *New report identifies workforce opportunities of the clean energy transition*. cleanenergycouncil.org.au/news-resources/new-report-identifies-workforce-opportunities-of-the-clean-energy-transition. Accessed February 2026.

7 International Energy Agency (IEA), *Energy employment has surged, but growing skills shortages threaten future momentum*. iea.org/news/energy-employment-has-surged-but-growing-skills-shortages-threaten-future-momentum. Accessed February 2026.

8 McKinsey & Company, *Build together: Rethinking solar project delivery*, 9 June 2023. mckinsey.com/industries/electric-power-and-natural-gas/our-insights/build-together-rethinking-solar-project-delivery. Accessed February 2026.

9 Mischke, J., Stokvis, K. and Vermeltfoort, K., McKinsey & Company, *Delivering on construction productivity is no longer optional*, 9 August 2024. mckinsey.com/capabilities/operations/our-insights/delivering-on-construction-productivity-is-no-longer-optional. Accessed September 2026.

10 Australian Manufacturing, *Report: Shortage of skilled workers poses major challenge to Australia's energy transition*. australianmanufacturing.com.au/report-shortage-of-skilled-workers-poses-major-challenge-to-australias-energy-transition. Accessed February 2026.

11 6Wresearch, *Australia Solar EPC Market* (industry report). 6wresearch.com/industry-report/australia-solar-epc-market. Accessed February 2026.

12 Autodesk and Deloitte Access Economics, *State of Digital Adoption in the Construction Industry 2026* (survey of 954 construction businesses in Australia, Hong Kong, India, Japan, Singapore and Vietnam). deloitte.com/au/en/services/economics/perspectives/state-digital-adoption-construction-industry.html. Accessed September 2026.

Prepared by Jenna Connellan, CEO and Co-Founder of Surya, 14 October 2026.