
Sustainability through process control

From grid parity to green parity

How to deliver sustainability in an era of overwhelming cost pressure

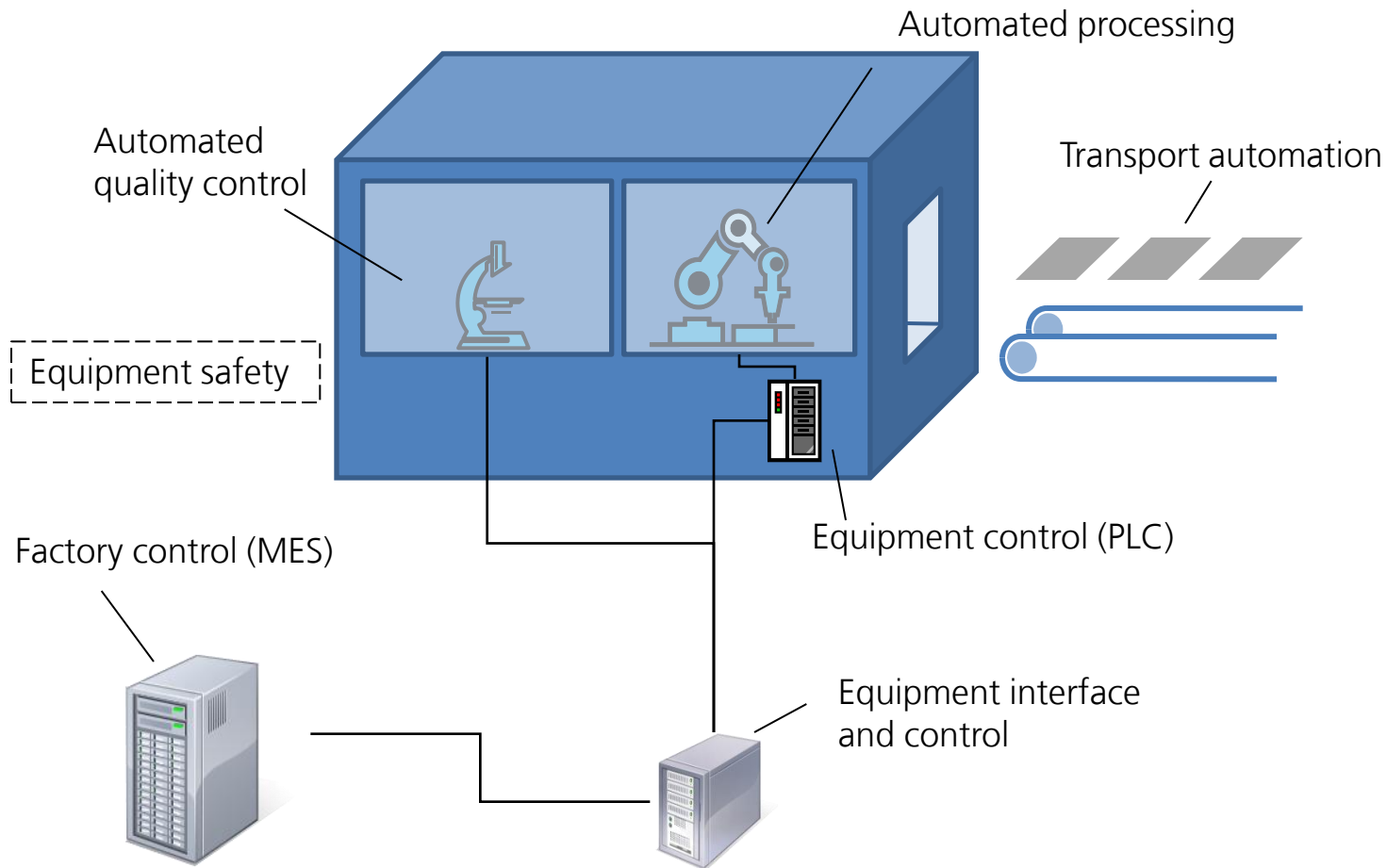
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Outline

- What are the typical functionalities and scope of process control
 - With focus on Equipment Interfaces (EI) and Manufacturing Execution Systems (MES)
- Why it might be necessary to install and operate a full functional MES
 - Mapped to current requirements of process control
- What can you achieve with manufacturing IT
 - Adding specific value by facilitating manufacturing and raising product quality

Schematic representation of the integrative automation approach



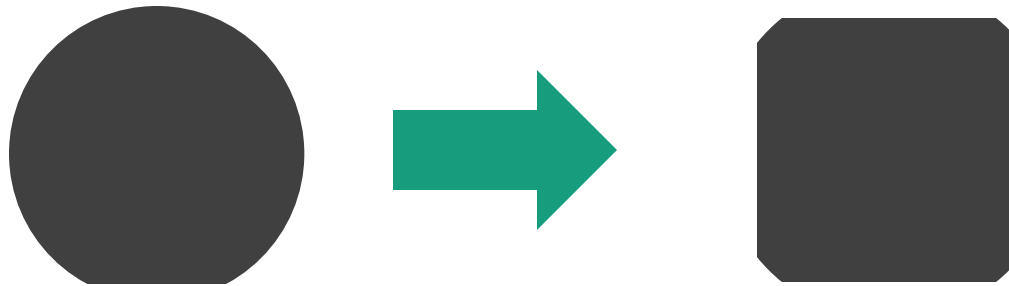
A brief trip into manufacturing IT

- where are we heading? -

- For a long time PV manufacturers wanted a simple approach to manufacturing IT
 - Simple IT interface
 - Simple line controller to run the manufacturing lines
 - Rarely a single wafer tracking in manufacturing
- Within the last two years, this attitude changed somewhat
 - A full-sized IT interface standard was created
 - Some manufacturers even think about Advanced Process Control (APC)
 - Single wafer tracking is now being discussed

Move from semiconductor to PV

- In the first discussions about standardization, which started in 2006, manufacturers expressed concerns about complexity and costs of semiconductor standards
- The first standard for equipment interfacing is in large parts now very similar to semiconductor standards
- Many semiconductor experts switched into PV industry and now bring in their expertise and their ideas of manufacturing



What can you do with process control?

- Some typical functionalities are:
 - Data gathering (e.g. for quality aspects)
 - Equipment Control
 - Recipe management
 - Control of durables and consumables
 - Inventory control
 - Substrate tracking
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Example: Correlation of data

- Statistical Process Control (SPC) can be used to correlate metrology data with the goal of improving certain process steps
- One approach is the intentional variation of process parameters at a specific process step
- By analyzing metrology data (e.g. cell performance at a flasher) influences of this process step can be determined
- The same method can be used in many other forms
- Requirement is the reliable availability of both metrology data and process control data

Example: Maintenance Planning

- For some process equipment in PV several hours of maintenance and repair have to be invested for a few days of operation
- Maintenance procedures from the supplier recommend a regular maintenance cycle
- Manufacturers often lack the man-power to execute these maintenance procedures
- Equipment not in operation has to be avoided

- Result: A good maintenance planning should be included into manufacturing IT to schedule maintenance and repair

Example: Maintenance Planning (cntd.)

- Result: Suppliers and manufacturers have to work together, supported by manufacturing IT
 - Locate and improve maintenance and repair intensive equipment parts
 - Facilitate maintenance for operators
 - Plan maintenance according to availability of maintenance personnel

What might be the future of process control?

- High-efficiency cells will probably demand good process control
 - Sophisticated equipment control
 - Frequent automated measurements
 - Overall control of the process chain
- With good understanding of the process, standard cells could be produced without much additional effort
 - Rare intervention at the line
 - Samples for detailed measurement
 - Focus on final quality measurement

Some other challenges in PV production

- other than cost reduction -

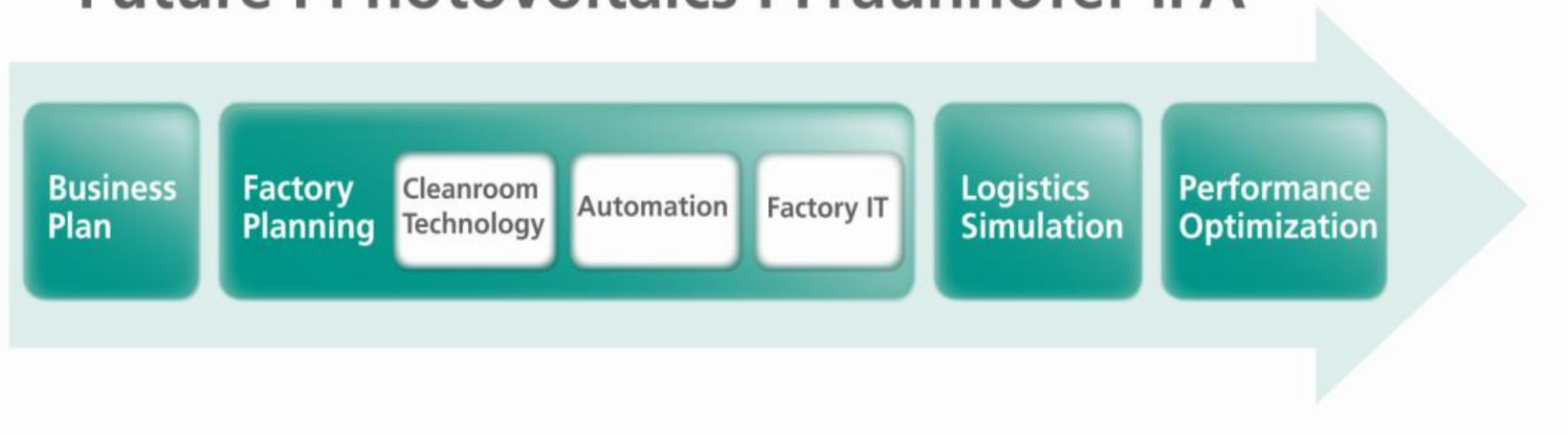
- Acceleration of the production processes
 - Acceleration of the automation and response times
- Larger production lines and factories
 - Standardization of components and systems
 - Higher process and production control through manufacturing IT
 - Automation has to guarantee a high equipment utilization
 - Fully integrated factories will need a high degree of process control
- Higher efficiencies in production (from lab into fab)
- Possible conversion to 210mm edge length, but currently there is not much activity

Conclusion

- Manufacturing IT is a key enabler for many beneficial aspects
- In terms of cost reduction manufacturing IT does not have the greatest lever, compared e.g. with prices of silicon
- Gathering of data is only valuable, if someone can make use of it
- The goal of manufacturing should be the uninterrupted operation of a line with only occasional interference, by
 - Knowing the characteristics of the used material
 - Having in-depth knowledge about the processes
 - Doing all process steps alike

Thank you very much for your attention

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