CONNECTED PV 4.0

Industry Leading Process Analytics for SMART PV Manufacturing

Tom Thieme | Intersolar & VDMA Workshop | October 6th 2021
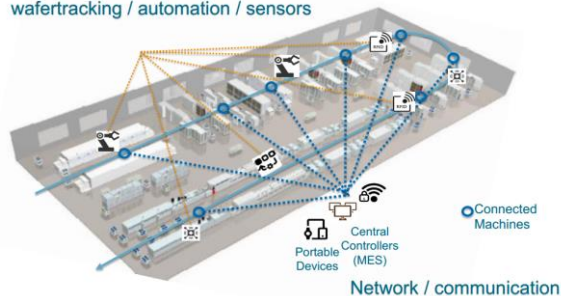
2018 VDMA for Smart PV Fab's

➡ Latest Technology

- Fully automated, self-learning,
- High yield & productivity

➡ Flexible Concept

- Most complete quality inspection capabilities
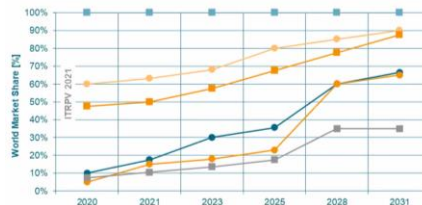- Fast ramp-up, design change and operation friendly

2021 ITRPV Roadmap

➡ Smart PV fab trends

- More inline inspection system have to be integrated
- Targeting cost reduction & yield improvement
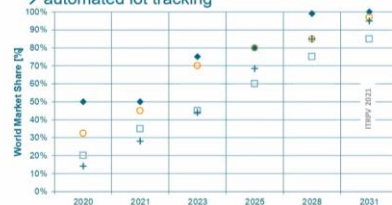- Automated recipe management and data analytics

Market driver

➡ Smart PV fab trends

- **More** inline inspection system have to be integrated
- Targeting cost **reduction & yield** improvement
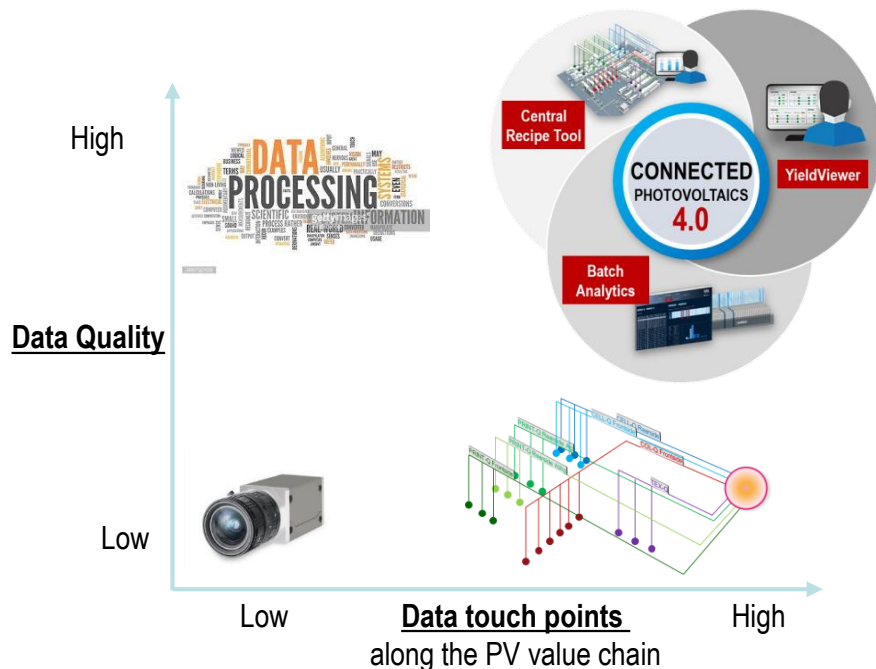- **Automated** recipe management and data analytics

➡ Latest Technology

- Fully **automated, self-learning**,
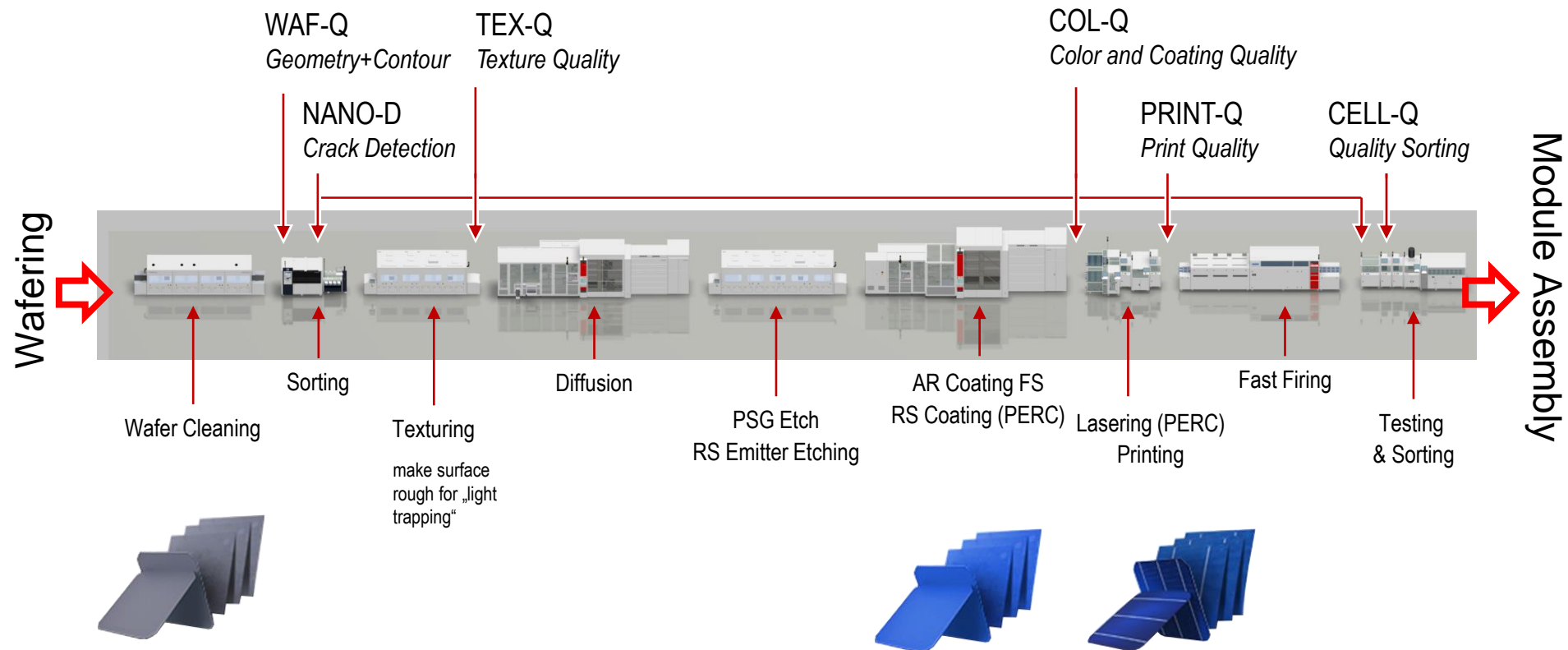- High yield & productivity

➡ Flexible Concept

- Most complete quality inspection capabilities
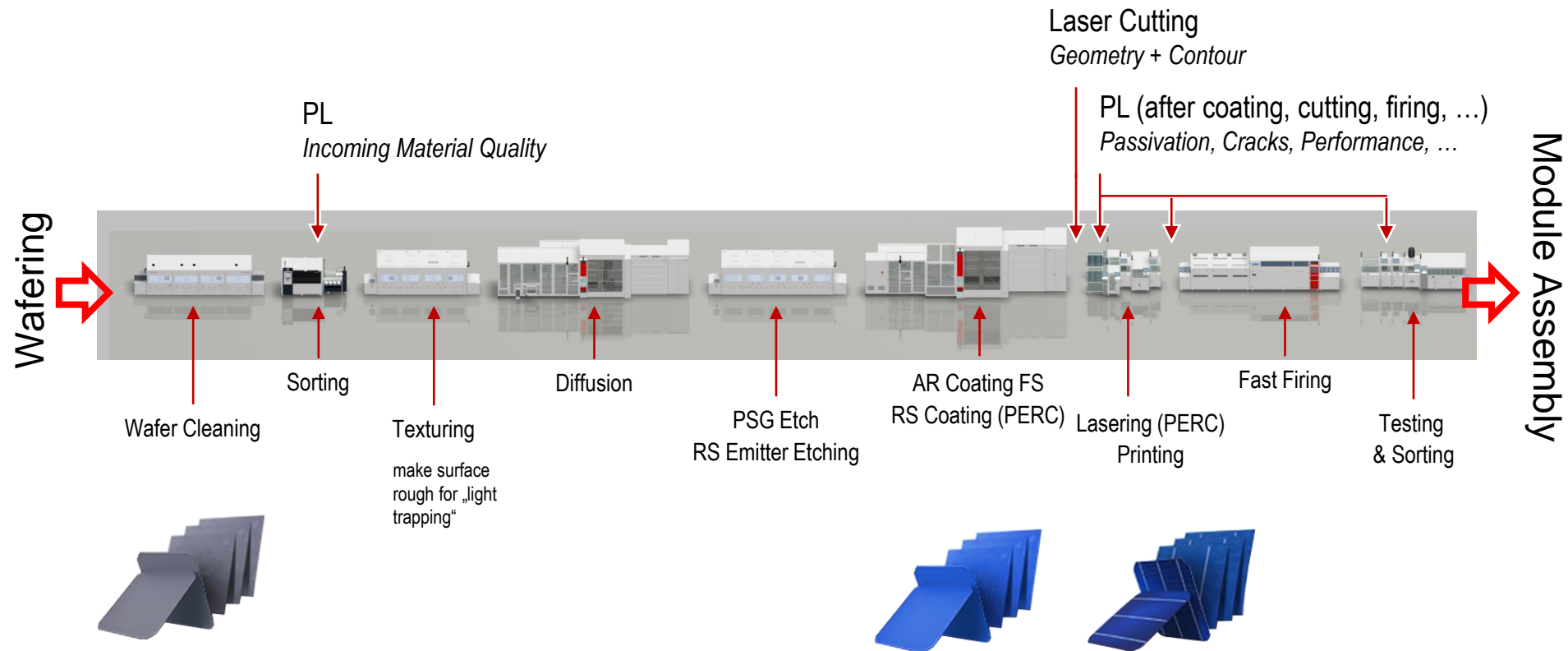- **Fast ramp-up, design change** and operation friendly

Quality of Process Data

High

Data Quality

Low

Low   **Data touch points**   High
along the PV value chain

Data touch points along the PV value chain

We provide all important inspection systems.

Laser Cutting
Geometry + Contour

PL (after coating, cutting, firing, …)
Passivation, Cracks, Performance, …

PL
Incoming Material Quality

Wafering

Module Assembly

Sorting

Diffusion

AR Coating FS
RS Coating (PERC)

Fast Firing

Wafer Cleaning

Texturing

make surface
rough for „light
trapping"

PSG Etch
RS Emitter Etching

Lasering (PERC)
Printing

Testing
& Sorting

Data touch points along the PV value chain

Reliable analysis based on trustworthy inspection data
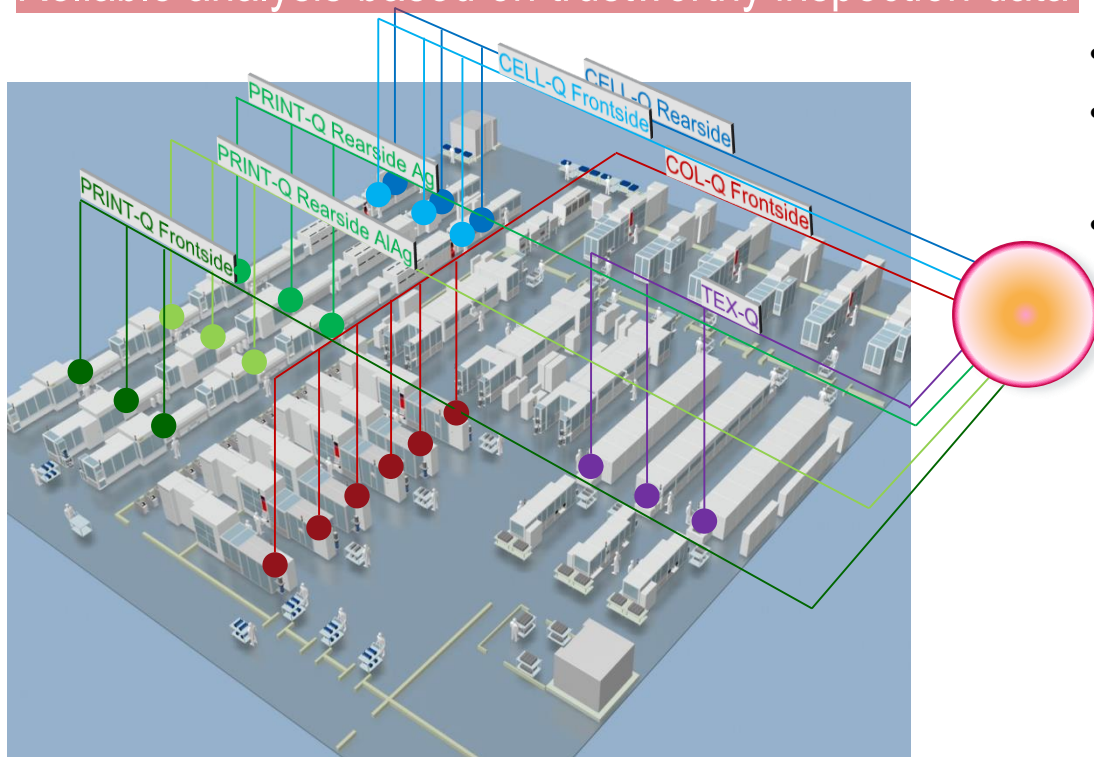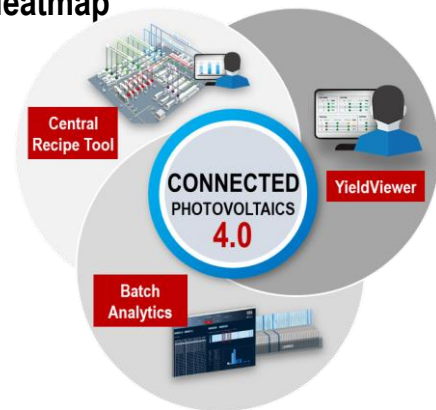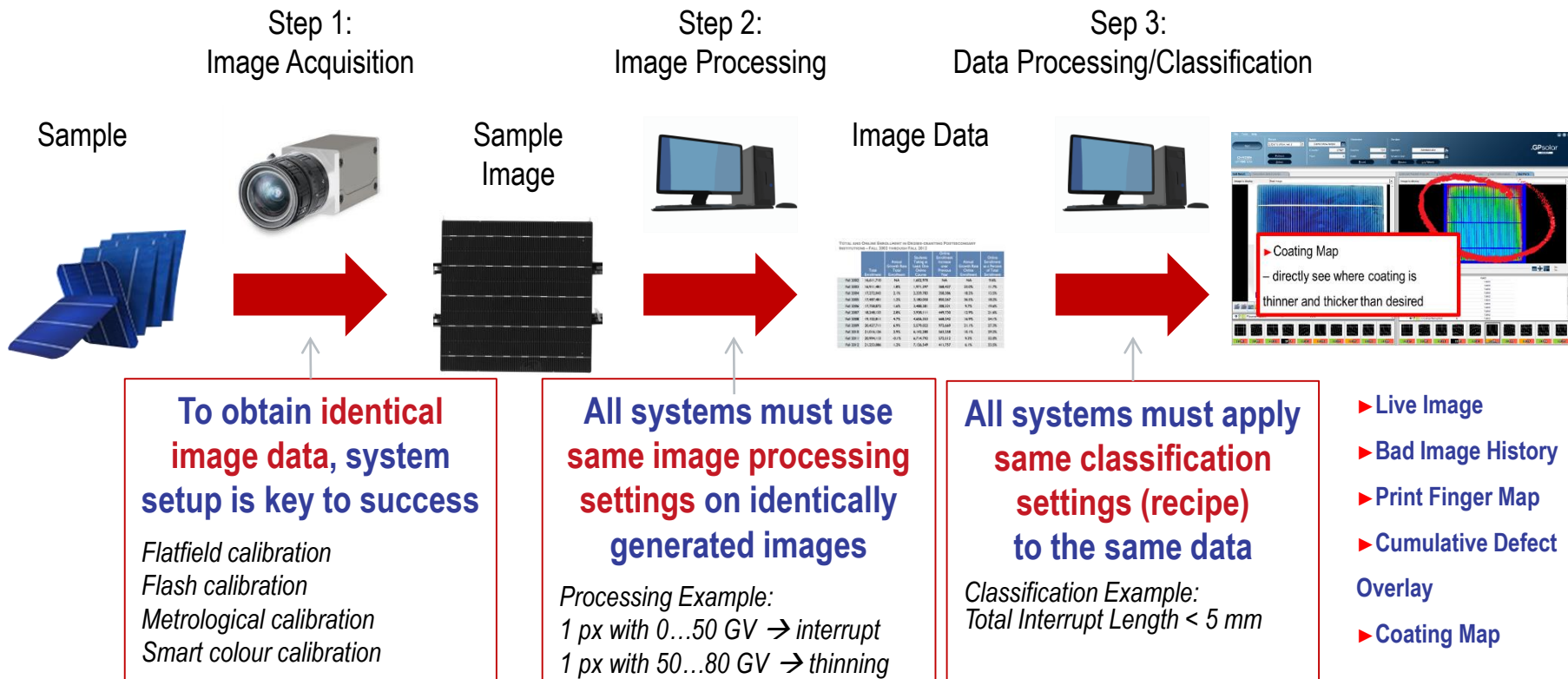
- Connect all systems
- Manage all systems
  - **Central Recipe Management**
- Central data analytics
  - **CPV YieldViewer**
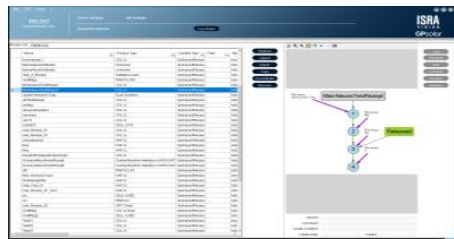 - **CPV BoatViewer**
  - **CPV Defect Heatmap**
  - **Trend charts**

To obtain identical data…

Step 1:
Image Acquisition

Step 2:
Image Processing

Sep 3:
Data Processing/Classification

Sample

Sample
Image

Image Data

►Coating Map
– directly see where coating is
thinner and thicker than desired

To obtain identical image data, system setup is key to success

Flatfield calibration
Flash calibration
Metrological calibration
Smart colour calibration

All systems must use same image processing settings on identically generated images

Processing Example:
1 px with 0…50 GV → interrupt
1 px with 50…80 GV → thinning

All systems must apply same classification settings (recipe) to the same data

Classification Example:
Total Interrupt Length < 5 mm

►**Live Image**

►**Bad Image History**

►**Print Finger Map**

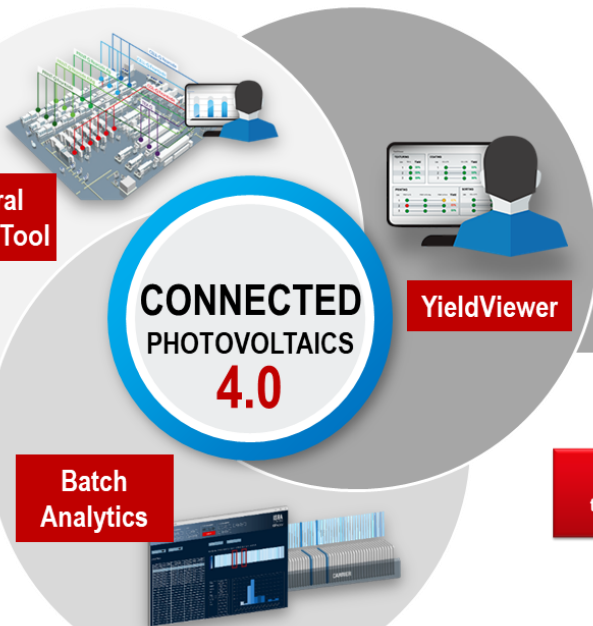►**Cumulative Defect**

Overlay

►**Coating Map**

CONNECTED PV 4.0 | Merge Advanced Image Data Along the Value Chain

Central Recipe Tool

- Up to 15 additional production days
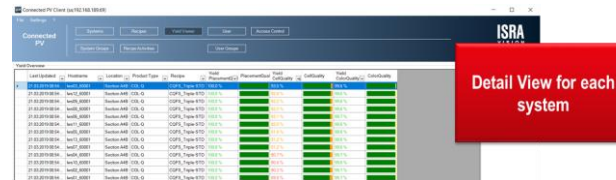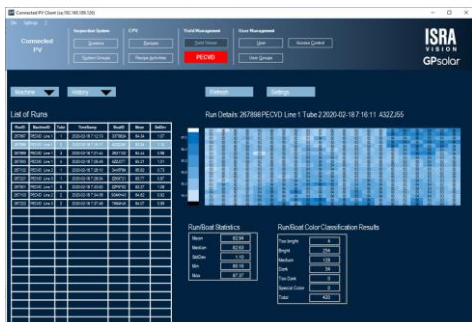- Fab-wide identical quality settings
- Reduced engineering time

YieldViewer

- Real-time overview of production status
- Efficient troubleshooting

Detail View for each system

CONNECTED PHOTOVOLTAICS 4.0

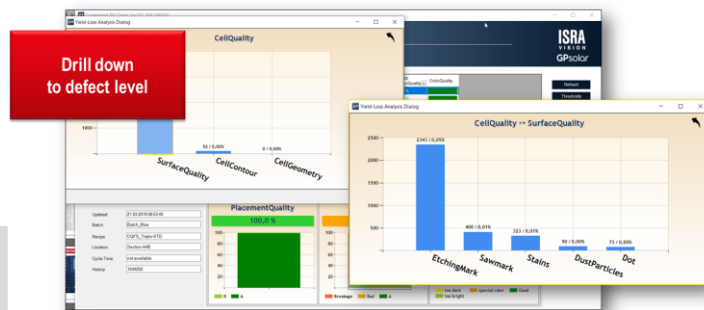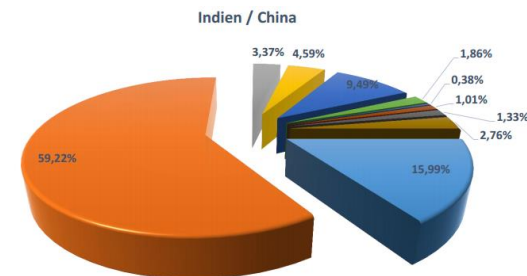**Batch Analytics**

- Batch-based visualization of the process performance
- Best process stability

Drill down to defect level

ISRA
V I S I O N

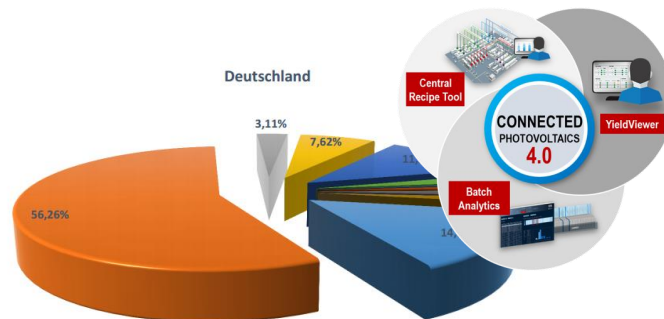### Indien / China

3,37% 4,59%
9,49%
1,86%
0,38%
1,01%
1,33%
2,76%
15,99%
59,22%

Courtesy: RCT Solutions GmbH

- Polysilicon
- Electricity
- Depreciation equipment
- Utility, waste treatment
- Spare&Wear, maintenance
- Materials / consumables
- Labour
- Depreciation build./fac.
- Facility operational cost
- Yield

TCO: ~ 25 $c /Wp
(2018 data)

Deutschland

3,11%
7,62%
56,26%

Central Recipe Tool
CONNECTED PHOTOVOLTAICS 4.0
YieldViewer
Batch Analytics

Courtesy: RCT Solutions GmbH

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TCO: ~ 27 $c /Wp
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VS

15,000 miles
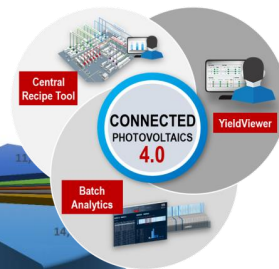
- 2020/2021 => global supply chain issues increases logistic cost significantly

- 2020/2021 => cost efficient & smart GW manufacturing pay's off anywhere globally

- Smart & intelligent process cost saving & yield improving fab solutions are "Must have" in PV

Customer values

- **Real time** quality tracking

- **Full** production transparency

- **Consistent** quality standards

- Historical and trend **analytics**

- **Comparable** process insights

- Identify **champion** lines

- Industry **proven** data system

- **Fast** recipe changes & adoption

- **Reliable** decision base

Central yield analysis with Central Recipe Tool

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Thank you for your attention

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