**visual
intelligence**

# Compounding Solar Lifecycle Savings with Precision Data

**By replacing assumptions with measured reality, Visual Intelligence prevents rework, protects energy yield, and compounds value across the solar lifecycle.**

Visual Intelligence removes solar project risk at the source, cutting rework, preventing long-term energy loss, and unlocking millions in lifecycle savings through early, engineering-grade insight.

## Summary

**|$20m**

Total potential lifecycle cost savings during construction and eary operations.

Utility-scale solar projects routinely experience cost leakage driven by early-stage uncertainty, construction rework, incomplete commissioning, and reactive operations - inefficiencies often accepted as unavoidable. Visual Intelligence (VI) challenges this assumption. By applying engineering-grade terrain modeling, construction verification, and panel-level performance baselining early in the project lifecycle, VI removes the root causes of downstream cost and performance degradation. For solar asset owners, EPCs, developers, and investors, conservative modeling shows that VI can reduce total lifecycle costs by approximately $15–20 million, with payback achieved during construction or early operations.[1]

- **Removing early project risk** through accurate terrain, layout, and construction validation before errors propagate.
- **Preventing costly rework** by identifying misalignment, installation defects, and deviations during construction.
- **Reducing O&M cost compounding** by establishing panel-level baselines that enable proactive maintenance and higher lifetime energy yield.

## Challenge

Traditional solar workflows depend on preliminary surveys, sampled inspections, and reactive maintenance. Civil uncertainty drives grading overruns, construction errors often go undetected until late in the build, and commissioning typically reviews only a subset of installed assets. These gaps carry forward into operations, resulting in higher O&M costs and persistent energy losses.[2]

Because mistakes made early in the project permanently raise the cost baseline, they represent a disproportionate share of total lifecycle cost - even when projects are delivered on schedule.

Savings realized early permanently lower the cost base carried through every subsequent phase. Those reductions then compound year after year during O&M, making early adoption the most financially impactful approach. [3]

**Fig. 1**
Cumulative Lifecycle
Cost Reduction

### Cumulative Solar Lifecycle Cost Reduction



- **Traditional Lifecycle Cost**
- **Lifecycle Cost with VI**

**1 Development**
High-accuracy terrain and grading, drainage validation, reduced civil overrun risk.

**2 Engineering**
Optimized layout and pile counts, fewer design change orders.

**3 Construction**
Pile tracker alignment, electrical install verification, rework avoided pre-energization.

**4 Commissioning**
Panel-level defect detection, QR / serial number capture, warranty-ready baseline.

**5 Operations & Maintenance**
Avoided 1-3% annual energy loss, reduced inspection labor, targeted maintenance & RMAs.

visual intelligence

## Stages

**1** **Planning & Development**

Decisions made during planning and development set the permanent cost and performance baseline for the project. Incomplete terrain data, optimistic assumptions, or unvalidated layouts often result in grading overruns, tracker misalignment, late-stage design changes, and long-term O&M inefficiencies.

Drone data shifts planning and development from assumption-driven to engineering-grade decision-making. By surfacing terrain, civil, and constructability risks early, it prevents errors from propagating into construction and operations—where they compound over time.

# 5–15%

*Civil and grading overruns of 5–15% are common due to limited terrain fidelity. VI replaces approximation with centimeter-accurate terrain modeling and constructability validation, reducing uncertainty before construction begins.[4]*
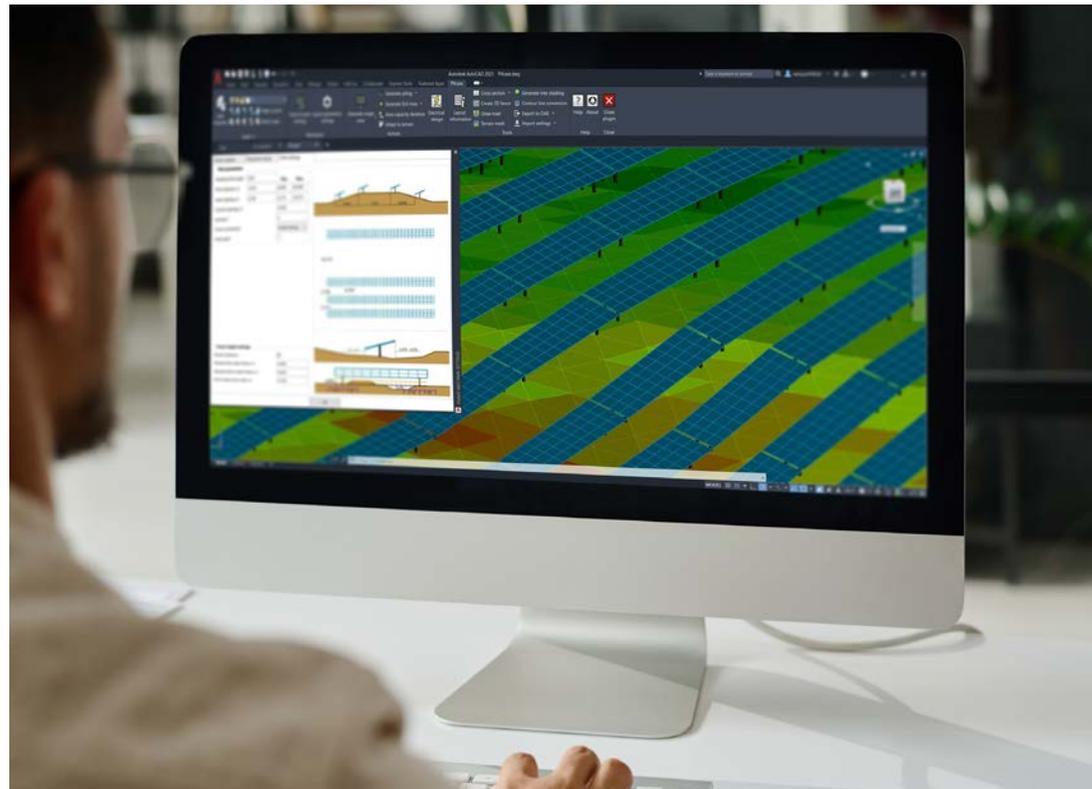
- **Rapid site feasibility screening** using high-resolution aerial data to quickly identify slopes, drainage issues, access constraints, and other civil risks before land or design decisions are finalized.
- **Accurate terrain and grading models** built from centimeter-level data to improve cut/fill estimates, balance earthwork, and reduce grading overruns during construction.
- **Validated layouts and constructability checks** that confirm tracker alignment, row spacing, and slope tolerances on true terrain—avoiding late-stage redesigns.
- **Improved permitting and environmental documentation** through time-stamped visual records that support wetlands delineation, setback verification, and agency review.
- **More reliable financial models** informed by precise civil quantities and risk-adjusted assumptions, lowering contingency and improving confidence for lenders and investors.
- **Clear site baselines for construction handoff**, aligning developers, EPCs, and owners on existing conditions to minimize scope disputes and rework later in the project lifecycle.

**2** **Engineering**

The engineering stage translates intent into execution. Accuracy, coordination, and constructability at this phase directly determine whether a solar project is delivered on budget, on schedule, and at expected performance—or whether hidden assumptions surface later as costly change orders.

Drone data transforms design from theoretically correct to field-validated and build-ready. By grounding engineering decisions in reality, it prevents errors from cascading into construction—where they are far more expensive.

- **Engineering-grade terrain truth** replaces design assumptions, improving grading, drainage, and access road accuracy before plans are finalized.
- **Validated tracker and structural designs** confirm slope and alignment tolerances on real terrain, reducing rework and performance loss.
- **Optimized electrical layouts** use accurate topography to minimize trenching, cable overruns, and construction conflicts.
- **Faster permitting and design approval** through clear, time-stamped visual evidence that supports engineering decisions.
- **Cleaner handoff to construction** with a defensible site baseline that reduces RFIs, change orders, and schedule risk.



**visual intelligence**

**visual** intelligence

### 3   Construction

Construction is where most project capital is deployed and where design assumptions are tested against reality. Errors made during this phase are far more expensive to correct than earlier stages and often become permanent performance or O&M liabilities.

## 50–70%

*Mechanical and electrical rework commonly represents 5–10% of EPC cost. VI verification identifies misalignment and installation defects while correction is still inexpensive, reducing rework by 50–70%.[5]*

- **Real-time construction verification** compares installed work against design to identify grading, pile, and tracker deviations while corrections are still inexpensive.
- **Early detection of installation defects** surfaces misalignment, missing components, damaged modules, and out-of-tolerance work before it propagates downstream.
- **Objective progress tracking** provides accurate, visual percent-complete metrics to support schedule management, pay applications, and stakeholder reporting.
- **Reduced rework and change orders** by catching errors early, lowering mechanical and electrical rework that typically drives EPC cost overruns.
- **Improved QA/QC coverage at scale** enables full-site inspection rather than sampled checks, increasing confidence in construction quality.
- **Defensible as-built documentation** creates a verified construction record that supports commissioning, warranty claims, and long-term O&M.

### 4   Commissioning

Commissioning is the last opportunity to identify and correct construction defects at the EPC's expense. Gaps at this stage—especially reliance on sampled inspections—allow issues to enter operations, where they become persistent performance and O&M liabilities.

## 3%

*Traditional IV/IR sampling misses early-stage defects affecting 1–3% of panels. VI establishes a complete panel-level baseline enabling warranty recovery and long-term tracking.[6]*

- **Complete panel-level inspection** identifies defects, misalignment, or damage across the entire site, not just sampled sections.
- **Rapid IV/IR data capture** provides high-resolution electrical and thermal imaging to detect underperforming panels or hotspots early.
- **Baseline performance documentation** establishes verified energy output for warranty claims and O&M tracking.
- **Accelerated punch-list resolution** by pinpointing exact defect locations with georeferenced imagery for EPC teams.
- **Enhanced QA/QC coverage** ensures no areas are missed, reducing risk of latent defects entering operations.
- **Defensible as-built and performance record** supports final acceptance, interconnection approval, and long-term asset management.

**5  Operations & Maintenance**

O&M is where long-term revenue and asset performance are realized. Decisions here—about maintenance frequency, defect detection, and proactive interventions—directly impact energy yield, O&M cost, and the total lifecycle economics of the solar farm.

- **Continuous panel-level monitoring** detects underperforming or damaged modules across the entire site, not just sampled areas.
- **Rapid RGB and IR inspections** identify cracks, hotspots, electrical faults, and degradation before they impact energy yield.
- **Proactive maintenance planning** uses georeferenced data to prioritize repairs, reducing unplanned downtime and O&M costs.
- **Performance baseline tracking** enables year-over-year comparisons and warranty enforcement.
- **Comprehensive site documentation** provides a defensible record for insurance, regulatory compliance, and asset management.
- **Data-driven lifecycle optimization** supports decisions on retrofits, repowering, and operational efficiency improvements.

visual intelligence

## O&M Deep Dive

### Operations & Maintenance

Operational savings drive the majority of lifecycle value because they repeat each year and compound over decades. Figure 2 illustrates cumulative O&M cost growth over 20 years with and without VI.[7]

**Fig. 2**
20-Year O&M Cost Avoidance



20-Year O&M Cost Avoidance

The shaded region represents avoided energy loss, reduced inspection labor, and improved warranty recovery enabled by VI's commissioning baseline and predictive analytics. The buildup detail for the chart above is listed below.

|$7.3m

Total enabled value over 20 operating years.

| O&M Value Driver | Assumption (Base Case) | 1Yr Value | 20Yr Value | NPV @ 6% |
|---|---|---|---|---|
| Avoided energy loss (AEP)[1] | 100 MW, CF 24%, $0.045/kWh; 2.0% avoidable loss; VI recovers 55%<br>*Annual revenue × loss% × recovery%* | $104,069 | $2,081,376 | $1,193,661 |
| Reduced inspection & troubleshooting labor[2] | O&M $19/kWdc-yr; 10% inspection share; 60% reduced<br>*Annual O&M × share × reduction* | $114,000 | $2,280,000 | $1,307,571 |
| Improved warranty /RMA recovery[3] | Panel-level, evidence-backed claims<br>*Assumed annual recoveries* | $150,000 | $3,000,000 | $1,720,488 |
| Total O&M-Enabled Value | | $368,069 | $7,361,376 | $4,221,720 |

*Notes: Base case is tunable; see Appendix for spreadsheet inputs and references.*

# Conclusion

Utility-scale solar economics are shaped far earlier than most stakeholders recognize. Errors introduced during planning, engineering, and construction permanently raise the cost baseline and compound into lost energy, higher O&M expense, and reduced asset value over decades of operation. Visual Intelligence demonstrates that applying engineering-grade drone data early—before assumptions harden into infrastructure—removes root-cause risk, prevents rework, and establishes a defensible performance baseline that compounds savings across the full asset lifecycle. On a representative 100-MW project, conservative modeling shows this approach can unlock approximately $15–20 million in lifecycle value, with payback achieved during construction or early operations and benefits that persist for the life of the asset.

Key Takeaways

- Early-stage accuracy permanently lowers lifecycle cost by preventing downstream rework and performance loss.
- Construction and commissioning are inflection points where full-site verification delivers outsized returns.
- Panel-level baselining enables proactive O&M, avoided energy loss, and stronger warranty recovery.
- Operational savings dominate lifecycle value because they repeat annually and compound over decades.
- Early adoption of Visual Intelligence materially improves risk-adjusted returns and total cost of ownership.

*Author*

*Jay Tilley, CTO, Visual Intelligence*

*Page Footnotes:*

[1] *NREL Photovoltaic Module Soiling Map and NREL PV degradation benchmarks.*

[2] *DOE/NREL cost benchmarks for utility-scale PV O&M ($/kWdc-yr).*

[3] *NREL PV O&M Best Practices (record-keeping and evidence supporting warranty recovery).*

[4] *NREL utility-scale PV construction/cost guidance on civil uncertainty and cost drivers.*

[5] *Industry EPC benchmarks on construction rework and QA/QC costs.*

[6] *IEA PVPS degradation & failure fact sheets and module reliability literature.*

*References:*

[1] *Lifecycle value modeling based on conservative 100 MW utility-scale benchmarks.*

[2] *NREL construction and O&M benchmark studies.*

[3] *VI lifecycle cost model (this document).*

[4] *NREL grading and civil cost studies.*

[5] *EPC post-mortem analyses.*

[6] *Utility-scale commissioning defect studies.*

[7] *NREL PV O&M performance benchmarks.*

# Appendix

## CFO One-Page Summary (With Cost Build-Up)

Reference case (tunable): 100 MWdc utility-scale PV, 20-year operating horizon, $0.045/kWh energy value, 24% capacity factor, 6% discount rate.

Mechanism: Eliminate early-stage uncertainty, prevent construction rework, and establish a panel-level commissioning baseline enabling predictive O&M.

Financial Impact (100 MW reference case):

- Lifecycle cost reduction: $15–20M
- Payback: Construction to early operations
- Dominant value driver: avoided energy loss over 20 years

Risk Framing: Conservative assumptions; savings scale with project size and operating duration.

Conclusion: Early adoption of VI materially improves risk-adjusted returns and lowers total cost of ownership.

The table below provides an auditable cost/value build-up aligned to the lifecycle value claim.

| Value | Assumption Range | Type | Value ($) | Reference |
|---|---|---|---|---|
| Development/ civil overrun avoided[4] | 5–15% civil uncertainty; VI reduces major rework 40–70% | One-time | 600,000 | NREL utility-scale PV construction/cost guidance |
| Construction rework avoided[5] | Rework 5–10% of EPC; VI reduces 50–70% | One-time | 2,100,000 | EPC benchmarks; QA/QC rework studies |
| Commissioning defects & warranty readiness[6] | 1–3% latent defects; baseline improves claim success | One-time | 300,000 | Reliability / degradation & failure literature |
| O&M avoided energy loss + labor + warranty[123] | 1–3% annual avoidable loss; O&M $/kWdc-yr benchmarks | 20-year total | 7,361,376 | NREL ATB/DOE benchmarks; NREL soiling; O&M best practices |
| Less: VI program cost | Scope dependent; tunable | One-time | -250,000 | Proposal dependent |
| Illustrative total lifecycle value | | | 10,111,376 | Sum of components above |

visual intelligence