



**SIEMENS**



**Efficient, standardized and  
scalable automation  
solutions – the basis for a  
successful FC production**

Battery Storage & Fuel Cell  
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[www.siemens.de/batterie](http://www.siemens.de/batterie)

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# Our organization

Four Sectors cover the global trends



## Industry



- Industry Automation
- Drive Technologies
- Customer Services
- Metals Technologies<sup>1)</sup>

## Infrastructure & Cities



- Rail Systems
- Mobility and Logistics
- Low and Medium Voltage
- Smart Grid
- Building Technologies

## Energy



- Fossil Power Generation
- Wind Power
- Power Transmission
- Oil & Gas
- Energy Service

## Healthcare



- Imaging & Therapy
- Clinical Products
- Diagnostics
- Customer Solutions

Attractive markets driven by megatrends

Climate change

Demographic change

Globalization






Urbanization

1) Sector-led Business Unit

# Industry Automation: A leading position in automation technology and industry software



## Industry Sector – Industry Automation Division

Industrial Auto- mation Systems (AS)	Sensors and Communication (SC)	Control Compo- nents & Systems Engineering (CE)	PLM Software (PL)	Water Technologies <sup>1)</sup> (WT)
				
<ul style="list-style-type: none"> <li>• SIMATIC S7 (PLC)</li> <li>• SIMATIC PCS 7 SIMATIC IPC</li> <li>• SIMATIC HMI</li> <li>• SIMATIC IT (MES)</li> <li>• Digital Engineering</li> <li>• Solutions Factory &amp; Process Autom.</li> </ul>	<ul style="list-style-type: none"> <li>• Process Instrumentation</li> <li>• Process Analytics</li> <li>• Industrial Identification</li> <li>• Industrial Communication</li> <li>• SITOP Power Supplies</li> </ul>	<ul style="list-style-type: none"> <li>• SIRIUS Control Components</li> <li>• SIPLUS Customized Solutions</li> </ul>	<ul style="list-style-type: none"> <li>• Digital Product Development (NX)</li> <li>• Digital Manufacturing (Tecnomatix)</li> <li>• Collaborative Data Management (Teamcenter)</li> </ul>	<ul style="list-style-type: none"> <li>• Industrial Solutions</li> <li>• Municipal Solutions</li> <li>• Health Science Solutions</li> <li>• Aquatics and Leisure Solutions</li> </ul>

**#1 Industry automation systems – #2 Industry software**

1) Sale planned

## Market and technology focus

Value added chain and process

Automation technology and inline measuring

Cell voltage supervision system

Summary

# Overview of Siemens activities in the eCar environment



## Outside eCar

- Energy supply, storage & load flow management
- Medium-voltage distribution
- Smart grid & metering
- Charging
- Stationary applications of Li-ion battery storages (SIESTORAGE)

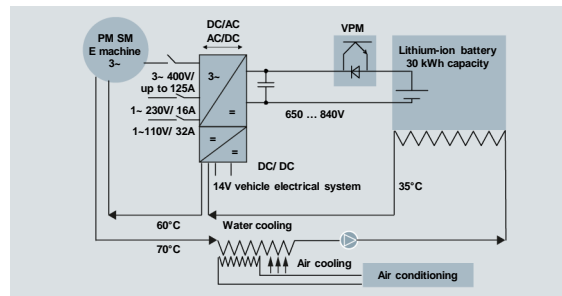


## Inside eCar

- E motor



- Power electronics



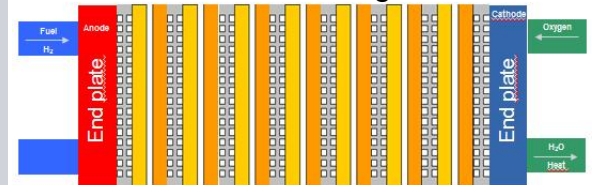
## eCar production

### Automation of

- Vehicle production



- Fuel cell manufacturing



- E motor production







Market and technology focus

## Value added chain and process

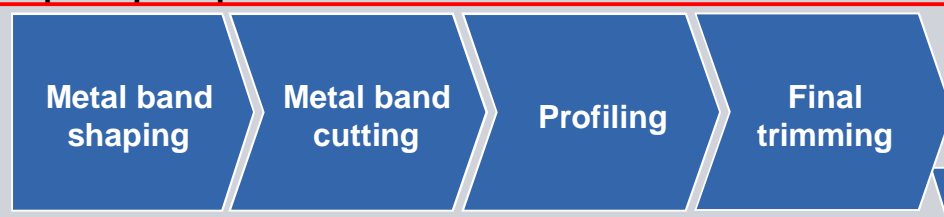
Automation technology and inline measuring

Cell voltage supervision system

Summary

# Production steps of a PEM fuel cell (abstract representation)

## Bipolar-plate production



### Requirements for bipolar plates

- Electrical conductivity and a low resistance for the current to the neighboring cell.
- Corrosion resistance and no changes of the properties under thermal stress.
- Minimum pressure lost over the flow fields

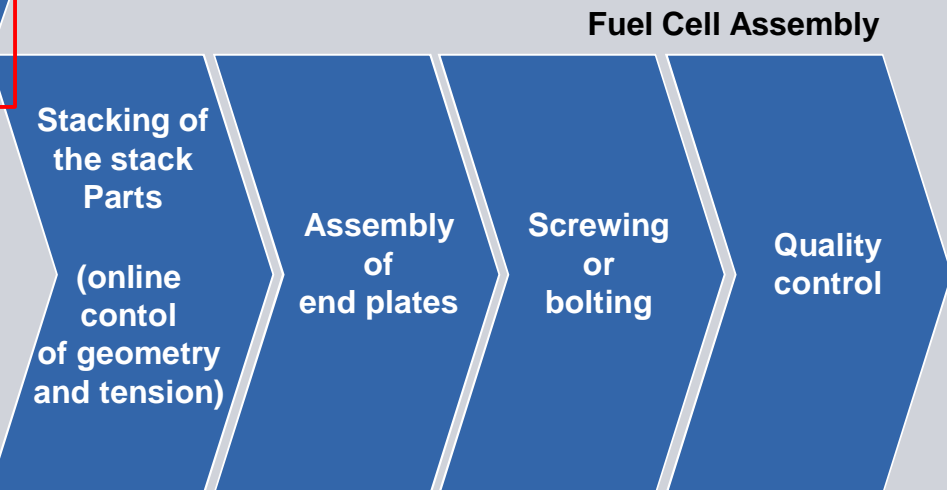
## MEA\* production

(\* Membrane Electrode Assembly)



### Requirements

- Preventing cross-over of the reactants
- High proton conductivity, no electrical conductivity for electrons
- High resistance against mechanical, thermal, and chemicals stress.








### Required properties

- Extremely stability
- Constant chemical behavior
- Low weight
- Consistent distribution of the contact pressure via the whole cell area. A low contact pressure results in a stack leakage.
- For prevention of a short-circuit of Anode and Cathode the whole cell or at least a end plate must be isolated electrically.

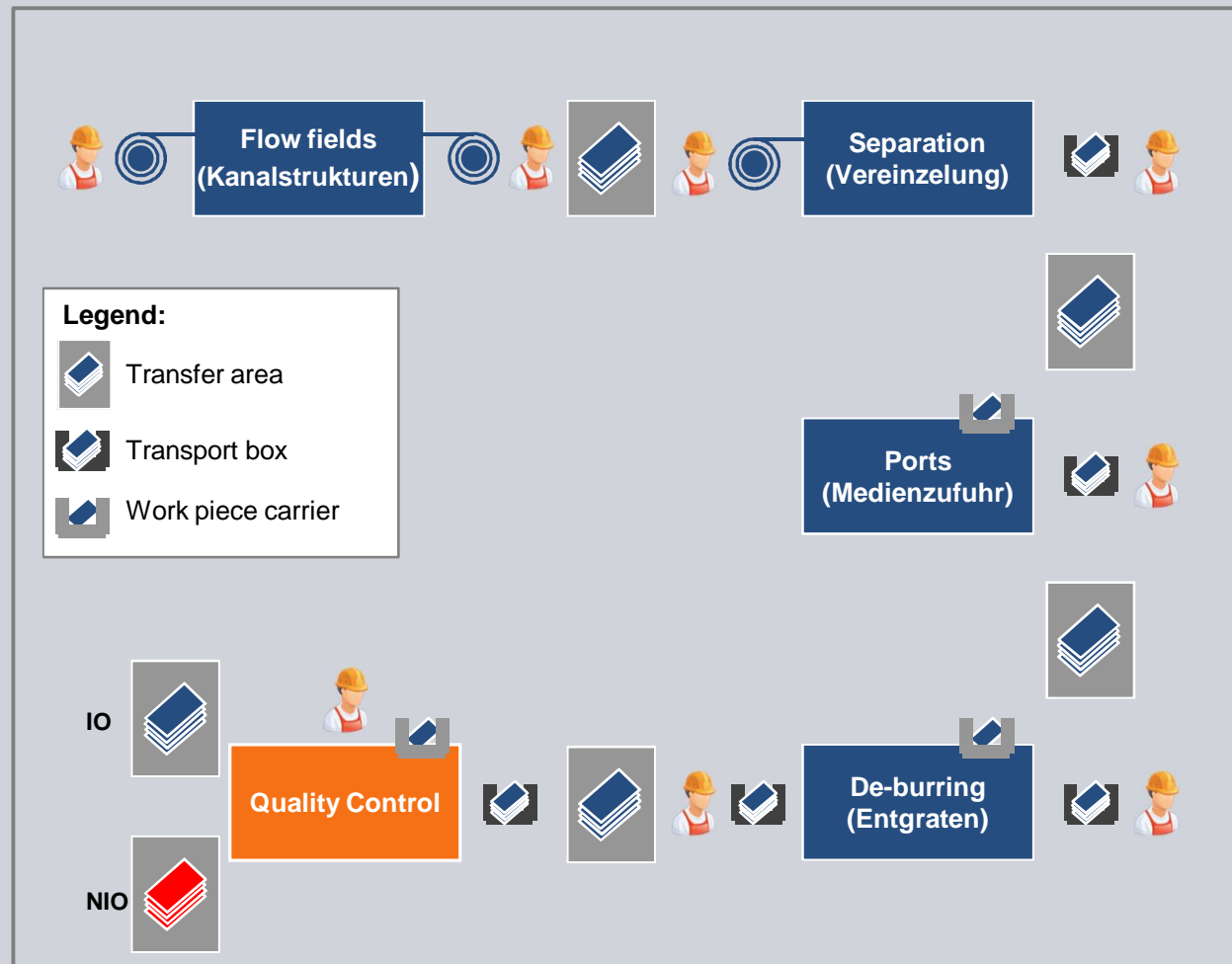
## Bipolar half plate (First expansion stage)

### First expansion stage

-  Loading of the flow field machine
-  Loading of the separation machine
-  Inserting of the ports
-  De-burr
-  Quality control

### Description




- Single machines (not integrated)
- Manual placement
- Work pieces within transport boxes or work piece carriers.





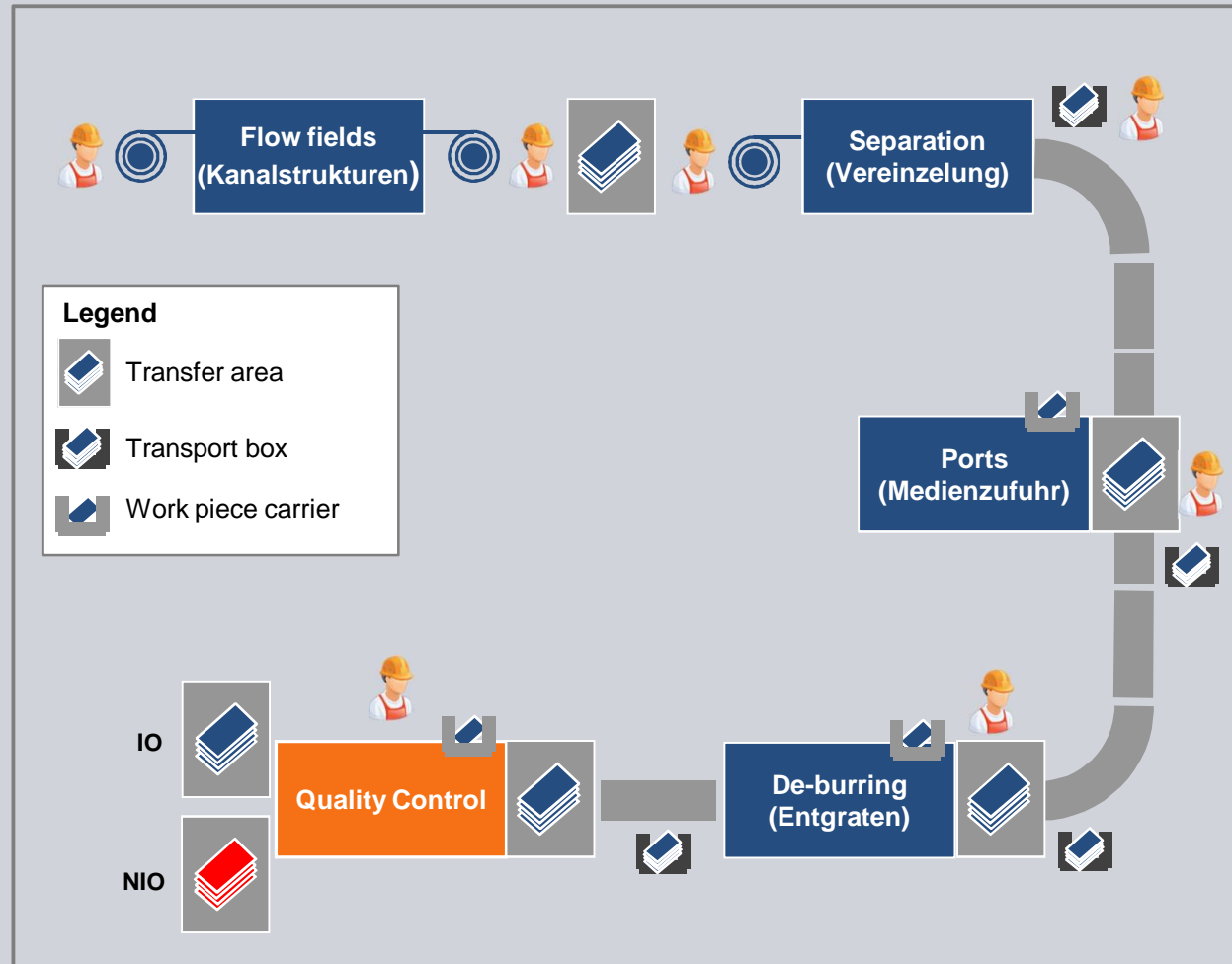
## Bipolar half plate (Semi-automatic manufacturing)

### Second expansion stage

-  Loading of the flow field machine
-  Loading of the separation machine
  - Inserting of the ports
  - De-burr
-  Quality control

### Description

- Machines are integrated into a transport system
- User access to the magazine
- Quality control manually



## Bipolar half plate

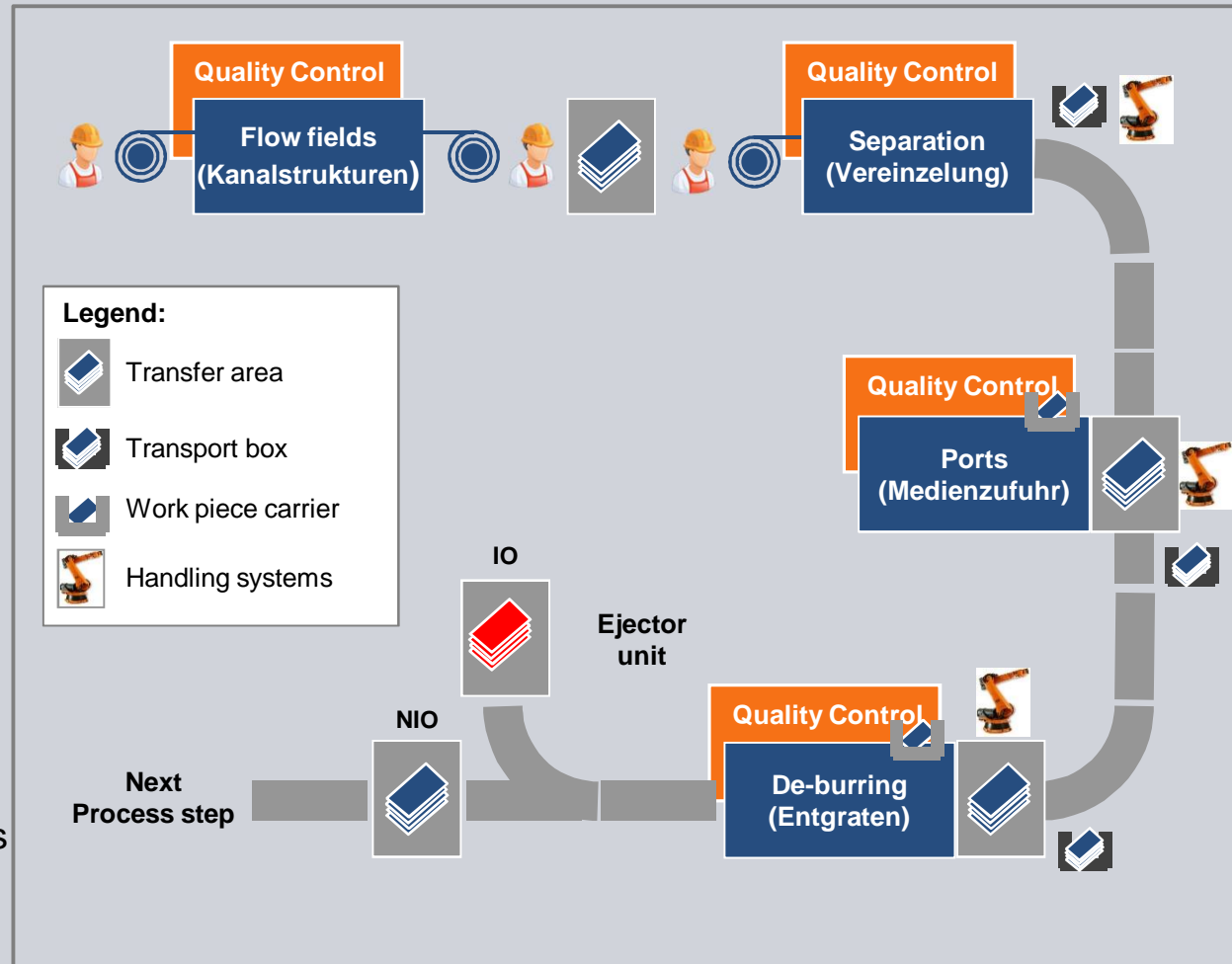
(Fully automated manufacturing)

### Third expansion stage

- Loading of the flow field machine
- Loading of the separation machine
- Inserting of the ports
- De-burr
- Quality control

### Description

- Single machines are integrated
- Loading of the machines will be done via handling systems
- Integrated inline measurement systems





Market and technology focus

Value added chain and process

**Automation technology and inline measuring**

Cell voltage supervision system

Summary

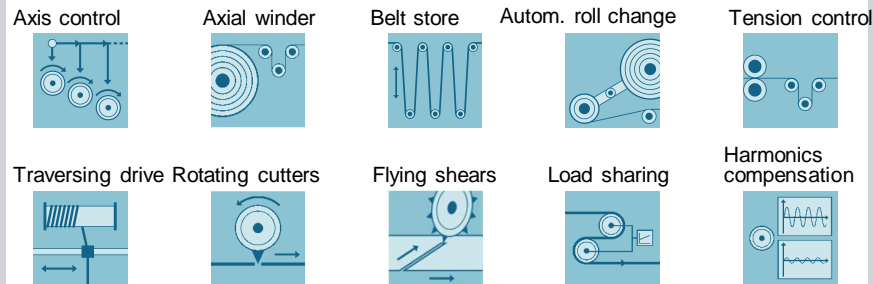
# Converting Toolbox

Achieve the perfect converting solution in record time



## Converting Toolbox

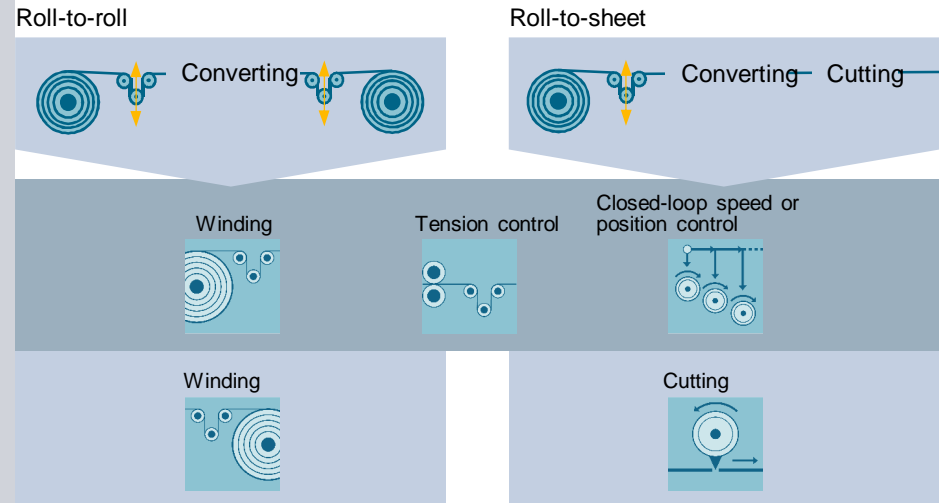
The Converting Toolbox is a library of off-the-shelf, tested, standard applications for most conversion requirements. It can be easily modified and freely combined to meet the particular requirements of the machines.



## Advantages of the Converting Toolbox

- Shorter commissioning and service
- Transparent and tested software
- Global application center support
- Open source for simple adaptations
- Solutions for SIMOTION, SINAMICS and SIMATIC
- The applications are free

## Applications in battery manufacture



## Components of the application

- Documentation
- The core functionality is provided in the form of a library (SIMOTION) or a function block diagram (SINAMICS DCC)
- Demonstration and test environment for familiarization
- Sample solutions for visualization

# Application of electrode coating (CCM)

## Coating catalyst material onto a release film

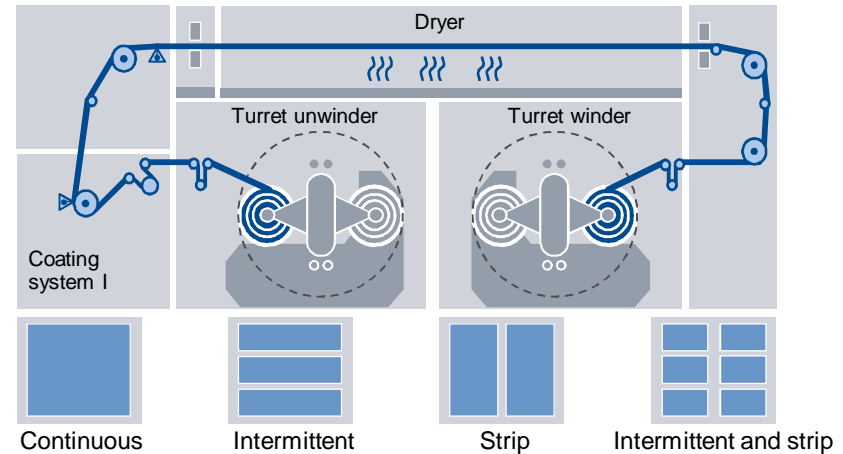


### Requirements

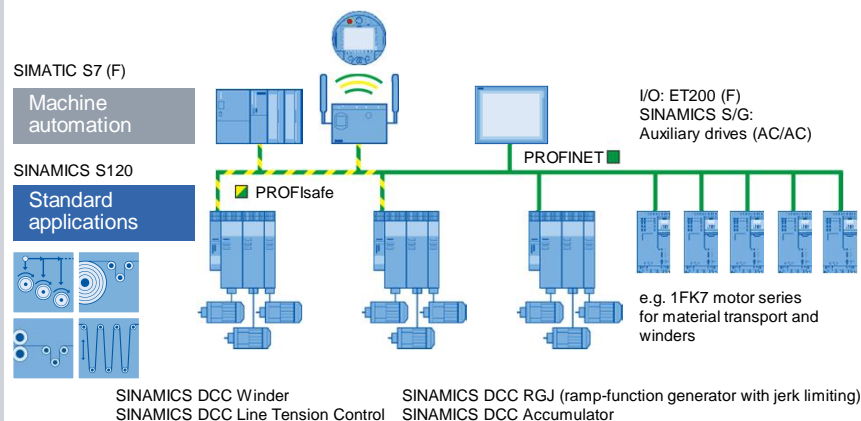
#### Flexible, double-sided, intermittent strip coating at up to 40 m/min:

- Homogenous coating thickness of 10-30  $\mu\text{m}$
- Tolerance of the coating of 1-2 $\mu\text{m}$
- Prevention of build-ups at the start and end of the coat
- Integrated quality inspection of coating thickness, area mass, and surface structure
- Fast adaptation of the process in the case of quality flaws
- Constantly high speed of the winder drives Automatic roll change for minimum downtimes
- Automatic roll change for minimum downtimes
- Integration into plant network

### Machine



### Automation solution



### Customer benefits

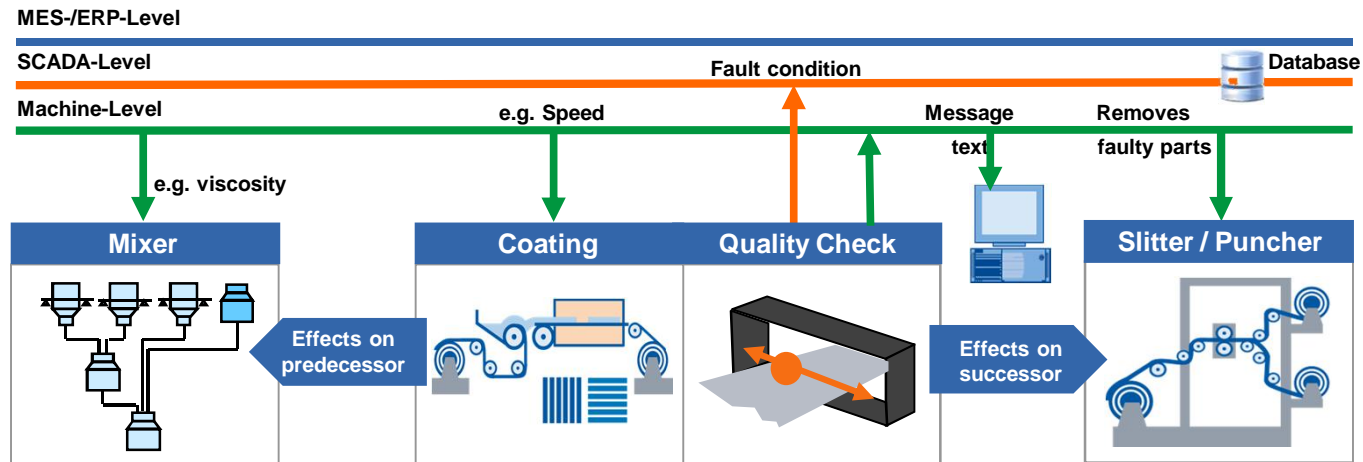
- Flexible and fast control of the coating system with SIMATIC S7 for high-precision coating
- Easily parameterized standard applications for setpoint-cascade, winder with tension control, etc.
- Less downtimes thanks to automatic roll change during operation with winders or accumulator
- Controllers, drives and motors scalable for all requirements and power ratings
- Simple and safe integration of quality measuring systems into the automation solution on Profinet based on Standard Ethernet



# Application of electrode coating (CCM) Integration of inline measurement systems

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## Process integration



### Typical tasks of a control system

- Administration of orders, recipes, and batches
- Production and material flow control
- Integration of inline-, offline-, and laboratory measurement systems
- Trend analysis and (long-term) archiving of data
- Gapless traceability based on assembly structures in combination with quality data

## Quality control

### Measurement

- Wet layer thickness via laser
- Mass per unit area distribution continuously via Beta radiation

### Notification

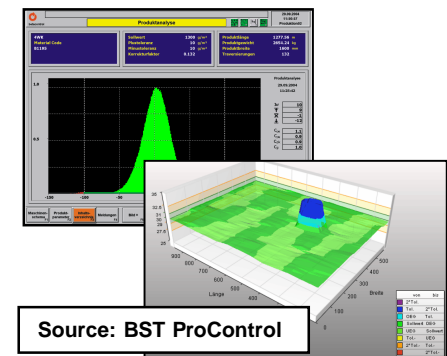
- Max-, Min-, Average, Variance, Good/Worse

### Application

- Detection and identification of faulty material parts
- Automatic process optimization by changing process values
- Reporting of the product quality

## Measurement solution

- PC-based application – measurement and analysis within „one“ automation device
- Simple integration into already existing structures because of same system environment SIMATIC S7
- Reuse of existing know-how



Source: BST ProControl

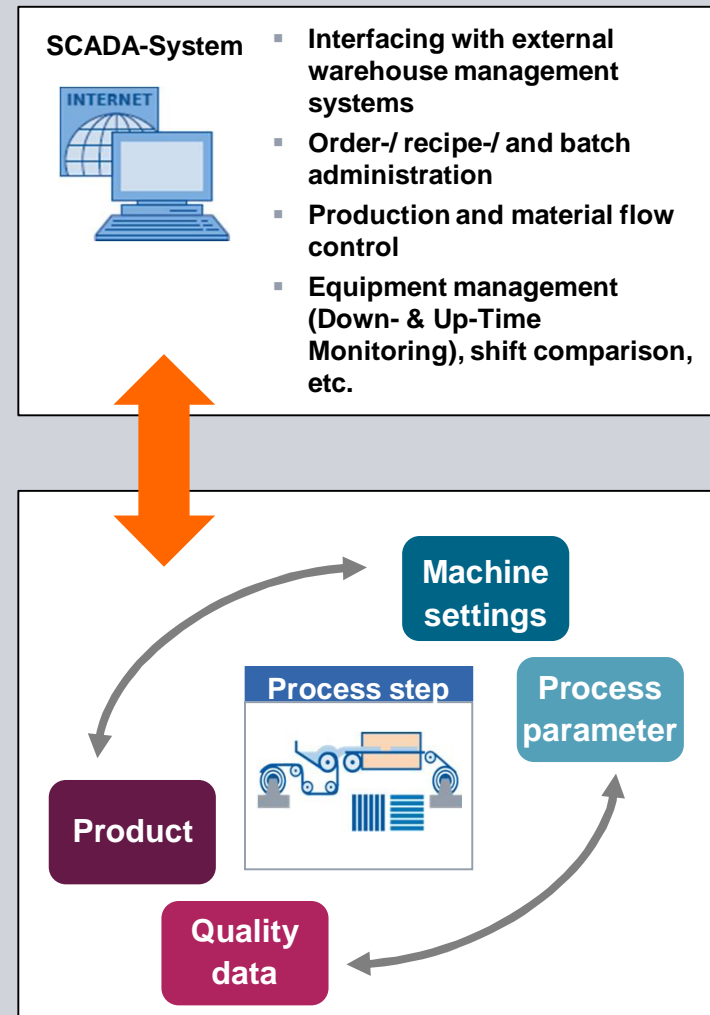
## Integration of inline-measurements software

### General

- Monitoring and controlling of specific process parameter of the machines continuously.
- Supervision of the product quality via inline measurement systems and control of the process parameter via loop control.

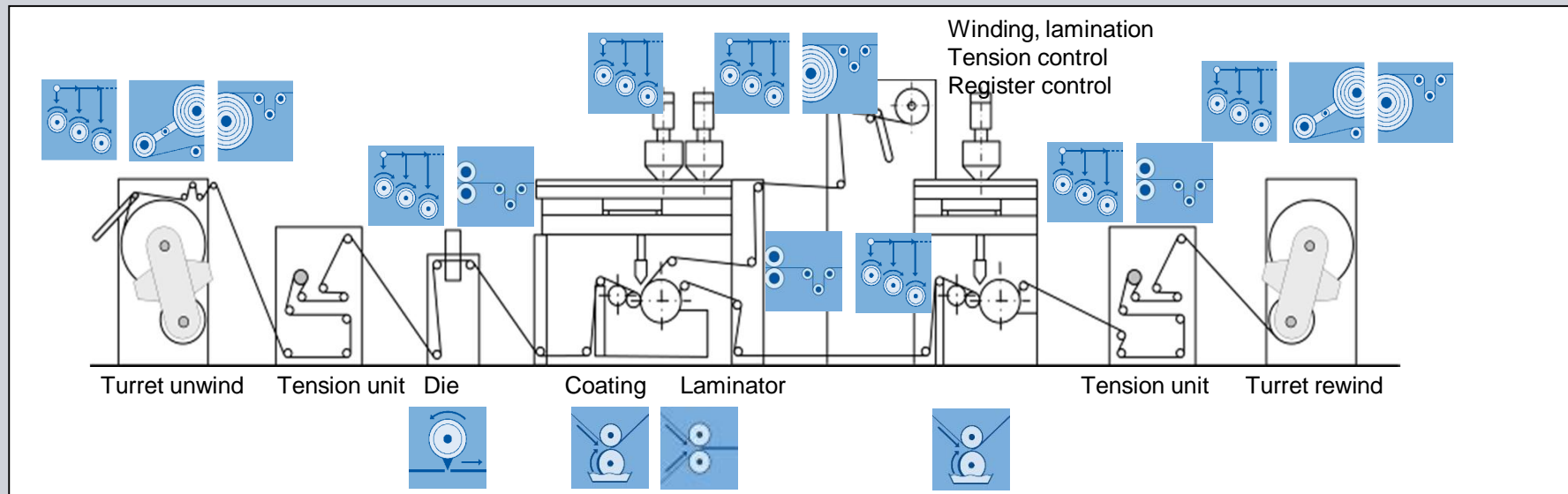
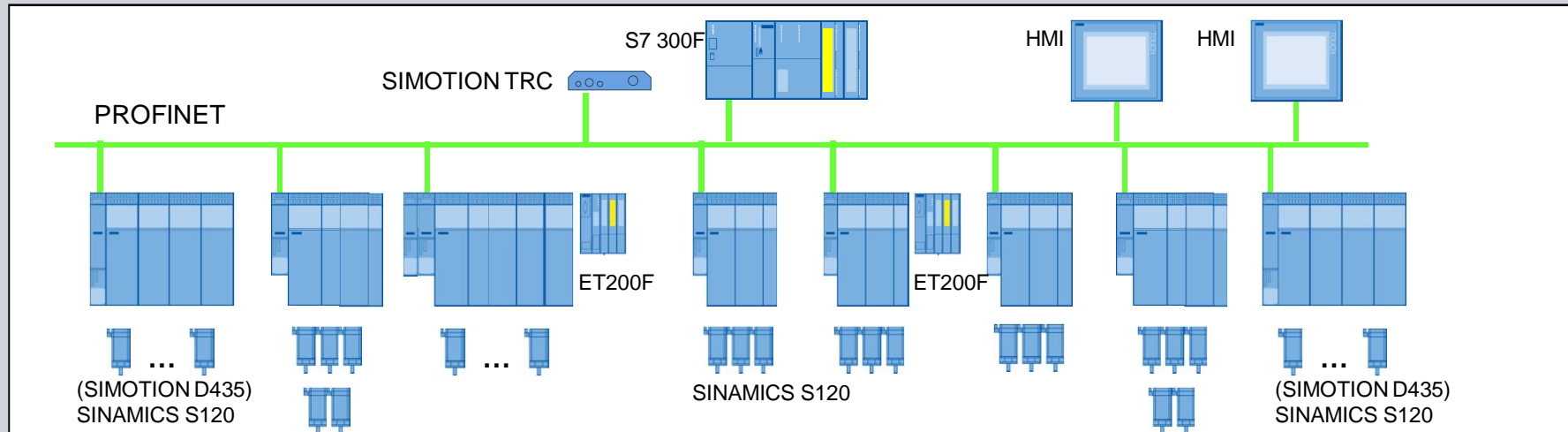
### Objectives

- Gapless traceability focused on assembly structures and dedicated quality data
- Integration of measurement data into a common (long-term-) archive and visualization of selected data as trend within SCADA system

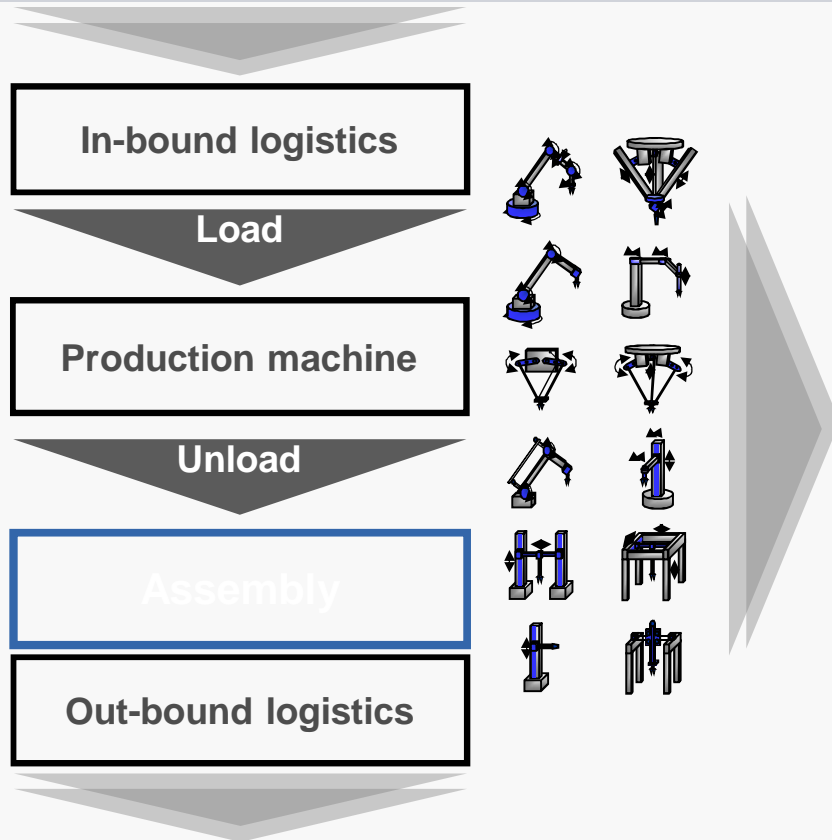


# Coating & Laminating

## Example Solution for coating CCM



# Handling automation is an essential key for high productivity



### Example: Assembly of a fuel cell stack

The diagram shows a cross-section of a fuel cell stack. From left to right, the components are: a red 'End plate', an 'Anode', a yellow 'Bipolar plate', a grey 'CCM' (Current Collector Matrix), another yellow 'Bipolar plate', another grey 'CCM', and a blue 'End plate'. On the far right, a 'Cathode' is indicated. Gas inlets are shown on the left: 'Fuel H<sub>2</sub>' and 'Oxygen'. Gas outlets are shown on the right: 'H<sub>2</sub>O' and 'Heat'.

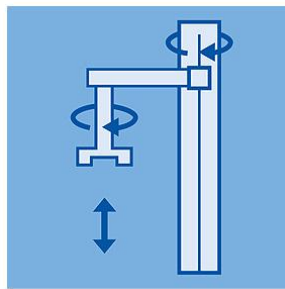
#### Placing of the stack parts

1. End plate
2. Current collector plate
3. Bipolar plate (with integrated seal)
4. CCM
5. Bipolar plate (with integrated seal)
6. Current collector plate
7. End plate

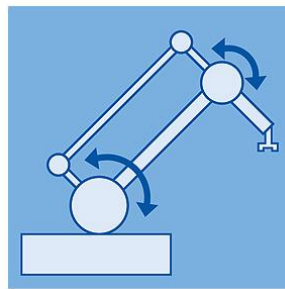
- Handling performance is an essential factor for short cycle times
- High technical variance – from simple positioning up to complex kinematics

**Most of the market standards are available as integrated standard kinematics**

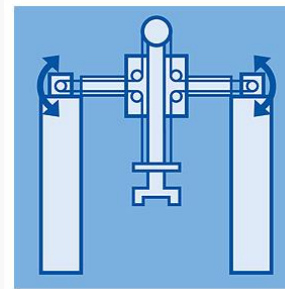
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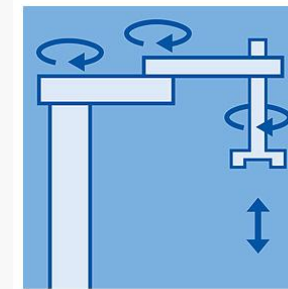
Swivel arm



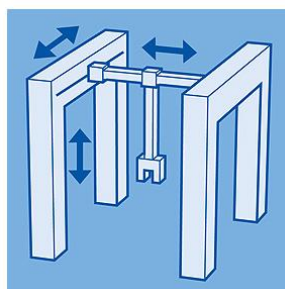
Jointed arm



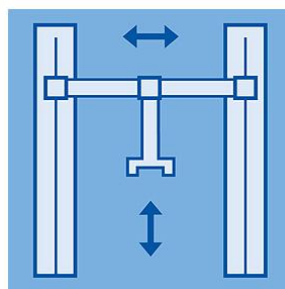
Roll picker



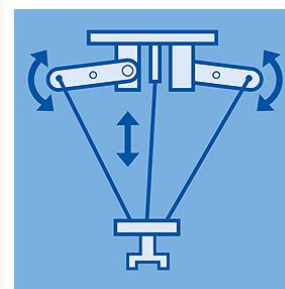
SCARA



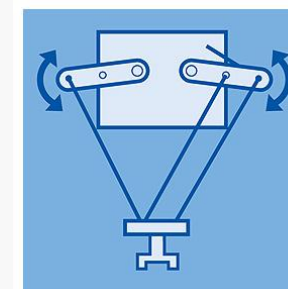
Cartesian 3D



Cartesian 2D



Delta 3



Delta 2

- Standard kinematics are already integrated and “ready to use”
- Predefined modules allow fast and efficient engineering





Market and technology focus

Value added chain and process

Automation technology and inline measuring

**Cell voltage supervision system**

Summary

# Cell voltage supervision system

Monitoring of a fuel cell within operation



## Analogue measurement module for fuel cells and electrolytic

- Proof voltage 650 VDC
- Over voltage category III and
- Pollution degree 2
- CE, with cUL for electrolytic applications

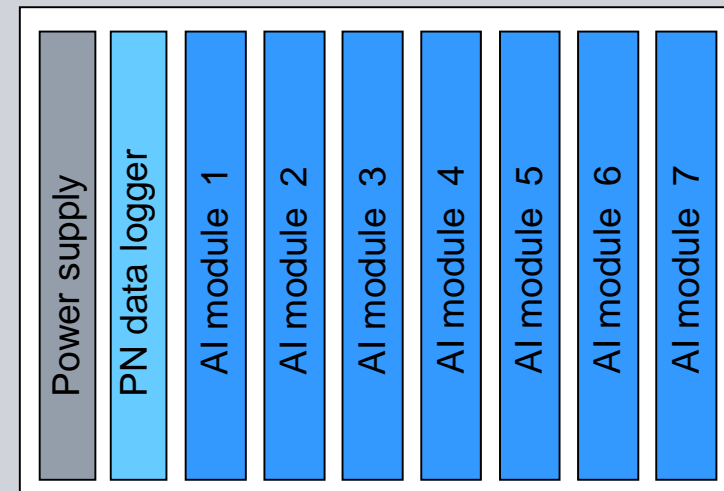


## Measuring channels

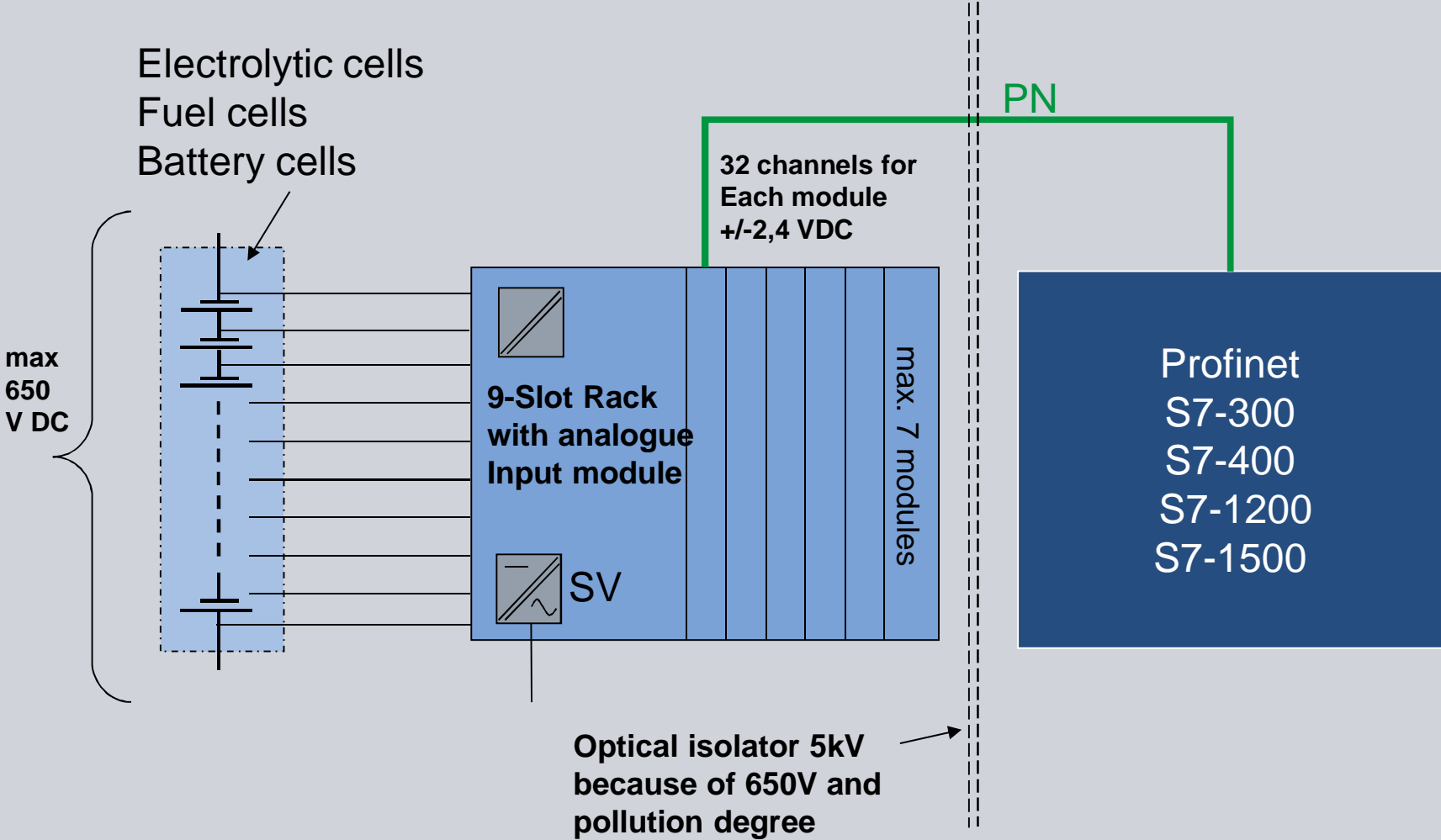
- 32 measuring channels for each module
- 2,4 mV resolution
- 25 msec for each module (with 32 channels)

## Applications

- Electrolytic (4500 channels)
- Fuel cells (224 channels)



Block diagram





Market and technology focus

Value added chain and process

Automation technology and inline measuring

Cell voltage supervision system

**Summary**

# Fuel cell fabrication is within wide areas manufactory

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## Automation

### Hurdles for automation

- Still insufficient quantities
- Manufactory is still competitive up to specified quantities
- For small- and medium-sized quantities to high investment costs

### Automation results in ...

- Scalable quantities
- Integrated quality management
- Faster market growth
- Improved quality management

## Our focus

- Scalable automation, which is able to growth with the requirements to the production.
- Integration of inline-/ offline-/ and laboratory measurements
- Capturing, processing, and archiving of quality data
- Information & reporting system (orders, state, trends, ...)
- Visualization of the process quality & performance data (OEE, KPI, ...)
- Order and recipe management
- Tracking & Tracing and genealogy

**Siemens as automation supplier is able to offer an essential contribution within the transition to an efficient production focused on high volume**



# From manufacture to an industrial high quantities production

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## Short- and medium-term requirements to fuel cell fabrication

- 1 Cost reduction through economies of scale, e.g. by using line integration
- 2 Increase of the production quality and efficiency through automated capturing of quality data (KPI)
- 3 Substitution of manual work places and continuous transition to fully automated fabrication by using PLM tools.
- 4 Analysis of the results of the learning curve immediately e.g. through systematic capturing of the production data

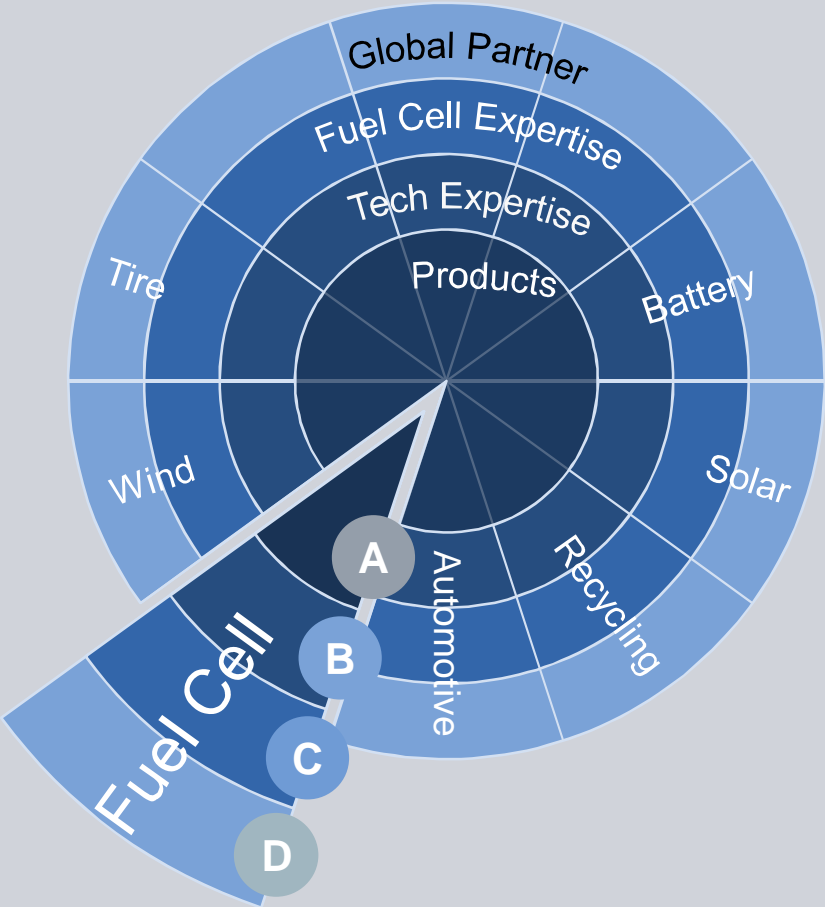
**Siemens as automation supplier can provide a significant contribution for the setting up of a efficient high quantities production**

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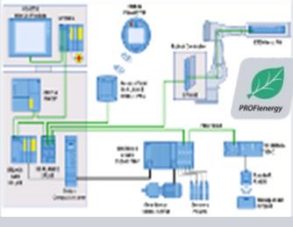
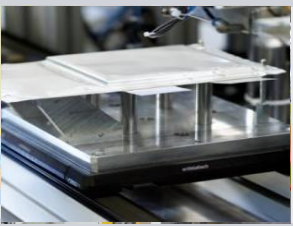


Industry Sector

**Benefit from having a strong partner**

Products, solutions, service and industry know-how from a single source



**The Siemens portfolio for machine manufacturers in the fuel cell industry:**

<p><b>A</b></p>	<p><b>Products</b></p> 	<p>Extensive <b>automation and drive portfolio</b> for open and integrated automation concepts in the battery industry (TIA)</p>
<p><b>B</b></p>	<p><b>Technology expertise</b></p> 	<p>Decades of <b>experience</b> with the <b>core technologies</b> for fuel cell manufacture in other industries such as <b>converting</b> in the paper industry</p>
<p><b>C</b></p>	<p><b>Fuel cell expertise</b></p> 	<p>Know-how in the fuel cell industry: From the <b>process</b> through <b>automation</b> right up to <b>cell chemistry</b> with references at all stages of the value added chain</p>
<p><b>D</b></p>	<p><b>Global network</b></p> 	<p>We bring supply and demand together and provide support in training, consulting, and networking. We like to promote our partners!</p>

**Many thanks for your attention!**



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