Thermal- and Electrical Energy Savings for the Paper Machine´s Drying Section with Smart Process Control Systems

45th International Annual Symposium DITP
14th/15th November 2018, Bled, Slovenia

Dr. H. Schwarz

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Agenda

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Siemens since October 2017/18
Flat and market driven organization along the value chain

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Go-to-market

Americas | Middle East, CIS[1] | Europe, Africa | Asia, Australia

Divisions (Global P&L)

Power and Gas (PG)

Power Generation Services (PS)

Energy Management (EM)

Building Technologies (BT)

Mobility (MO)

Digital Factory (DF)

Process Industries and Drives (PD)

← Separately managed →

Siemens Healthineers

Siemens Gamesa Renewable Energy

Financial Services (SFS)

Managing Board

Siemens offers the most comprehensive portfolio for Process Industry and Drive

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Process Industry and Drive

PD SLN FI (P&P)

Process Automation

- Distributed control system (hardware and software) and plant engineering software
- Process instrumentation for flow, level, pressure, temperature, weighing and positioners
- Process analytics and analytical solutions
- Wired and wireless industrial communication, rugged communication
- Industrial identification
- Industrial power supplies

Large Drives

- Low voltage motors and low voltage converters
- High voltage motors and medium voltage converters
- Motors, converters, control units and gears for traction, including rail, hybrid drives and mobile mining
- Wind generators
- Products, solutions and systems for cranes
- Hydrogen solutions

Mechanical Drives (Separate)

- Helical gear units
- Bevel-helical gear unit
- Planetary gear units
- Application specific gear units for industries
- Couplings
- Gear units and couplings services, spare parts

Process Solutions

- Closed ring power system (drilling)
- BlueDrivePlusC™ diesel electric propulsion system (drilling and marine)
- Pipeline solutions
- Tankfarm & refinery solutions
- Fiber-, mining- and cement industry Systems and solutions
- Off shore & on shore production solutions

Integrated drive systems

Life cycle services

Portfolio for cement, chemicals, cranes, fiber industry, food & beverage, glass & solar, marine, mining, oil & gas, pharmaceuticals, water

Fiber Industry – a Process Industry demanding integrated solutions and a complete product portfolio

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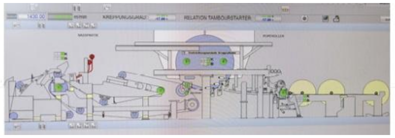
Power Generation

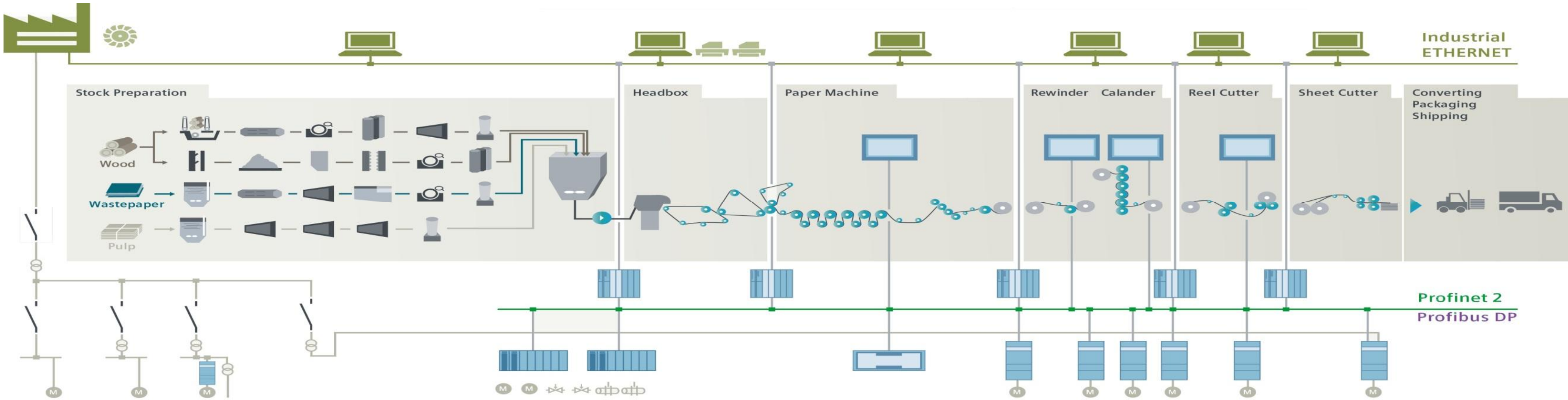
Process Control System

Integrated Engineering



Integrated Service

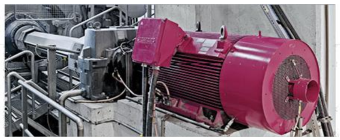
Data Analytics



Power Distribution, Motor Control Centers, Drives

Instruments

Quality Control



Sectional Drives

Gear Units

Process Motors

Driving the Digital Enterprise in the Fiber Industry – with SIPAPER!

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The **SIPAPER** Portfolio

World-class products + perfectly matching, industry-specific modules

Drive Technology
SINAMICS, SIMOTICS, FLENDER, .

Industrial Automation
SIMATIC, SIPLUS, …

Energy Management
SIMOCODE, SIVACON, SIPROTEC, ...

Industry Services
Life Cycle Services, Plant Data Services, …

SIPAPER Drive Systems

SIPAPER Drives APL

SIPAPER Winder APL

FLENDER Gear Units for SIPAPER


SIPAPER Process Automation

SIPAPER DCS APL

SIPAPER QCS APL

SIPAPER DPO

SIPAPER PPA


SIPAPER Power Distribution

SIPAPER Power

SIPAPER Operations

SIPAPER Services

Integrated **SIPAPER** Solutions

Digitalization is the next level to yield productivity in the process industry

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Technology is ready

- Data Analytics
- Computing Power
- Connectivity
- Sensors

Digitalization

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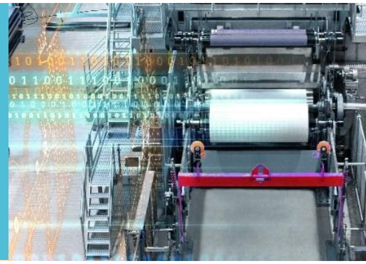
Next level of productivity

Automation

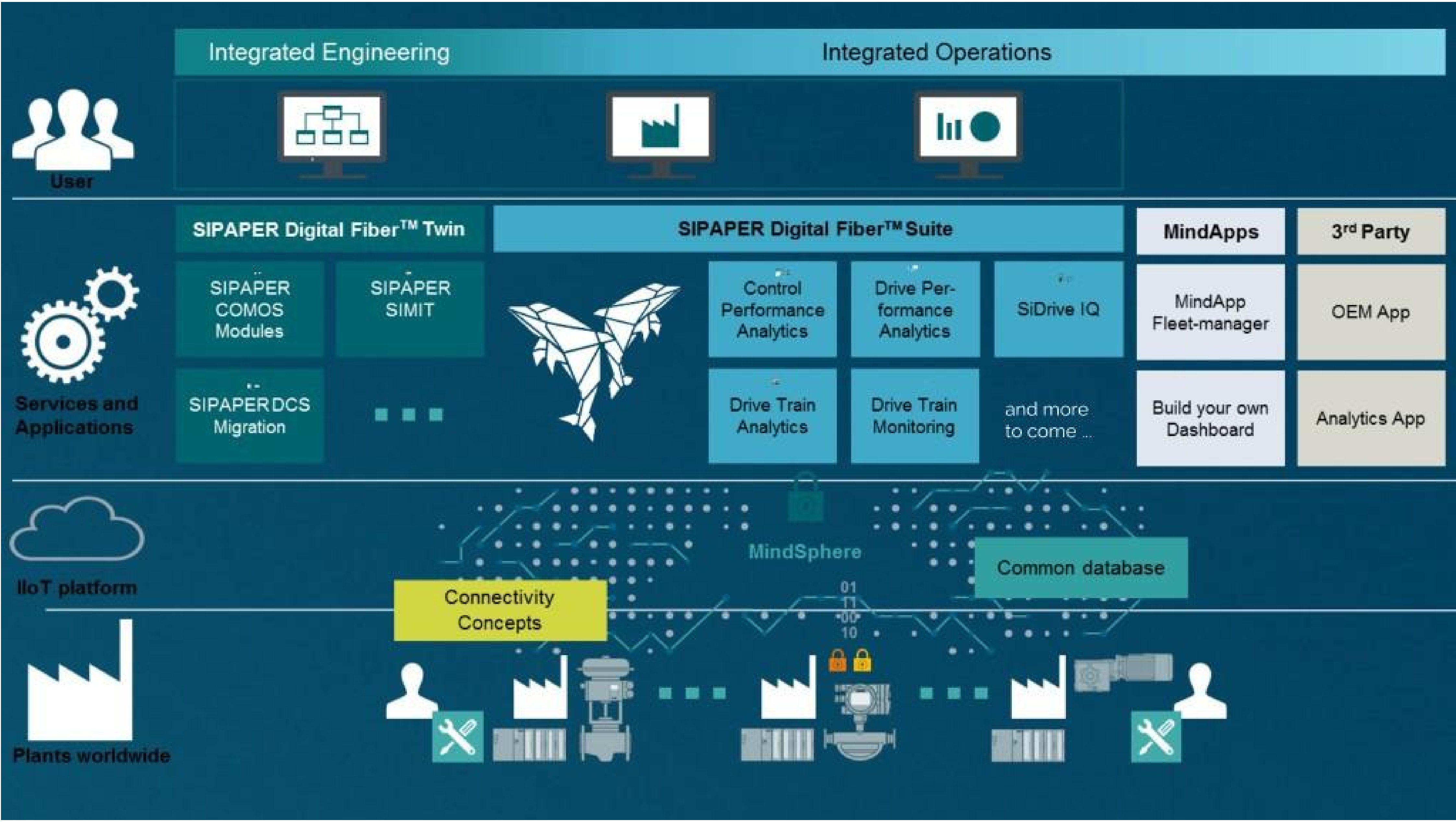


Siemens as experienced partner for Automation and Electrification

Electrification

Pioneer for Electrification in industry

Time



Integrated Engineering
Integrated Operations
User
SIPAPER Digital Fiber™ Twin
SIPAPER Digital Fiber™ Suite
MindApps
3rd Party
SIPAPER COMOS Modules
SIPAPER SIMIT
Control Performance Analytics
Drive Performance Analytics
SiDrive IQ
MindApp Fleet-manager
OEM App
Services and Applications
SIPAPER DCS Migration
Drive Train Analytics
Drive Train Monitoring
and more to come ...
Build your own Dashboard
Analytics App
IIoT platform
MindSphere
Common database
Connectivity Concepts
01
11
00
10
Plants worldwide

Agenda

1	Smart Controls
2	*Dynamic Process Optimization (Advance Process Control APC)*
2a	SIPAPER Bleach and Flotation (DIP)
2b	SIPAPER Dry Sec
5	Outlook

Siemens SIPAPER Optimization

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Maintain Mill Operability

- Industrial Network Analytics
- Drive Train Analytics
- Machine Tool Analytics

Process Efficiency

- Control Performance Analytics
- Process Event Analytics
- Dynamic Process Optimization

Industry Security

- Assess Security
- Implement Security
- Manage Security

Energy efficiency

- Energy Analytics

Mind your digital future

- MindSphere – Siemens Cloud for Industry

Cost Efficiency through a Managed Service Approach

Process Data Analytics

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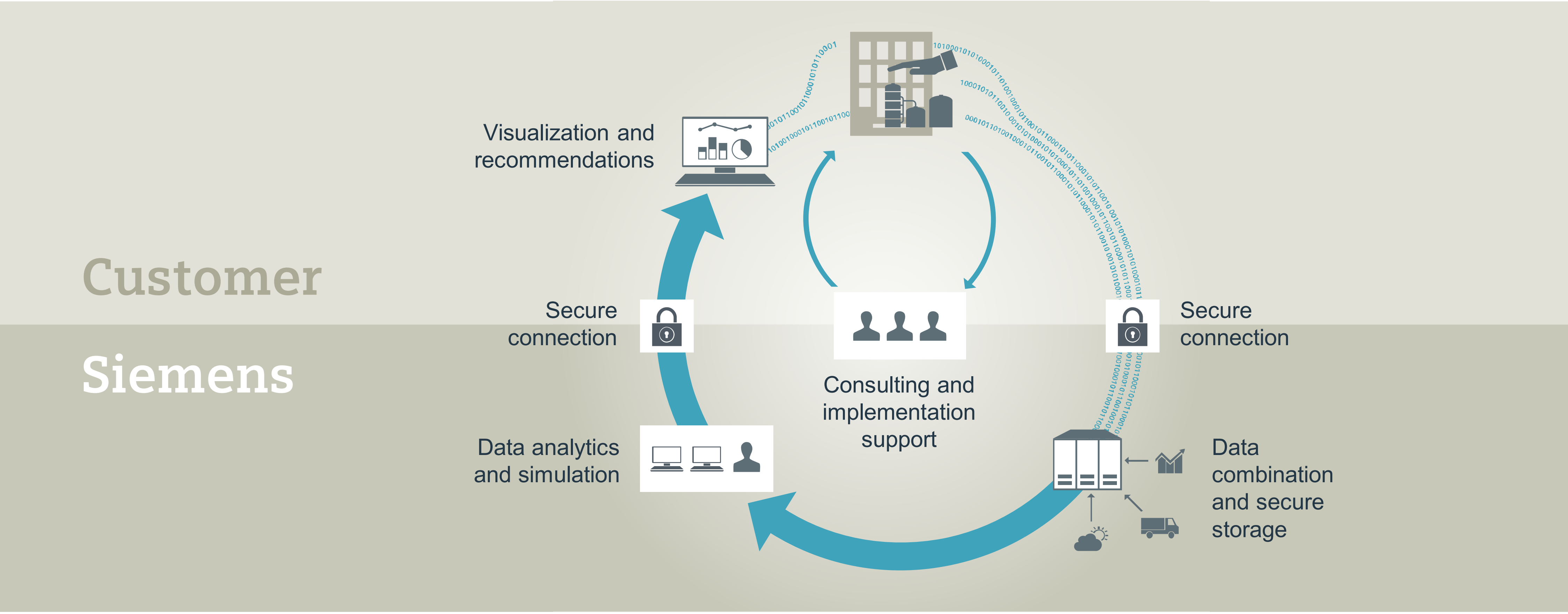

Optimized process based on transparent control performance

Process Data Analytics

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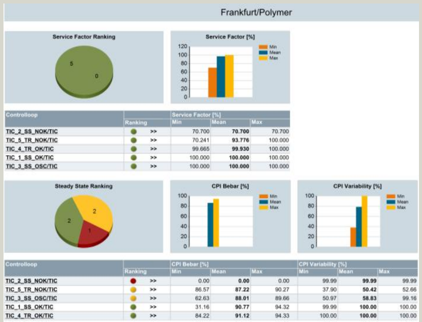
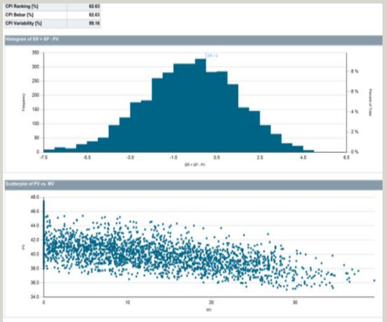
Performance Reporting



- Long-term plant overview on control performance of all control loops
- Visualization of important indicators for prioritized optimization actions
- Stiction* recognition KPI
- Analytics of historic data from 3rd party DCS

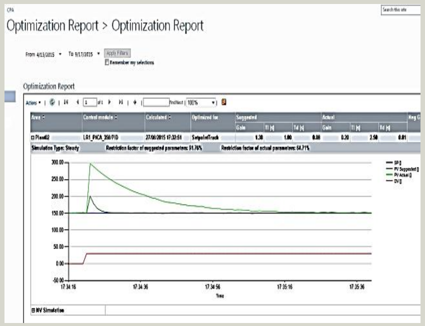
* static friction

Characteristics Reporting



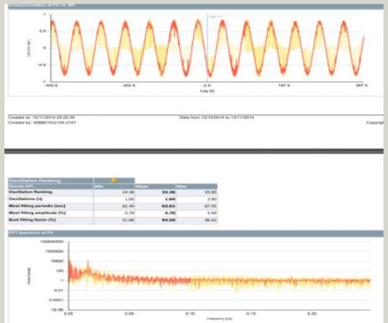
- Detailed information on control performance of each single loop
- Detailed KPIs for varying time frames
- Visualizes process data and characteristic diagrams like scatterplot, FFT spectrum, cross correlation for stiction recognition etc.

Optimization Reporting



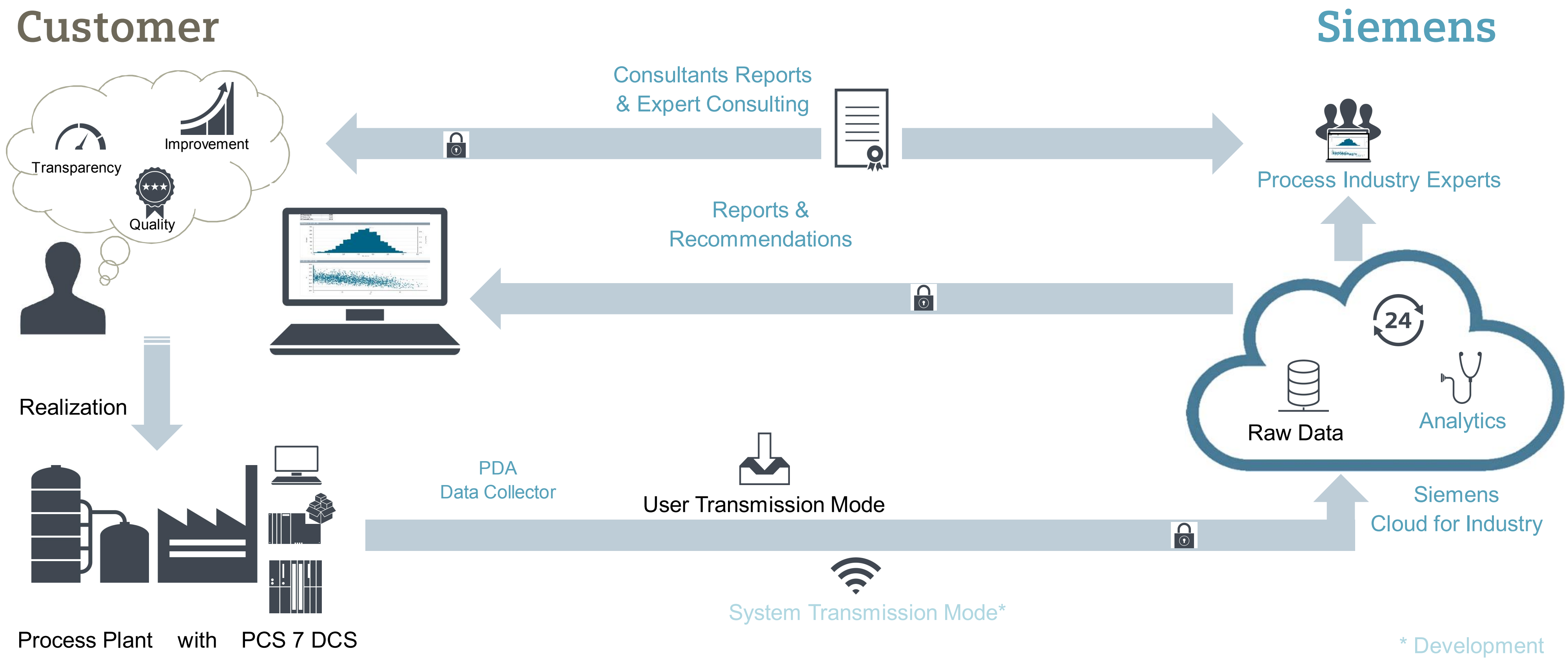
- Optimized control parameter for increased control loop performance

Consultants Report



Provides expert statements about the performance of individually analyzed control loops on request

Continuous Process Improvement with Siemens
Process Data Analytics



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Use Case: Asset and Process Performance

Control Performance Analytics

Customer benefits
Increased product quality, minimized equipment utilization, increased throughput, reduced operator work load

- Only **50%** of control loops are well tuned
- Siemens **Control Performance Analytics** is a cloud-based **service** that collects control loop data in an anonymized form via secure data connection and provides detailed reports and **suggestions for implementation**
- **Successful installations** in pulp and paper mill in **China**

Automation Hierarchy
ISA 95 Level Definitions

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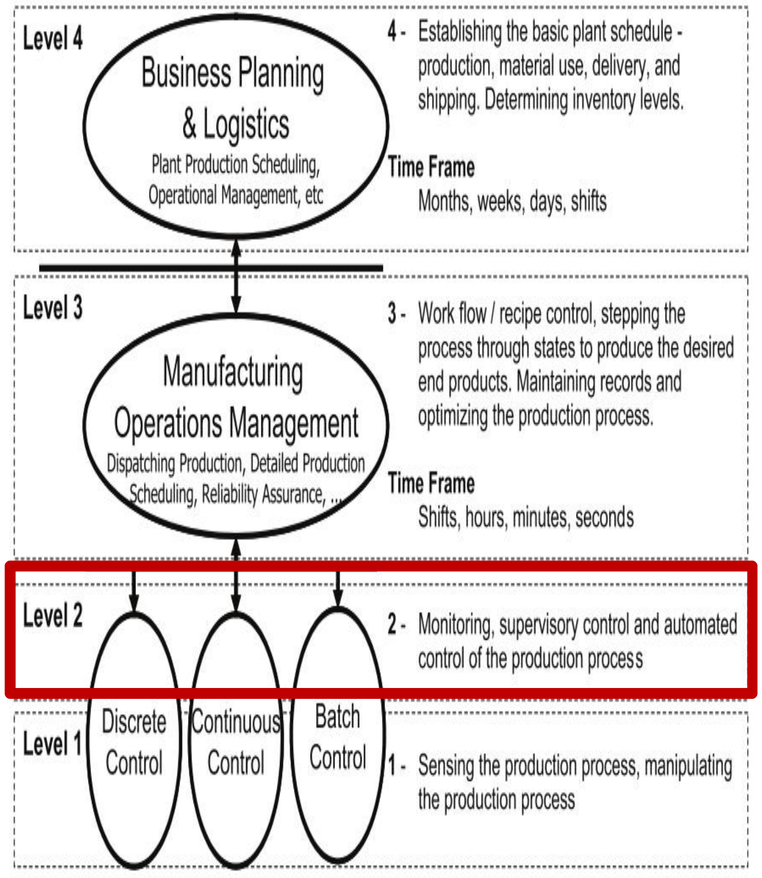
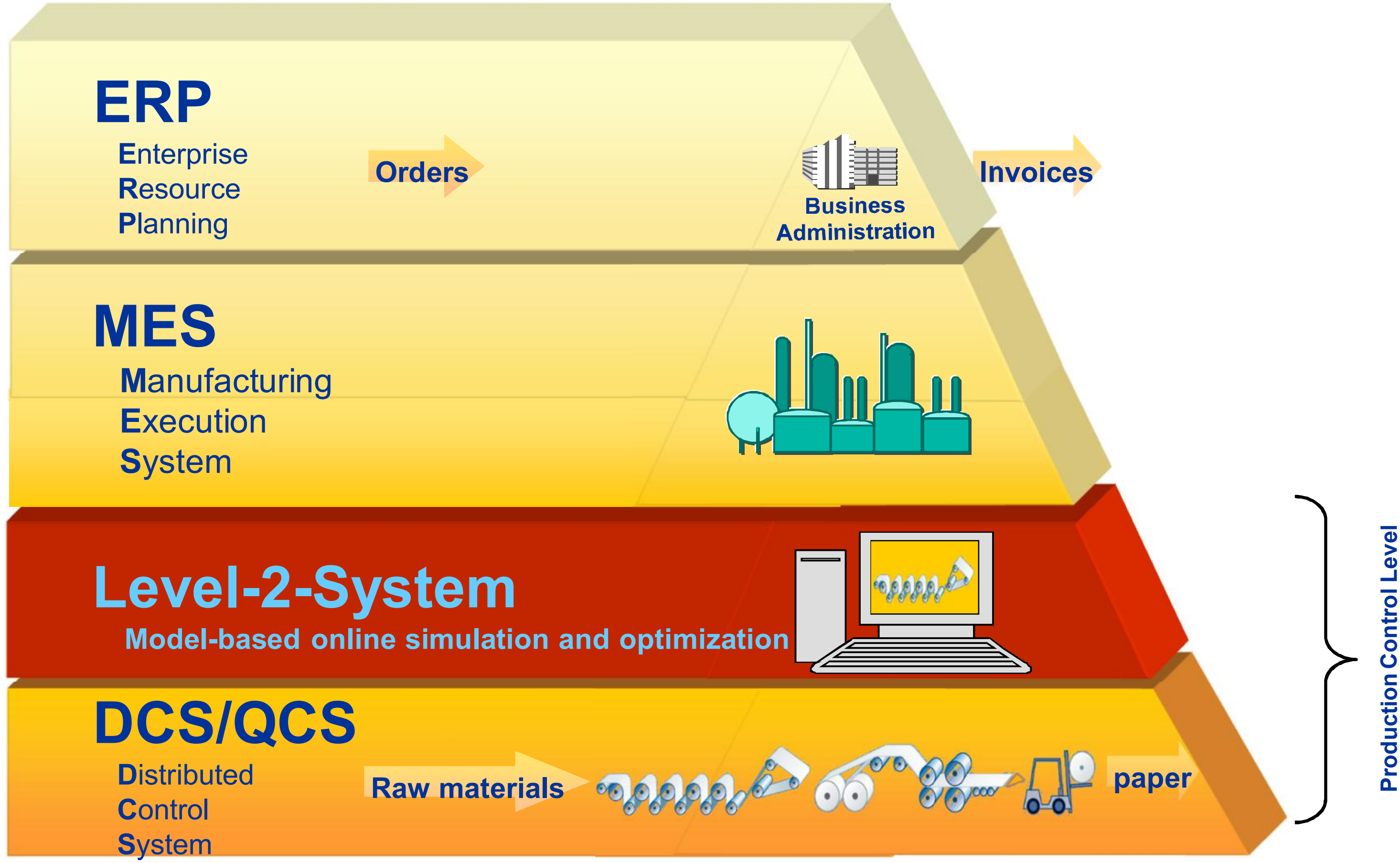
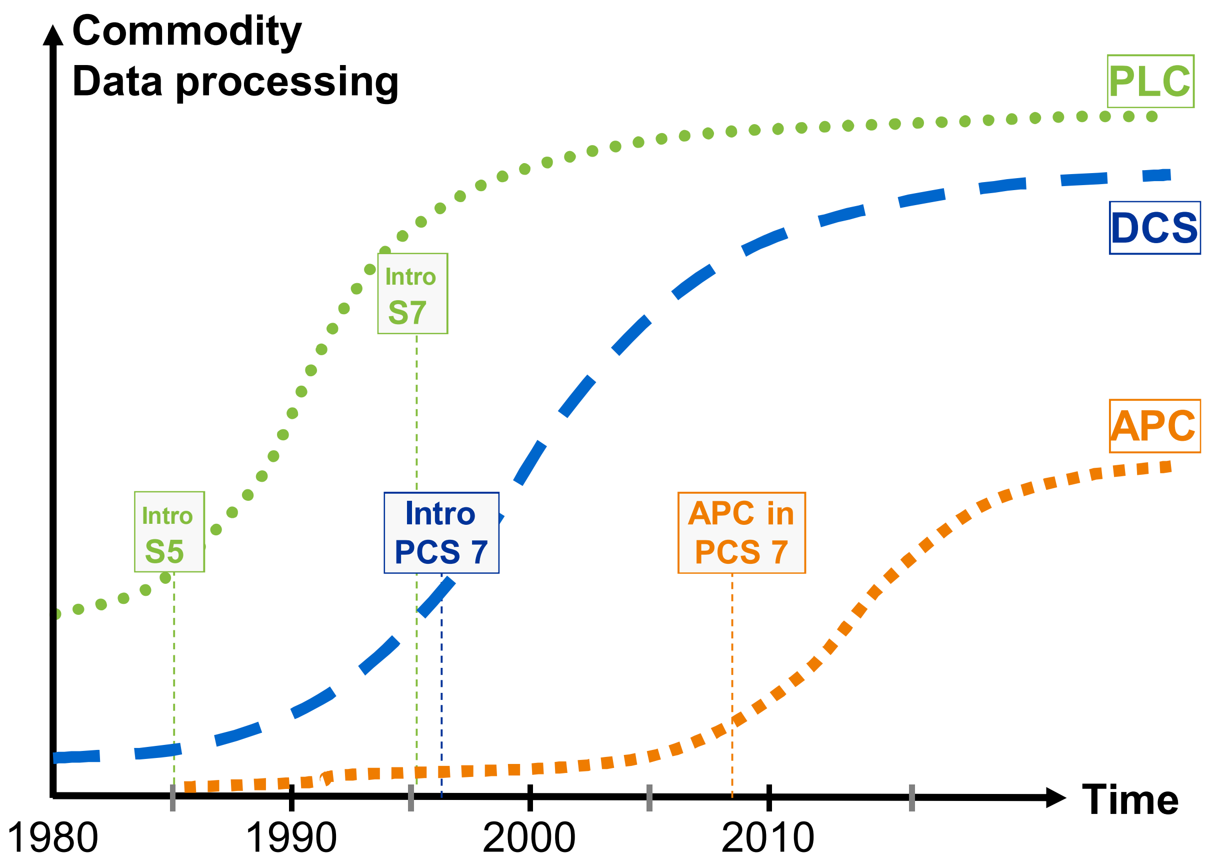


Figure from ISA 95.00.03 Draft 20



APC is more and more becoming commodity



The right tool for the right job:
Improved Process Control through embedded APC

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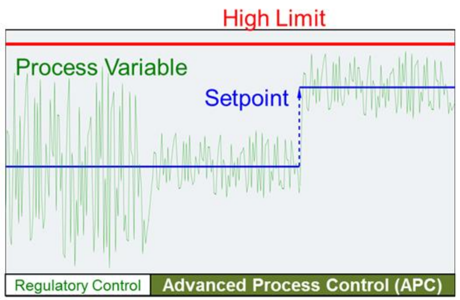
Industrie 4.0 use case – Optimizing operation: *Embedded APC with SIMATIC PCS 7*

Initial situation



Value Proposition

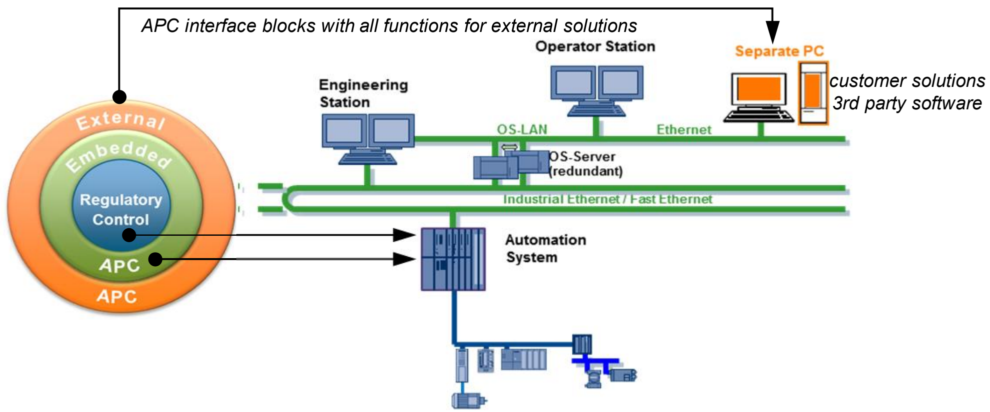
- Realize economic plant potential
- Reduced variability
- Reduced energy and raw material
- Increased quality and throughput
- Increasing trend

Challenges

Variations

Challenges	Separate PC *(External)*	DCS integrated *(Embedded)*
Low barrier for **small applications**		✓
Sophisticated functionality for **large applications**	✓	
Standardized across the company with central support	✓	
High **availability** and same look and feel in operation		✓
Reduced **cost of technology** (design, implementation)		✓
Low **lifecycle cost** (e.g. Migration, transfer to other units)		✓
Low **training expense**		✓

Full flexibility



Value-add

- Powerful controllers allow more embedded functionality and capabilities
- Set of functionalities available depending on application:
  - PID Tuner
  - Gain scheduling, override control, disturbance compensation, Smith Predictor
  - Model Predictive Control (MPC (4x4) or MPC10x10)
  - APC interface blocks with watch dog, central switch-over, etc.
- Control- and equipment modules (CM, EM), unit templates with APC

What is DPO in principle?

Data driven set-point optimization for Process industries and Batch processes

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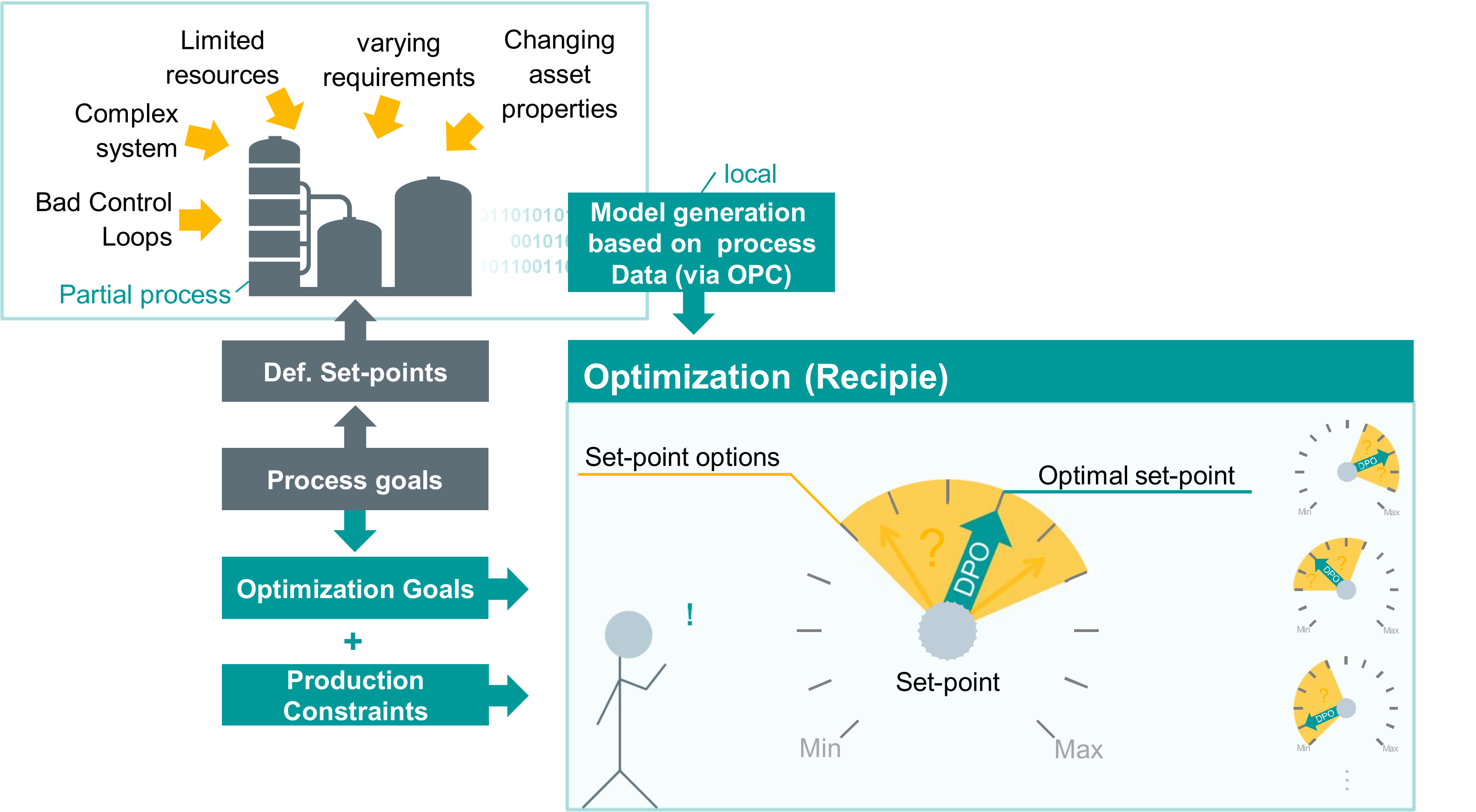
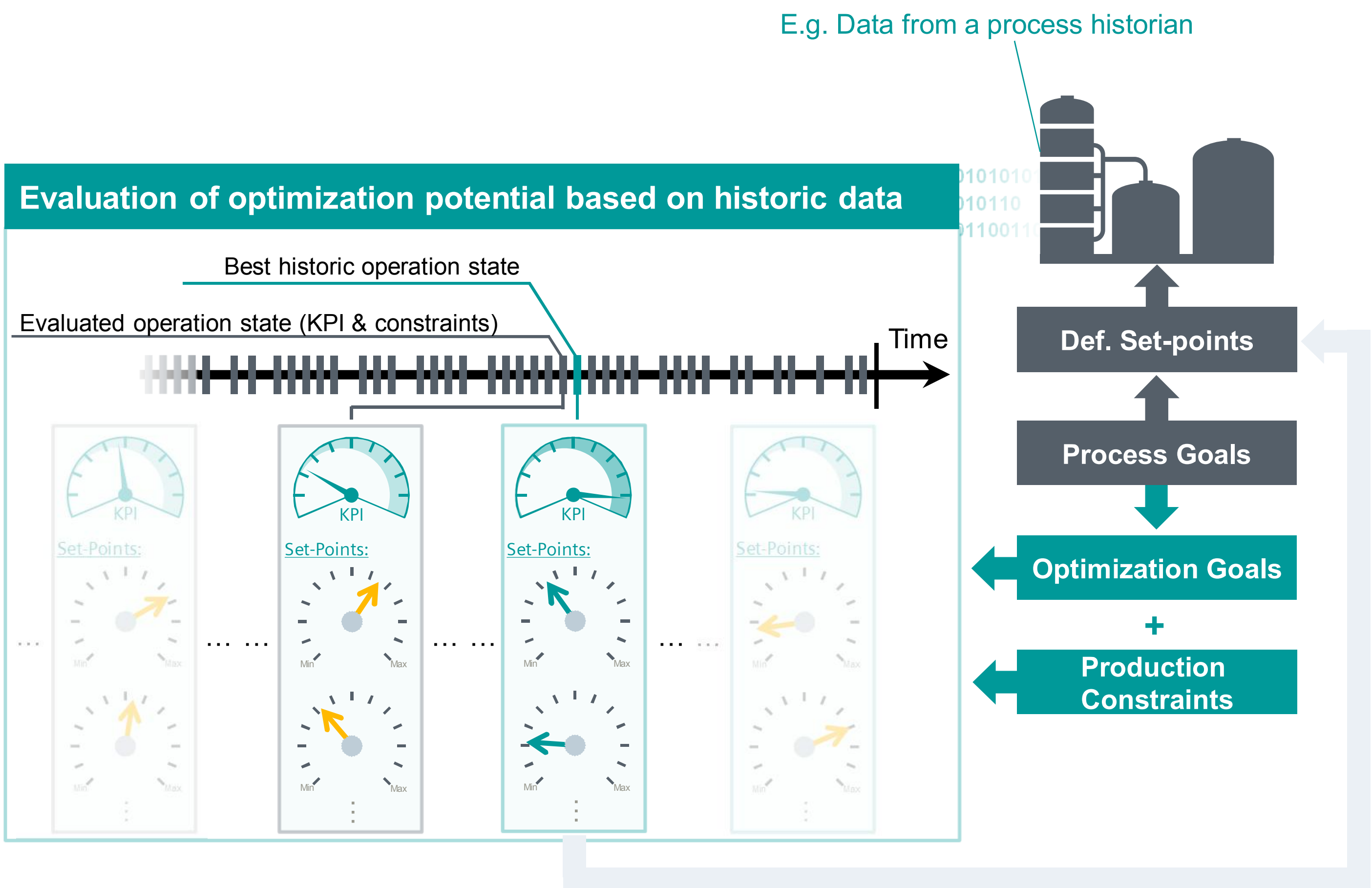


DPO Historic

Evaluation of optimization potential based on historical data

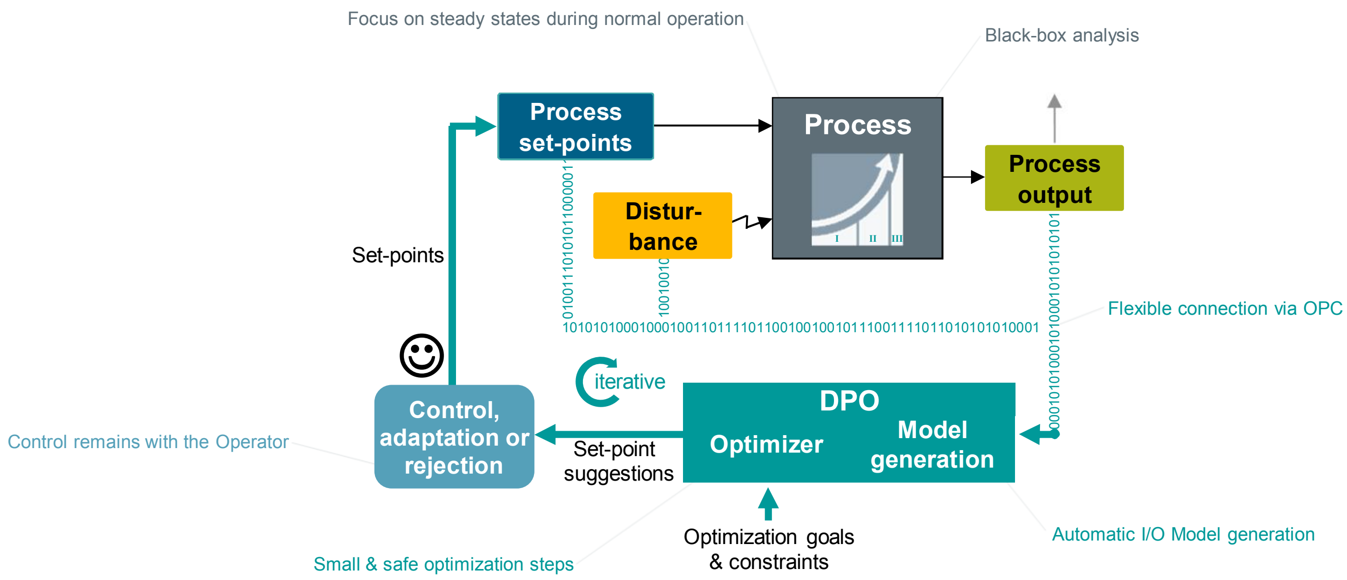


Value

- Identification of the best historic operational state based on the selected performance index (KPI) that fulfills all production constraints
- Evaluation of optimization potential
- Verification of the optimization approach

DPO Live

Universal, iterative & data-driven economical optimization



DPO optimization steps overview

1. Collection of measurement data
2. Model generation of the stationary operation state
3. Optimization regarding a selected optimization goal in compliance with all process constraints
4. Generation of a new set-point suggestion
5. Adoption or adaption of the set-points
6. Continue with 1. until the optimization goal is achieved

Dynamic Process Optimization
Universal & Data-Driven Optimization

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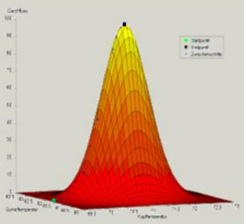
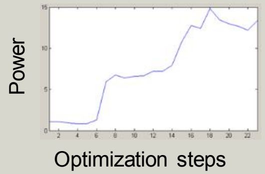
Proof of Concept

Economic optimization focus



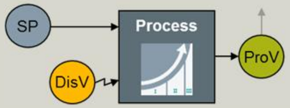
- Objective Performance & optimization transparency
- **Low application pre-requirements**
- Directly applicable optimization results

Effective, simple, quick



- **Cost effective**
- During normal operation in steady state
- No retrofitting
- Improvements after few iterations

Safe asset optimization



- Checks before applying changes
- Compliant to all process constraints
- **Incremental optimization in small & controlled steps**

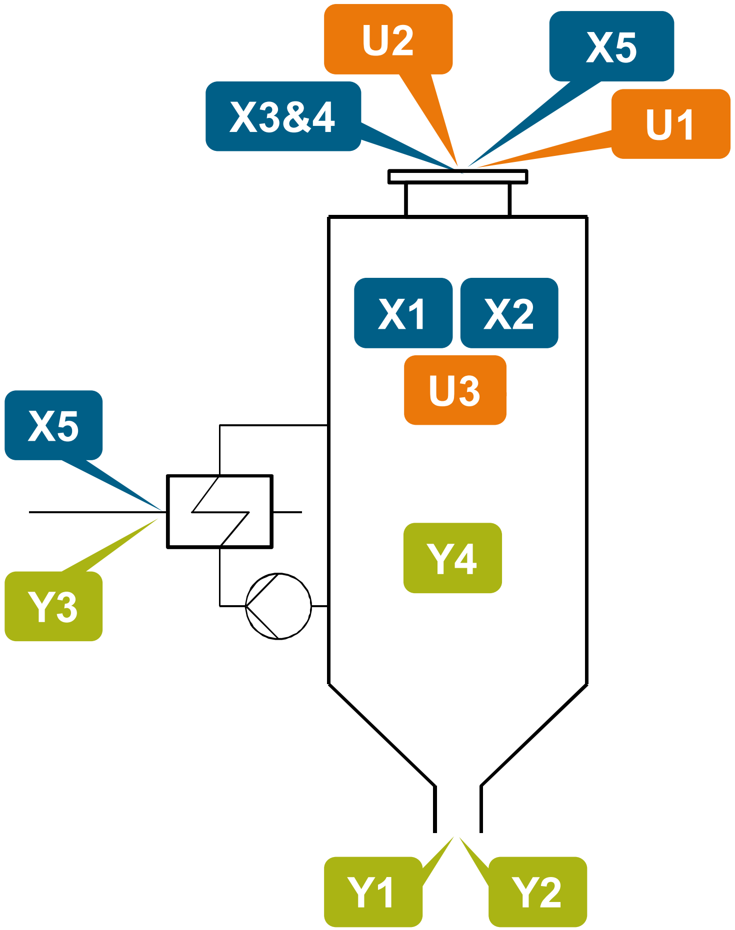
Flexible usability

- **For almost all processes with steady states**
- Freely selectable optimization goal
- Data-driven
- Little effort for the operator

Economical optimization of the stationary operation point based on selectable criteria

Energy – Throughput – Quality – Resources –Abrasion …

Pulp Impregnation & Cooking Example



Recipe parameters

X1: Impregnation Pressure
X2: Cooking Pressure
X3&4: Amount of NaOH & Na_2S
X5: Cooking Temperatures
X6: Quantity of raw material

Influences

U1: Raw Material quality properties (Humidity, type, temperature)
U2: Concentrations of NaOH & Na_2S
U3: Input Temperatures of materials

Process output

Y1: Cellulose (Paper) quality parameters
Y2: Lignin remainder (KappaNr)
Y3: Energy consumption
Y4: Resource consumption

Rough example!
TODO: adapt, complete, verify

Potential Optimization Goals?

- Balance NaOH vs. Na_2S
- Minimizing Operating Cost (Steam, Wood, Energy)
- Reduction in Chemical usage (NaOH & Na_2S)
- Maximizing process throughput/ Batch sizes

Agenda

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Challenges and potentials in paper making Overview

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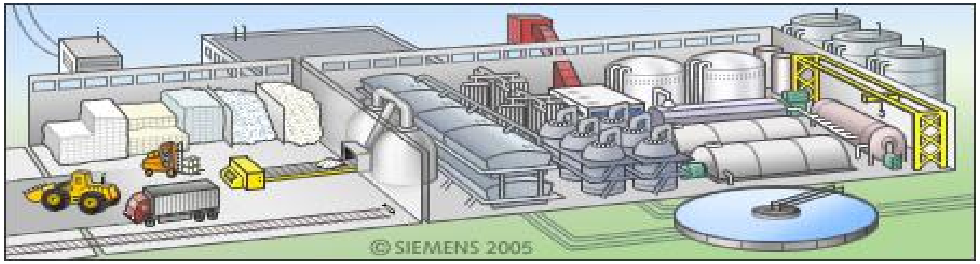
SIPAPER Bleach

- Stability and flexibility in process control of line
- Stable brightness on a high level
- Reduction of chemicals

SIPAPER Flot

- Smooth run of the DIP
- Minimization of reject loss in Pre- and Postflotation
- Balanced Ash content in DIP



Challenges and potentials: Stable brightness on high a level

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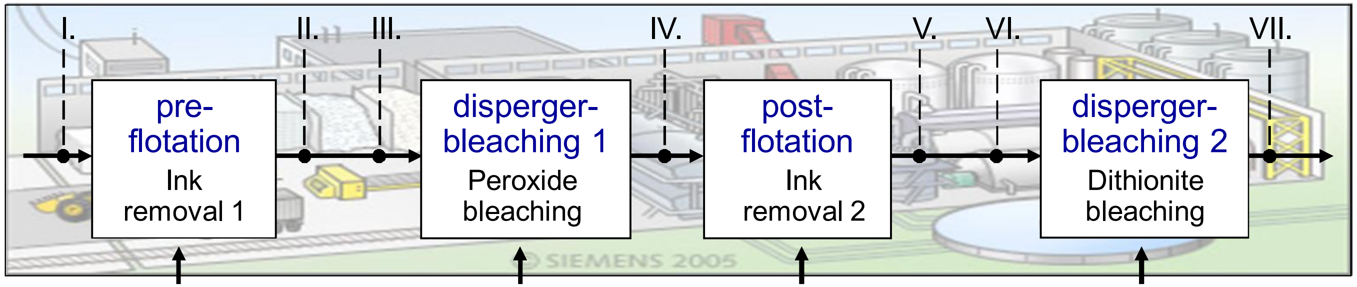
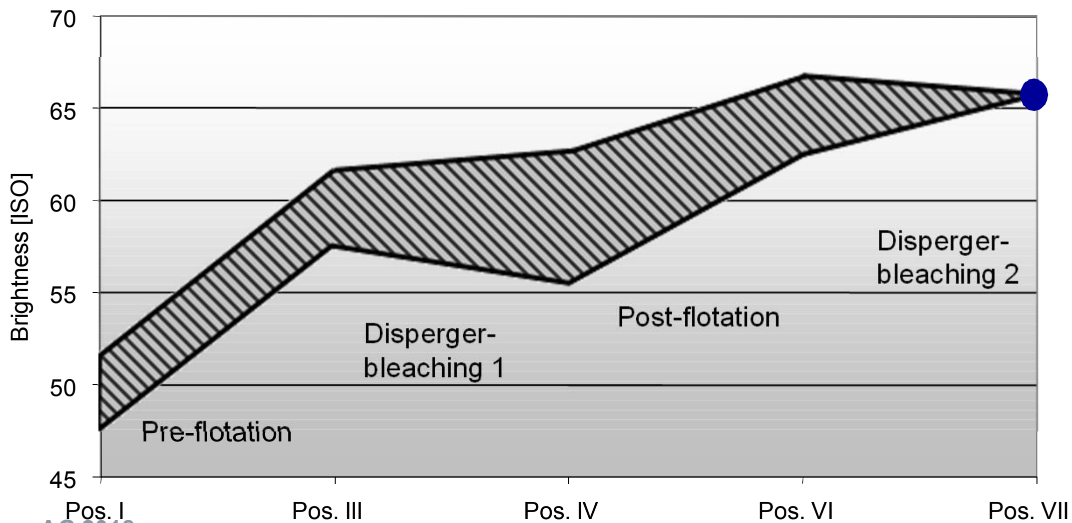


- Operating mode
- Deinking chemistry
- Fiber losses / reject

- Energy consumption
- Chemical dosage

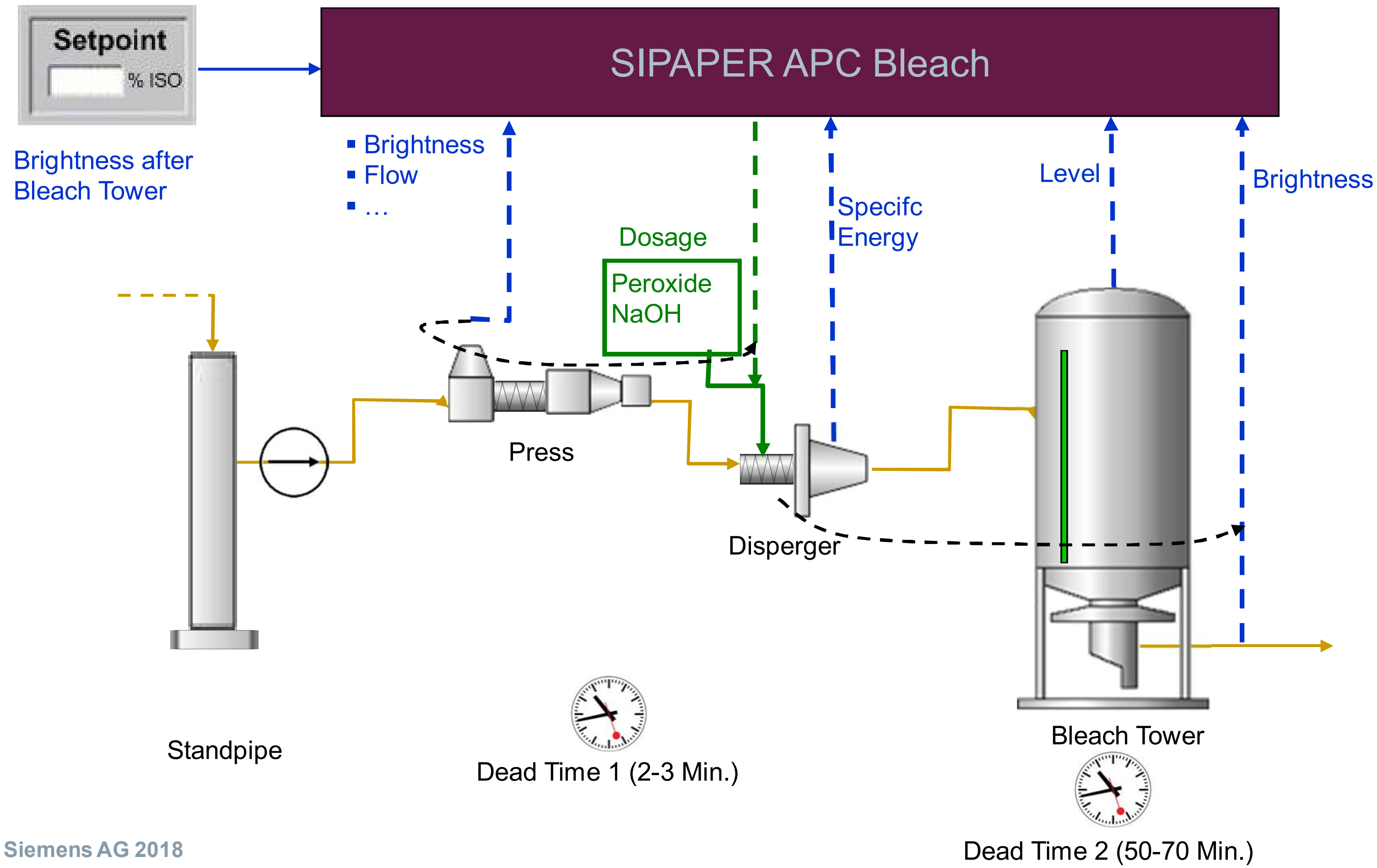
- Operation mode
- Deinking chemistry
- Fiber losses / reject

- Energy consumption
- Chemical dosage



Target:
Achieving desired brightness:
- accurately
- at minimum cost

SIPAPER APC Bleach – Example for oxidative Bleaching step



SIPAPER APC Bleach – Reliable quality with optimized chemical consumption

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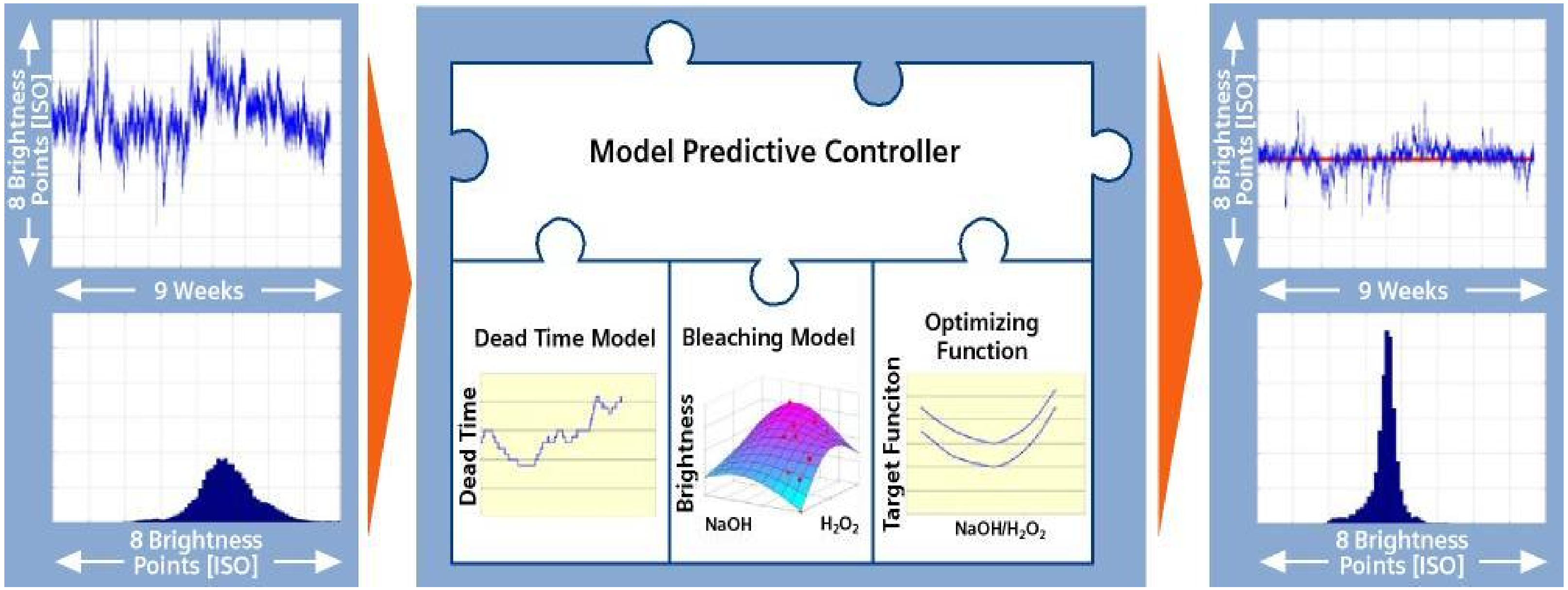
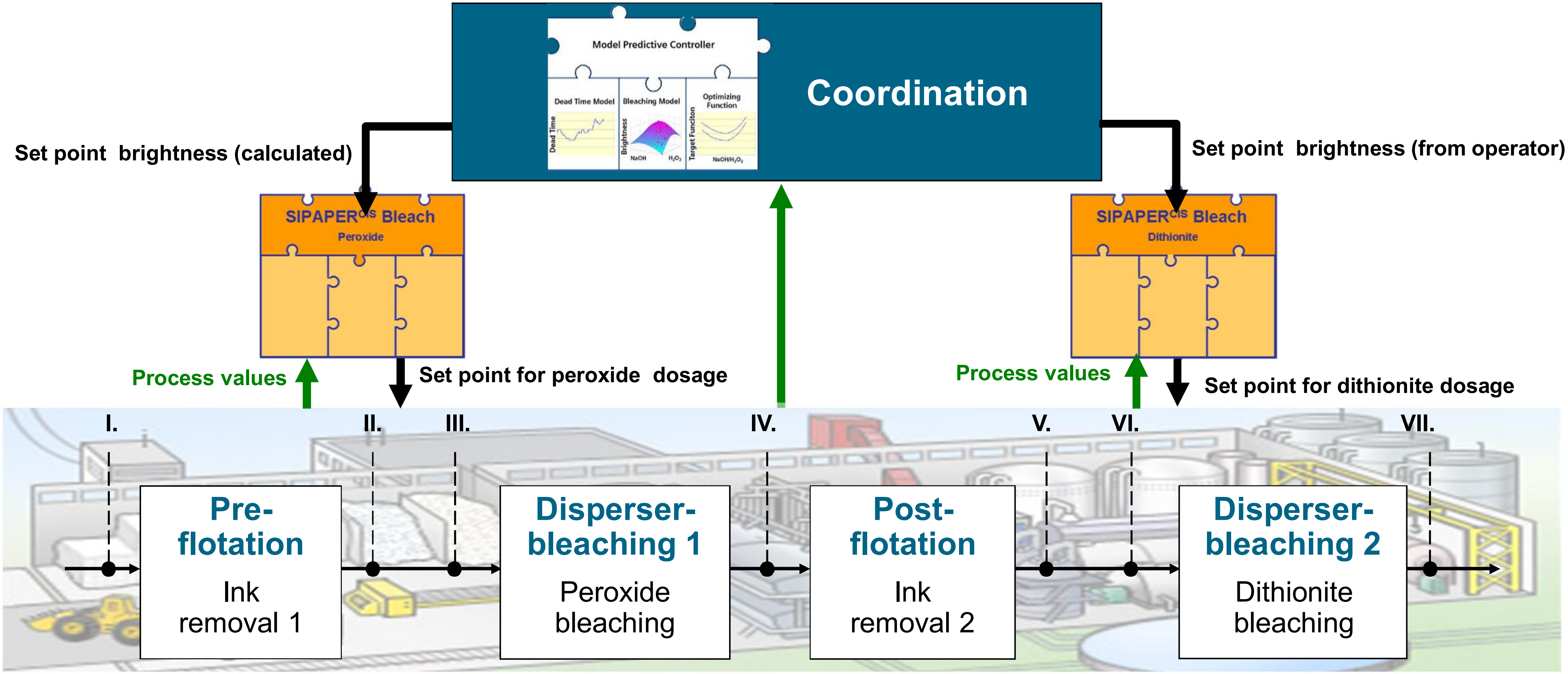


SIPAPER APC Bleach – Coordination of two bleaching stages



Overview Face Plate Flotation area of the DIP

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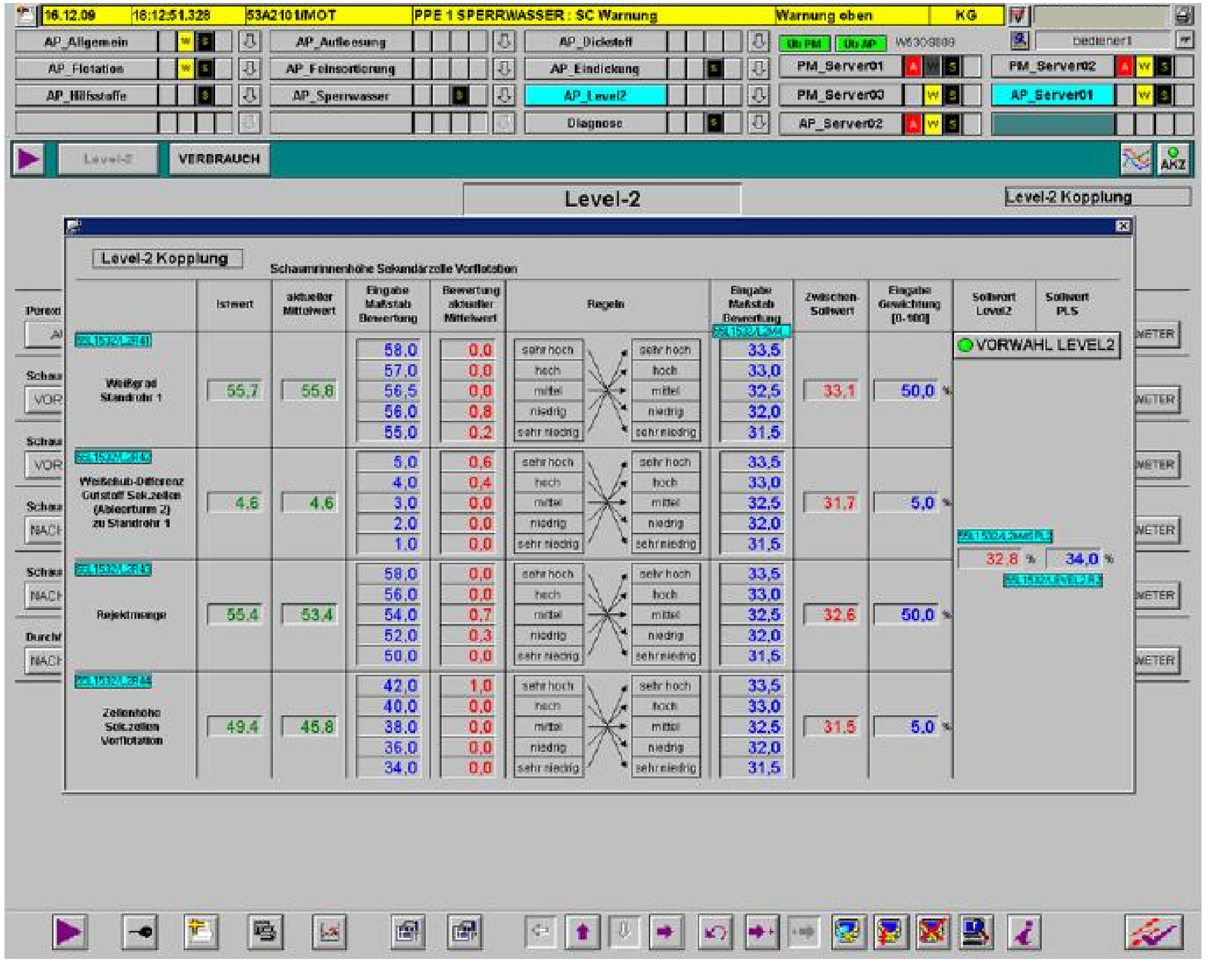

Target:
Ash content balance
- accurately
- optimized chemical consumption
- at minimum cost
- optimized reject discharge
- less fiber losses

Agenda

SIPAPER APC DrySec – Drying Section optimization

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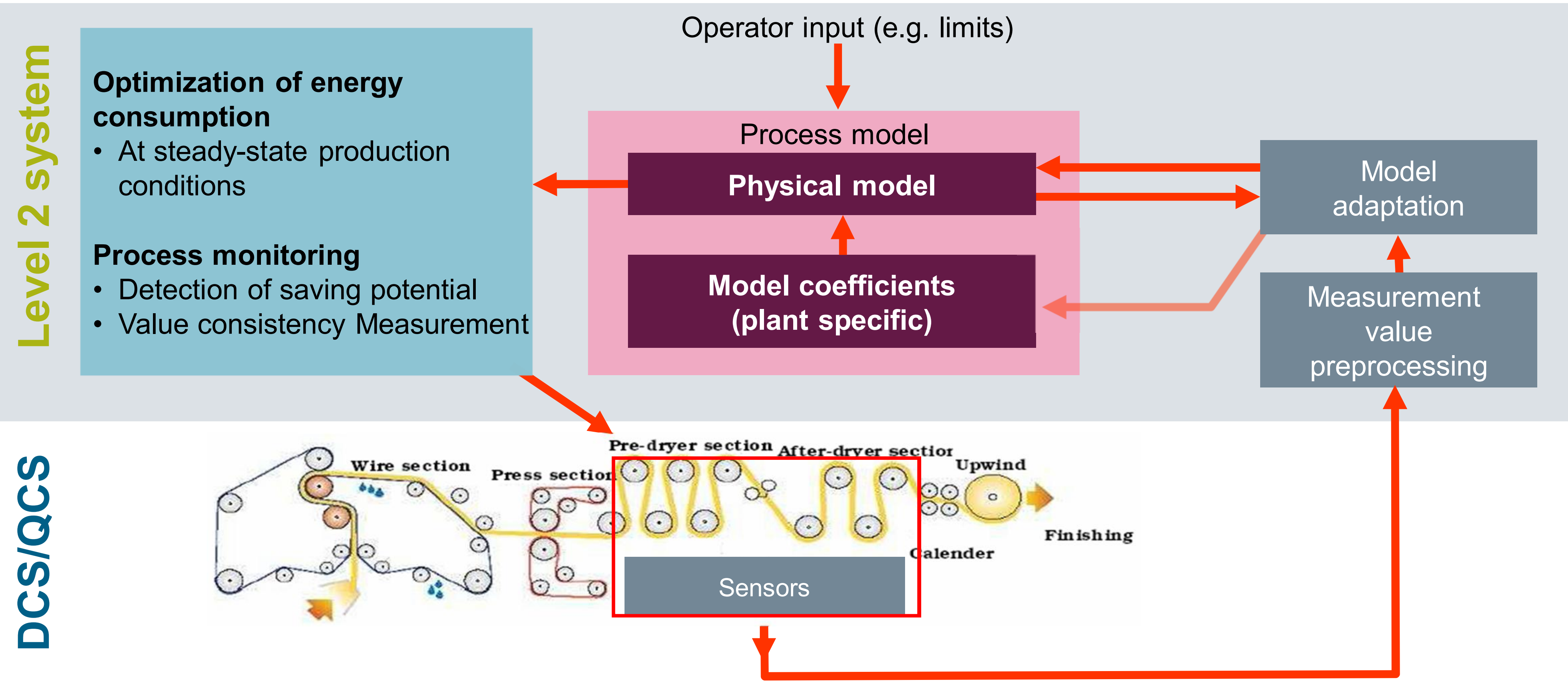

SIPAPER APC DrySec
Energy saving potentials in dryer section

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Steam consumption in steam groups

- Vary of steam pressures of the steam groups
- Optimize use of flash steam

Hood supply air

- Reduction of the amount of leakage air
- Reduction of the amount of supply air
- Optimal relation between (exhaust) air temperature and dew point

Heat recovery system

- Improved heat recovery by increasing moisture in exhaust air

Condensate

- Improved heat removal from the condensate

SIPAPER APC DrySec – Typical optimized set points

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Exhaust Air

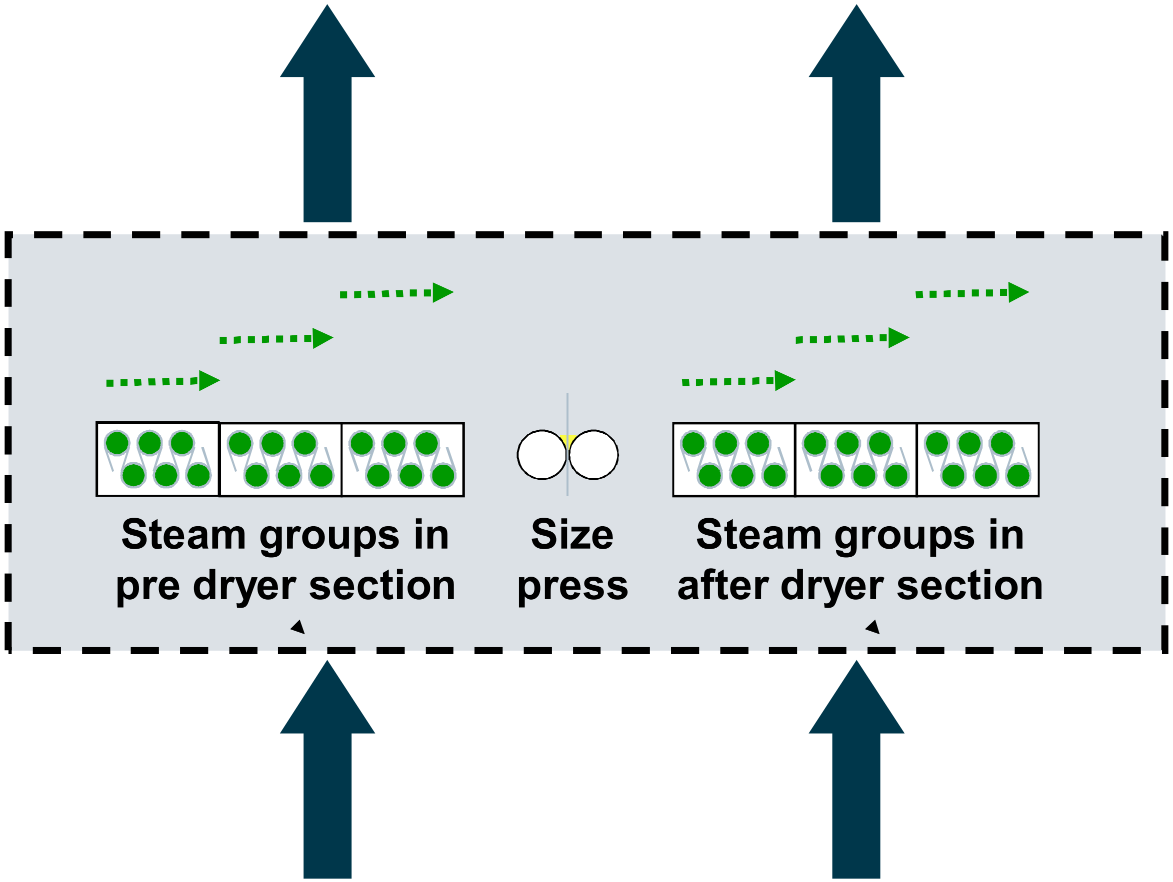
- Amount (Flow rate)

Steam and Condensate:

- Steam Pressure in all Steam Groups excluding Main Steam Group (Main Steam Group is calculated by QCS)

Hood Supply Air

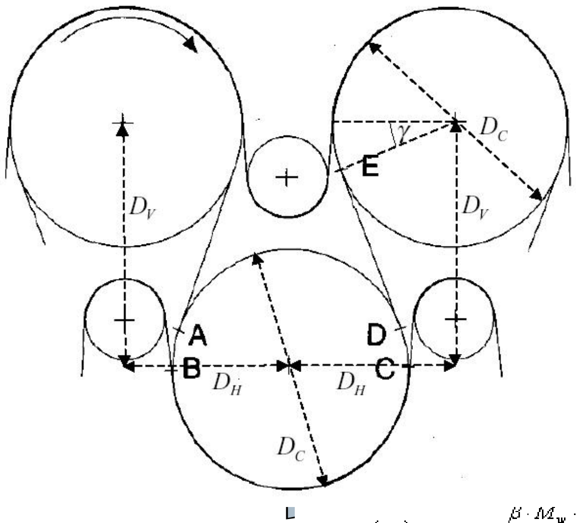
- Amount (Flow rate)
- Temperature



SIPAPER APC DrySec
What is modelled ?

- Paper drying process in the dryer hood
  - Mass and energy balance
  - Paper properties before and after each cylinder
  - Influence of hood air onto the drying process
  - Influence of leakage air
  - Calculation of dew points of the hood air
- Steam and condensate system (Cylinders, Separators)
  - Mass and energy balance
- Heat recovery system (heat exchangers)
  - Mass and energy balance
  - Amount of energy recovered dependent of exhaust air properties

SIPAPER APC DrySec
Physical Process Model



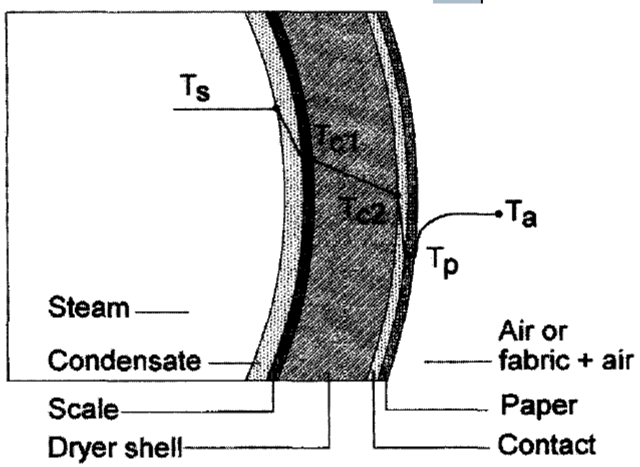
ıüssen in Summe gleich der für die Verdampfungsrate $m(x,t)$ benötigten
ırerseits zusammensetzt aus der Verdampfungswärme r_P (pro Flächen- und Zeit-
ie zur Erwärmung des Dampfes von der Papier-Oberflächentemperatur auf die
ndig ist:

$$\cdot\left(r_P\left(T_P(x,z,t),u(x,t)\right)+c_V\cdot\left(T_H(x,z,t)-T_P(x,z,t)\right)\right),\quad 0\le x\le L_c,\; z=0,\, d_P(x,t),\, t>0. \qquad \text{Gl. 17}$$

zw. m_o (nachfolgend zusammenfassend mit m bezeichnet) von der Papierbahn-
Haubenluft genügen der Stefangleich

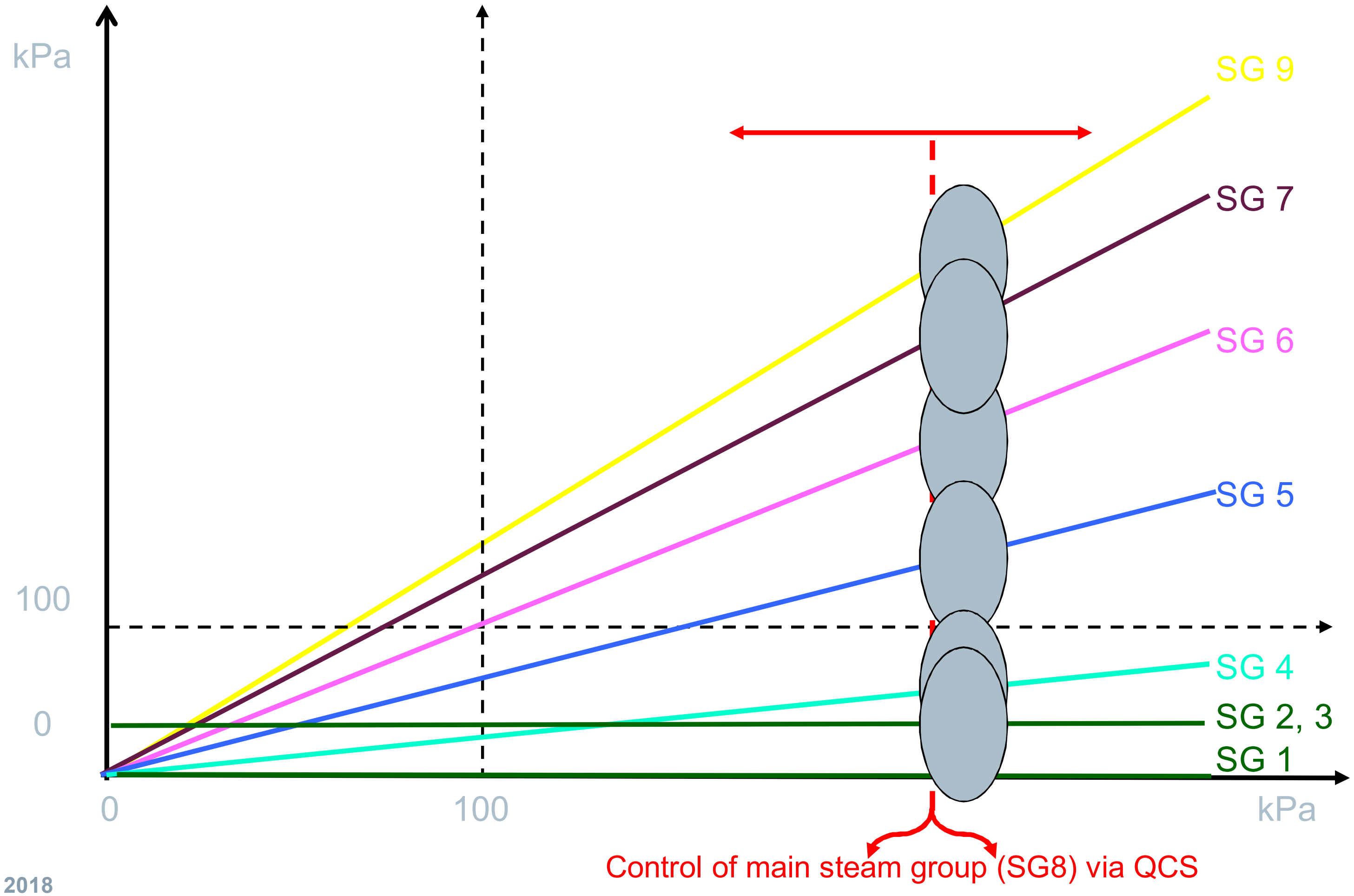
$$m(x,t)=\frac{\beta\cdot M_w\cdot p_{tot,H}}{R_G\cdot\left(T_H(x,z,t)+T_P(x,z,t)\right)/2}\log\left(\frac{p_{tot,H}-p_{V,H}(x,t)}{p_{tot,H}-p_{V,P}(x,z,t)}\right.$$

In Gl. 18 bezeichnen β den Massetransferkoeffizienten, M_W die
samtdruck in der Trockenhaube, $p_{V,H}$ den Wasserdampf-Partial
Gaskonstante, T_H die Haubentemperatur und $p_{V,H}$ den Wasserda

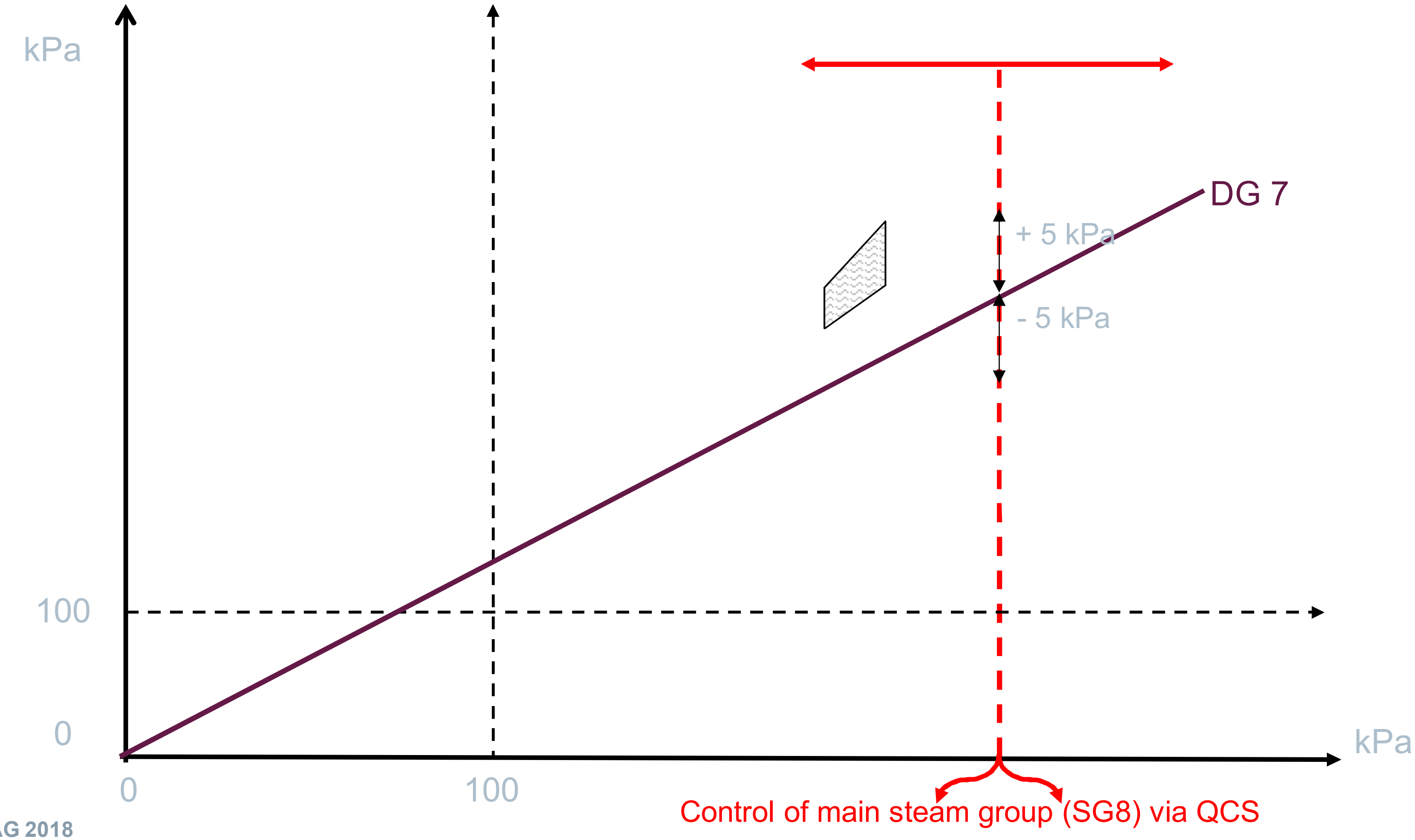


SIPAPER APC DrySec

Constraints: example steam pressure



SIPAPER APC DrySec
Constraints: example steam pressure



SIPAPER APC DrySec
Summary

Detailed physical process model as basis of calculation

Mathematical optimization algorithm
- ➔ Minimizing consumption of fresh steam
- ➔ Minimizing energy consunption of fans

Transfer of optimized setpoints to the DCS
- ➔ hood supply air (amount and temperature)
- ➔ steam pressure
- ➔ ...

Typical saving of fresh steam: 2% and 5%
- ➔ depending on plant configuration
- ➔ average savings of existing installations

Outlook

1	With smart control optimization works very efficient
2	Becomes more flexible with higher hardware performance
3	Trend moves to off line solution
4	Mindsphere, *cloud based open platform*
5	Optimization beyond start up leads to gap to integrate smart control systems

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Thank You!

Dr. Hermann Schwarz
Product Manager Technology
PD SLN FI PPM
Werner-von-Siemens-Str. 60
91052 Erlangen
Germany
Phone: +49 9131 7-42917
Mobile: +49 173 7031762
E-mail: hermann.hs.schwarz@siemens.com