

Direct and indirect control of process plants with neural network

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Facts about Uniper

Our operations

Power **Generation** | Commodity **Trading** | Energy **Storage**
Energy **Sales** | Energy **Services**

Main activities



Gas-fired plants
19.2 GW



Wind



Nuclear plants
1.9 GW



Energy sales



Coal-fired plants
10.5 GW



Gas pipelines & infrastructure



Hydroelectric plants
3.6 GW



Engineering services



Energy storage
Gas: 8.5 bn m³



Liquefaction & regasification



Trading



Digital solutions

Content of today's lecture

- **Uniper AI Solution can improve MVA (WIP) Operations**
- **Presentation of the implemented improvements** through the implementation and operation in a pilot plant
- **Presentation of the AI implementation at Uniper**
 - Examples of AI Operator
 - Examples of AI Prediction

Uniper AI-Solution can improve MVA (WIP) Operations

Development of AI applications with the following challenges:

- **Volatile incineration process** (e.g. fresh, damp waste versus high-calorie waste)
- **Long dead times**, e.g. in connection with CO generation, are challenges for plant operators and automation
- **Optimization** of several key figures (e.g. waste throughput, energy efficiency, flue gas reduction, reduction of emissions and consumables, etc.)
- **Human plant** operators often control several blocks / lines in parallel
- **High requirements** with regard to plant and data security
- **Limited budget** for additional equipment



The pilot: 27 months of operation in an MVA (since July'19)

The pilot project	First results	Safety First
<p> waste2energy</p> <p> </p> <p>>17.000 Hours</p> <p>First of its kind</p> <p></p> <p></p>	<p>+10%  Power Generation & Wastethroughput</p> <p>-30%  O2-Level</p> <p>Reduction  Consumables (e.g. oil)</p> <p>Reduction  Emissions (e.g. CO)</p>	<p></p> <ul style="list-style-type: none"><li>✓ Human operator sits in the control room – No replacement<li>✓ AI operator can be stopped at any time<li>✓ Strict separation from boiler protection<li>✓ No external access possible

Uniper's AI solution differs from other AI tools in the energy sector

□ Focus below

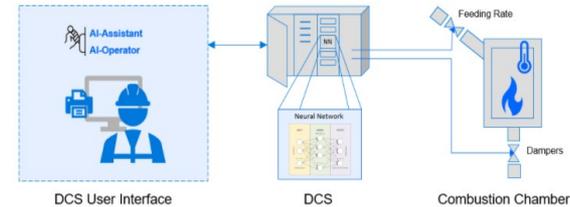
Analyse AI-Tools



- Centralized data analysis
- Mostly cloud-based
- Tools belong to Condition Monitoring, Predictive Maintenance, Combustion Modelling



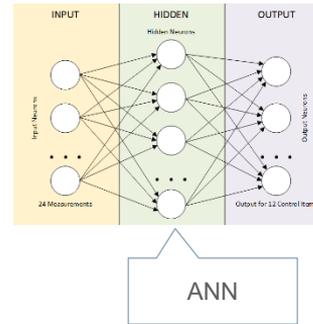
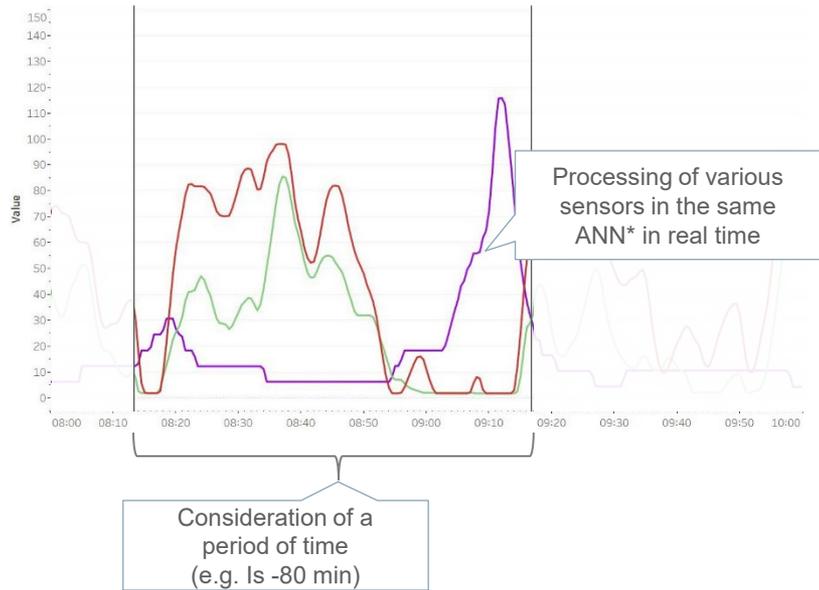
Uniper AI-Tools



- The aim is to operate/automate the system
- Directly embedded in the DCS
- No cloud connection due to the local control system in the plant

Use of artificial intelligence to analyze process data

Analysis of process data with artificial intelligence (ANN*)



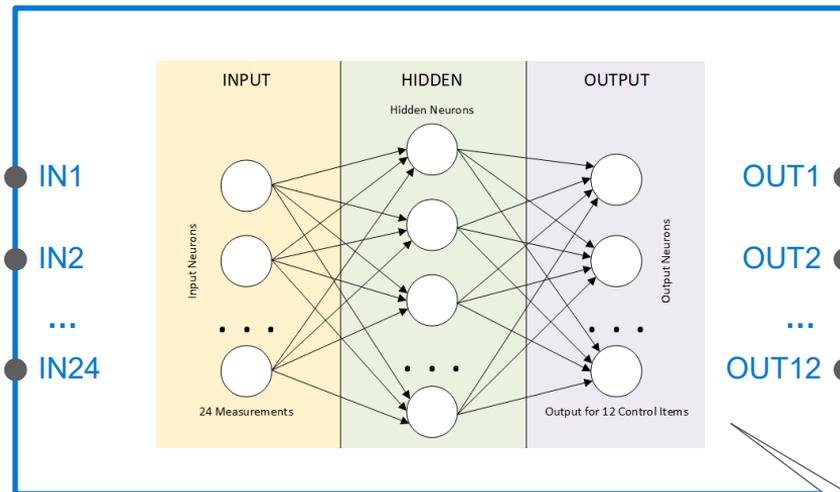
Strengths ANN*

- Detecting correlations
- Pattern recognition
- Recognition of dead times (time-shifted relationships)

AI processes complex relationships

The neural network learns the process image

- 24 measured values
Use of relevant sensor data
- 80 minutes history
- Includes values derived from measured values, e.g. gradient and curvature



Control by AI

- 12 learned control outputs
- Max/Min Values Learned
- Continuous control without delays
- AI can operate the system in 24/7 mode
- AI can handle dead times

Implemented as a **function block** in the DCS
Plant **safety system** is not changed
No cloud – high **data security**



Different operating modes are possible

AI-Prediction



AI anticipates the process



Operator controls the system

AI-Assistant



AI recommends actions



Operator controls the system

AI-Operator



AI controls the system



Works like an autopilot



Operator monitors AI

Example: AI-Assistant/ AI-Operator - 1

Project Setup		Solution	
Type	MVA (WIP)	Step 1: AI-Assistant	
Fuel	waste (350,000 t/a)	<ul style="list-style-type: none">• Recommendations for the air flaps; Optimization of air distribution• Recommendations for the setpoint of the load• Operator control	
Automation	Manual operation	Step 2: AI-Operator	
Location	GER, Lower Saxony	<ul style="list-style-type: none">• Automation of air flaps and automation of the oad setpoint• Operator can switch the AI operator on/off at any time• Positive feedback from the AI Operator by the Operators	
Challenges & goals of the pilot project: <ul style="list-style-type: none">• Older boiler with low automation• Old sensors (tw. over 25 years old)• Older boiler design leads to suboptimal air distribution• Long dead times• Higher waste throughput possible if steam production is equalized			<div><p>AI Operator</p><hr/> AI controls the process  Similar to autopilot-mode  Human Operator supervises process and AI</div>

Example: AI-Assistant/ AI-Operator - 2

Project Setup	
Type	Circulating fluidized bed
Fuel	Sewage sludge (200,000 t/a) dewatered, coal
Automation	Manual operation
Location	GER, NRW
Challenges & Goals:	
<ul style="list-style-type: none">• Keep the temperature in the combustion chamber of the CFB furnace constant at about 890°C• Increase in sewage sludge throughput and steam production• Avoidance of:<ul style="list-style-type: none">- Support burner insert- Unavailability in case of temperature limit violation	

Lösung
Step 1: AI-Assistant <ul style="list-style-type: none">• Recommendations for optimal control of vortex air and the return flue gas• Operator control
Step 2: AI-Operator <ul style="list-style-type: none">• Automation of the frequency converter for the vortex air and the control flap of the return flue gas• The Operator can switch the AI-operator on/off at any time
<div><p>AI Operator</p><hr/><p> AI controls the process</p><p> Similar to autopilot-mode</p><p> Human Operator supervises process and AI</p></div>

Example: AI-Assistant/ AI-Operator - 3

Project Setup		Solution	
Type	Gas-fired power station	Step 1: AI-Assistant	
Fuel	Gas	<ul style="list-style-type: none">• Recommendations for the Lambda correction (fuel/air ratio) to achieve optimum CO, NO2 and O2 at full load• Operator control	
Automation	Fire-Rate-Control		
Location	GER, Bayern		
Challenges & goals of the pilot project:		Schritt 2: AI-Operator	
<ul style="list-style-type: none">• NO2 can only be influenced directly by the firing process• Control of the combustion air to achieve optimum CO, NO2 and O2		<ul style="list-style-type: none">• Automate the Lambda Correction• The Operator can switch the AI-operator on/off at any time	<div><p>AI Operator</p><hr/><ul style="list-style-type: none"> AI controls the process Similar to autopilot-mode Human Operator supervises process and AI</div>

Different operating modes are possible

AI-Prediction



AI anticipates the process



Operator controls the system

AI-Assistant



AI recommends actions



Operator controls the system

AI-Operator



AI controls the system



Works like an autopilot



Operator monitors AI

Example: AI-Prediction – 1 and indirect control

Project Setup	
Type	BMHKW (Biomass)
Fuel	Wood (160.000 t/a)
Automation	Fire-Rate-Control
Ort	GER, NRW

Challenges & Goals:

- Too high boiler ceiling temperatures lead to caking in the boiler, which can damage the grate, when falling down
- However, temperature must remain above 850 degrees C
- Temperature fluctuations are difficult for the Operator to predict

Solution
Step 1: AI-prediction to support the Operator
Boiler ceiling temperature prediction
<ul style="list-style-type: none">• Using this information, the Operator can proactively control the combustion and operate the temperature more evenly• Optimization of combustion temperature• This is the concept of indirect control!
Step 2: AI-operator (planned)
<ul style="list-style-type: none">• Training of the AI operator on the basis of the optimized manual operation with the help of AI Prediction!

AI Prediction

 Predicting certain process developments (Steam, CO, O2 etc)



Full control with Human Operator

Example: AI-Prediction – 2 and indirect control

Projekt Setup	
Type	MVA (WIP)
Brennstoff	Müll (447.000 t/a)
Automation	Fire-Rate-Control
Location	GER

Challenges & Goals:

- Fresh, damp waste will be delivered around 8:00 a.m.
- The Fire-rate-control interprets the data incorrectly, it will heap the grate
- This regularly leads to steam drops
- Oil use is required to reach combustion temperature again

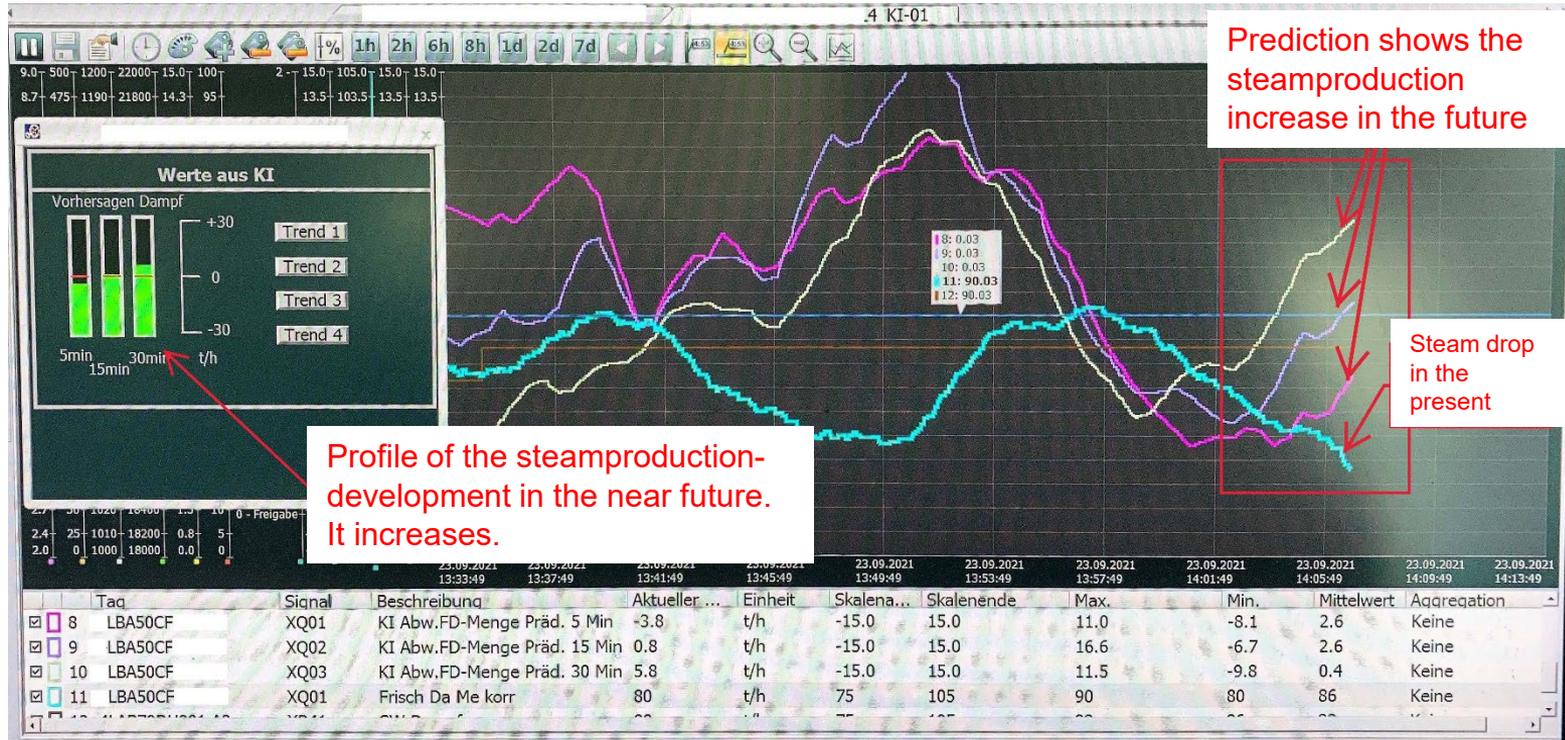
Lösung
Step 1: AI-Prediction Tool <ul style="list-style-type: none">• Prediction of steam production• Based on the forecast, measures can be taken to avoid the steam drop• Avoidance of steam drops, maintaining temperature and more efficient combustion• This is the concept of indirect control!
Step 2: AI-Operator (planned) <ul style="list-style-type: none">• Training of the AI operator on the basis of the optimized manual operation with the help of AI Prediction!

AI Prediction

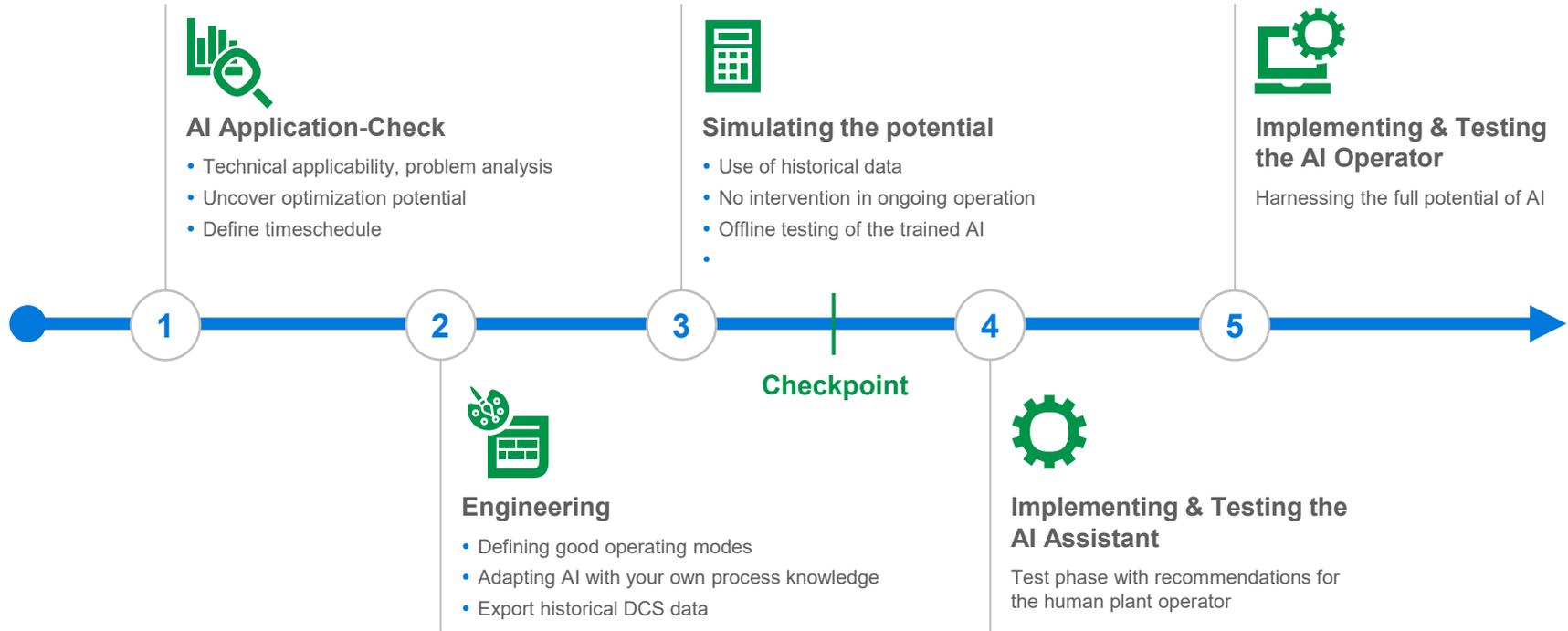
 Predicting certain process developments (Steam, CO, O2 etc)

 Full control with Human Operator

Example: AI-Prediction – 2 and indirect control



5 simple steps to a successful AI project



We have developed our AI for different use cases

Project References (Excerpt)

Grate furnace: Waste / Biomass

- Reduction of emissions and increase the steam production and waste throughput through **optimization** of the **incineration process**
- Reduction of boiler contamination / extension boiler operating period by reducing boiler temperature
- **Prediction of steam drops**
- **Prediction of CO peaks**

Fluidized bed

- **Control of combustion air**

Gas boiler

- Increase of maximum performance by **trimming combustion air** (Gas boiler)



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