# Thinking in Acquisition Age
## – GW PV Plant Results Analysis

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Excellence for your Business

# Thinking in Acquisition Age
## Background

From NEA

China plans to install 17.8 GW PV power plants in 2015



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## Assessment Map

2015.3
800MW

2015.8
1.8GW

In public market, TÜV NORD has performed most of the technical due diligence service for transaction.

In other words, we can see how hot the PV plant market is!



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## Background

- The financial risk of PV power plant investment is to produce safety and reliable energy with many uncertainty.
- To face the risk, precise and timely information currently and in the future is necessary, including solar resource and other relevant parameters (device characteristic, environment, design and etc.)



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# Thinking in Acquisition Age
## Background


Gain extensive experience and strong support from investors

- Global – 4GW
- China – 1.8GW
- 2015 YTD – 1.3GW



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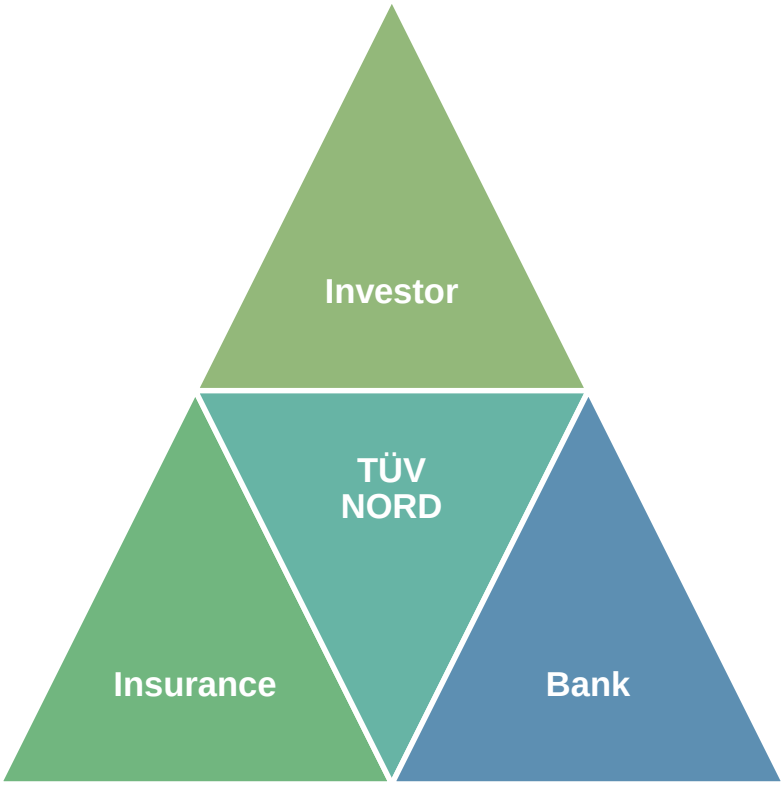
# Thinking in Acquisition Age
## Background

**We – TÜV NORD -act as the role of interface among stakeholders.**




- Competent in PV system area
- Independent
- Extensive project experiences
- Global fame



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# Thinking in Acquisition Age
## Standards

| | |
|---|---|
| IEC 60364 | • Low-voltage electrical installations |
| IEC 62446 | • Grid connected photovoltaic systems |
| IEC 62548 | • Installation and safety requirements for photovoltaic (PV) generators |
| IEC 61829 | • Crystalline silicon photovoltaic (PV) array - On-site measurement of I-V characteristics |
| IEC 61724 | • Photovoltaic system performance monitoring - Guidelines for measurement, data exchange and analysis |
| IEC 62109 | • Safety of Power converters for use in PV power systems |
| IEC 61727 | • Photovoltaic system - Characteristics of the Utility interface |

# Thinking in Acquisition Age
## Technical due diligence

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Only diligence work brings valuable report to investor



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# Thinking in Acquisition Age

## Sampling – Minimum Requirement

| Larger Scale PV Power Plant | | | | | |
|---|---|---|---|---|---|
| Category | Stage 1 | Stage 2 | Permit | Construction | Completion |
| Conformity Check | 2%-5% | N/A | ✓ | ✓ | ✓ |
| DC degradation | 2%-5% | 5%-10% | ✓ | ✓ | ✓ |
| IR inspection | 2%-5% | 5%-10% | ✓ | ✓ | ✓ |
| Visual inspection | 2%-5% | 5%-10% | ✓ | ✓ | ✓ |
| Energy yield review | 100% | 100% | ✓ | ✓ | ✓ |
| Performance ratio | N/A | 100% | ✓ | ✓ | ✓ |
| Inverter evaluation | N/A | 1pcs / type | ✓ | ✓ | ✓ |
| On-site assessment | N/A | N/A | ✓ | ✓ | ✓ |
| Supplier evaluation | N/A | N/A | ✓ | ✓ | ✗ |
| Power verification | N/A | 5pcs / MW | ✓ | ✓ | ✓ |
| Production surveillance | N/A | N/A | ✓ | ✓ | ✗ |



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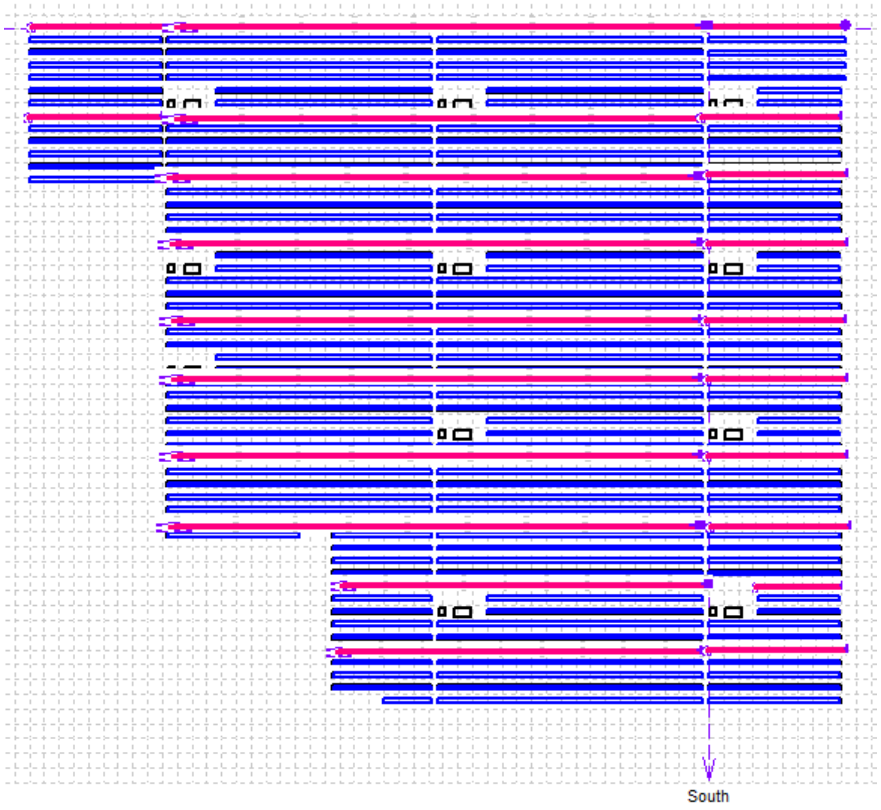
## Distributed Sampling

Reason

The Power Plant could be installed by different installers.

Equipment type could be different in different blocks.

Small climate could impact and result in various failures.



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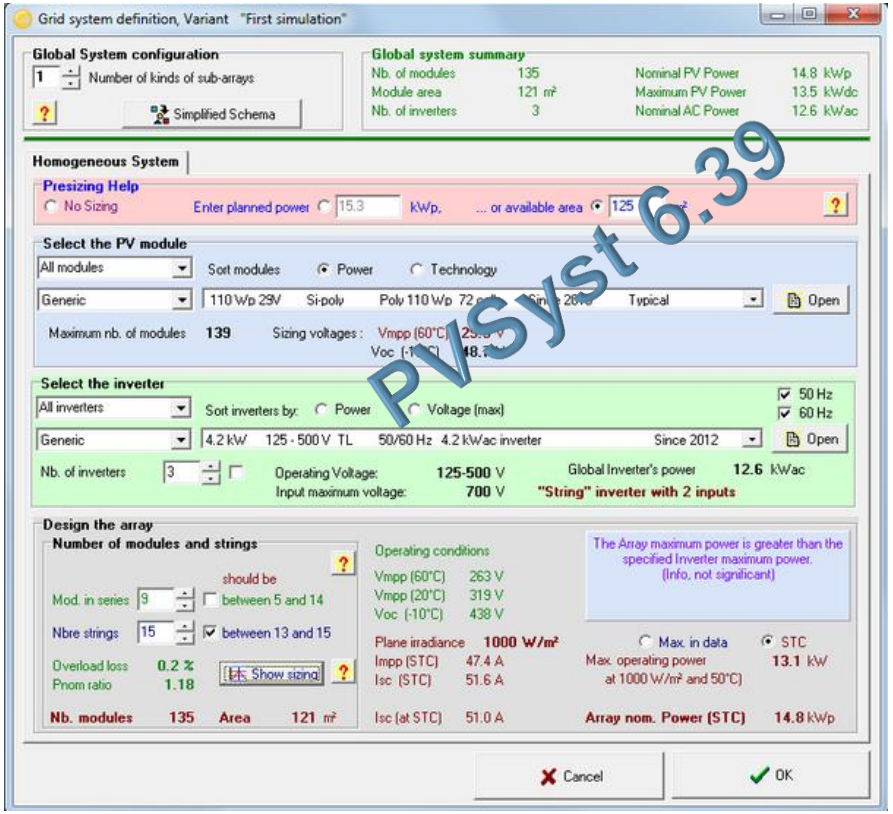
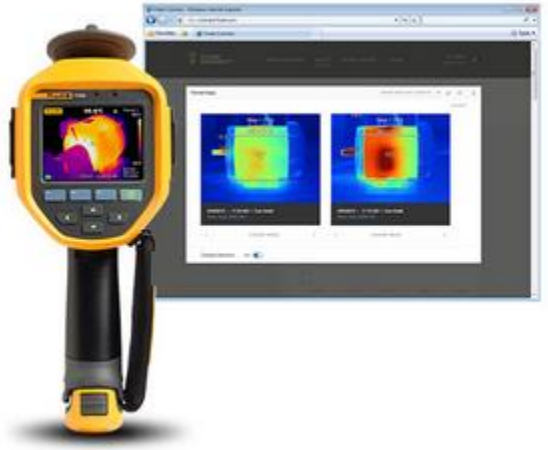
## Tools





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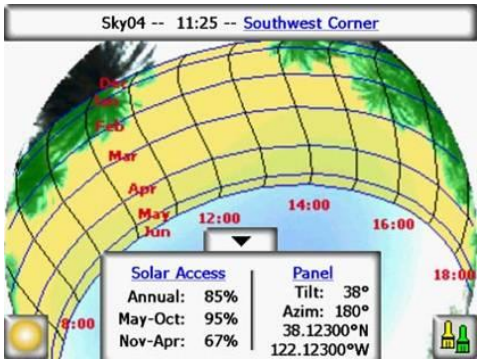
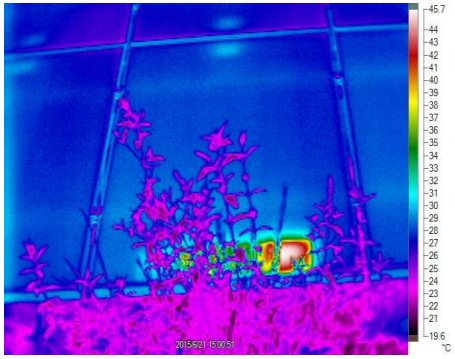
## Site





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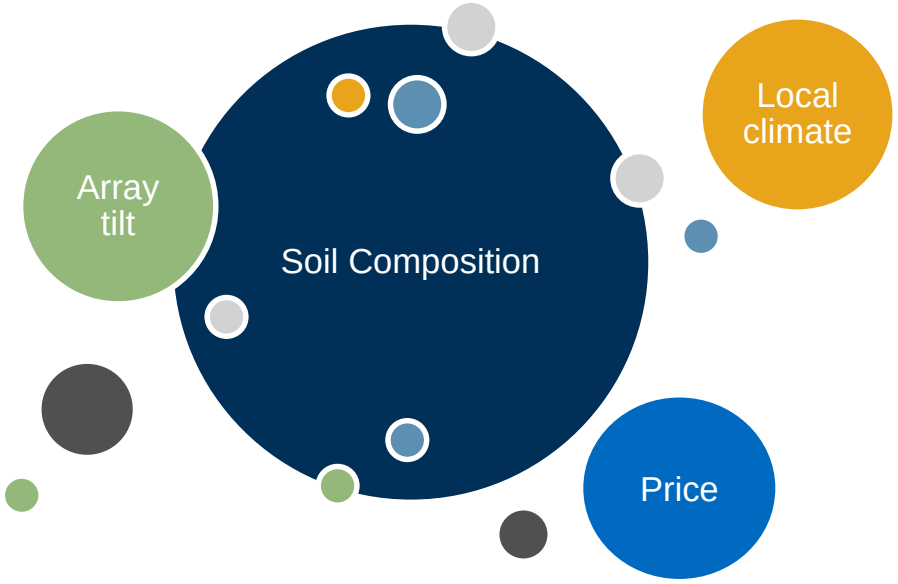
## Foundation

# What is the best foundation?

It depends



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## Environment Concerns

Before installation

After installation

The environment issues need considered, especially for the installation of PV plant in western China, when the soil is too vulnerable and hard to recover.



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# Thinking in Acquisition Age
## Foundation

Screw drilling piles

Concrete piles

Static Pressure Piles



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## Potential Cause of Failures for Racks

- Damage from corrosion
- Incorrect grounding
- Installation error
- Mixing & matching of products
- Poor system design
- Storm, heavy snow
- Animal damage

Fence protecting from wildlife



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## Quality assurance

### Sand Bag Loading test

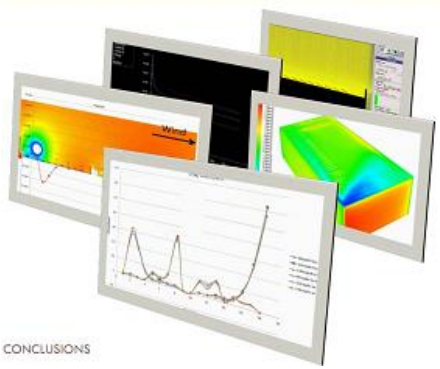
- Design load according to extreme wind load and snow load

### Acceleration test

- Simulate force on different directions
- Consideration of acceleration and duration due to load

### Computer simulation

- Wrong assumption could be leaded to unreal results
- Need calibration to reality
- Extensive experienced expert needed



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## Installation



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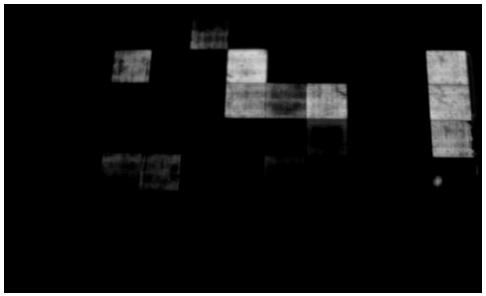
## PID



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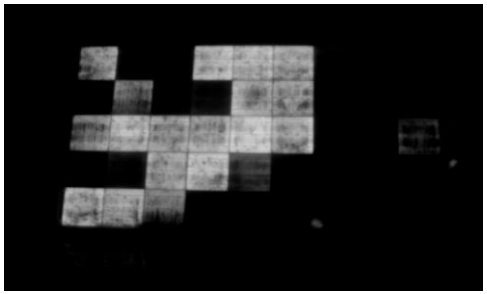

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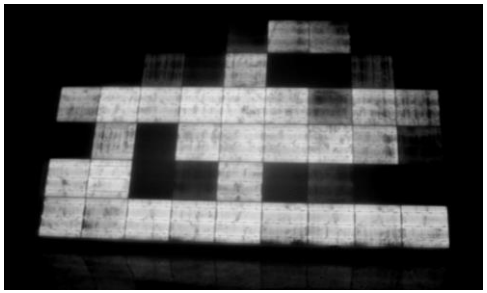
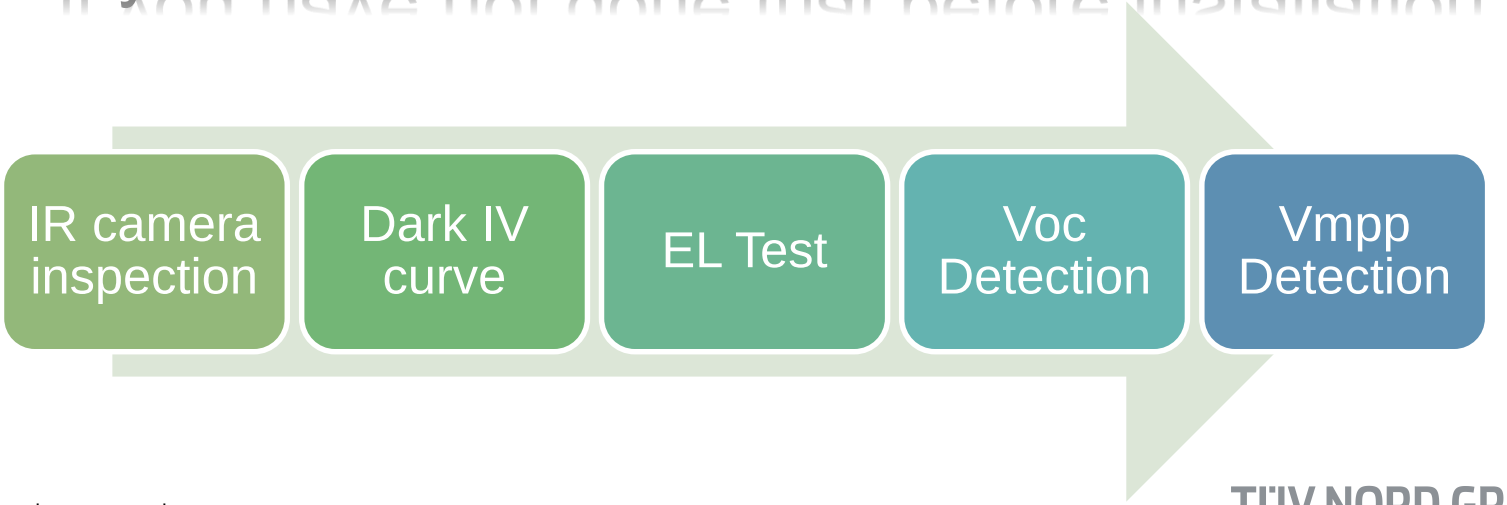


(-) No.3

First 3 samples in 20 modules serial connected strings.

IEC 62804 helps you to verify the BoM. But if you have not done that before installation



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## Snail Trail

Snail trail is more and more common to find on-site for the PV system operation after 6 months.

Some institute has declared that they have invented the test method to produce the snail trail. But you need to think about the repeatability.

TC200 ✚ DH ✚ HF ✚ OD

No obvious power degradation occurs
No significant discolored area enlargement

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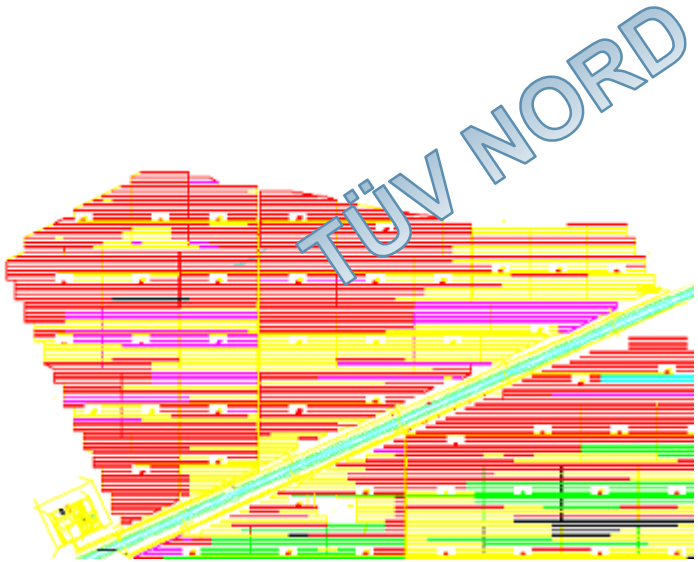
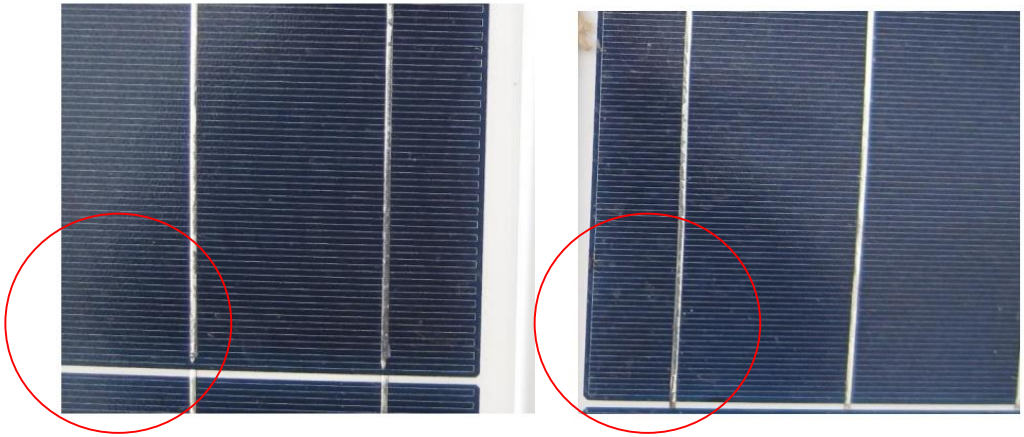
## Conformity

Deviation between design and construction

Deviation between procurement and installation



**It is late to find it on-site.**



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## On-site inspection




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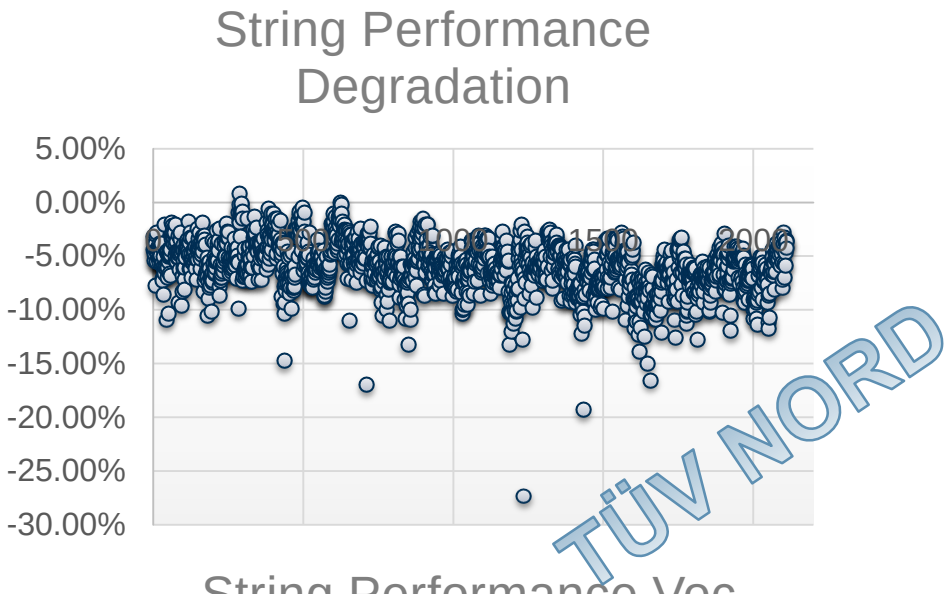
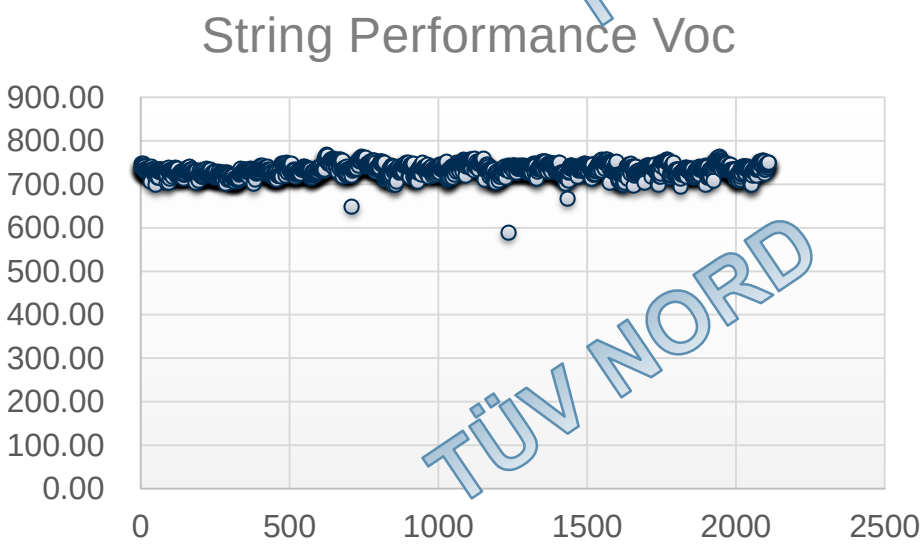
## PV String Performance




Soiling

Mismatch

Degradation

Near shading

Installation error

PID

Aging



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# Thinking in Acquisition Age
## PV String Performance

| | | Plant Info | | | | | | PV Module | | | | | | String Performance | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Index | Client | Province | City | Scale | Type | Grid Year | Test Year | Brand | Type | Serial Num | Rated Power | Block No. | CB No. | String No. | Voc | Vmpp | Isc | Impp | Pmpp | FF | Degradation |
| 2106 | [redacted] | Gansu | [redacted] | 100 | Ground | 2013 | 2015 | [redacted] | [redacted] | 17 | 290 | 93 | 93-10 | 11 | 745.57 | 559.5 | [redacted] | 8.397 | 4698.29 | 70.06% | -4.70% |



Database have been created for 5,398 strings

More than 20 module types have been tested.
Tier 1, 2 and 3 are included.

-6.79%: Mean degradation for 5,398 strings

Worst PV plant: -22.48%, Rooftop 20MW

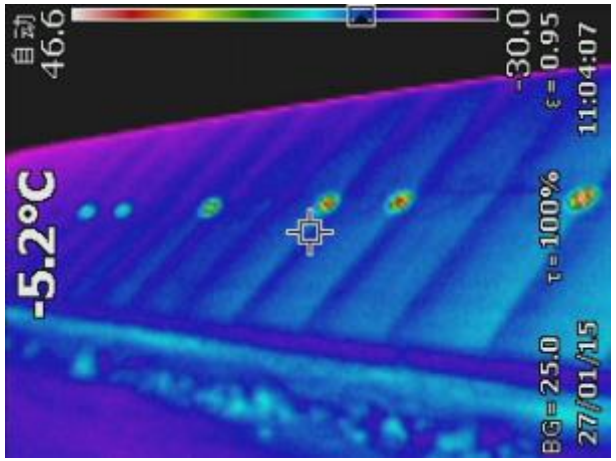
Best PV plant: -3.95%, Ground 100MW

# Thinking in Acquisition Age
## PV Module Performance

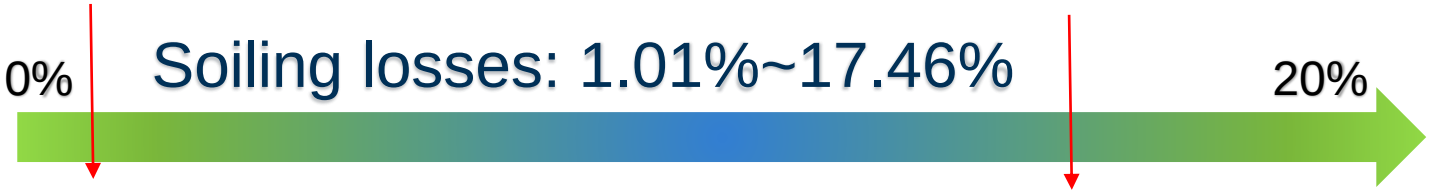
More than 20 module types have been tested.
Tier 1, 2 and 3 are included.

-6.60%: Mean degradation for 4,385 PV modules

Worst PV plant: -10.16%, Ground 100MW




Best PV plant: -4.35%, Ground 60MW



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## IR Camera Inspection

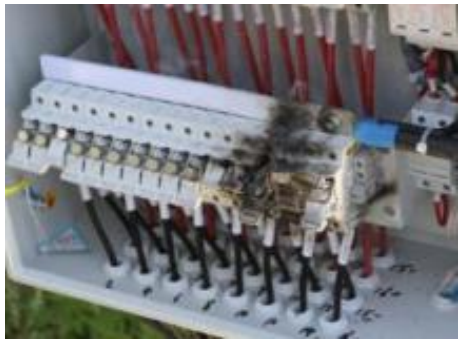
From 121,500 PV modules, CB, Connections

Average Hot-spot Rate: 0.43%

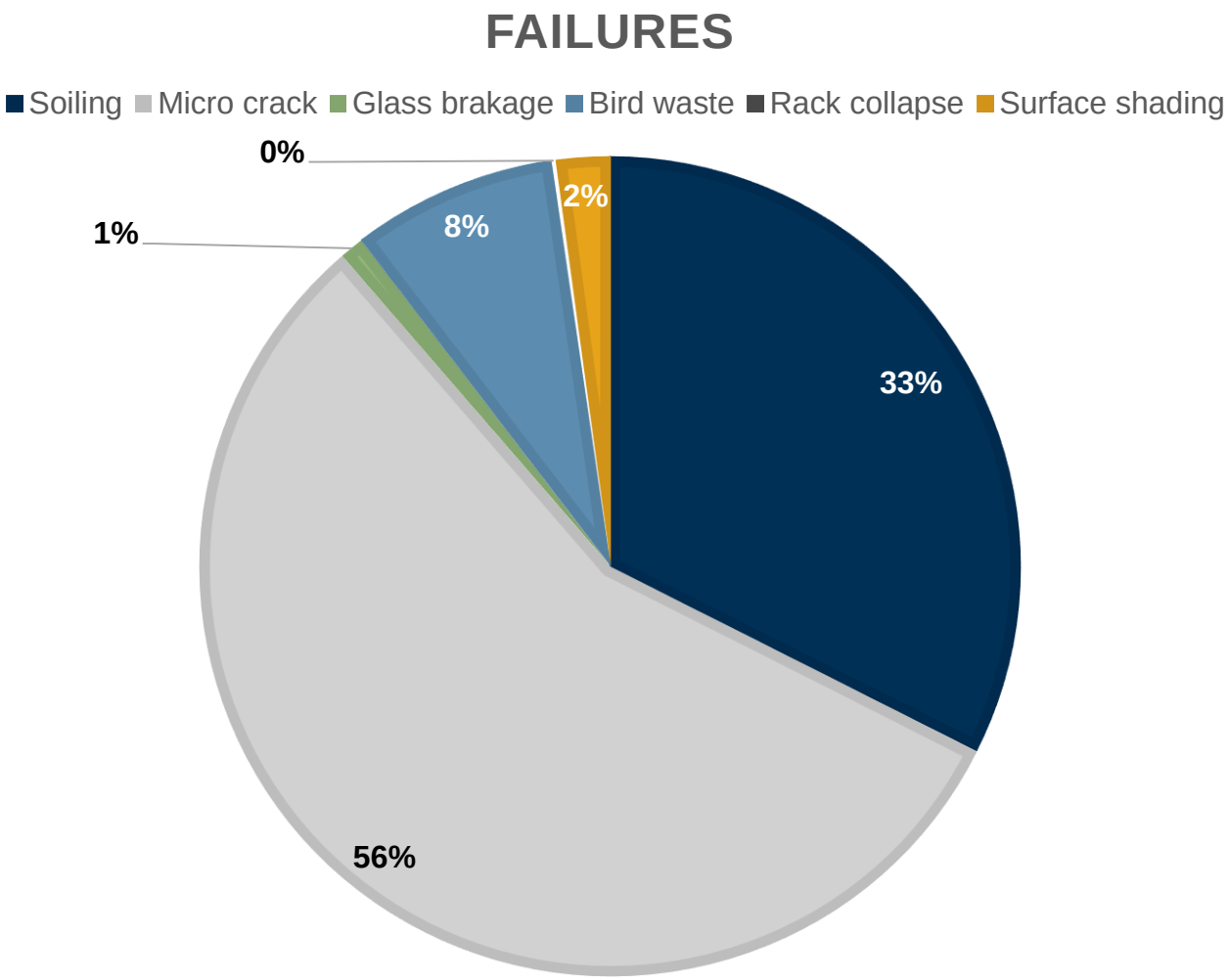
Best PV plant: 0.023%, LSPV 50MW+,25000 Modules

Worst PV plant: 10.25%, Rooftop 20MW,1600 Modules

One CB Failure



# Thinking in Acquisition Age
## IR Camera Inspection





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## Energy Yield Review

Detailed solar assessment

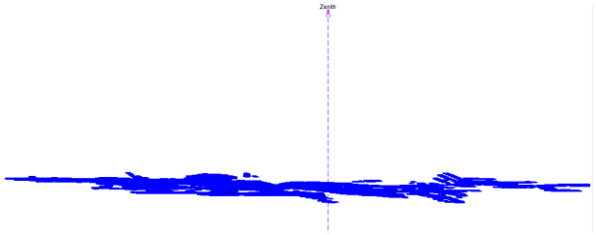
Shading analysis

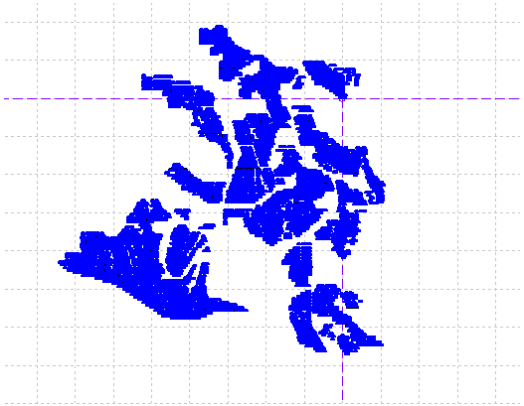
Loss factor analysis and calculation of Performance Ratio (PR)

P50 and P90 production forecasts and annual degradation estimate

Monthly breakdown of P50 forecast

Annual variation and uncertainty analysis





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# Thinking in Acquisition Age
## Cleaning Tools

Source: ionicsolar

Source:喀什思拓光伏科技有限公司



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# Thinking in Acquisition Age
## Cleaning Tools

| Methods | Cleaning tools | Water required for 10MW per once | Cleaning speed | Cleaning results | Cleaning cost |
|---|---|---|---|---|---|
| Manpower solution | No need of any vehicles and special tools | <10 ton | Slow | Good | Low |
| Spray Pipes | Water sources inside and spray pipe installation is required | 50-60 ton | Medium | Excellent | High |
| Flashing Water | Water holding vehicles are required | ≥100 ton | Medium | Excellent | High |
| Special washing vehicles | Require special washing vehicles or special tools | 30-40 ton | Fast | Excellent | High |
| Auto robot cleaning | Require special robot | Not need | Fast | Excellent | Depending on design |

# Conclusions

- Diligence altitude brings trust from investors
- Distributed sampling reaches actual results
- TÜV NORD use “big” data to see more stories behind
- Maintenance is always a good question for owner.
- Optimistic mind leads to success



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# TÜV NORD – CONTACT

**Thank you for your attention!**


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