Flexibilisation of Power Plants

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Agenda

About Uniper

EU market requirements for flexibility

Our response: Coal

Our response: CCGT

Wrap up and Q&A

Uniper is an international energy company currently having ~42GWs under operations

European Generation

- One of the largest European generators with 31 GW of own, mostly dispatchable generation capacity
- Diversified base across technologies and main NWE markets
- Strong capabilities in construction, operations and maintenance

Global Commodities

- A leading physical energy trader with global footprint
- Trading financial and physical gas
- Long term contract gas and stakes in pipelines
- LNG liquefaction and regas, fields and gas storage sites
- Trading financial and physical power
- Trading financial and physical coal and freight

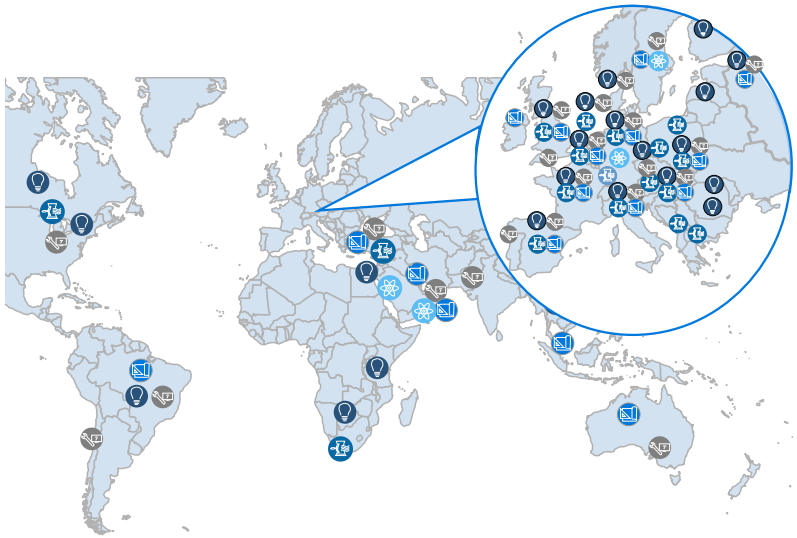
International Power

- Number 3 privately-owned Russian generation company
- ~30% capacity increase since 2010
- 11 GW of generation assets
- JV in Brazil with assets under operation and strong pipeline

Our assets, capabilities enable delivery of bespoke, competitive energy products & services

Uniper's portfolio and capabilities allows to offer technology services with global footprint

Global footprint and broad service offerings



- Innovation delivery
- Project management / development
- Engineering services
- Nuclear services
- Maintenance and asset optimization

Value proposition

Leading one-stop-shop energy solutions provider with services across the value chain and life-cycle

Optionality to tap into global new-build project opportunities

Business at a glance (UEG[1])

- ✓ Expertise across multiple technologies
- ✓ Services to more than 600 customers[2]
- ✓ Active in more than 40 countries[2]

1. Uniper Engineering GmbH
2. Based on 2015

Uniper & India Power have formed a strategic partnership to service Indian power sector

uniper + INDIA POWER 97 Years of Discipline Dedication Devotion
Adding Power To Life

India Uniper Power Services

- 50:50 joint venture in power plant services
- A value-based service provider
- Offering a broad range of flexible and customised services
- Headquartered in Kolkata

The joint venture will combine strengths of strong partners with complementary scope and portfolio. Key service offerings:

- Plant operations and maintenance,
- Asset monitoring software and analytical tools,
- Flexibilisation of units, Lifecycle extension,
- Engineering and integration of pollution control equipment and systems, etc.

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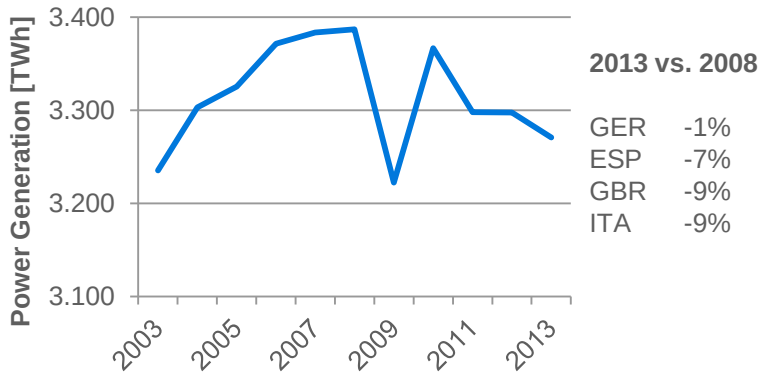
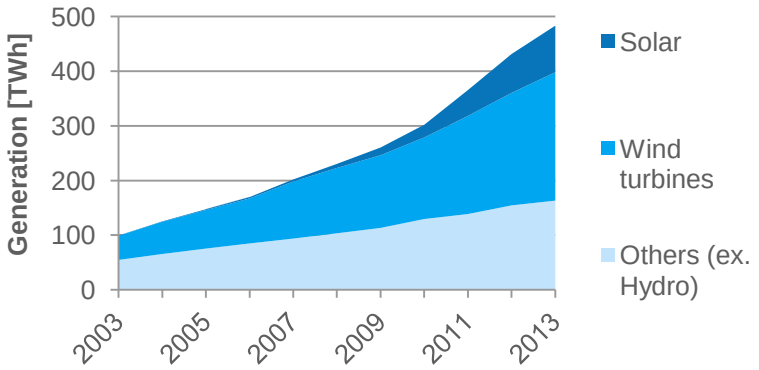
What is happening in Europe today?

European power generation with decreasing trend



Strong renewables growth in Europe



Source: Eurostat (code: nrg_105a)

1. Reduction in Demand

- Global recession has destroyed power demand across Europe

2. Global Commodity Prices

- CO_2 prices have dramatically fallen caused by oversupply – attempts to reform have failed to date
- US shale gas has increased US coal exports making coal generation cheaper than gas
- Recently this has reversed as global gas prices have fallen putting coal at margin

3. Renewables Growth

- Incentive schemes designed to deliver European 2020 targets have caused the strong and constant growth of Renewables

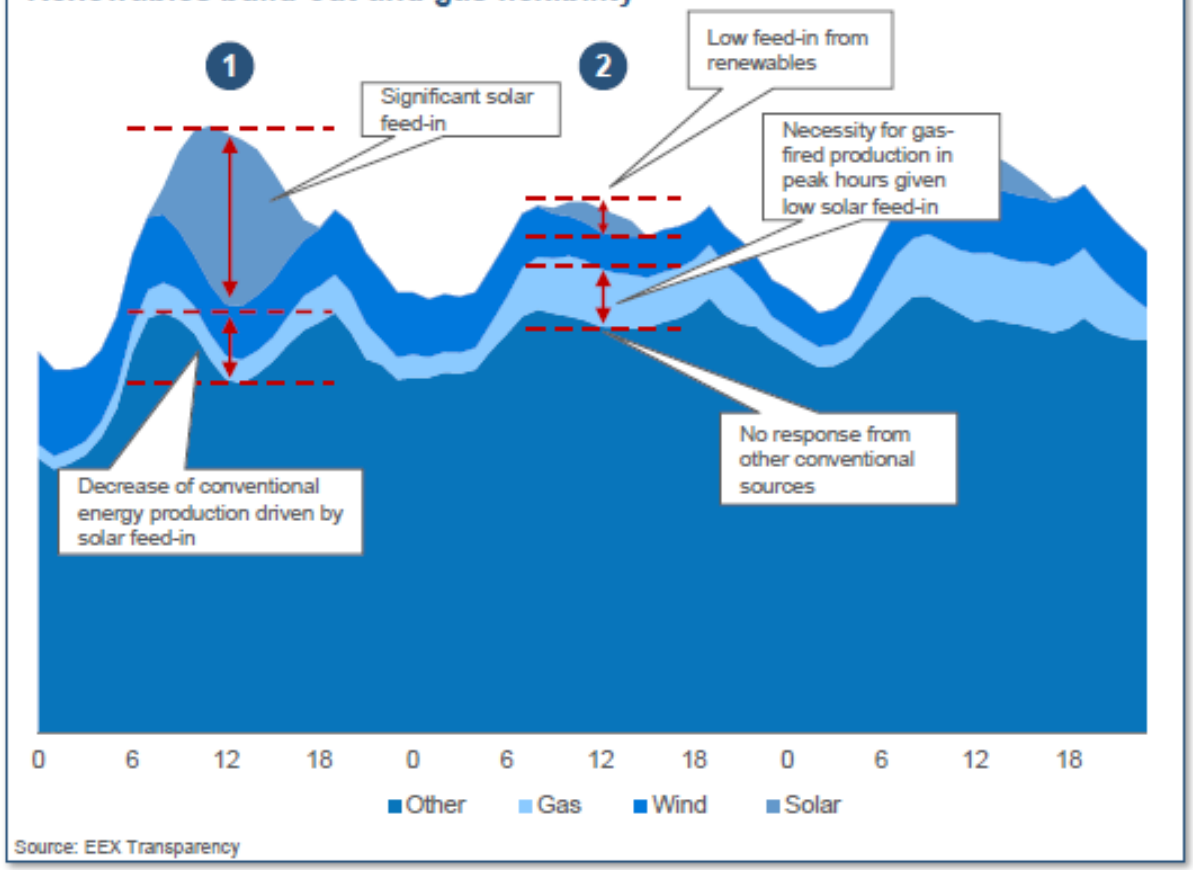
4. Political Intervention

→ **Change in operating regime for coal and gas power plants from base load to flexible**

→ **Sometime gas needs to be flexible and sometime coal**

On May 08, renewable electricity “probably” covered ~90% of power demand in Germany

Renewables build-out and gas flexibility[1]



Source: EEX Transparency

Key considerations

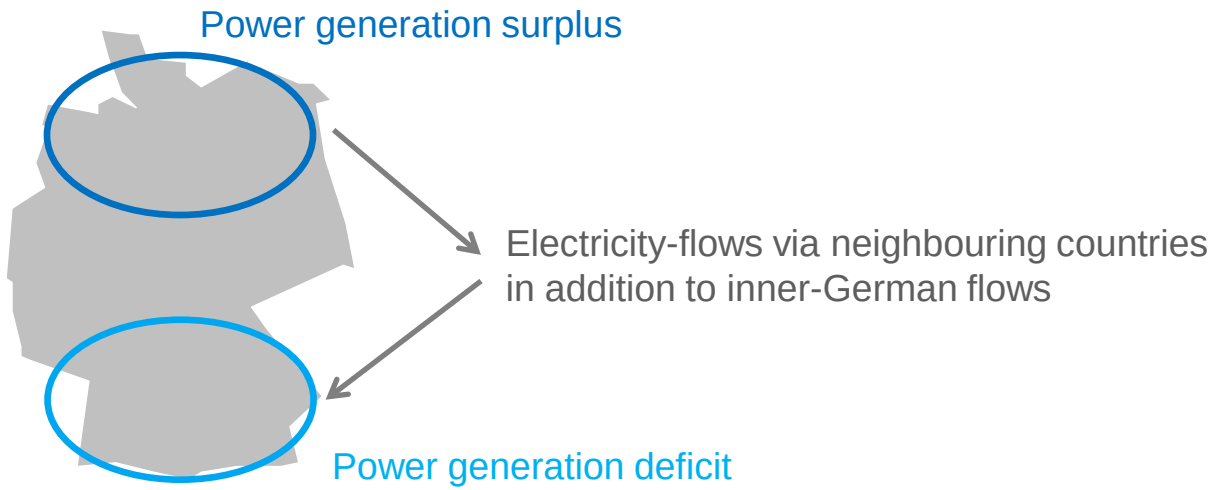
1. Significant renewables feed-in with direct impact on electricity production from conventional power plants

   Very limited production by conventional power plants in times of high renewables feed-in

2. Conventional power plants required to address hours of limited renewables production

→ **It is very difficult to predict the role of fossil generation as it is very dependent upon weather patterns**

The German energy transition has also implications for other European countries



⇒ Power generation surplus in the north; power generation deficit in the south; this discrepancy will even become stronger over time

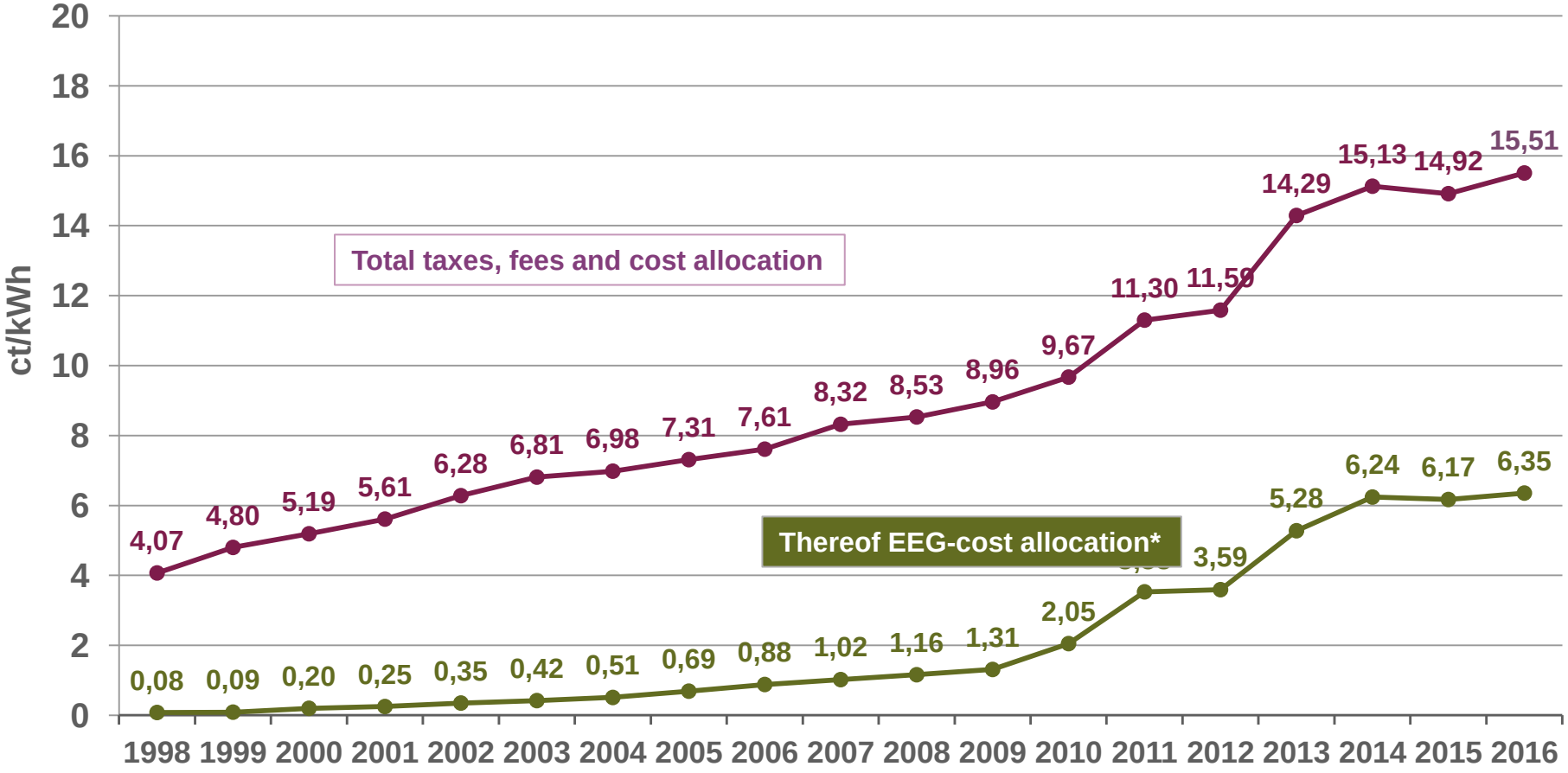
⇒ Grid extension needed to bring the electricity to where it is needed

⇒ Lack of transmission routes in Germany leads to electricity-flows via neighbouring countries, causing power system stability issues

……and for customers

Components of average power-prices for households (ct/kWh)

Yearly demand of 3.500 kWh

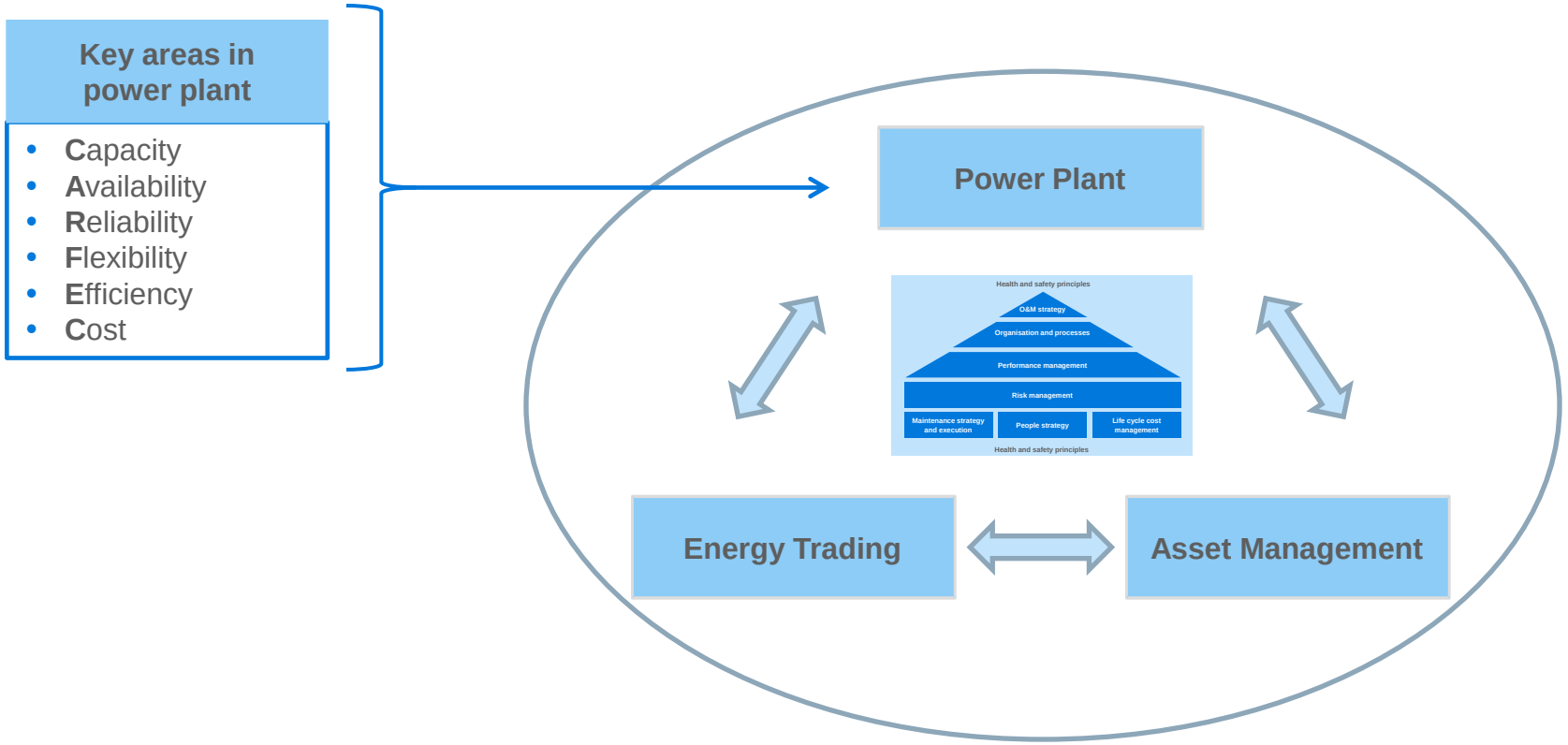


* ab 2010 Anwendung AusgleichMechV

Source: BDEW, Stand: 01/2016

Rapidly evolving power market puts pressure on power plants from various dimensions

Once you understand the market you can focus on a number of key areas to adapt the plant



- 6 basic technical parameters (CARFEC) that can be optimised
- All parts of the organisation must work together
- Trade offs have to be made while choosing one or more of the CARFEC parameters for optimisation

Various potential scenarios for operating fossil plants arise from flexibility requirements in EU

Scenario	Requirement for fossil plants	Adaption response (CARFEC)
High renewables in feed meets demand (e.g. summer / windy)	Standby mode / preservation	Availability, Reliability & Cost – Preservation strategy
Intermittent renewables (e.g. solar in Northern EU)	Start at short notice for TSO (often within 1 hour), fast ramping	Reliability, Flexibility & Cost – reduce start costs and increase performance
High solar (e.g. Southern EU)	Night time only operation	Availability, Reliability & Cost – change operations
No wind/sun (anticyclone in winter)	Must run	Availability, Reliability & Cost - back to old operations regime
Grid constraints and poor renewable reactive power and frequency response performance	Offer reliable ancillary service products	Reliability, Flexibility & Cost

Impact on auxiliary systems depends upon flexibility required

Preservation equipment

- New auxiliary equipment required for preservation strategy (e.g. dehumidifiers, stack balloons)
- Needs to be able to be installed and removed as required by the market

Variable and low load operation

- Many motors replaced by variable speed drives
- Auxiliary boiler integrity
- Fuel supply, stocking and feeders
- By-products strategy
- Ammonia and limestone supply and stocking

DCS & monitoring

- DCS control changes may be required (e.g. drain valves)
- Monitoring may need to be more real time due to risk and commercial need
- A new data strategy is needed

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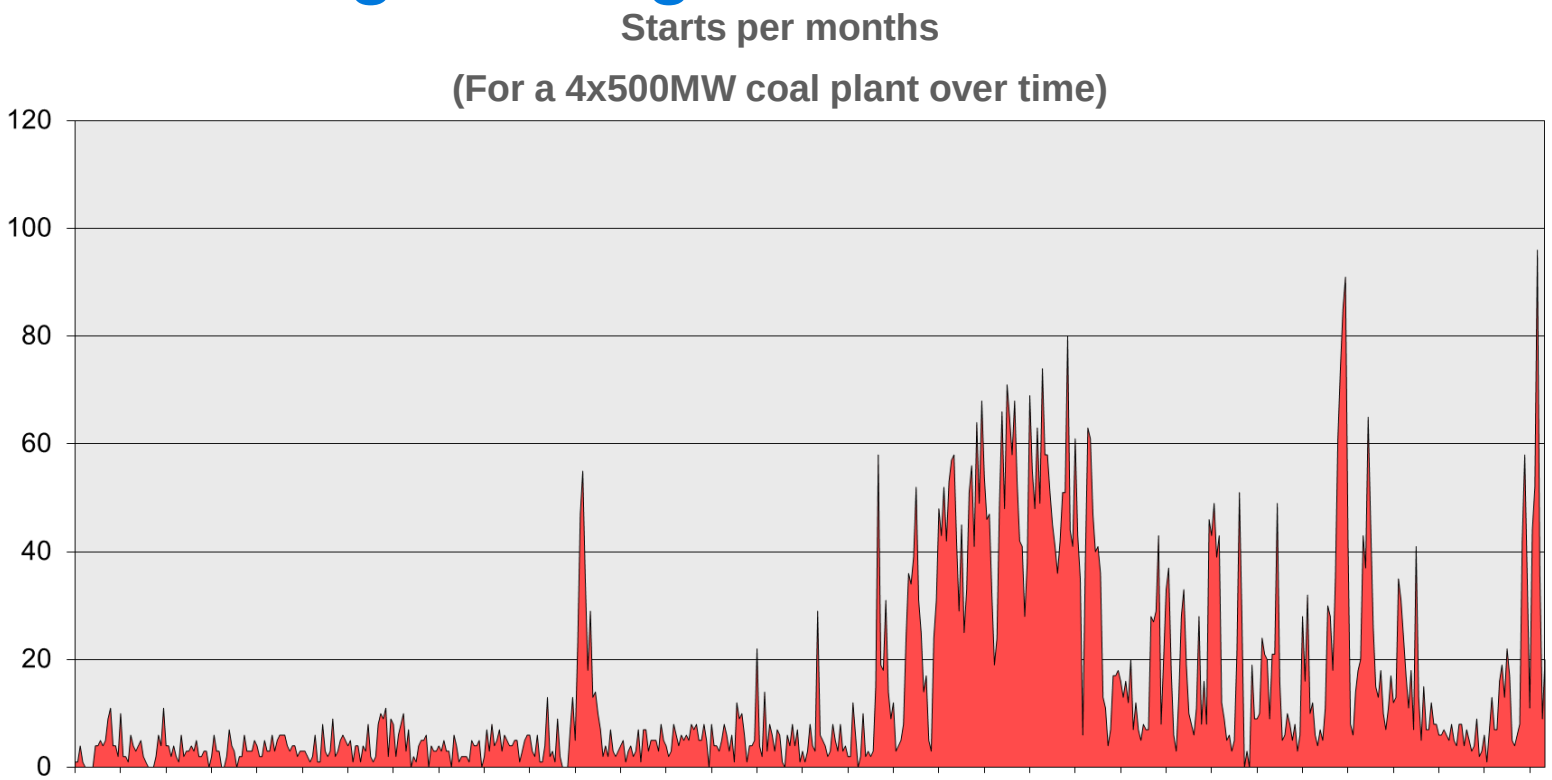
Aim: Provide flexibility without risking integrity or increasing running costs



Achievements for this plant:

- Efficient start up (reduction in time, variability and costs)
- Reduced notice to synchronise and unit synch intervals
- Increased ramp rates
- Efficient coal stock management and by-products management

By-products - 50mill EUR p.a. turnover from 15 flexible coal plants and stable customer demand

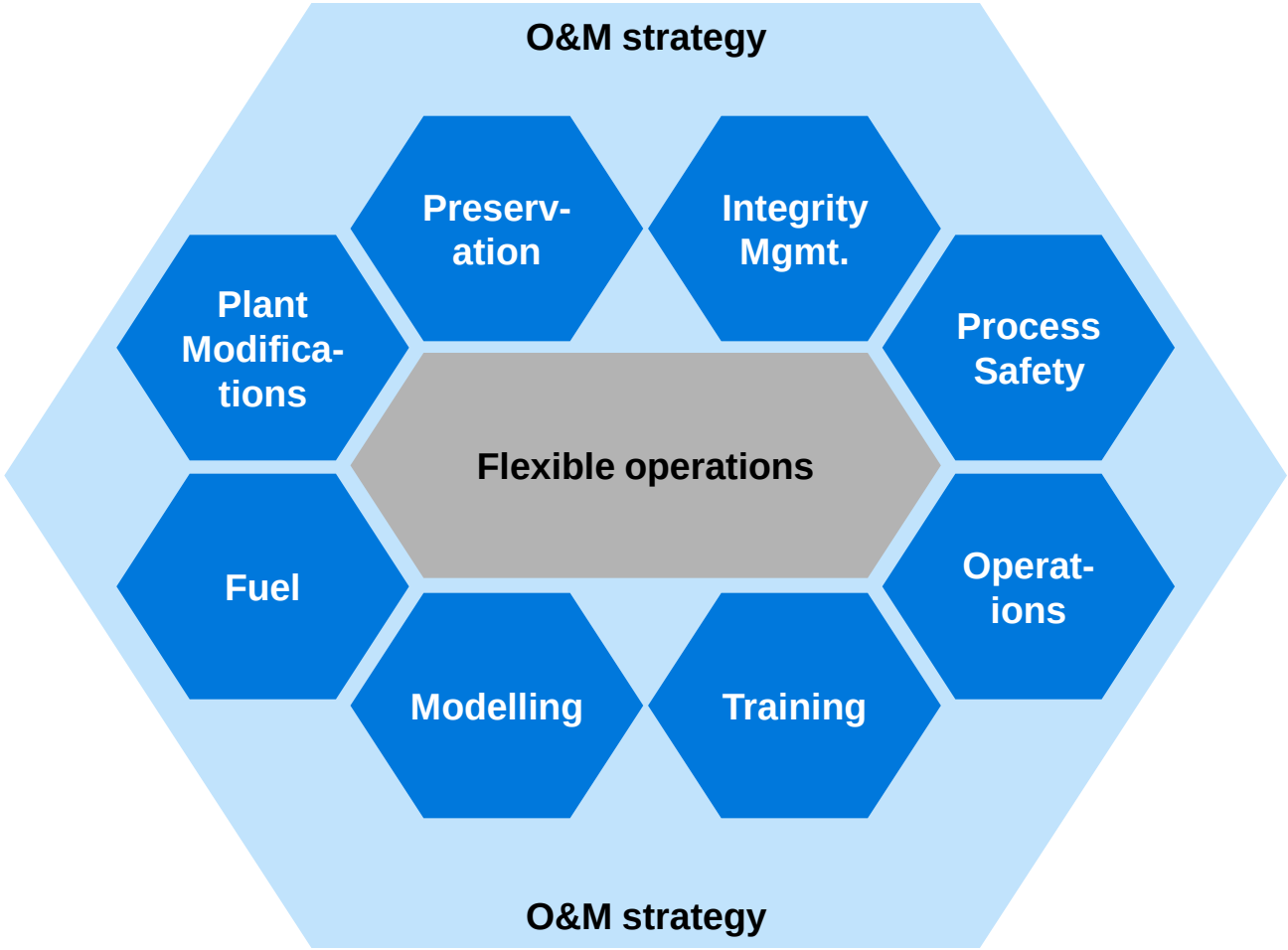
Products of BauMineral

- 1.3 million t of concrete addition EFA- Füller®
- 0.3 million t of hard coal fly ash BM-Füller®
- 0.2 million t boiler slag Isogran®
- 0.2 million t bottom ash Grobalith®
- 0.5 million t gypsum

BauMineral KraftWerkstoffe

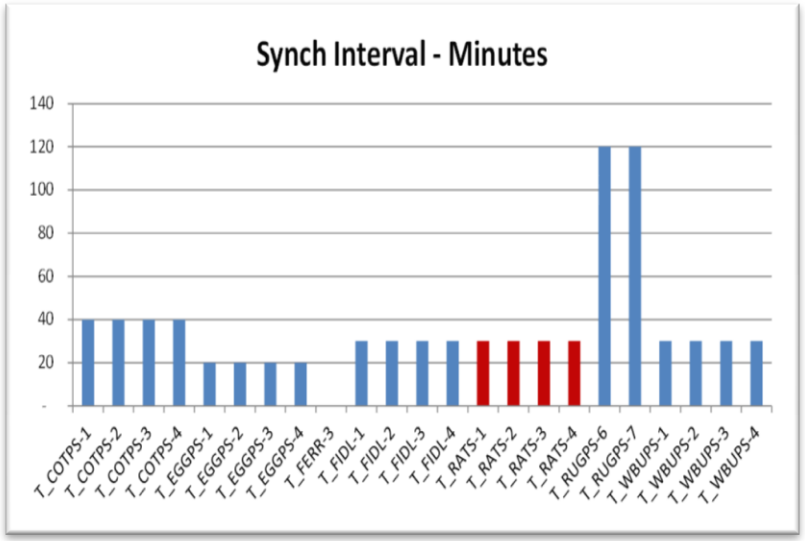
Separate specialist company manages all the storage and handling of by-products
Investing in silos, benefication and blending facilities at strategic locations
Not just on Uniper sites but in “clusters”
Can ensure customer supply and quality

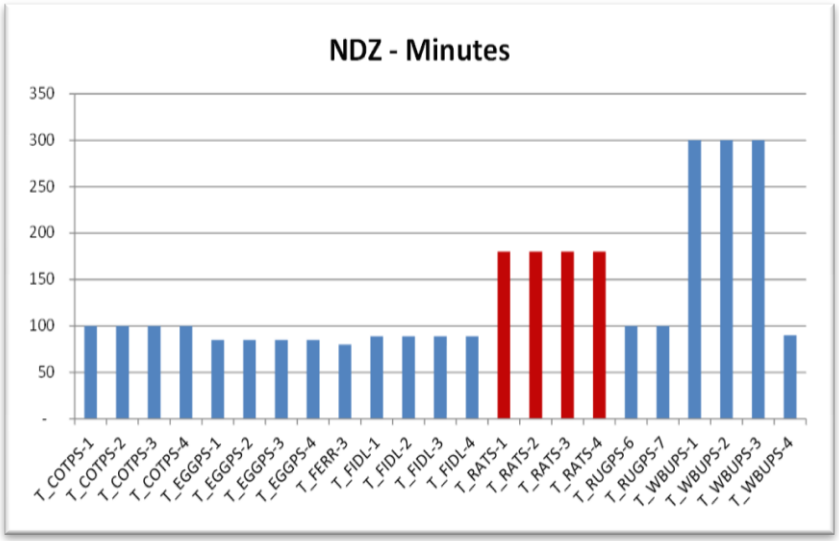
Most modifications are not to physical plant but to other areas of O&M strategy

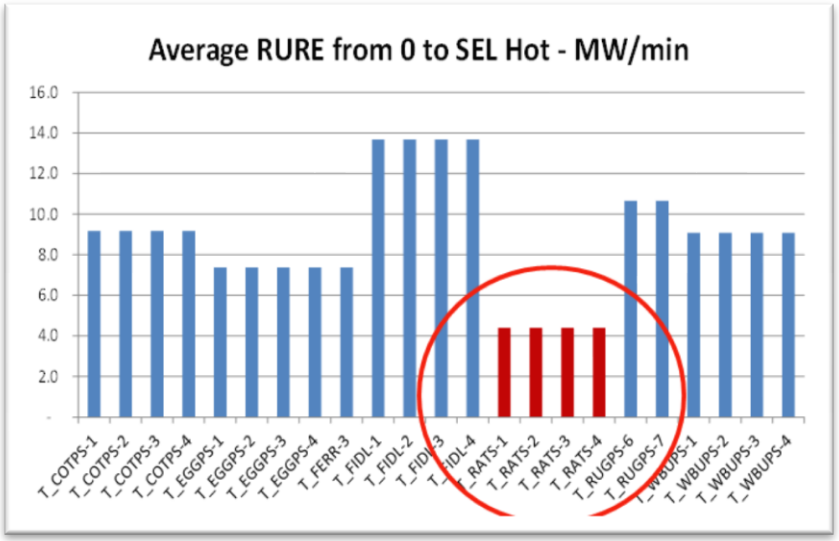


uniper …. underpinning it all Is monitoring and data

Data - Focus is on being best in class and continuous improvement using benchmarking

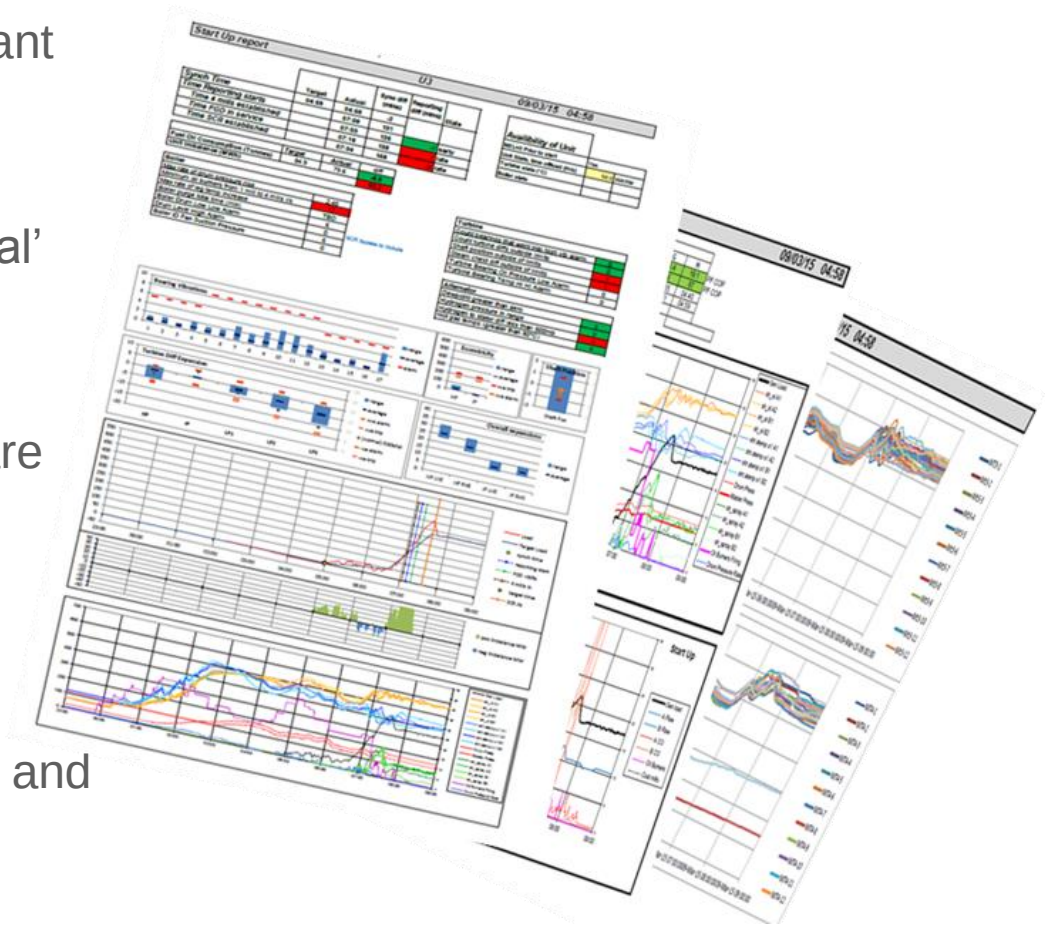






Monitoring - Understand deviation from ideal start to maximise value and consistency

- Auto generated report using plant data
- Compares each start to an ‘ideal’
- Used as a ‘passive’ tool by operators to review and compare starts and identify areas of improvements
- Has already played a part in reducing oil usage on start-ups and so reduce start up costs and increase competitiveness



Target training and best practice to improve consistency and performance of operators

Oil Use

Oil Burners

Boiler (and alarms)

Times synch, target synch

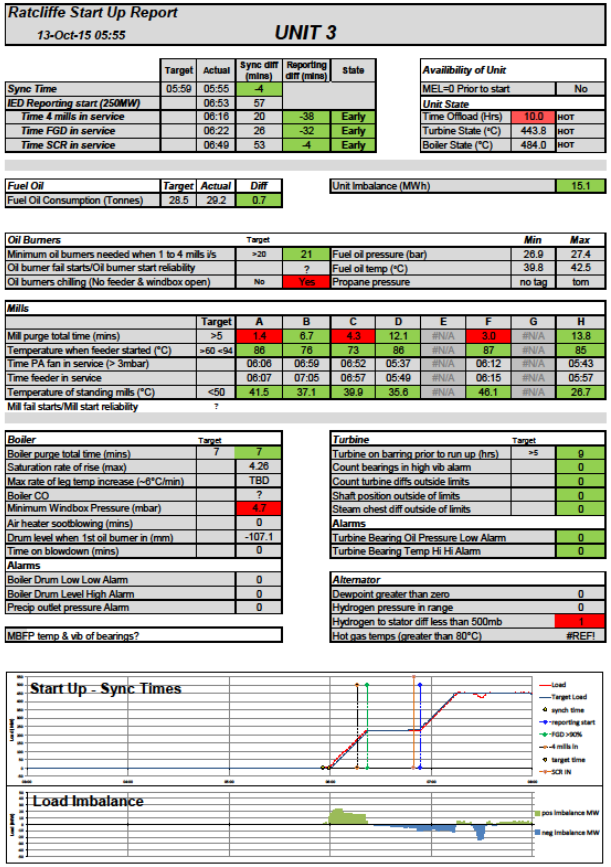
Mill Performance

Turbine (and alarms)

Alternator

Load / Target and key times

Imbalance



Ratcliffe Start Up Report

13-Oct-15 05:55

UNIT 3

	Target	Actual	Sync diff (mins)	Reporting diff (mins)	State
Sync Time	05:59	05:55	-4		
IED Reporting start (250MW)		06:53	57		
Time 4 mills in service		06:16	20	-38	Early
Time FGD in service		06:22	26	-32	Early
Time SCR in service		06:49	53	-4	Early

Availibility of Unit		
MEL=0 Prior to start		No
Unit State		
Time Offload (Hrs)	10.0	HOT
Turbine State (°C)	443.8	HOT
Boiler State (°C)	484.0	HOT

Fuel Oil	Target	Actual	Diff
Fuel Oil Consumption (Tonnes)	28.5	29.2	0.7

Unit Imbalance (MWh)	15.1

Oil Burners	Target			Min	Max
Minimum oil burners needed when 1 to 4 mills i/s	>20	21	Fuel oil pressure (bar)	26.9	27.4
Oil burner fail starts/Oil burner start reliability		?	Fuel oil temp (°C)	39.8	42.5
Oil burners chilling (No feeder & windbox open)	No	Yes	Propane pressure	no tag	torn

Mills	Target	A	B	C	D	E	F	G	H
Mill purge total time (mins)	>5	1.4	6.7	4.3	12.1	#N/A	3.0	#N/A	13.8
Temperature when feeder started (°C)	>60 <94	86	76	73	86	#N/A	87	#N/A	85
Time PA fan in service (> 3mbar)		06:06	06:59	06:52	05:37	#N/A	06:12	#N/A	05:43
Time feeder in service		06:07	07:05	06:57	05:49	#N/A	06:15	#N/A	05:57
Temperature of standing mills (°C)	<50	41.5	37.1	39.9	35.8	#N/A	46.1	#N/A	26.7
Mill fail starts/Mill start reliability		?							

Boiler	Target	
Boiler purge total time (mins)	7	7
Saturation rate of rise (max)		4.26
Max rate of leg temp increase (~6°C/min)		TBD
Boiler CO		?
Minimum Windbox Pressure (mbar)		4.7
Air heater sootblowing (mins)		0
Drum level when 1st oil burner in (mm)		-107.1
Time on blowdown (mins)		0
Alarms		
Boiler Drum Low Low Alarm		0
Boiler Drum Level High Alarm		0
Precip outlet pressure Alarm		0

MBFP temp & vib of bearings?

Turbine	Target	
Turbine on barring prior to run up (hrs)	>5	9
Count bearings in high vib alarm		0
Count turbine diffs outside limits		0
Shaft position outside of limits		0
Steam chest diff outside of limits		0
Alarms		
Turbine Bearing Oil Pressure Low Alarm		0
Turbine Bearing Temp Hi Hi Alarm		0

Alternator	
Dewpoint greater than zero	0
Hydrogen pressure in range	0
Hydrogen to stator diff less than 500mb	1
Hot gas temps (greater than 80°C)	#REF!

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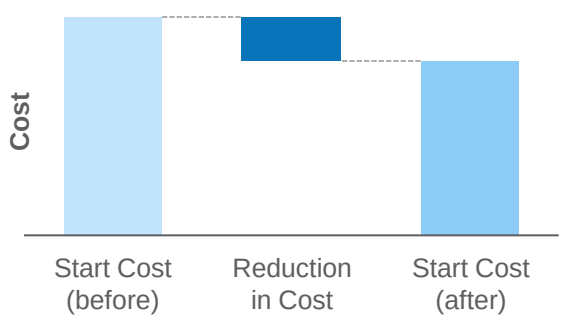
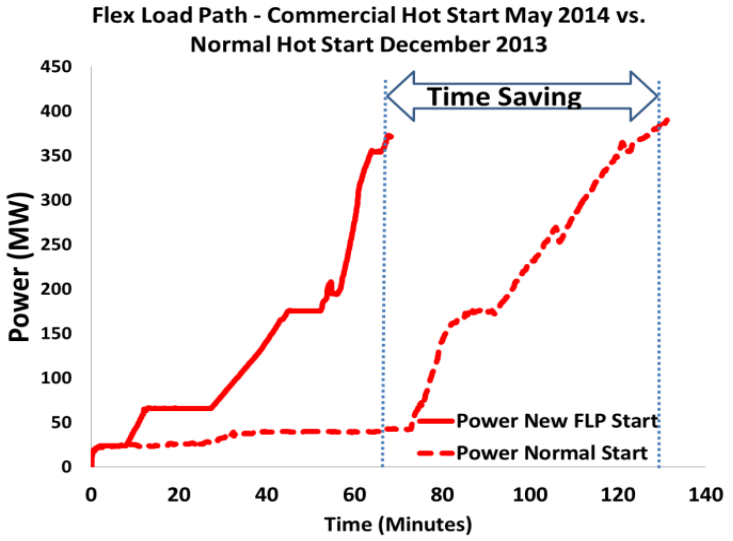
On CCGT plants we have achieved 50% reduction in start up time

Approach

- Steam cycle is the constraint
- For 9FA gas turbine
  - GE trial site for flex load path
  - Uniper engineers focused on HRSG and steam turbine
- Thermodynamic model of system built
- Validated by thermocouples and test runs
- Many control system changes for HRSG and BOP
- Main investment improving aux boiler, thermocouples, DCS mods and condition monitoring

Example





1 Original Equipment Manufacturer

Use of Real Time Data

Production

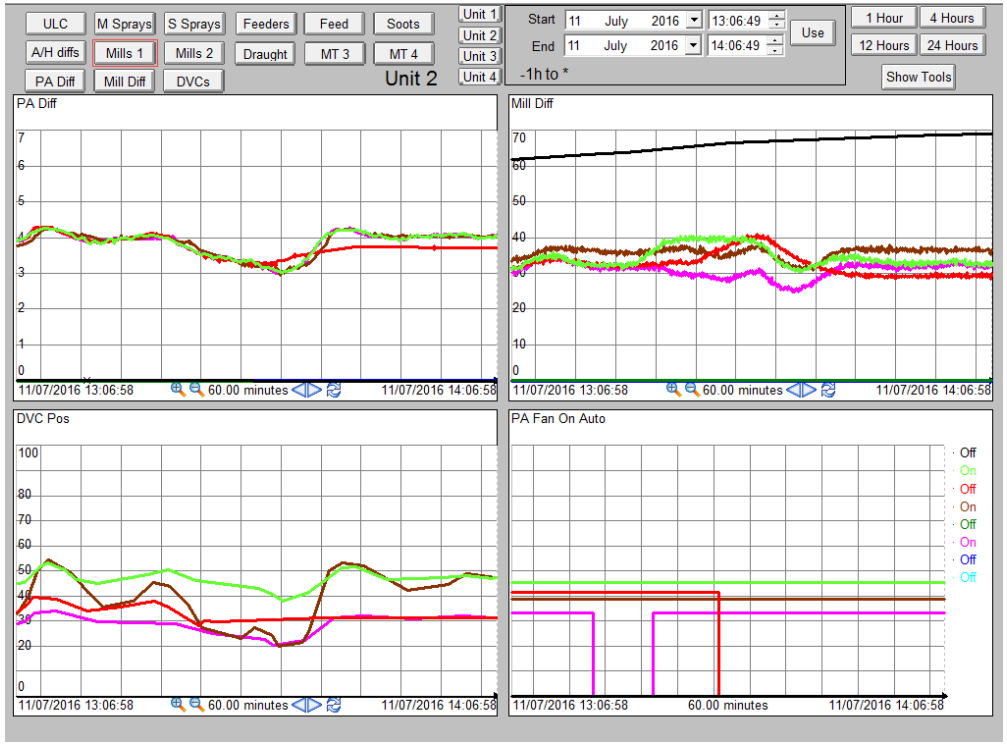
- Trends
- Process Reports
- Watchdog
- On Line Efficiency Monitor

Maintenance / Engineering

- Equipment running hours
- Number of operations (eg breakers)
- Brushgear Maintenance
- Plant Condition

Linking into Other part of business

- PROATES – thermodynamic model
- ACM/SPHERICAL
- Market data

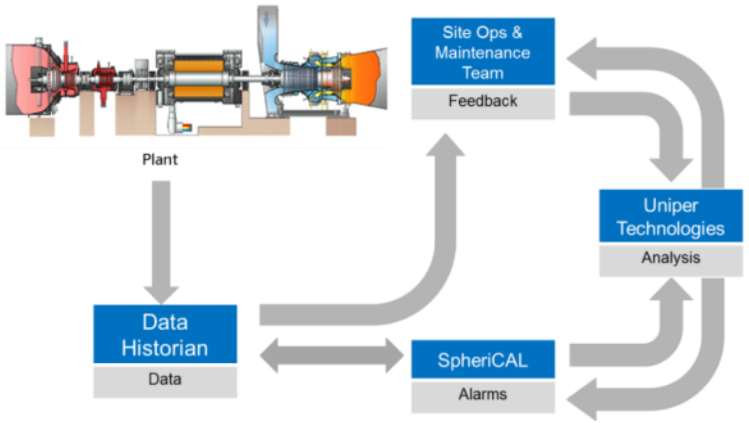


Data is analysed over time for asset integrity

Approach

- Uniper utilises plant data and advanced algorithms within Uniper proprietary software “Spherical” to provide full plant health monitoring
- Advance Condition Monitoring (ACM) provides a highly effective and efficient data screening solution
- Sites manage their plant operation and maintenance more efficiently
- Optimised condition based maintenance strategy reduces unplanned unavailability

Example

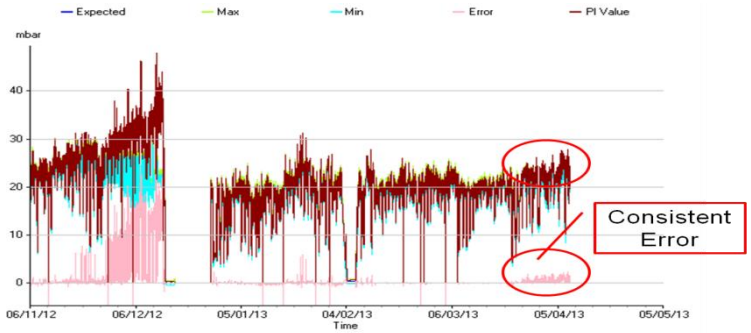


- Works in parallel with existing vibration monitoring services
- Issues are reviewed on exception during normal office hours
- Technical experts investigate and provide recommendations when necessary
- Communication is via web portal, email, phone and reports

Condition Monitoring : Case Study

Technology : Steam	Type : ACM	Site : Maasvlakte	

- ACM found early symptoms of an airheater blockage (approx 1 month)
- Reported to station shortly before a catalyst replacement outage
- Sufficient time to organise an airheater plan in the same outage



dP across Air Heater A side increasing, similar to 1 month before last clean

- SpheriCAL provided early warning of the developing problem – 1 month
- Avoided an additional 3 day outage later in the year **saving €250k**

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