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> compounding & extrusion
> materials handling
> service

Envisioning the i4.0 Compounding Plant

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What is Industry 4.0?

First Industrial Revolution 1760-1830

- Hand production to machine
- Steam power
- Factories

Second Industrial Revolution 1870 - 1914

- Electrical power
- Production Line
- Globalization

Digital Revolution 1980- Present

- Digitalization
- Microelectronics
- Information and communication technology

Industry 4.0 Present - ?

- Artificial Intelligence
- Internet of Things

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Principles of Industry 4.0

Interoperability

- Ability for machines, devices, sensors and people to connect and communicate with each other quickly

Information Transparency

- Ability of information systems to create a virtual copy of the physical world by enriching models with machine and device data.

Technical Support

- Ability for systems to support humans by aggregating and visualizing information or conducting tasks unpleasant for humans

Distributed Control Systems

- Autonomously operating modules without delegating decisions to a higher level
- Control function is distributed, communication path is shortened

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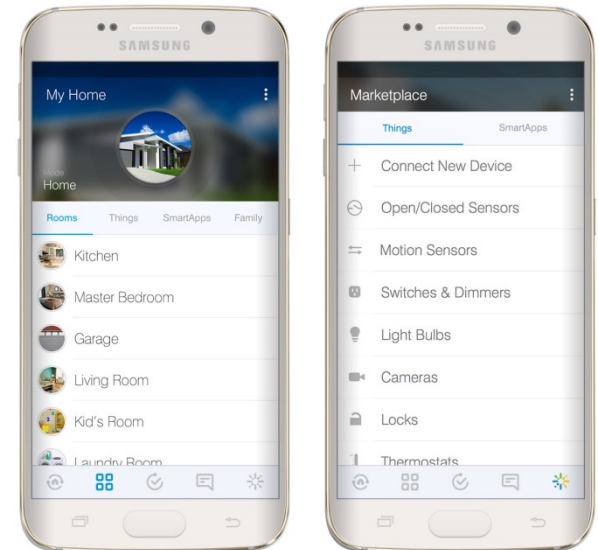
Household Smart Devices

Devices

- Smart Bulbs
- Smart Thermostat
- Smart TV / Casting Devices
- Motion Sensors

Networking and Interface

- Centerpiece
- Smart Hub
- Smart Phone

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The Smart Home

Integration

- See who's at the door from smartphone
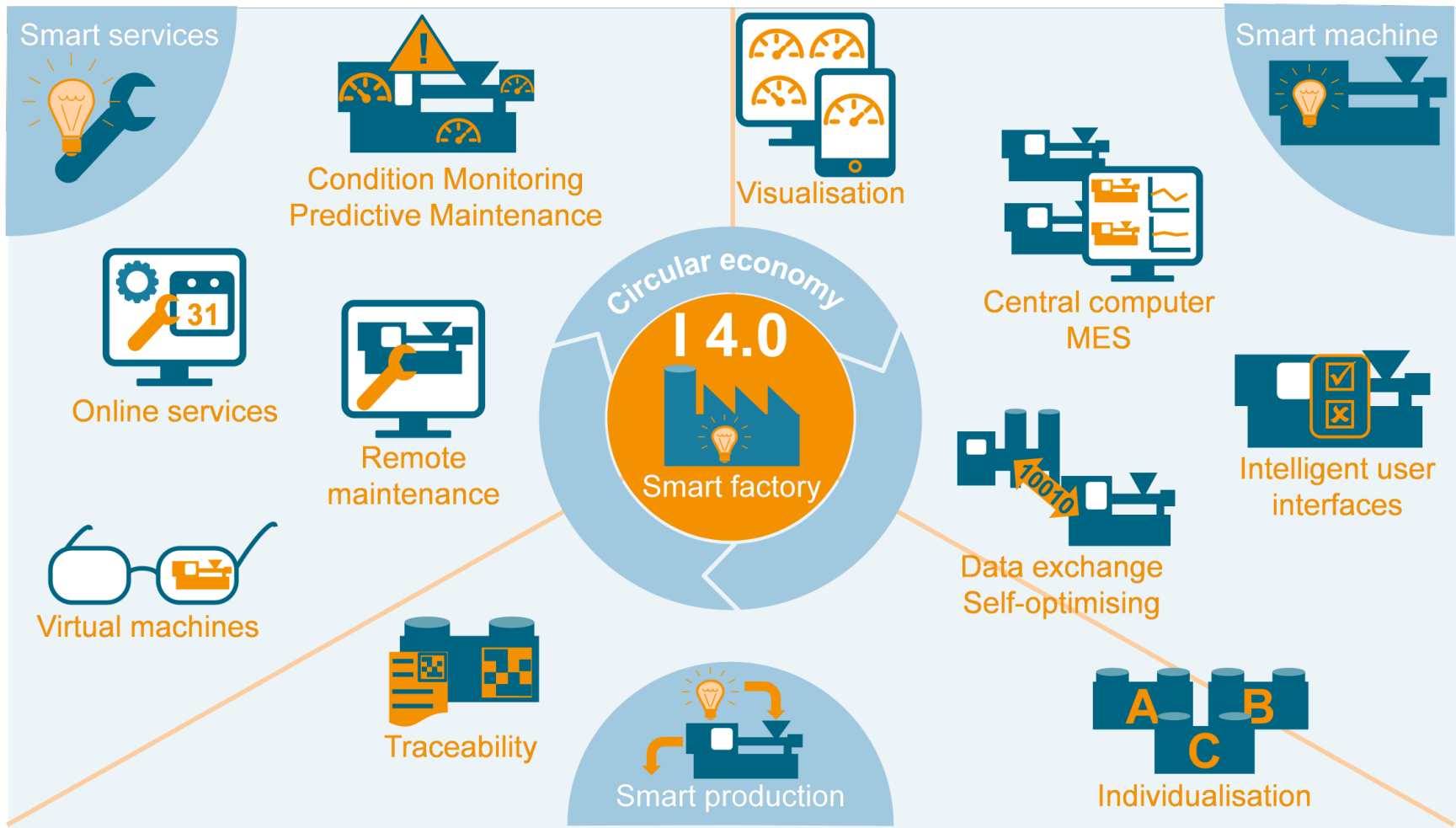- Turn off the lights with a voice command while sitting on the couch watching a movie

Automation

- Sensors on door detects entry and turns on lights or send a text when kids come home from school
- Set coffee maker to brew a cup of coffee when the morning alarm goes off

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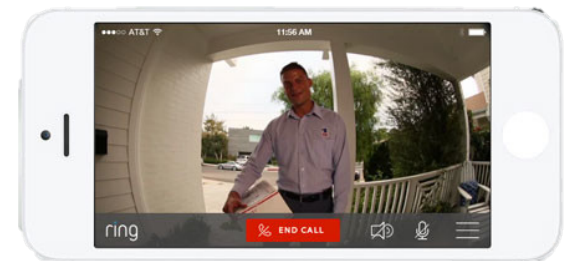
The Smart Factory
VDMA definition of Industry 4.0

Industry 4.0 Devices

Monitoring and Sensors:

- Feeder weight scale
- Temperature and pressure sensors
- Online rheometry
- Vibration sensors
- Condition monitoring

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Industry 4.0 Devices

Information Transparency & Traceability:

- Barcodes

- RFID

- Smart flow meter

- Allows tracking of assets

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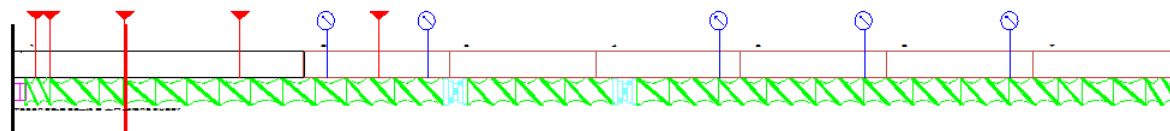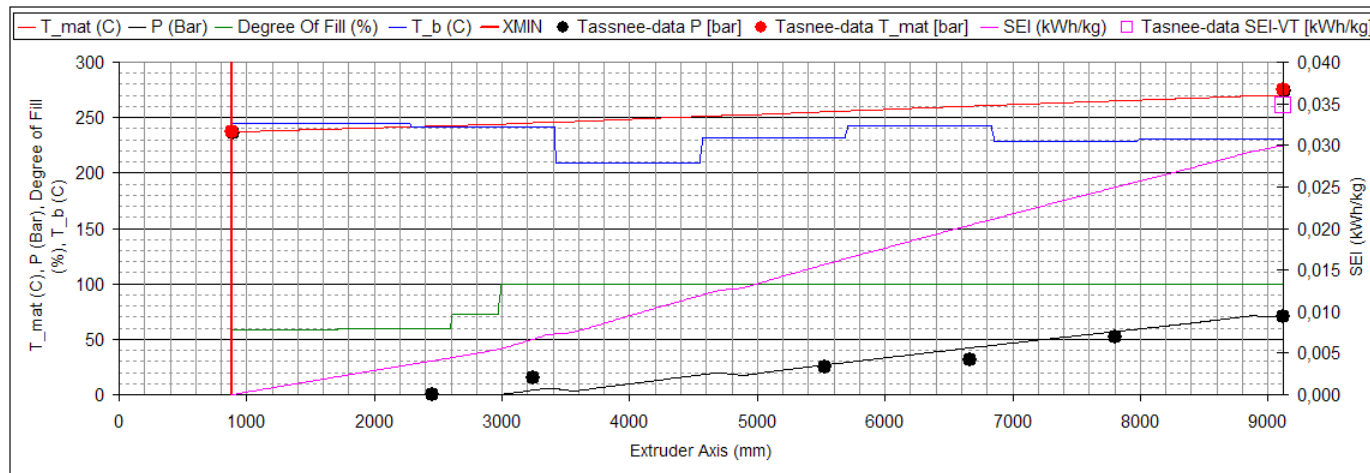
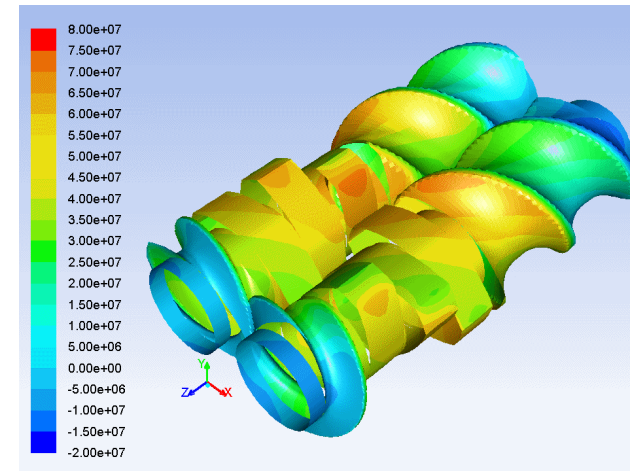# Industry 4.0 Devices

Visualization:

- Graphical interface

- Augmented reality

- 3D exploded models of parts assembly
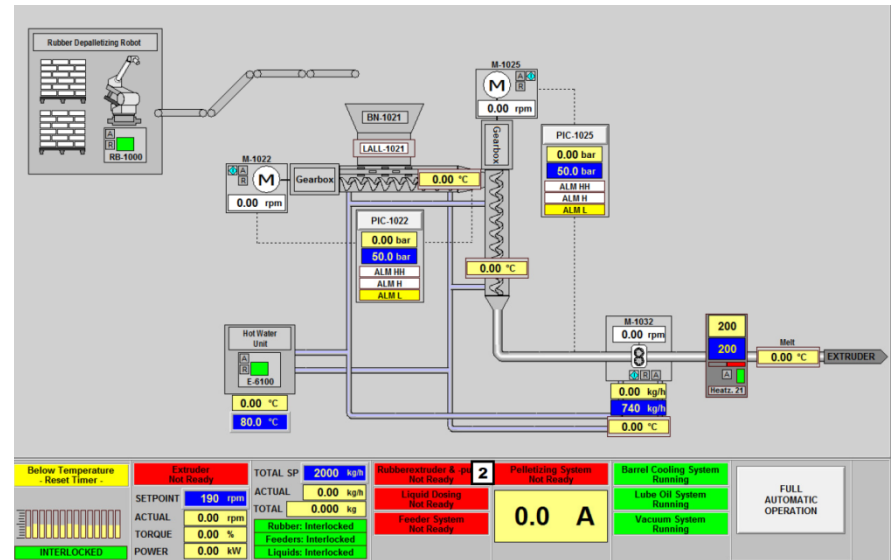
Industry 4.0 Devices

Simulation:

- 2D and 3D Modeling

- Trends

- Optimization

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Industry 4.0 Devices

Online services and web portals:

- Manuals and assembly drawings

- Spare parts ordering and tracking

- Scheduling service

- Mechanical and process support
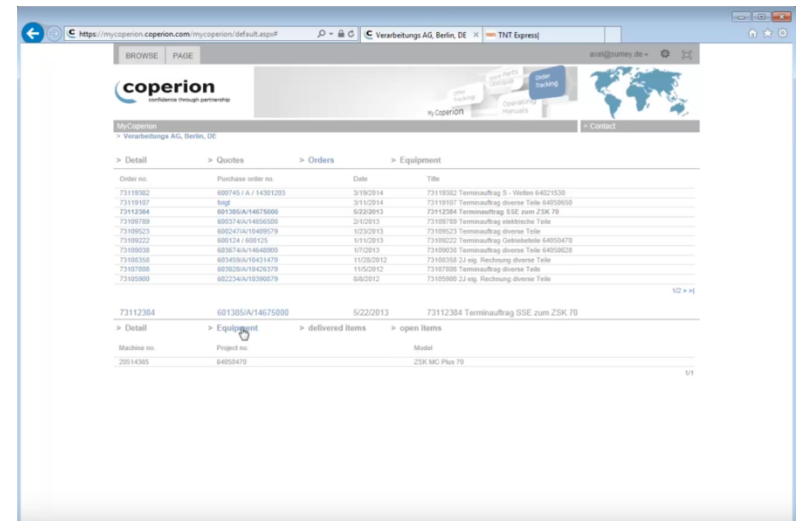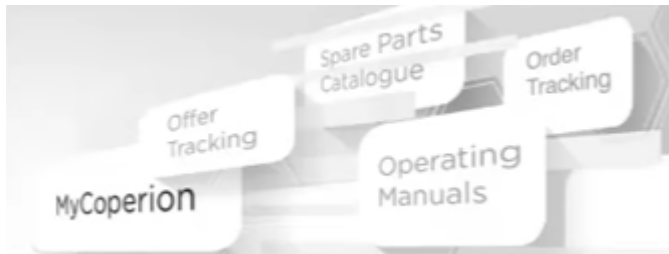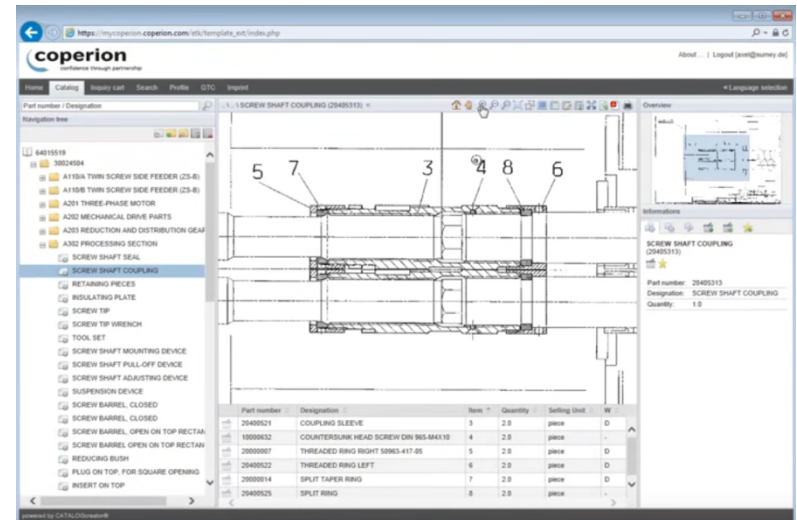
Industry 4.0 Devices

Remote control and connectivity:

- Ethernet Switch

- Web Port

- Virtual Network Computing (VNC)

Remote User

Modem

PLC

Ethernet Switch

HMI

Cellular

Cloud (Internet)

Web Port

Data Storage

Modem

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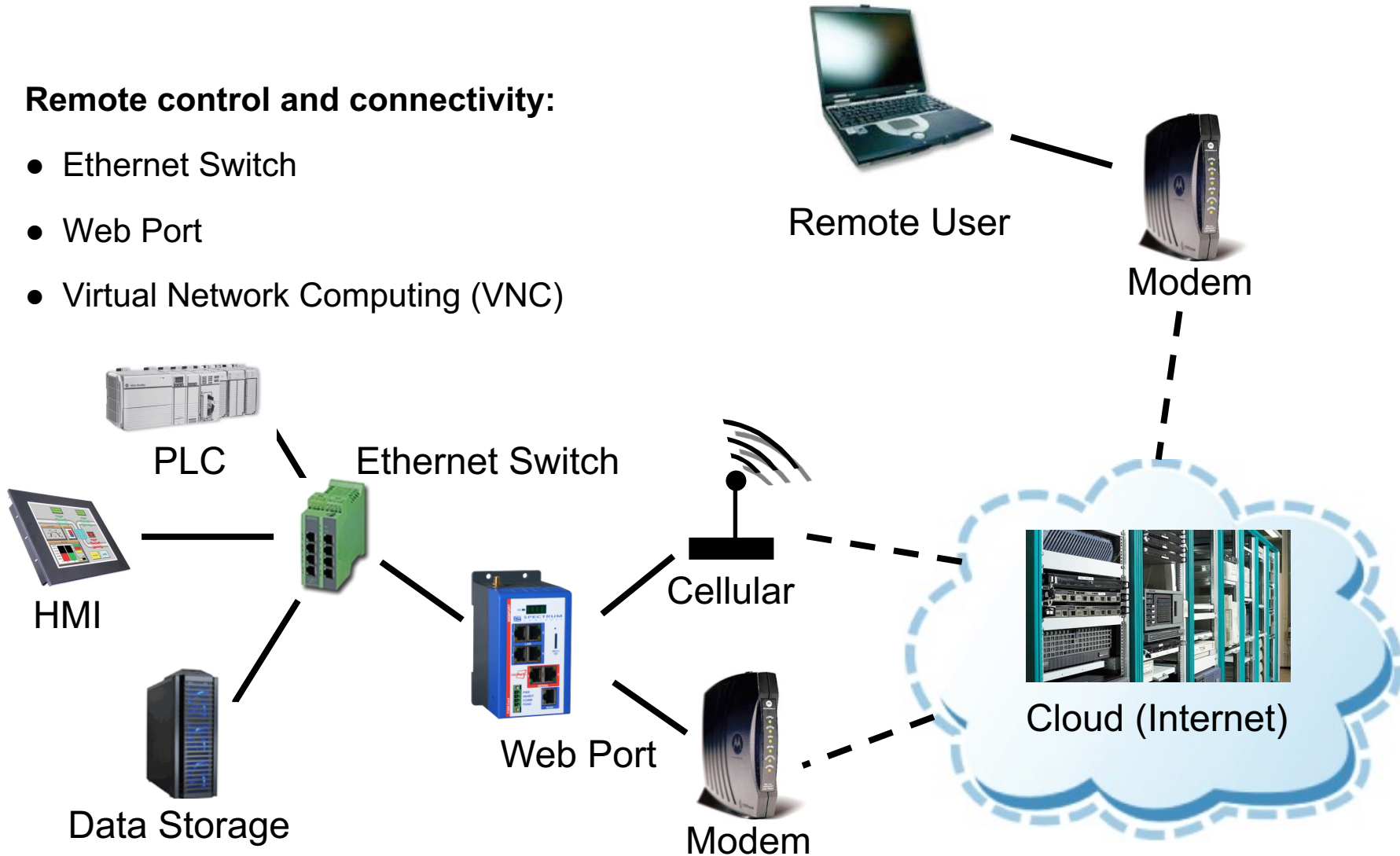
Typical Compounding Plant 2016

Asset Movement:

- Operators issue raw materials to a production job and load into feeders

- Feeders dispense raw materials into processing equipment

- Operators weight finished goods and enter into ERP

- Operators weigh unused materials and return them in the ERP
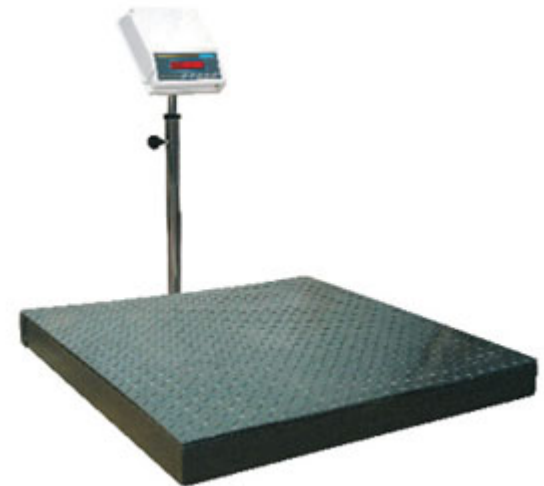
Typical Compounding Plant 2010

Process Monitoring and Quality:

- Operator responsible for observing trends during production among other responsibilities

  - ✗ Deviations often missed due to other workload

- Samples of finished goods taken to QC department at specified interval during production

  - ✗ Interval can be several hours and testing can take even longer, therefore a large quality of off-spec product may be generated before it is caught

- Process engineers may review previous day's production trends and QC data at start of day

  - ✗ Expertise for adjusting process variables may not be available quickly during 2nd and 3rd shift

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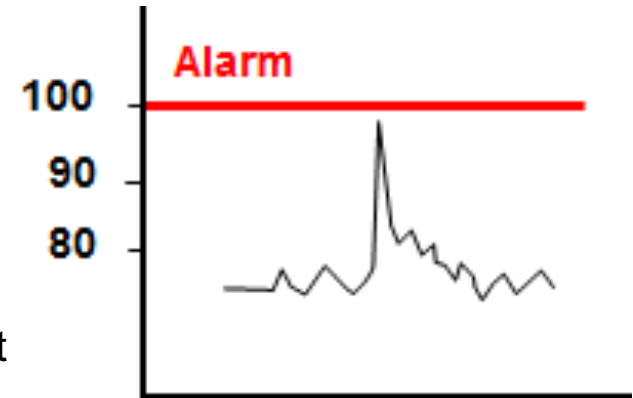
Typical Compounding Plant 2010

Maintenance and conditions monitoring:

- Need to hire maintenance personnel that have equipment specific experience, or initial training period to learn from more tenured personnel

- Operations requiring technical expertise require on-site visit which requires time for travel and is expensive

- Equipment manuals may be missing or printed and therefore not searchable

  - ✗ Replacement part numbers unknown, require getting on phone with customer service

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Typical Compounding Plant 2010

Global production:

- Plants cannot see live operations of other plants in the company

  - Unscheduled shutdown requires manual assessment to move production to another plant

  - Production scheduling occurs on a daily basis, rather than live

- Process technology not easily shared between plants

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Typical Compounding Plant 2010

Trends:

- Information flow is slow

- Lack of coordination between components

- Tasks are manual

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The Industry 4.0 Compounding Plant

Information Transparency and Cyber-Physical Systems:

- Manufacturing Execution System linking sales and inventory information from ERP to production equipment and vice-versa live
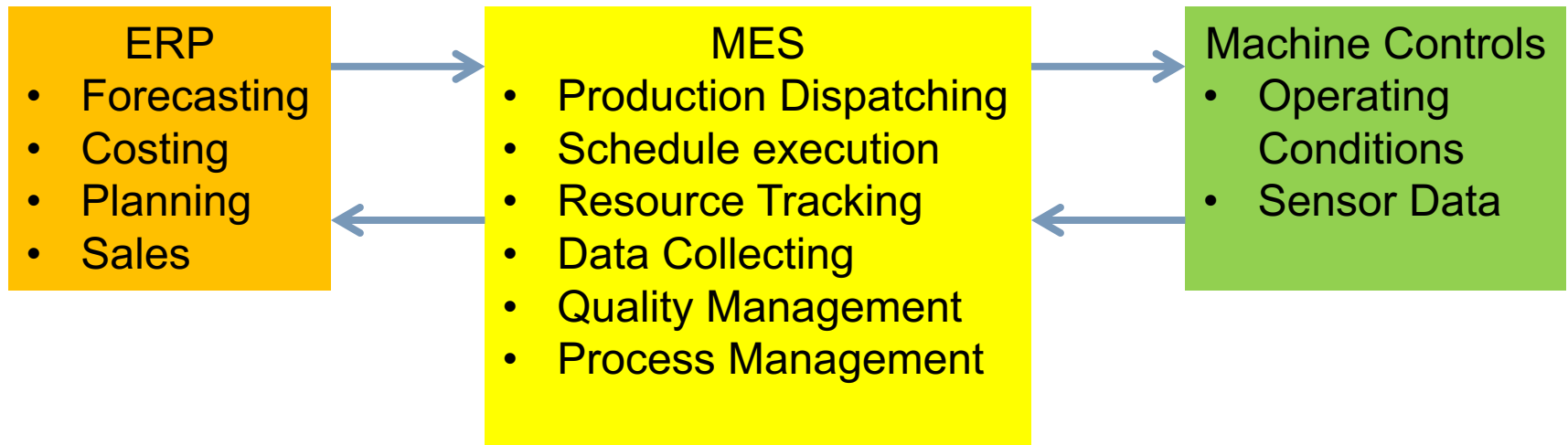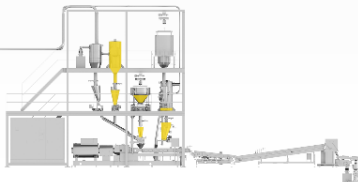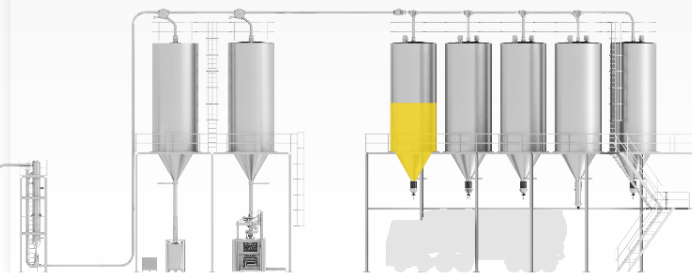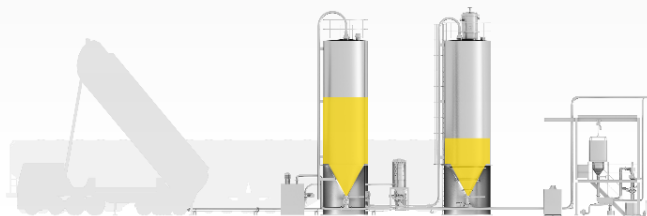
ERP	MES	Machine Controls
• Forecasting • Costing • Planning • Sales	• Production Dispatching • Schedule execution • Resource Tracking • Data Collecting • Quality Management • Process Management	• Operating Conditions • Sensor Data

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Houston Line 1

3D ⬤ 2D

RAW MATERIALS

COMPOUNDING

FINISHED PRODUCTS

Recipe

B

Next: B

Polypropylene PP		**47%** 1,222 kg/h
Calcium Carbonate CaCO3		**50%** 1,300 kg/h
Premix Premix		**3%** 78 kg/h

B	B	Setup	C	C	A	A
Sun, Oct 15	Mon, Oct 16	Tue, Oct 17	Wed, Oct 18	Thu, Oct 19	Fri, Oct 20	Sat, Oct 21

week

Silo 1

RAW MATERIALS | COMPOUNDING | FINISHED PRODUCTS

3D ⬤ 2D

‹ | Silo 1 | Silo 2 | Big Bag

Material	Quantity	Batch number
Polypropylene	16,000 kg	172332

	Tue, Oct 17	Wed, Oct 18	Thu, Oct 19	Fri, Oct 20	Sat, Oct 21	Sun, Oct 22	Mon, Oct
	B	B	Setup C	C	Setup A	A	

week

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Silo 2

RAW MATERIALS COMPOUNDING FINISHED PRODUCTS

3D ⬤ 2D

< | Silo 1 | Silo 2 | Big Bag

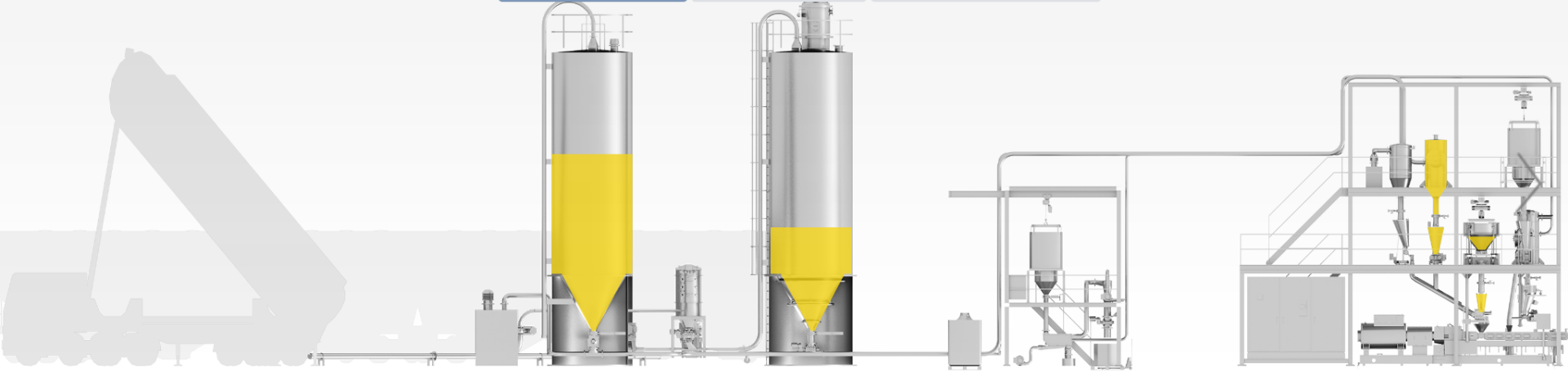| Material	Quantity	Batch number
Calcium Carbonate	15,000 kg	675291

Houston Line 1

3D ⬤ 2D

RAW MATERIALS

COMPOUNDING

FINISHED PRODUCTS

Recipe

B

Next: B

| Polypropylene | | 47% |
| PP | | 1,222 kg/h |

| Calcium Carbonate | | 50% |
| CaCO3 | | 1,300 kg/h |

| Premix | | 3% |
| Premix | | 78 kg/h |

| B | B | Setup C | C | Setup A | A |
| Sun, Oct 15 | Mon, Oct 16 | Tue, Oct 17 | Wed, Oct 18 | Thu, Oct 19 | Fri, Oct 20 | Sat, Oct 21 |

week

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Daybin 1

RAW MATERIALS | COMPOUNDING | FINISHED PRODUCTS
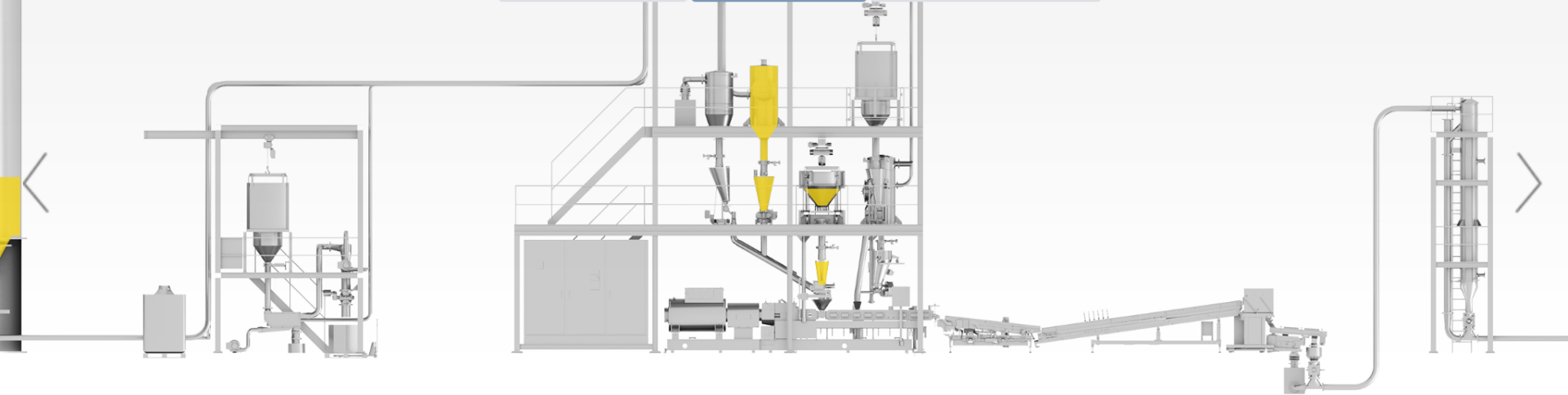
3D   ⬤   2D

‹   Daybin 1   Feeder 1   Daybin 2   Feeder 2   Hopper   Feeder 3   Big Bag 2   Feeder 4   Daybin 3   Feeder 5

Material	Quantity	Batch number

Sun, Oct 15	Mon, Oct 16	Tue, Oct 17	Wed, Oct 18	Thu, Oct 19	Fri, Oct 20	Sat, Oct 21
B	B	Setup C	C	Setup A	A	

week

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Daybin 2

RAW MATERIALS | COMPOUNDING | FINISHED PRODUCTS
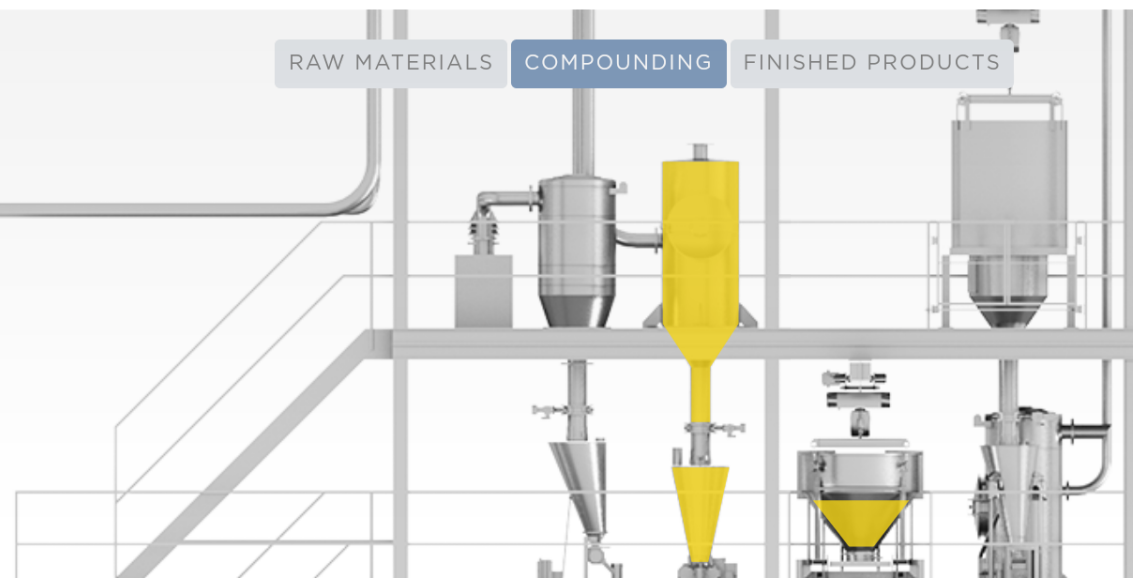
3D ⬤ 2D

‹ | Daybin 1 | Feeder 1 | Daybin 2 | Feeder 2 | Hopper | Feeder 3 | Big Bag 2 | Feeder 4 | Daybin 3 | Feeder 5

Material	Quantity	Batch number
Polypropylene	400 kg	815224

B	B	Setup	C	C	Setup	A	A
Sun, Oct 15	Mon, Oct 16	Tue, Oct 17	Wed, Oct 18	Thu, Oct 19	Fri, Oct 20	Sat, Oct 21	

week

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Feeder 2

RAW MATERIALS | COMPOUNDING | FINISHED PRODUCTS
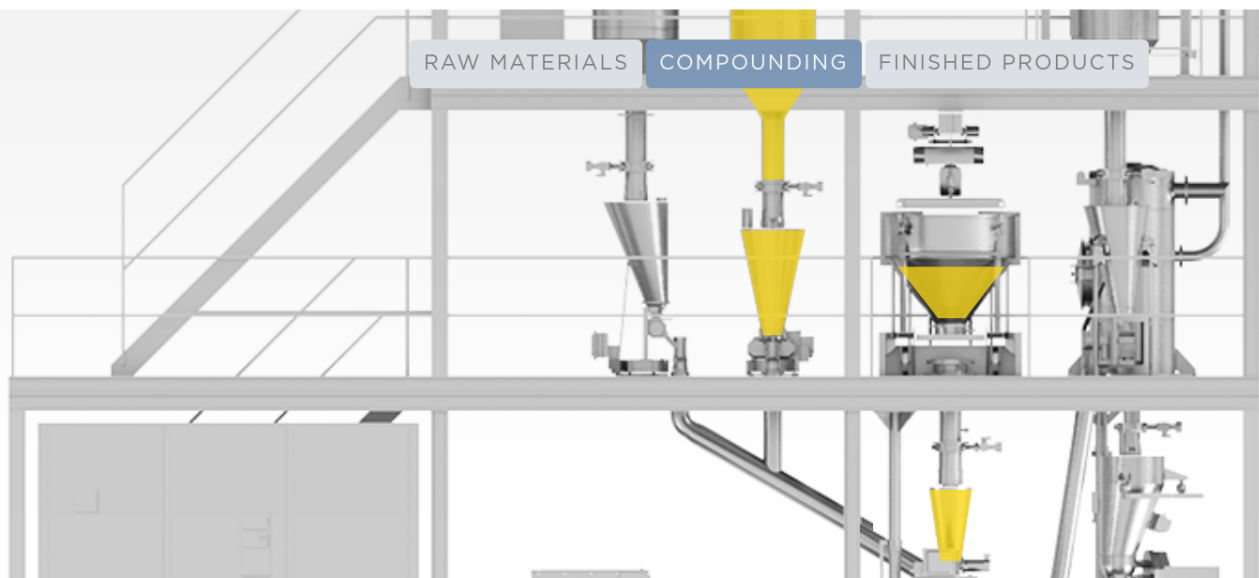
3D ⬤ 2D

Daybin 1 | Feeder 1 | Daybin 2 | **Feeder 2** | Hopper | Feeder 3 | Big Bag 2 | Feeder 4 | Daybin 3 | Feeder 5

Material	Quantity	Batch number
Polypropylene	62 kg	130326
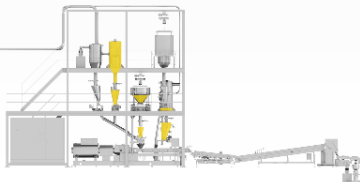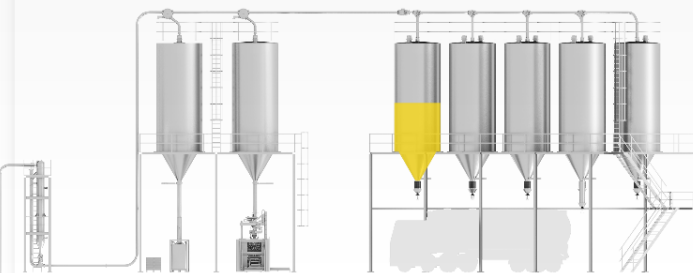
Sun, Oct 15	Mon, Oct 16	Tue, Oct 17	Wed, Oct 18	Thu, Oct 19	Fri, Oct 20	Sat, Oct 21
B	B	Setup C	C	Setup A	A	

week

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Houston Line 1

3D ⬤ 2D

RAW MATERIALS

COMPOUNDING

FINISHED PRODUCTS

Recipe

B

Next: B

Polypropylene		
PP		**47%**
		1,222 kg/h

Calcium Carbonate		
CaCO3		**50%**
		1,300 kg/h

Premix		
Premix		**3%**
		78 kg/h

Sun, Oct 15	Mon, Oct 16	Tue, Oct 17	Wed, Oct 18	Thu, Oct 19	Fri, Oct 20	Sat, Oct 21
B	B	Setup C	C	Setup A	A	A

week

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Silo 5

RAW MATERIALS | COMPOUNDING | FINISHED PRODUCTS

3D ⬤ 2D

< | Silo 3 | IBP 250 | Silo 4 | Silo 5 | Silo 6 | Silo 7 | Silo 8

Finished Products	Quantity	Material	Materialcode	Batch number	Order number
B	20.831kg	PP Premix CaCO³	9340482 181970 1409448	456198	1235931120227
B	17.518kg	PP Premix CaCO³	23734882 257817 2169929	439671	1185941289342

| | B | B | Setup | C | C | Setup | A | A | A |

| Sun, Oct 15 | Mon, Oct 16 | Tue, Oct 17 | Wed, Oct 18 | Thu, Oct 19 | Fri, Oct 20 | Sat, Oct 21 |

week

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Feeder K2-ML-D5-S60

RAW MATERIALS · COMPOUNDING · FINISHED PRODUCTS
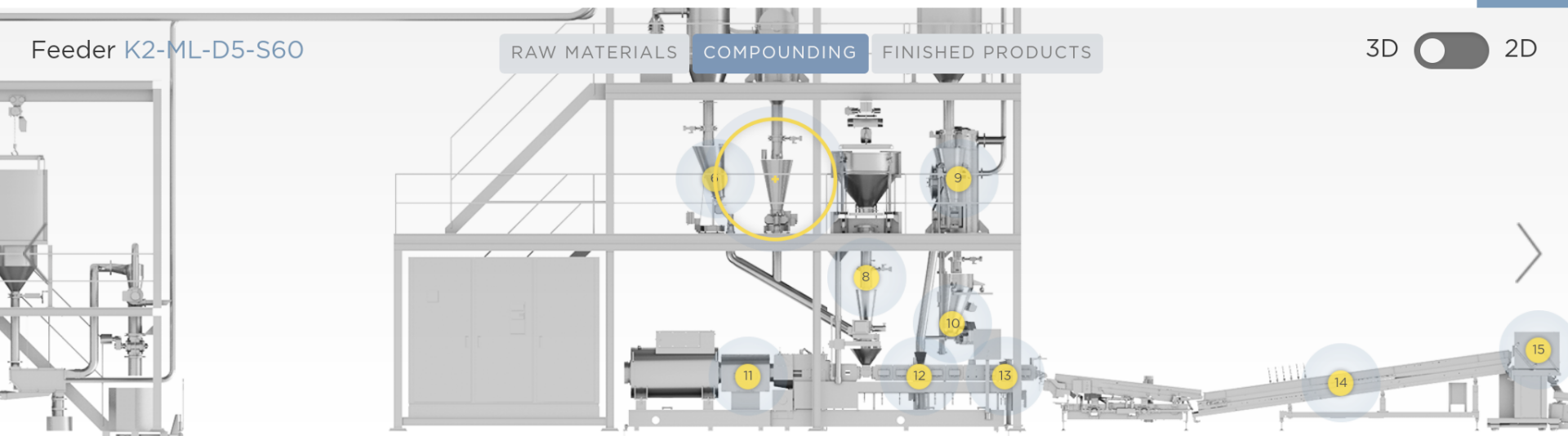
3D ⬤ 2D

< | 6 Feeder 1 | 7 Feeder 2 | 8 Feeder 3 | 9 Feeder 4 | 10 Feeder 5 | 11 ZSK | 12 ZS-B | 13 ZS-EG | 14 ASC | 15 SP 500 | 16 ZVB | 17 Screener

K-ML-D5-S60 kg/h

1500
1250
1000
750
500
250

06:40   06:50   07:00
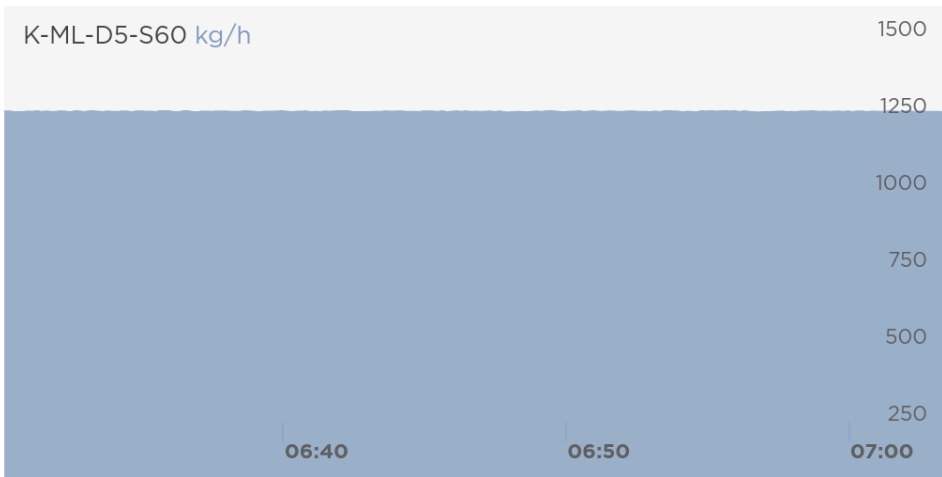
Feeder K2-ML-D5-S60
Product ID 84637383   **Initial Date** 03.07.2015

Component Information
Modular feeding design and interchangeable feeding tools. Highly accurate scale and controls. All product contact parts made from stainless steel and integrated horizontal agitator for improved material flow. Feed rates from 0.43 to 4,500 dm³/hr.

Maintenance Schedule	Contact Maintenance	Contact Coperion
NEXT Mon 19.12.2016	Eric Laser	Christoph Grimm
LAST Tue 20.09.2016	Service Department	Comp. & Extrusion

Get Spare parts at MyCoperion   Order

Sun, Oct 15 | Mon, Oct 16 | Tue, Oct 17 | Wed, Oct 18 | Thu, Oct 19 | Fri, Oct 20 | Sat, Oct 21

Week

ZSK

RAW MATERIALS   COMPOUNDING   FINISHED PRODUCTS

3D ⬤ 2D

6 7 9 8 10 12 13 14

< | 6 Feeder 1 | 7 Feeder 2 | 8 Feeder 3 | 9 Feeder 4 | 10 Feeder 5 | 11 ZSK | 12 ZS-B | 13 ZS-EG | 14 ASC | 15 SP 500 | 16 ZVB | 17 Screener

Vibration mm/s   2
          06:40   06:50   07:00

Gear oil quality %
                                          07:000
          06:40   06:50   07:00

Temperature °C
                                          07:000
          06:40   06:50   07:00

Torque Nm/cm³   80
          06:40   06:50   07:00

ZSK

Product ID 74839404   **Initial Date** 04.07.2015

Component Information

Increases in throughput up to 30%. Maximum operating safety up to a vacuum of 50 mBar. Easy handling due to quick-release locks of assembly and disassembly. Maximum efficiency of the compounding plant.

Maintenance Schedule	**Contact Maintenance**	**Contact Coperion**
NEXT Mon 14.11.2016	Eric Laser	Frank Mack
LAST Wed 12.10.2016	Service Department	Comp. & Extrusion

Get Spare parts at MyCoperion   Order

ⓘ

Sun, Oct 15 | Mon, Oct 16 | Tue, Oct 17 | Wed, Oct 18 | Thu, Oct 19 | Fri, Oct 20 | Sat, Oct 21

Week

The Industry 4.0 Compounding Plant

Virtual reality:

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Optimization

Week **18/17**
1.5-7.5

Intelligent
Sequencing

| Thu 04 | Fri 05 | Sat 06 | Sun 07 | Mon 08 | Tue 09 | Wed 10 |

Performance kg/h

2,500
2,000
1,500
1,000
500

B

C

A

C

6:00 14:00 22:00   6:00 14:00 22:00   6:00 14:00 22:00   6:00 14:00 22:00   6:00 14:00 22:00   6:00 14:00 22:00   6:00 14:00 22:00
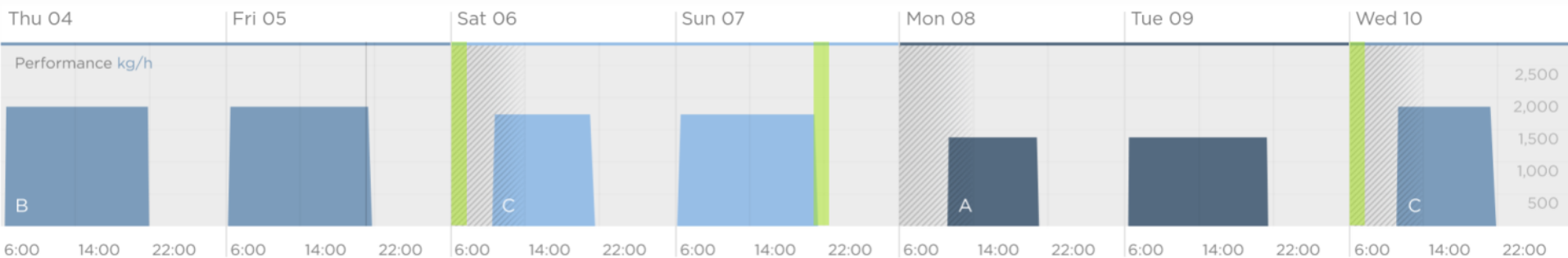
OPTIMIZATION POTENTIAL

Cleaning Cycle   **-50 min**
from 70 min

Off-Spec Material **-50 kg**
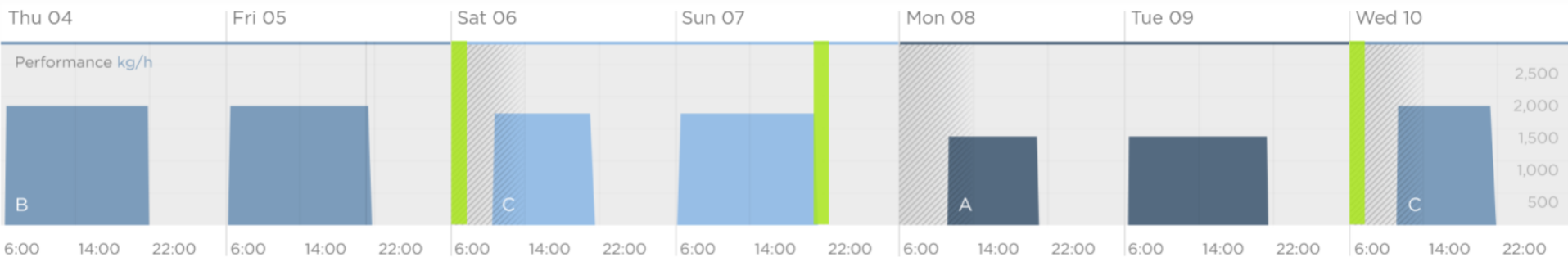from 100 kg

Change Job Sequence   ✕

| B | C | A | → | B | A | C |

OPTIMIZE!

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Week 18/17
1.5-7.5

Intelligent Sequencing

Performance kg/h

Thu 04	Fri 05	Sat 06	Sun 07	Mon 08	Tue 09	Wed 10

B

C

A

C

2,500
2,000
1,500
1,000
500

6:00 14:00 22:00   6:00 14:00 22:00   6:00 14:00 22:00   6:00 14:00 22:00   6:00 14:00 22:00   6:00 14:00 22:00   6:00 14:00 22:00

OPTIMIZATION POTENTIAL

Continue Production until **Hopper** is empty

Overall Time	**-20 min** from 45 min
Cleaning Cycle	**-35 min**
Surplus Production	**120 kg**

OPTIMIZE!

The Industry 4.0 Compounding Plant

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	PE		PP		Additive A		Additive B		Premix
Houston	53.6 t	58.5 t	133.0 t	147.5 t	2.3 t	3.7 t	2.7 t	3.6 t	
São Paulo	134.0 t	51.7 t	115.7 t	122.5 t	6.0 t	6.7 t	6.2 t	6.4 t	
Cologne	308.1 t	317.2 t	227.8 t	242.4 t	13.8 t	13.8 t	10.8 t	10.8 t	
Valencia			145.8 t	38.5 t			4.2 t	10.1 t	
Yulin	134.0 t	150.7 t	191.0 t	222.5 t	6.0 t	8.0 t	7.2 t	8.0 t	
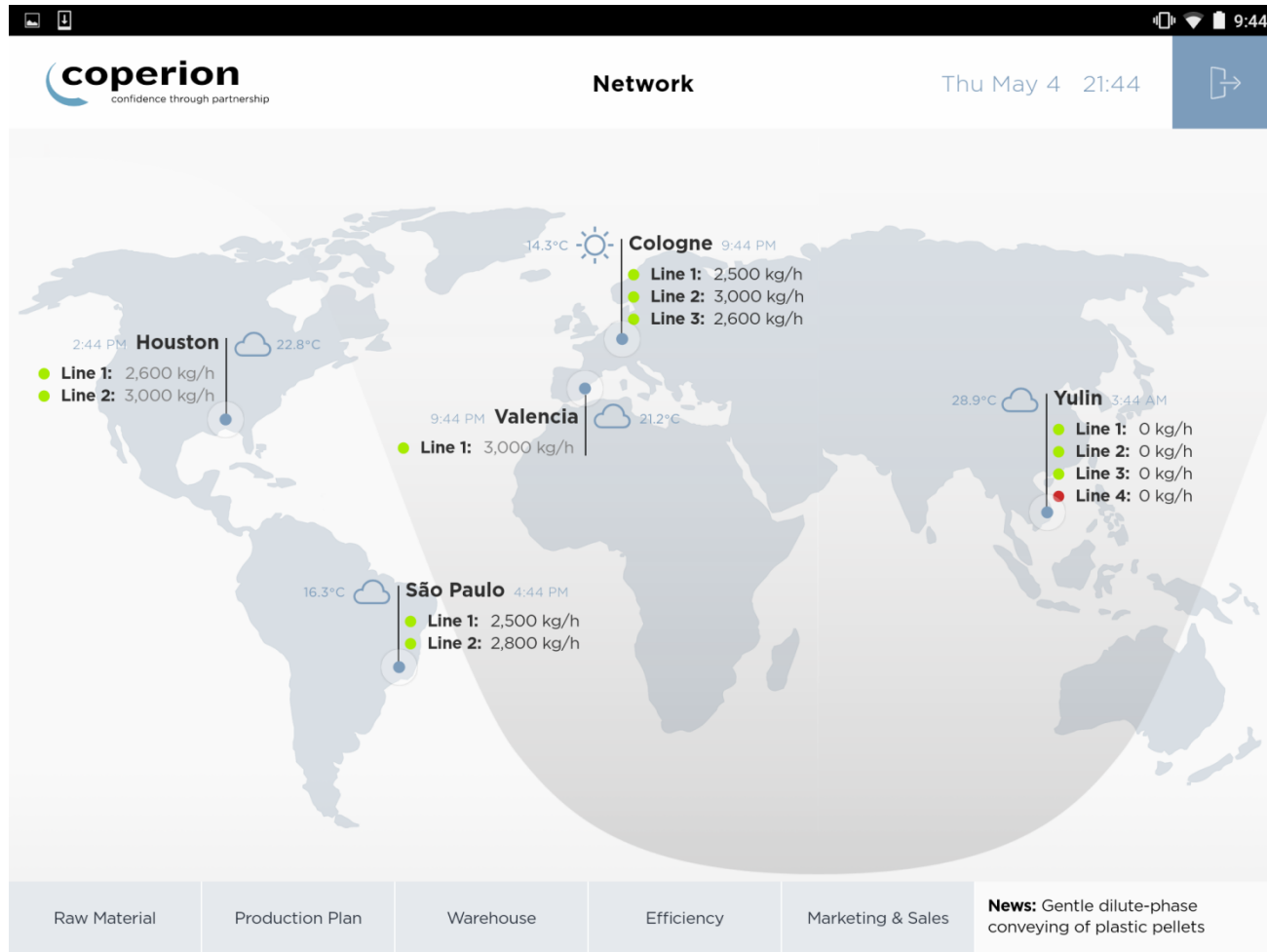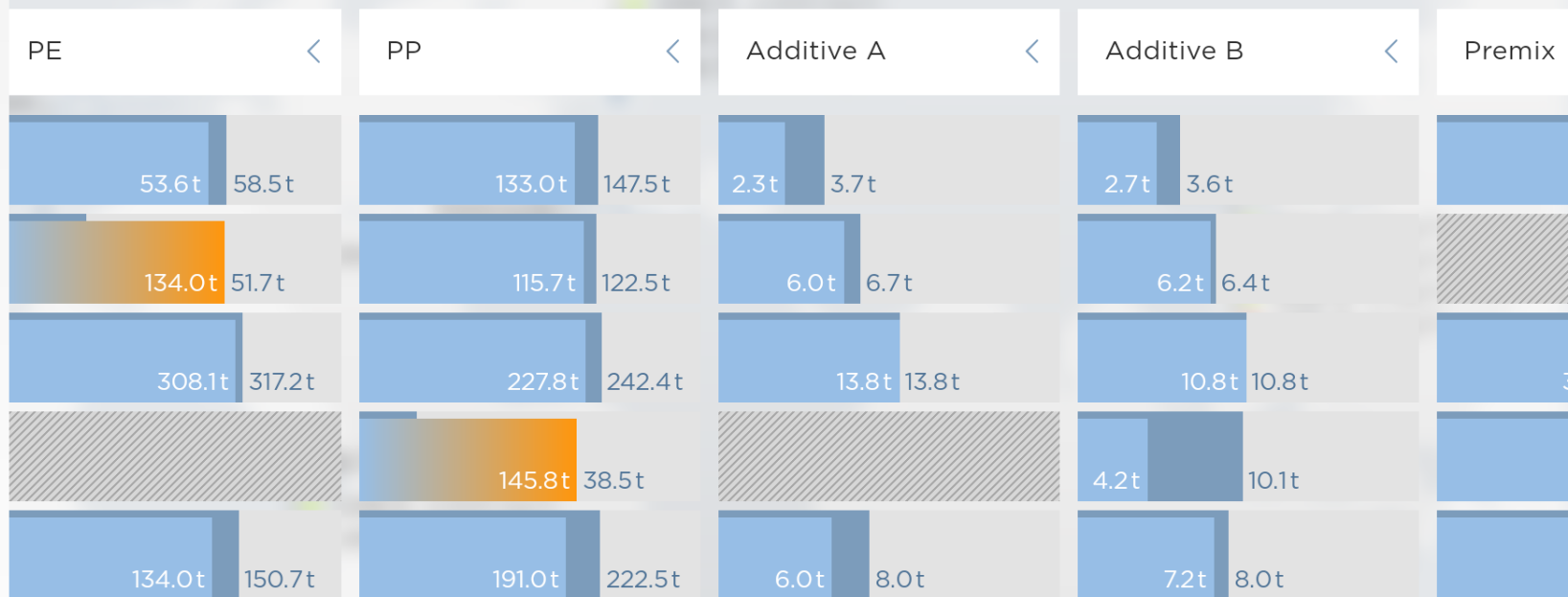
24 hours ⚪ 1 week

⬜ Booked for Production   ⬛ On Stock and Ordered   🟧 Overbooked

Raw Material	Production Plan	Warehouse	Efficiency	Marketing & Sales

News: New developments for high-accuracy feeding and conveying

Production Plan

	01.05. – 07.05.							08.05. – 14.05.						
	Mon 01	Tue 02	Wed 03	Thu 04	Fri 05	Sat 06	Sun 07	Mon 08	Tue 09	Wed 10	Thu 11	Fri 12	Sat 13	Sun 14
Houston														
Line 1	A	A	B	B	B			C	C	A	A	B		
Line 2	B	B	B	C	C			C	D	D	B	B		
São Paulo														
Line 1	A	A	A	A	A									
Line 2	C	C	C	D	E			B	B	B	C	C		
Cologne														
Line 1	A	A	A	A	A			A	A	A	A	A		
Line 2	C	C	C	C	C			C	C/D	D	D	D		
Line 3	A	A	A	B	B			C	C	C	C	C		
Valencia														
Line 1	B	B	B	C	C			C/D	D	D	A	A		
Yulin														
Line 1	A	A	A	B	B			B	A	A	B	B		
Line 2	C	C	C	C	C									
Line 3	A	A	A	B	B									
Line 4														

Legend: ■ Production　■ Product Change Over　■ Maintenance

Raw Material	Production Plan	Warehouse	Efficiency	Marketing & Sales

News: Gentle dilute-phase conveying of plastic pellets

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Houston 1:39 PM

Raw Material	Production Plan	Warehouse	Efficiency

	Booked	On Stock	Total
PE	53.6 t		58.5 t
PP	133.0 t		147.5 t
Additive A	2.3 t		3.7 t
Additive B	2.7 t		3.6 t
Premix	56.1 t		60.0 t
GF	48.0 t		60.0 t
CaCo$_3$	117.5 t		124.0 t

■ Booked   ■ On Stock   ■ Overbooked

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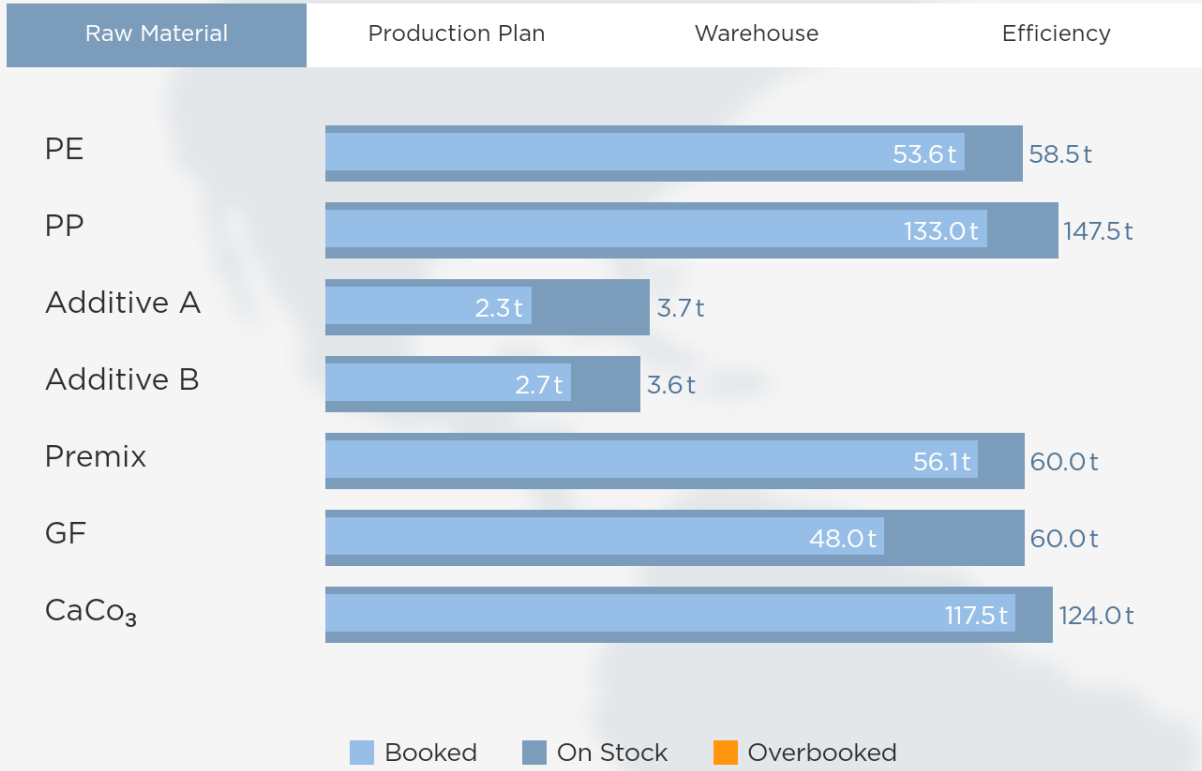
Houston 1:39 PM

Raw Material	Production Plan	Warehouse	Efficiency

		Line 1: ●	Line 2: ●
01.05. - 07.05.	Mon 01	A	B
	Tue 02	A	B
	Wed 03	B	B
	Thu 04	B	C
	Fri 05	B	C
	Sat 06		
	Sun 07		
08.05. - 14.05.	Mon 08	C	C
	Tue 09	C	D
	Wed 10	A	D
	Thu 11	A	B
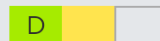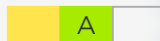
The Industry 4.0 Compounding Plant
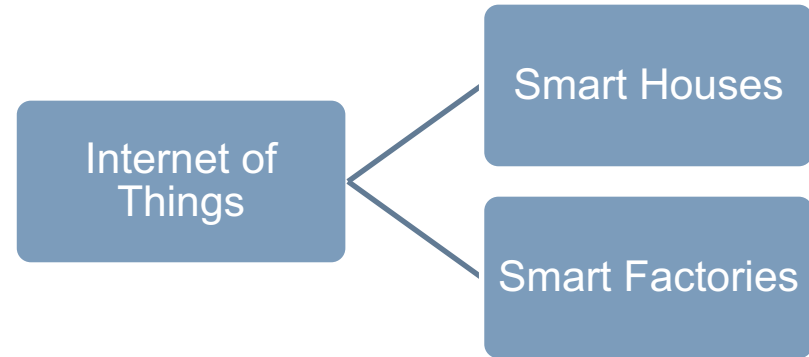
Remote Service:

- Online monitoring and failure recording

- Remote access by OEMs to reduce expensive on-site assignment of service technicians

Why is Industry 4.0 Important?

To increase efficiency!

- Automate more
- Increase productivity of assets
- Reduce scrap
- Respond faster
- Reduce costs

| Internet of Things |
| Smart Houses |
| Smart Factories |

Which tools and devices in your plant can be connected to simplify data or automate tasks on a local level?

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Thank you very much for your attention.

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