# CEA Quality Assurance Program Added Value

How to protect your investment from relying on 25 year PV module warranties

George Touloupas

23 June, 2016

CEA is a solar PV advisory firm that is able to provide unrivaled insight into the manufacturing process to ensure the success of solar energy projects worldwide

More than
**60** employees

Over
**35** engineers

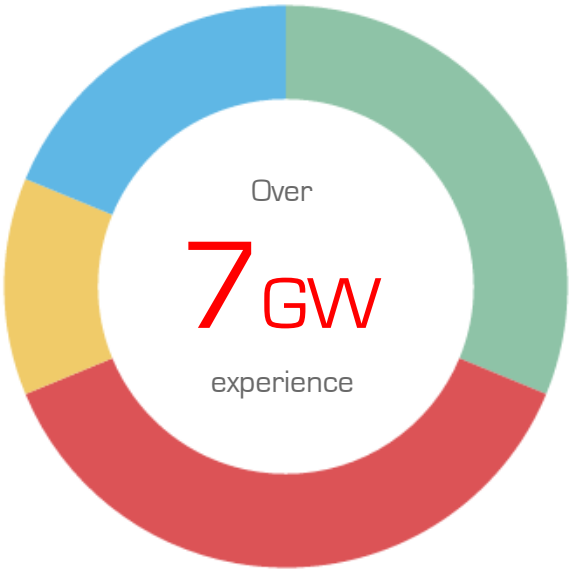
A presence in
**8** countries

Over
**8** years history


## Engineering Services

Technical Advisory

Supply Chain Management




## Quality Assurance

Certified by

Proud member of

Client engagements in
**27** countries


Audited
**125+**
solar factories worldwide

# With comprehensive solar industry and functional expertise, CEA is capable of providing holistic solutions for client needs globally

## MISSION

To help our clients and partners deploy solar energy solutions worldwide.

## VISION

To become by 2025 the leading global solar energy engineering services firm that creates tangible impact with every client

## VALUES

Passion | Client Orientation | Integrity
Accountability | Innovation | Sustainability

CEA's 25 years BHAG is to support high quality and reliable solar projects in every country globally

# CEA is differentiated due to its supplier independence and economies of scale from other advisory firms and provide its global clients with a unique advantage

- Solar focused services provider with expertise on **quality assurance, engineering services and supply chain management**
- **Supplier independence** with 100% foreign ownership and strong client base
- Customized solutions provider focused **long term client relationships**

# Thanks to a company-wide effort over the course of 2015, CEA became ISO 9001 certified, and is now better poised to serve its clients around the globe

SGS

CLEAN ENERGY ASSOCIATES (CHINA) LIMITED\Clean Energy Associates Limited

Suite 3104/08, 239 Garden Business Center Building, No. 889 Jiuli Road, Shanghai, P.R. China

Organization Code: 561902210-3

has been assessed and certified as meeting the requirements of

ISO 9001:2008

For the following activities

Provide supply chain management services for solar Photovoltaic (PV) related materials and equipment supply

Factory audit of solar Photovoltaic (PV) material and equipment based on client requirements, including process quality control, production monitoring and pre-shipment inspection & supervision

Further clarifications regarding the scope of this certificate and the applicability of ISO 9001:2008 requirements may be obtained by consulting the organization

This certificate is valid from 16 October 2015 until 15 September 2018 and remains valid subject to satisfactory surveillance audits. Recertification audit due a minimum of 60 days before the expiration date. Issue 1. Certified since 16 October 2015

Authorized by

SGS United Kingdom Ltd. Systems & Services Certification

Rossmore Business Park, Ellesmere Port, Cheshire, CH65 3EN, UK

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This certificate information can be verified on this web site of Certification and Accreditation Administration of the People's Republic of China www.cnca.gov.cn

ISO 9001 A (01 08) EN

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SGS

# CEA is active at global key solar industry events through participation in keynote speeches, panel debates, media interviews, sponsorship and hosting booths

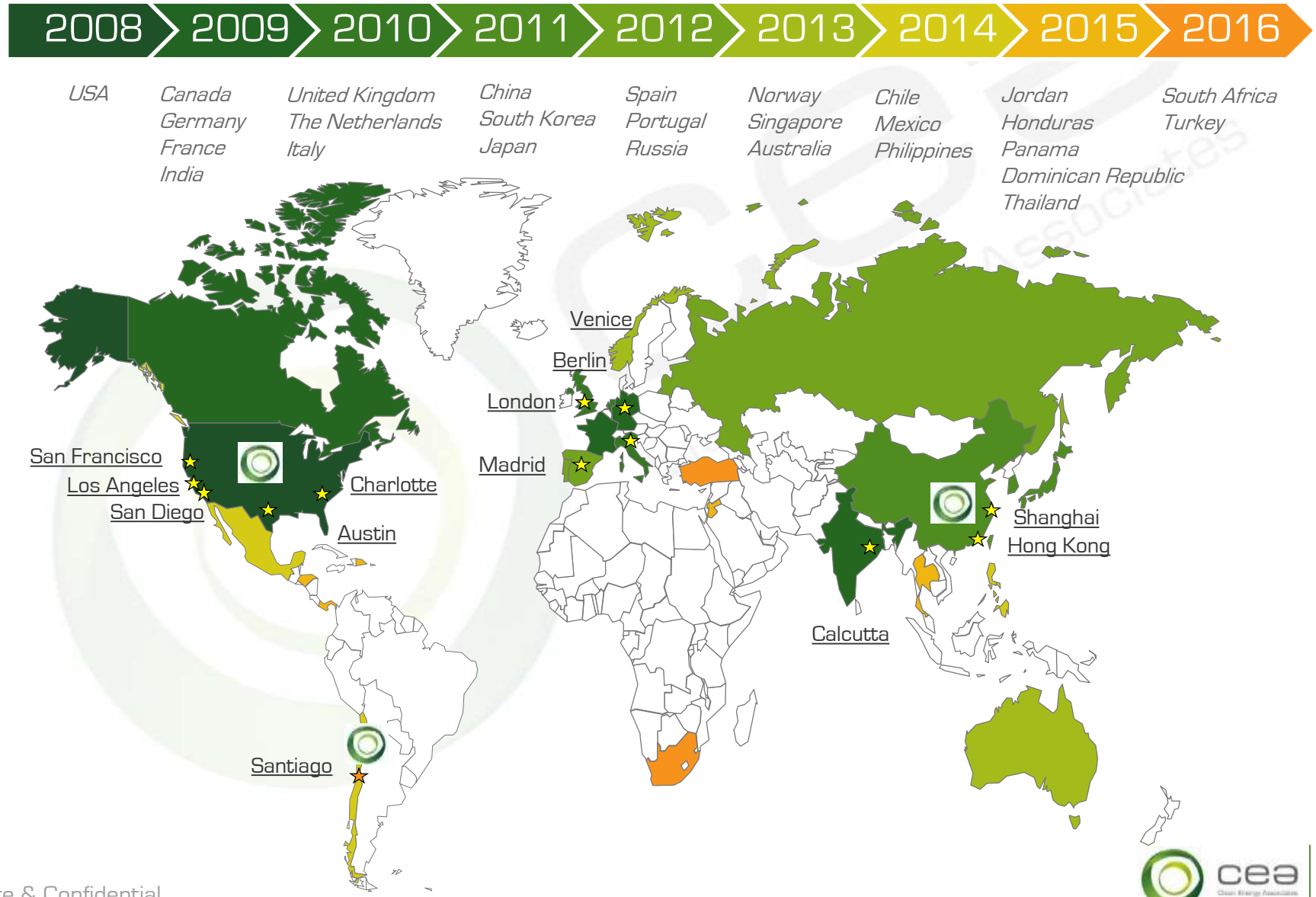
## 2008 – 2015

- CEO Andy Klump leads China's clean energy discussion with **Stanford GSB** students in 2011
- CEA leadership joined the Founder & CEO of CSI on a Chinese **television series** in 2012
- CEO Andy Klump hosts the 2nd International Syouolar Investment Summit (ISIS) in **Shanghai** in 2013
- CEO Andy Klump provided two speeches at Distributed Solar Summit in **San Diego, CA** , 2013
- CEO Andy Klump is selected to speak at Greentech Media's Solar Summit 2014 in **Phoenix, AZ**
- CEO Andy Klump is quoted by Bloomberg News in March 2014
- CEA team **exhibits** at Infocast's Solar Power Finance & Investment Summit in **San Diego, CA**
- **PV Magazine** features guest article by CEO Andy Klump entitled "Beyond Tier One"

## 2016

- CEA team attends the Solar Power Asset Management & Performance 2016 at **Newport Beach**, CA
- CEA team attends the Solar Power Finance & Investment Summit 2016 at **San Diego, CA**
- CEA team attends Recam Week in **Panama City**, Panama
- CEA team attends the PV Expo 2016 in **Tokyo**, Japan
- CEA team attends the Solar Asset Management conference in **San Francisco, CA**
- CEA team exhibits at the Solar Power Finance & Investment Summit 2016 in **San Diego, CA**
- CEA team attends **MIREC** in Mexico City, Mexico
- CEA team attends the SNEC PV Power Expo 2016 in **Shanghai**, China
- CEA team attends Solar Power Southeast in **Atlanta, GA**, US
- CEA team attends Solar Power Southwest in **San Antonio**, TX, US
- CEA attends the Grid Edge World Forum 2016 in **San Jose**, CA, US
- CEA team attends the 13th Annual Renewable Energy Finance Forum-Wall Street in **New York City**, New York, US
- CEA team attends the Intersolar Europe in Munich, Germany, and sponsors 3rd quality roundtable panel discussion of **PV Magazine**

# Since 2008, CEA has successful client engagements in 27 countries and has employees present in 8 countries



# CEA's service offerings are focused on three key areas, with a 8 year track record in over 7GW across a broad services portfolio in 27 countries

## Quality Assurance & Factory Audits

- CEA's Quality Assurance Program (CQAP) and Standards Implementation
- Bill-of-Materials (BOM) Analysis and Validation
- 24/7 Inline Production Quality Control
- Container Loading Oversight
- Comprehensive Factory Audits

## Supply Chain Management

- Manufacturer Due Diligence
- Global Supplier Market Research
- Supply Chain Sourcing Optimization
- Supplier Management and Benchmarking
- Tactical and Operational Procurement

## Engineering Services

- Technical Due Diligence (TDD)
- Owner's engineering support
- On-site Quality Control Inspections
- Performance Analysis and Optimization
- Energy Yield Assessments

# CEA's services cover a broad scope of solar PV business ranging from modules, BOS components to storage and transformer

Module

Inverter

Racking

Cable

Tracker

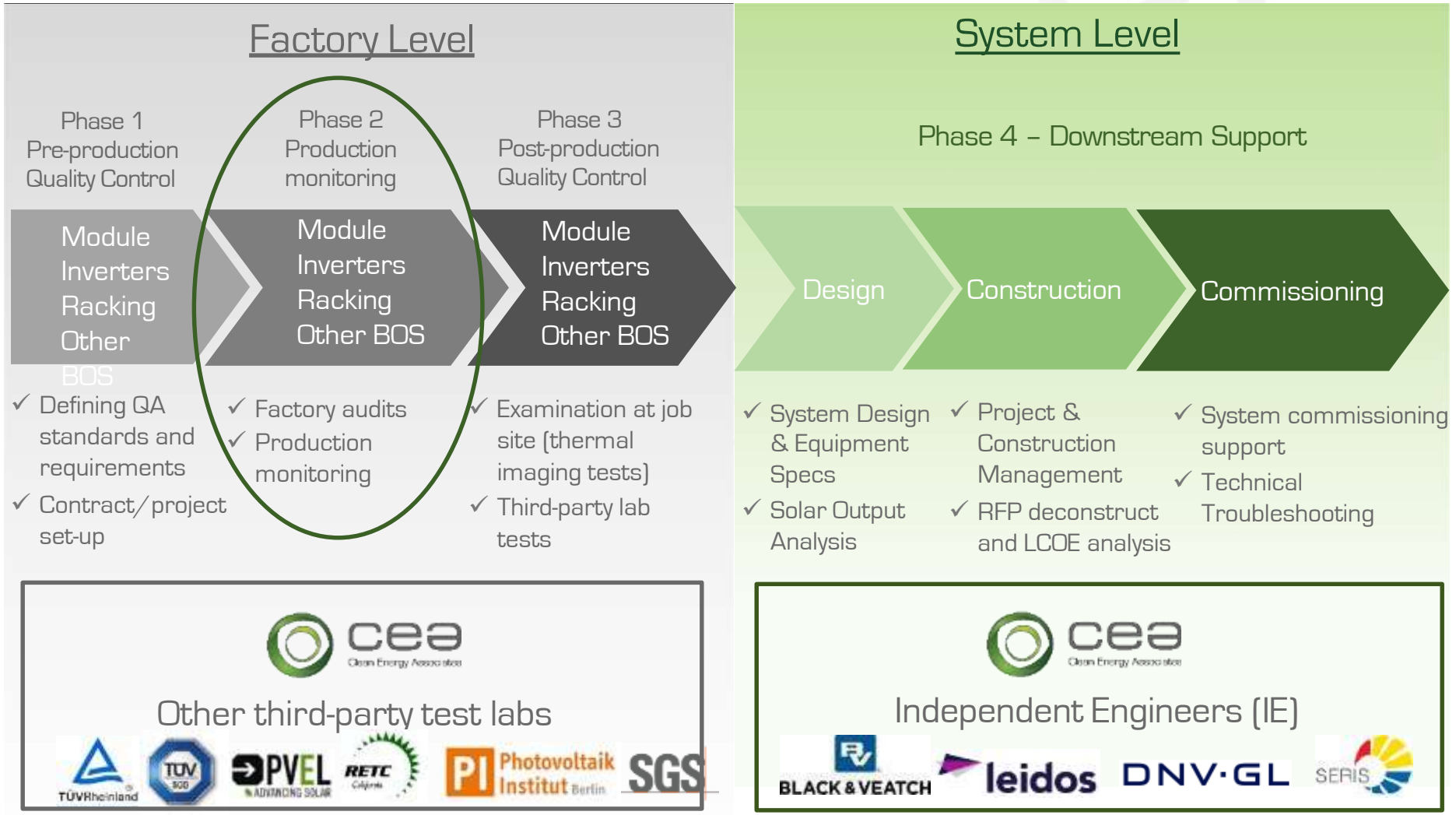
Storage

Transformer

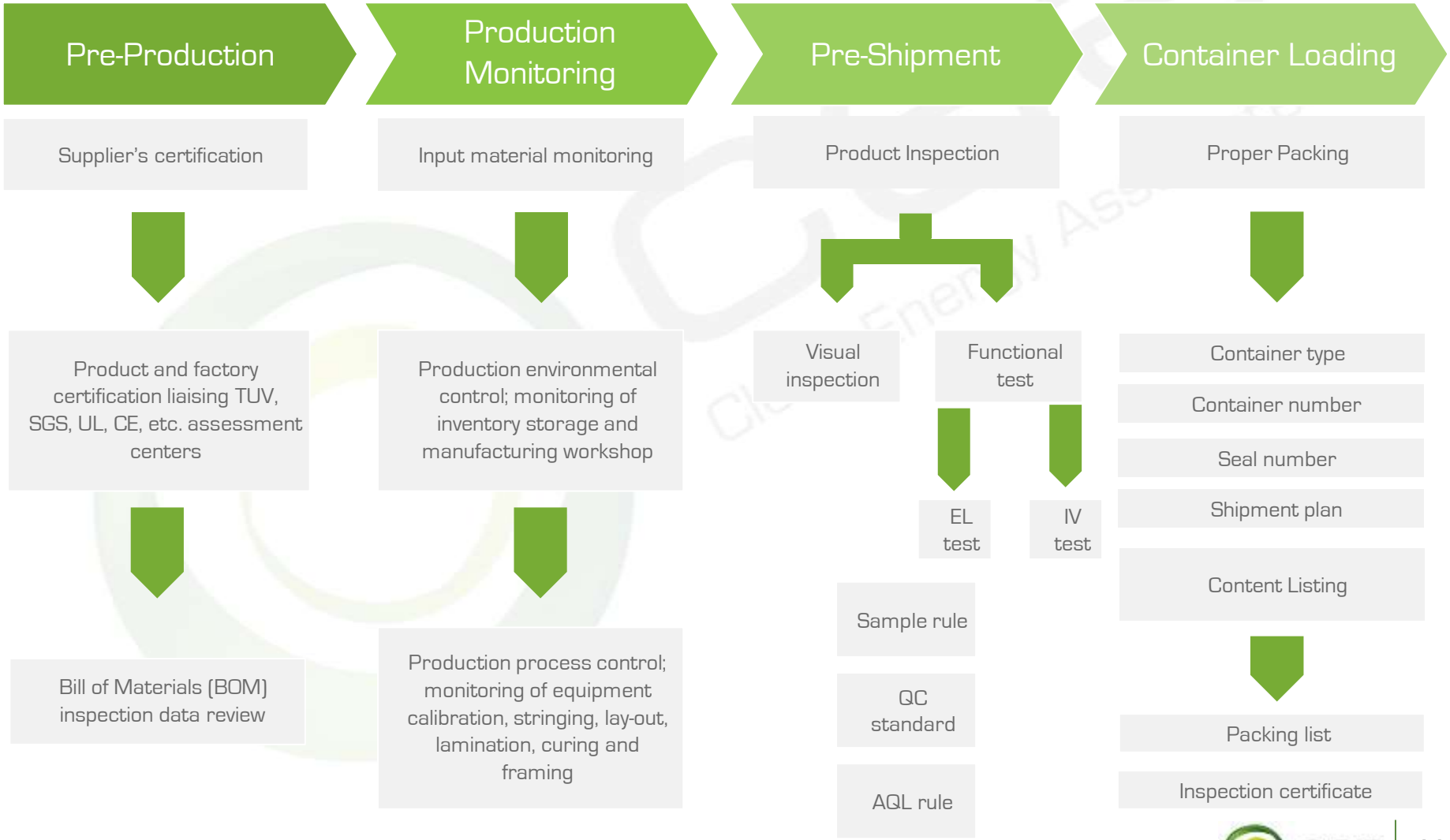
Solar System

Grid

# Technical Advisors in the past have overemphasized downstream quality without looking as closely on the product in more detail



# CEA's Quality Assurance Program (CQAP) prevents risk and ensures that downstream project stakeholders maximize the output of their system

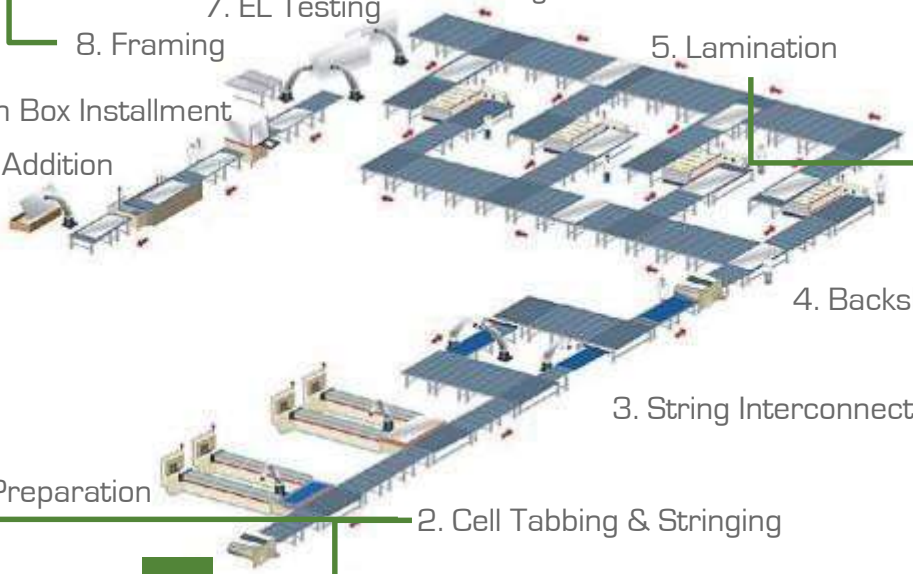


# Typical PV Module Production Process Flowchart








7. EL Testing

6. Trimming

8. Framing

5. Lamination

9. Junction Box Installment

10. AB Glue Addition

11.
IV test

12.
Packaging

4. Backsheet Lay Up

3. String Interconnection

1. Material Preparation

2. Cell Tabbing & Stringing




# Micro cracks are impossible to detect without the proper equipment, standards and an independent third party quality assurance advisor

## Serious cracks

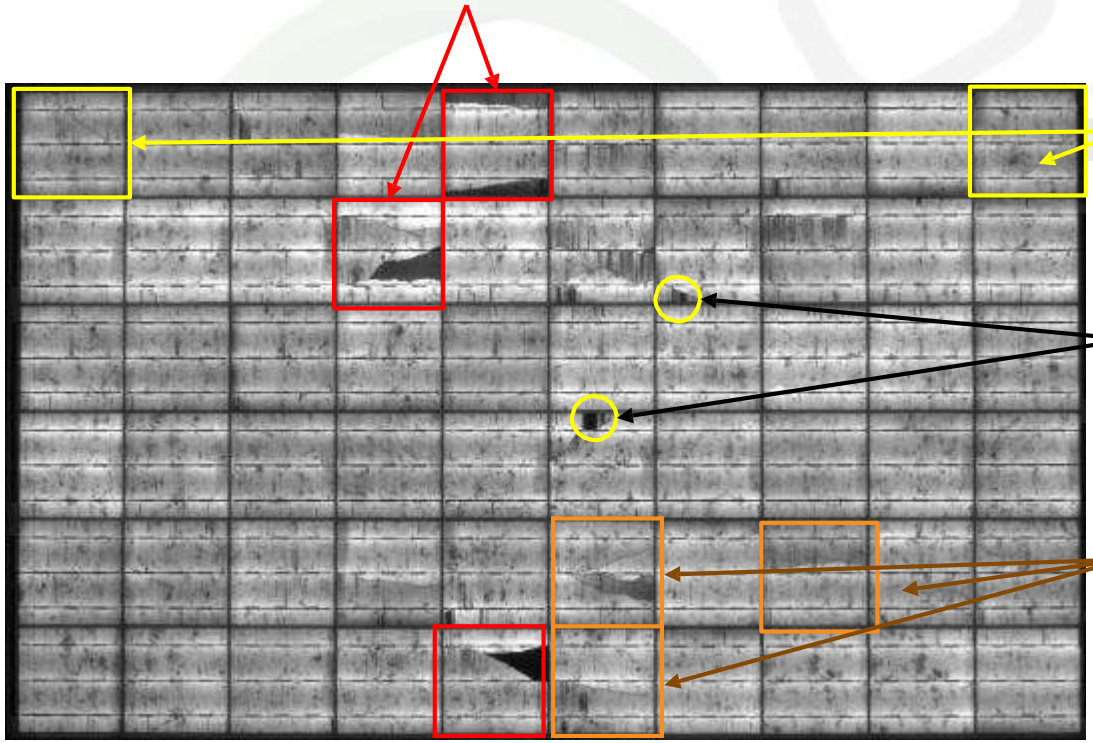
These are examples of the most serious types of cracks that a defective module may have, designated by the shaded areas. The size of the shaded areas typically corresponds to the degree of capacity lost. These three cells with large cracks correspond to approximately 4 W of capacity loss.

Summary

Module power decreased by 20W

Within 5 years, this rate may increase to 8-15W

EL testing utilizes special electromagnetic technology to identify defects hidden from the naked eye.



## Minor cracks

These minor cracks currently do not result in capacity loss – however, such cracks may deepen or become "contagious" and affect nearby cells. In a worst case scenario, a crack like this could lead to a loss of 1 W of capacity.

## "Broken fingers"

About 0.2 W loss

## Long cracks across whole cell

These long cracks are slightly more severe and may result in slightly lower cell efficiencies. However, if such cracks deepen, a cell could potentially lose one-third of its capacity. Nearby cells affected may cause further losses in capacity. For each of these cells, we can expect a 1.2 W loss in capacity

Source: CEA Internal Quality Control Findings

# Fire and electrical safety risk


Summary

Soldering residue between cells can act as an electrical conductor

This may lead to short circuiting amongst cells, a potential electrical safety risk


Cause ➔ Consequence

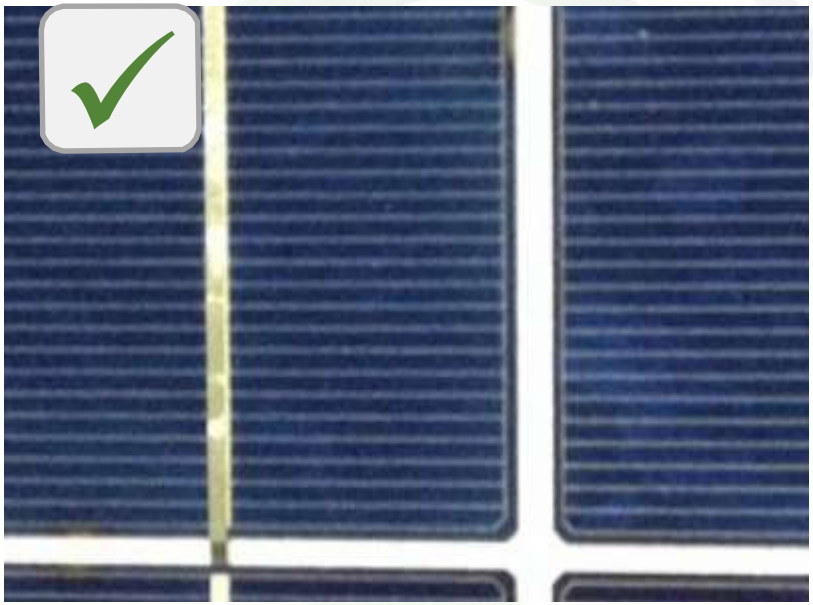
Poor handling during soldering process

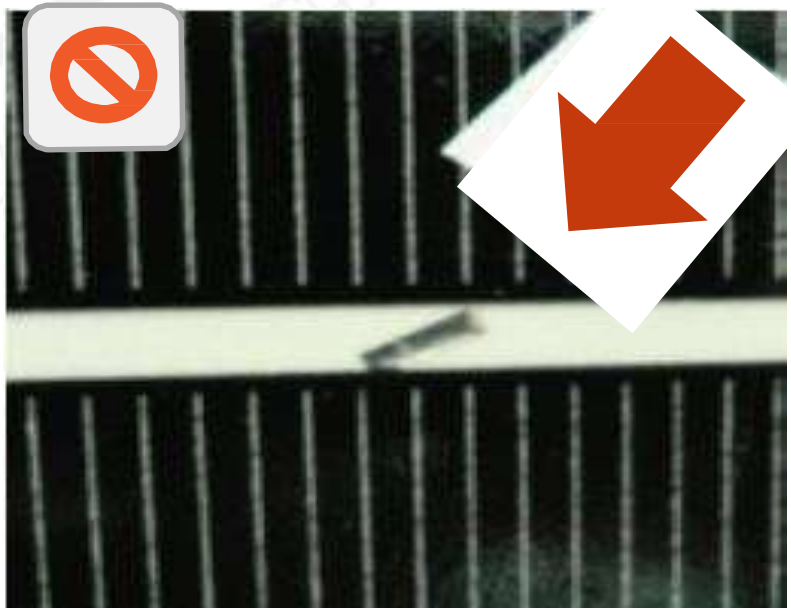
Soldering residue between cells

Short circuiting, electrical fires

Seriousness: Medium

Time Frame: 5 Years





Source: CEA Internal Quality Control Findings

# Fire and electrical safety risk

Cause ➔ Consequence

Sloppy soldering or shielding of cells

High cell operating temperature

Cell or backsheet overheating

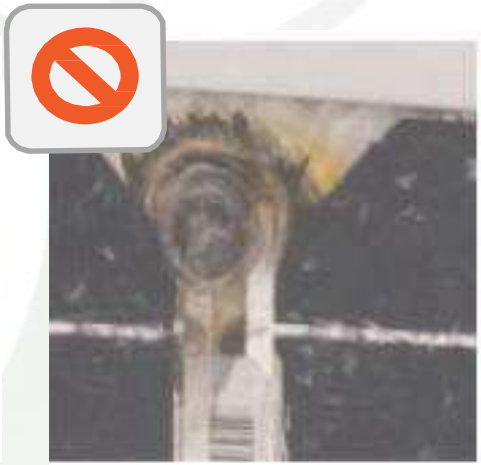
Seriousness — High

Time Frame — 3 Years

## Summary

Leftover residue during the soldering process can attract excess heat

Over time, this may cause the cell or backsheet to catch fire




Source: CEA Internal Quality Control Findings

# Fire and electrical safety risk

Cause ➔ Consequence

Poor silicon gel quality

Accelerated junction box aging

Short circuiting, electrical fires

Seriousness: Medium

Time Frame: 10 Years

## Summary

Silicon gel is used as a sealant around the junction box to protect against electrical risks

Poor silicon gel quality can lead to short circuiting as wire connections intersect in the junction box

Source: CEA Internal Quality Control Findings

# Cells with cold soldering

Cause ➔ Consequence

Cold soldering during cell stringing

Points of non-contact on back of cell stringing

Decreased power output

Seriousness — High

Time Frame — Entire life of module

## Summary

This cold soldering is caused by carelessness and lack of training and monitoring.

If these strings were to be laminated into the module, this issue could never be detected, but will seriously deteriorate the performance of solar module over time.

Source: CEA Internal Quality Control Findings

# Snail trails are a worrisome indicator of an underlying serial defect that must be caught at the factory level


## Summary

Snail trails are curving smears, or discolorations across one or more cells inside a module

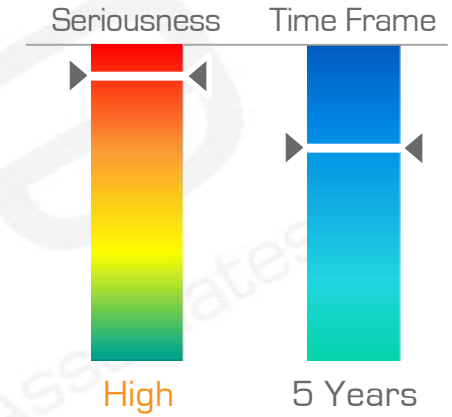
Snail trails themselves do not cause power output loss; however, they are caused by the underlying defect called micro-cracks


Cause ➔ Consequence

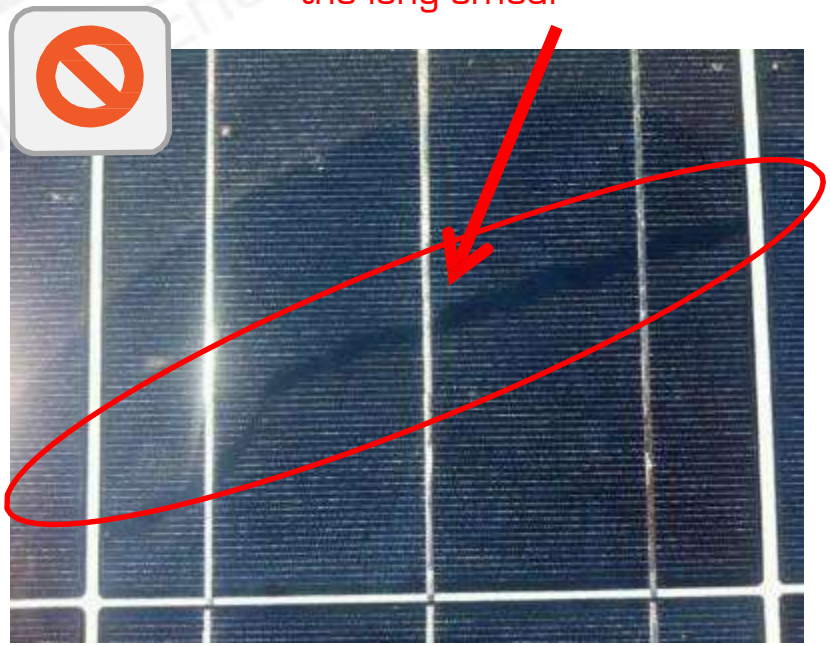
Micro-cracks, poor EVA or Backsheet

Discoloration of fingers

Snail trails

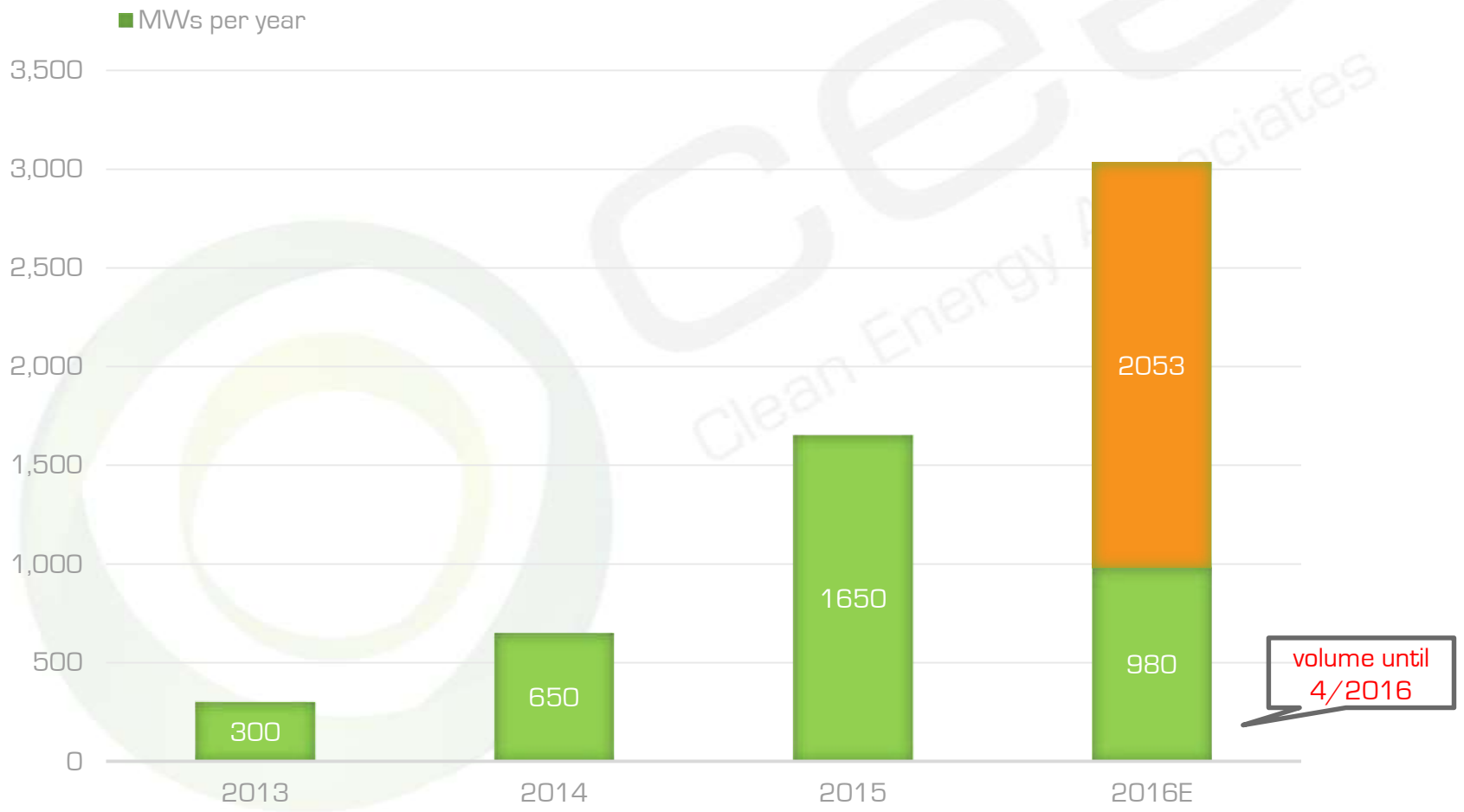



Notice the color difference of the long smear

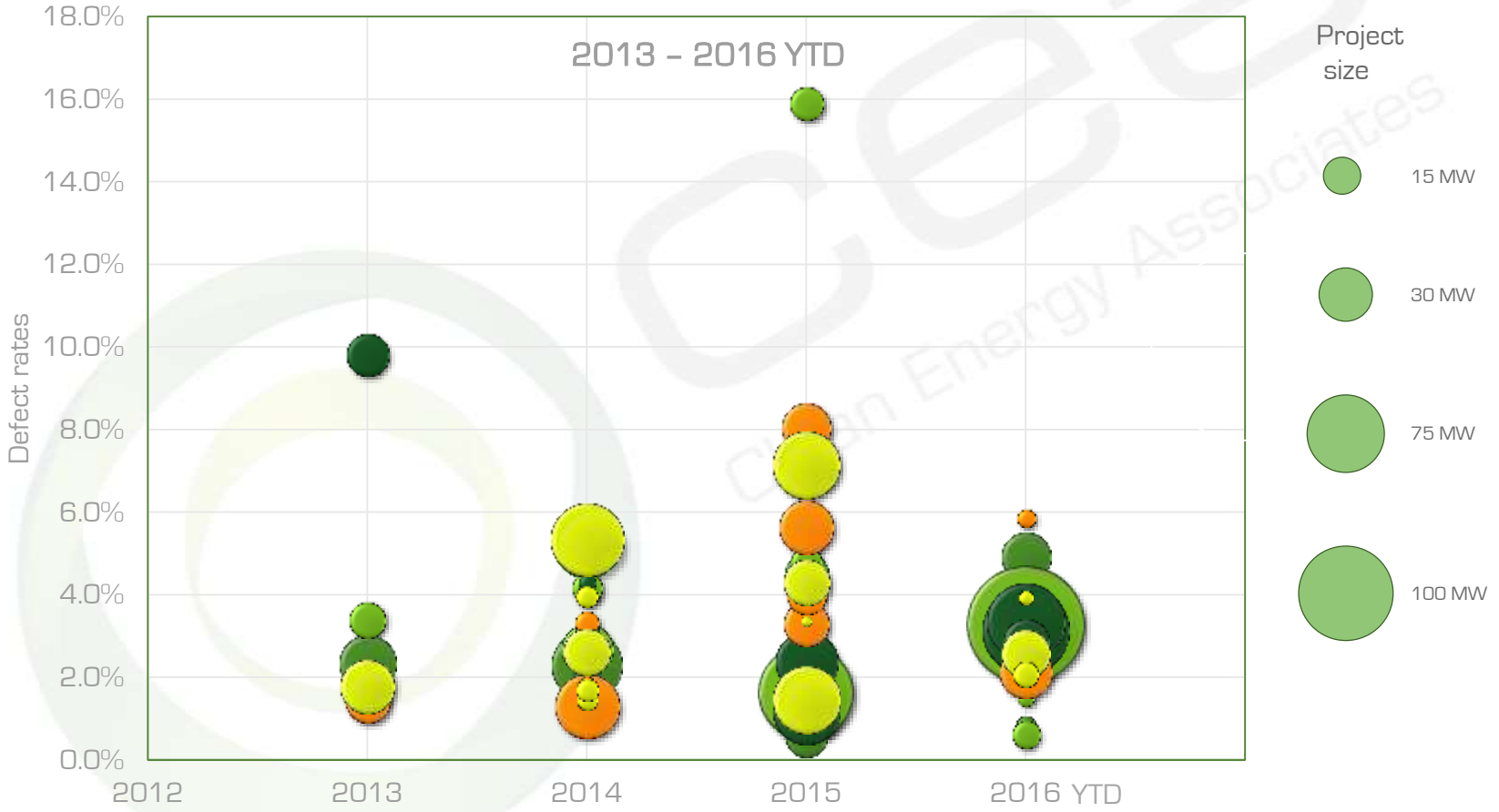


Source: CEA Internal Quality Control Findings

# In the last 4 years CEA has executed Quality Assurance for over 3 GW of solar PV modules

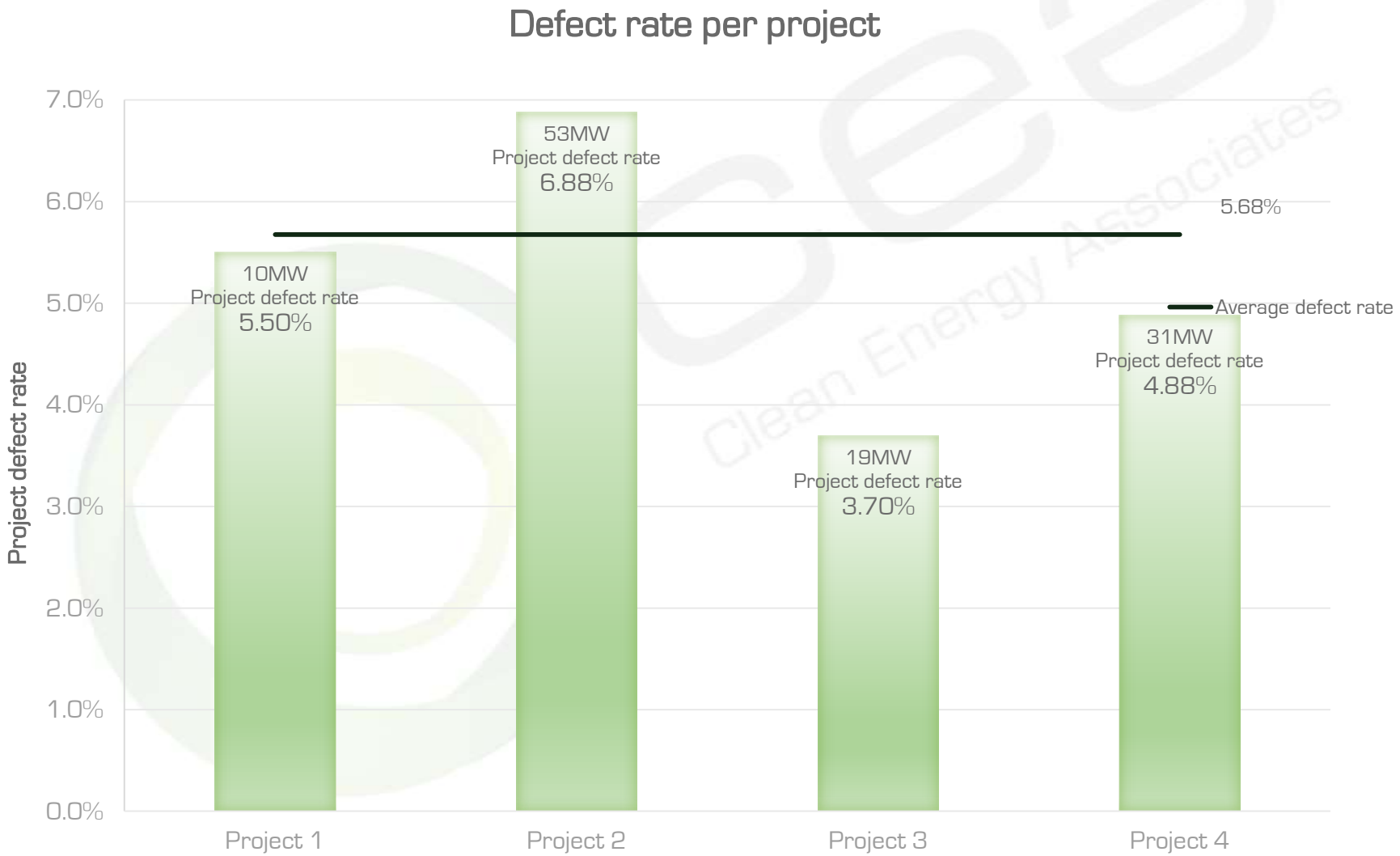


# Distribution of defect rates found at individual projects under Quality Assurance Programs:
# Visual, EL and IV inspection was performed before shipment

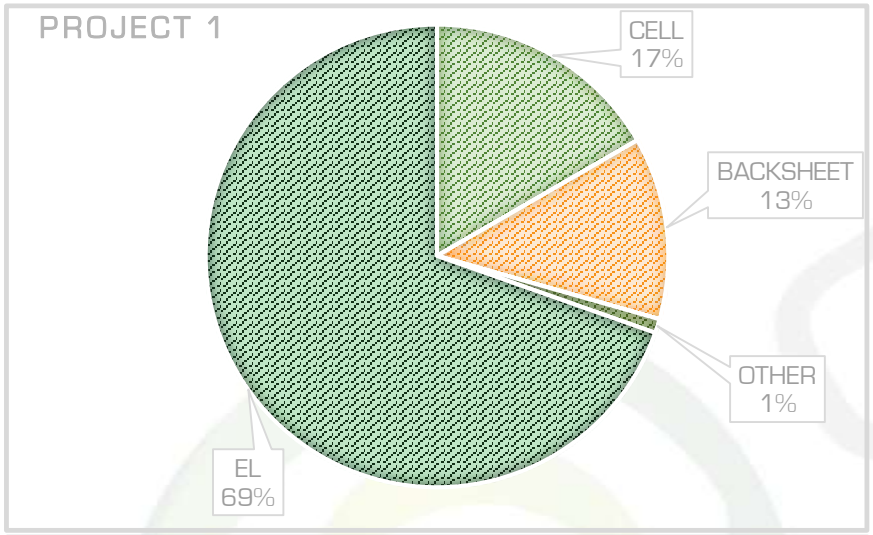


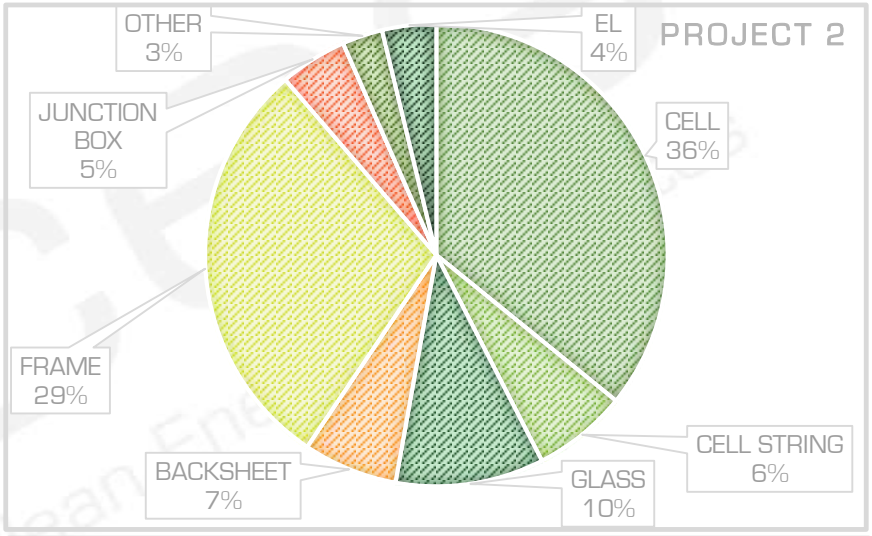

Defect data from QA performed on over 100 projects totaling 3,200 MW of modules

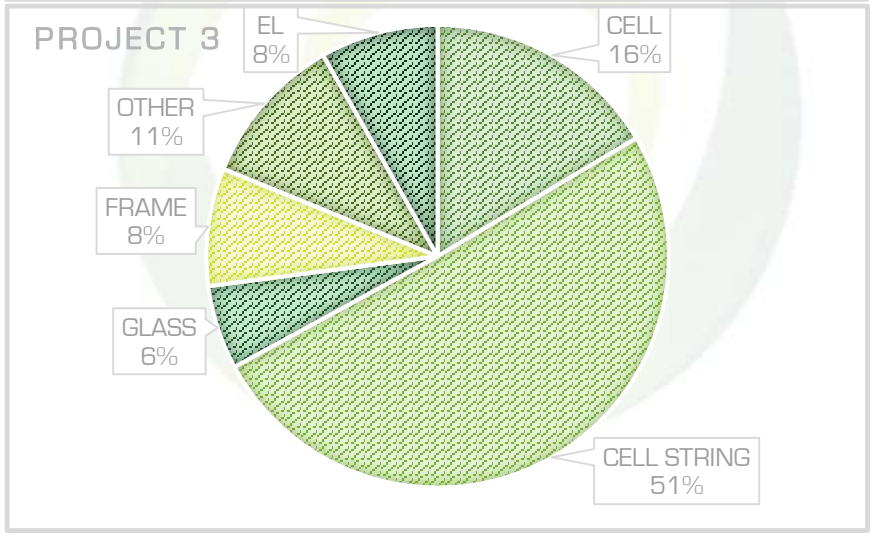
# 4 case studies of typical projects produced in 2015 at Tier 1 manufacturers

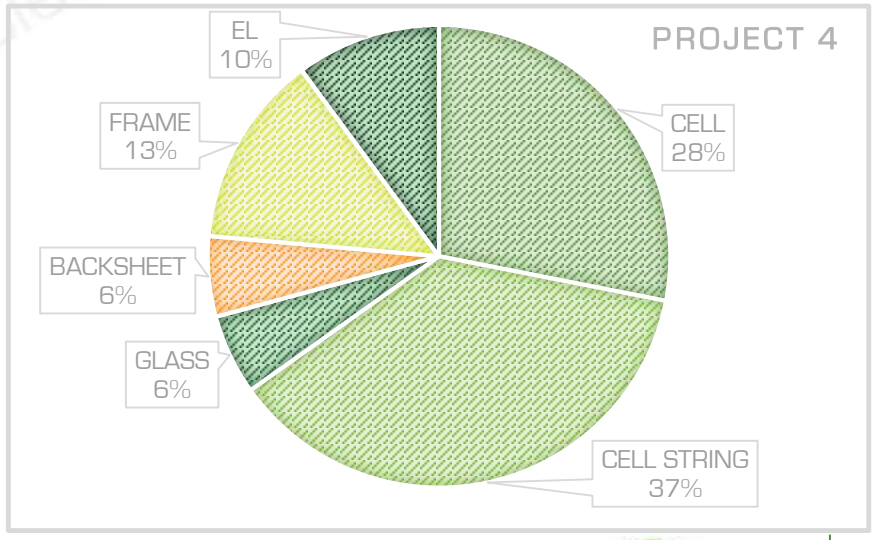


# Defect distribution by category for the 4 project case studies:
# Different projects may have totally diverse distributions, even on the same production lines, over time, as module assembly processes are not stable

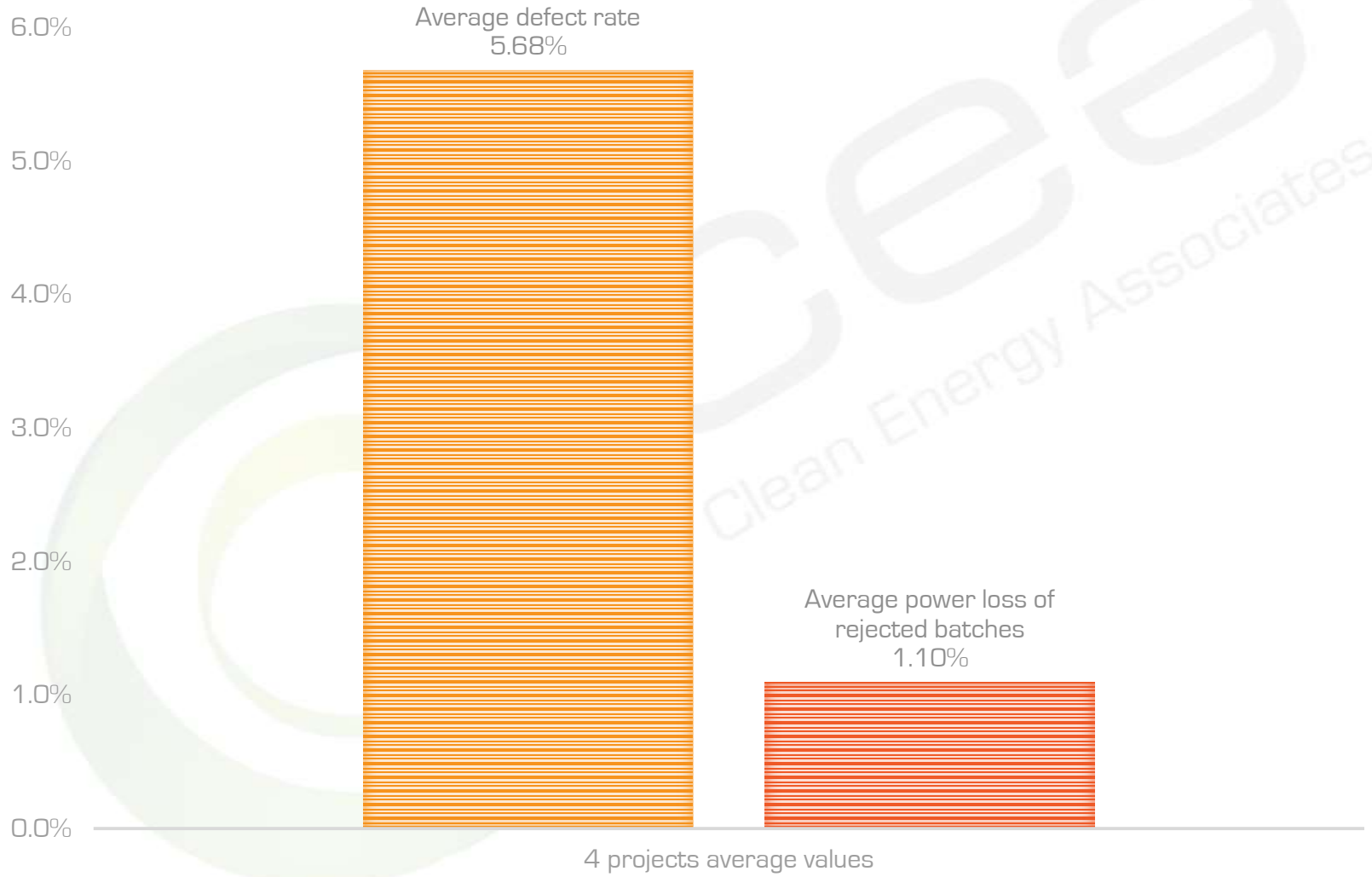


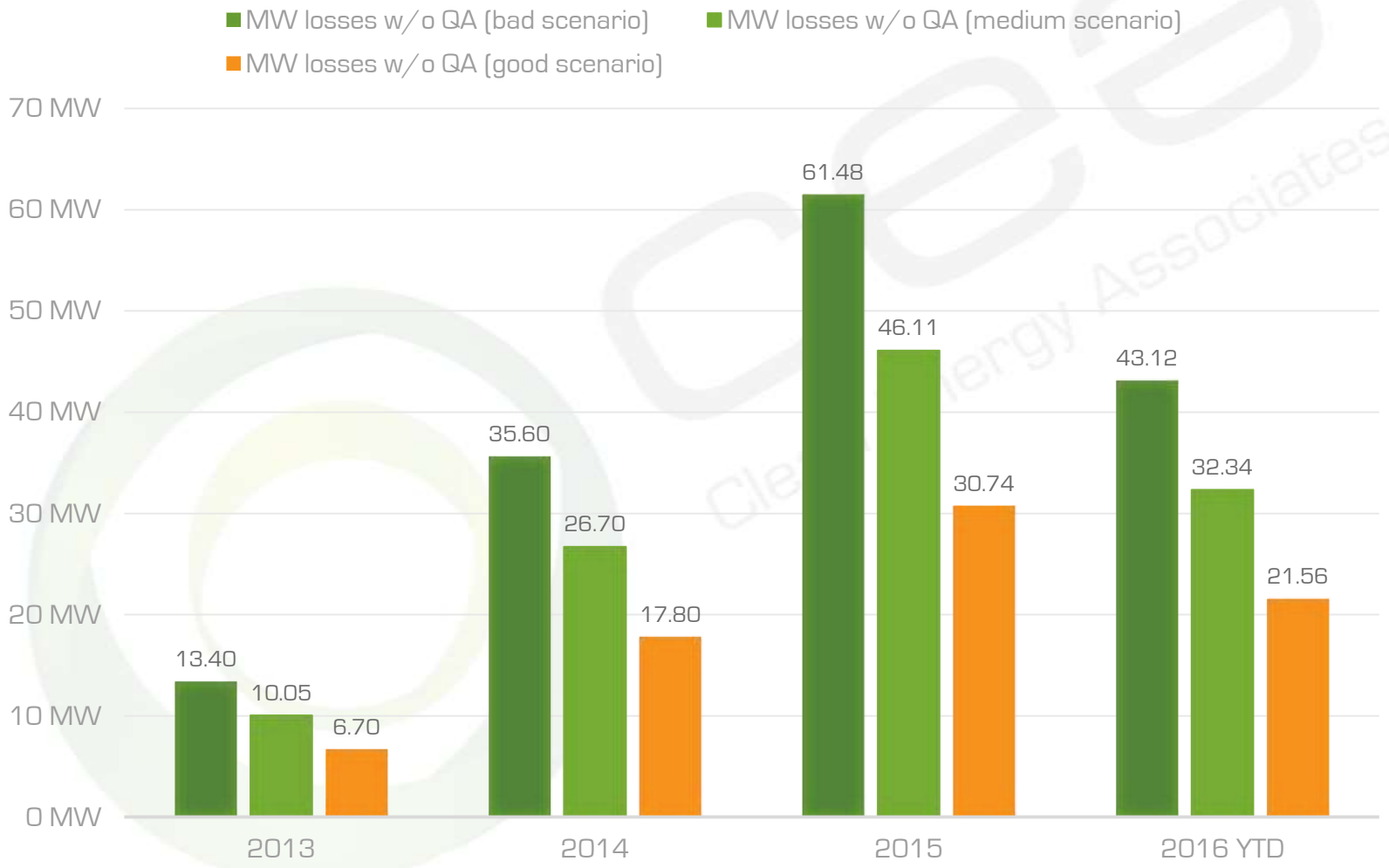



# Correlation of defect rates to average power loss mitigated in CEA Quality Assurance Programs, derived from 4 project case studies




* in excess of warranted degradation, after a few years of operation, based on reasonable assumptions about degradation caused by defects

# MWs of Power saved by performing CEA Quality Assurance Programs, based on 3 scenarios




Bad scenario: manufacturer shows a big drop in quality w/o QA program (4 x times defect rate)
Medium scenario: manufacturer shows a medium drop in quality w/o QA program (3 x times defect rate)
Good scenario: manufacturer shows a small drop in quality w/o QA program (2 x times defect rate)

# THANK YOU!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