emperature Imbalance And Fluctuations Due T
Difficult Fuels - Diagnosis, Counter Measures -

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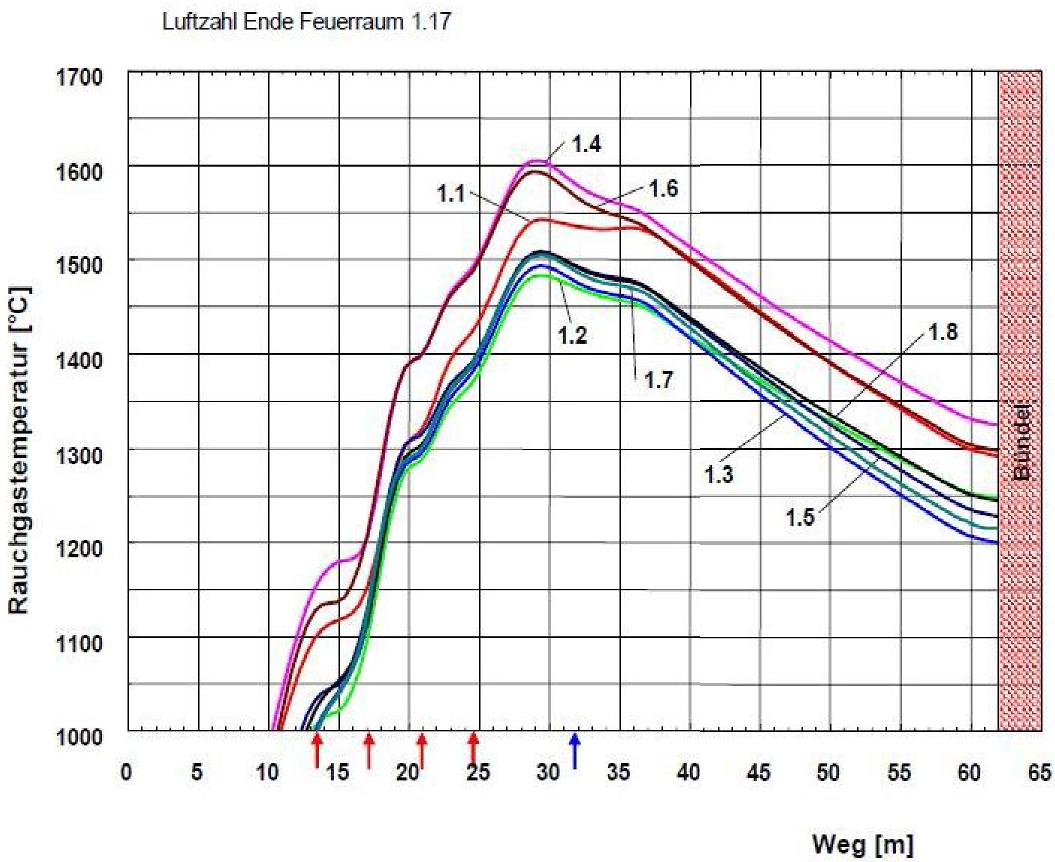
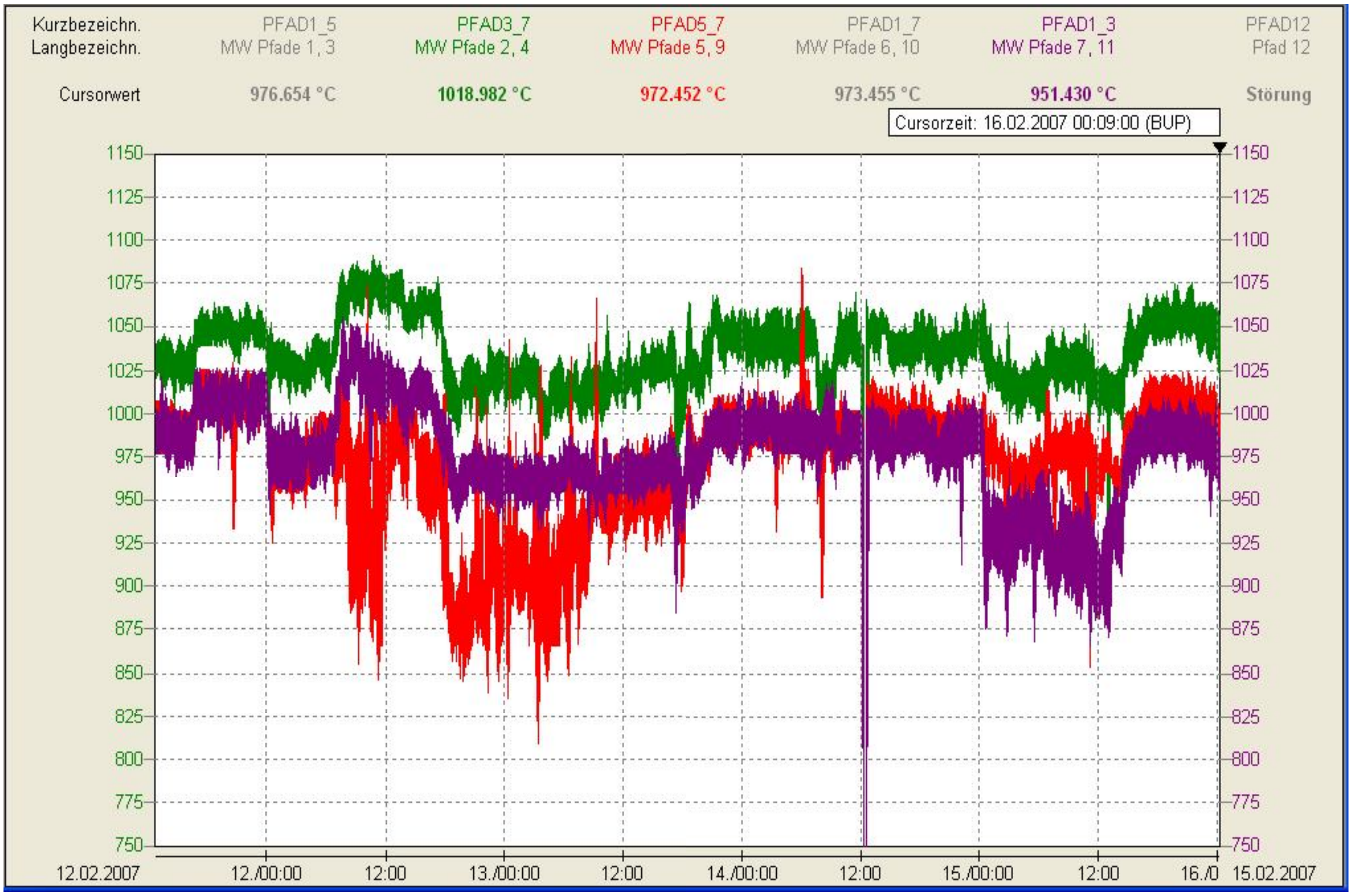
Bonnenberg & Drescher Projektentwicklung GmbH,
Aldenhoven, Germany

Average Temperature



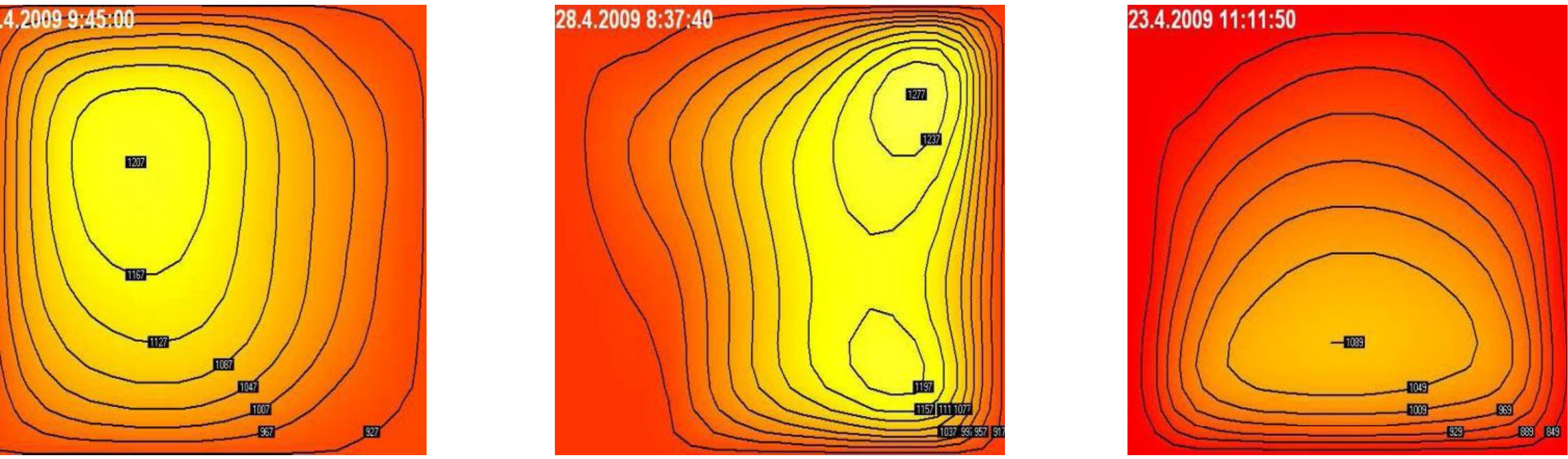
Brenn-stoff	Emissivität [-]
1.1	0,45
1.2	0,58
1.3	0,68
1.4	0,40
1.5	0,61
1.6	0,48
1.7	0,63
1.8	0,55

riation of FEGT for hard coal with different emissivity values

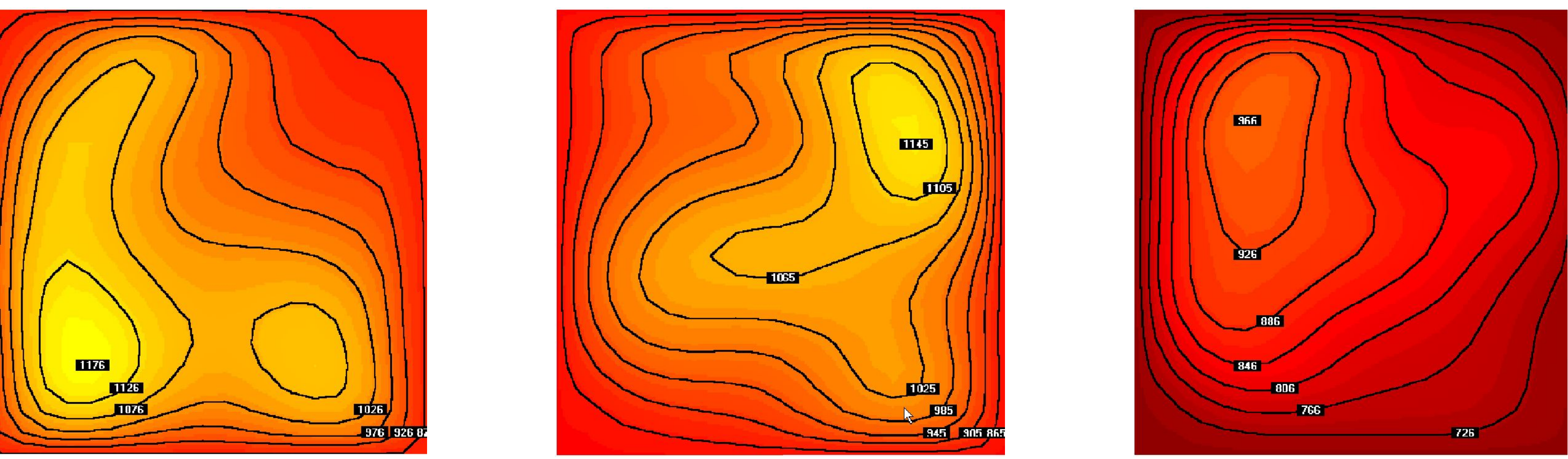


Temperature range indicating local fluctuations

Temperature imbalances

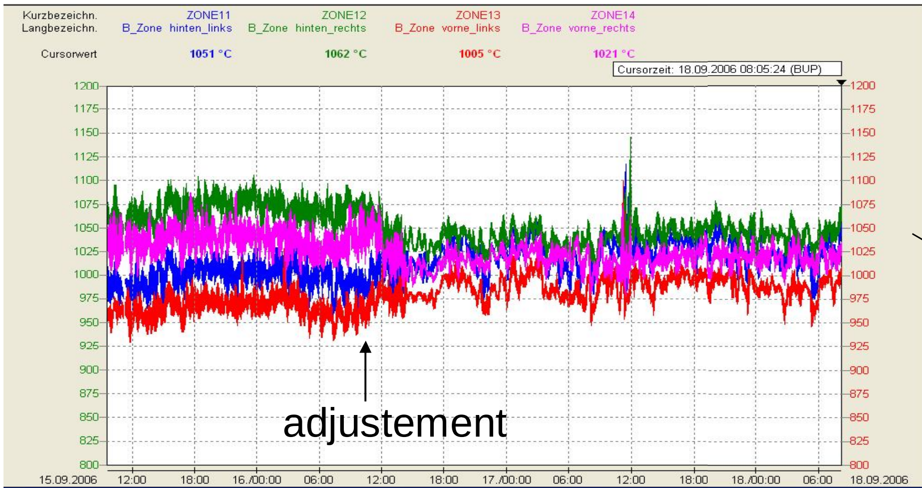


Hard Coal 200 MWel

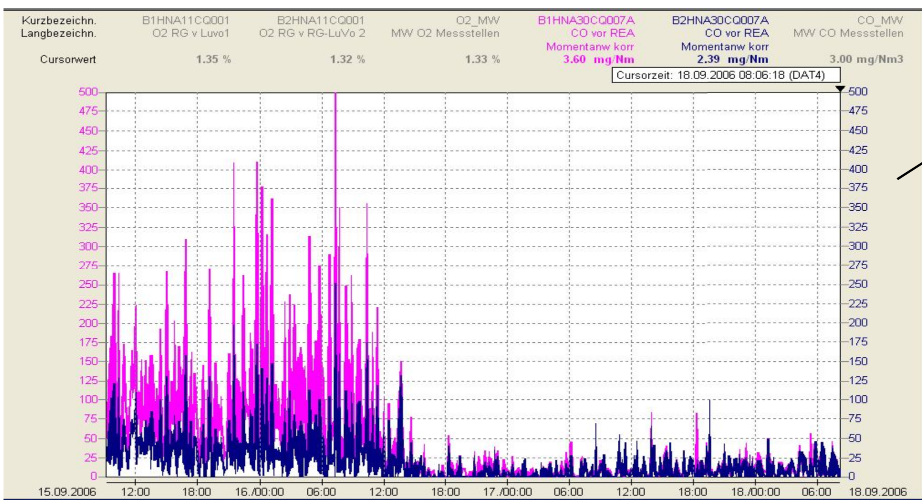


Lignite 800 MWel

Relation between T, O_2 and CO

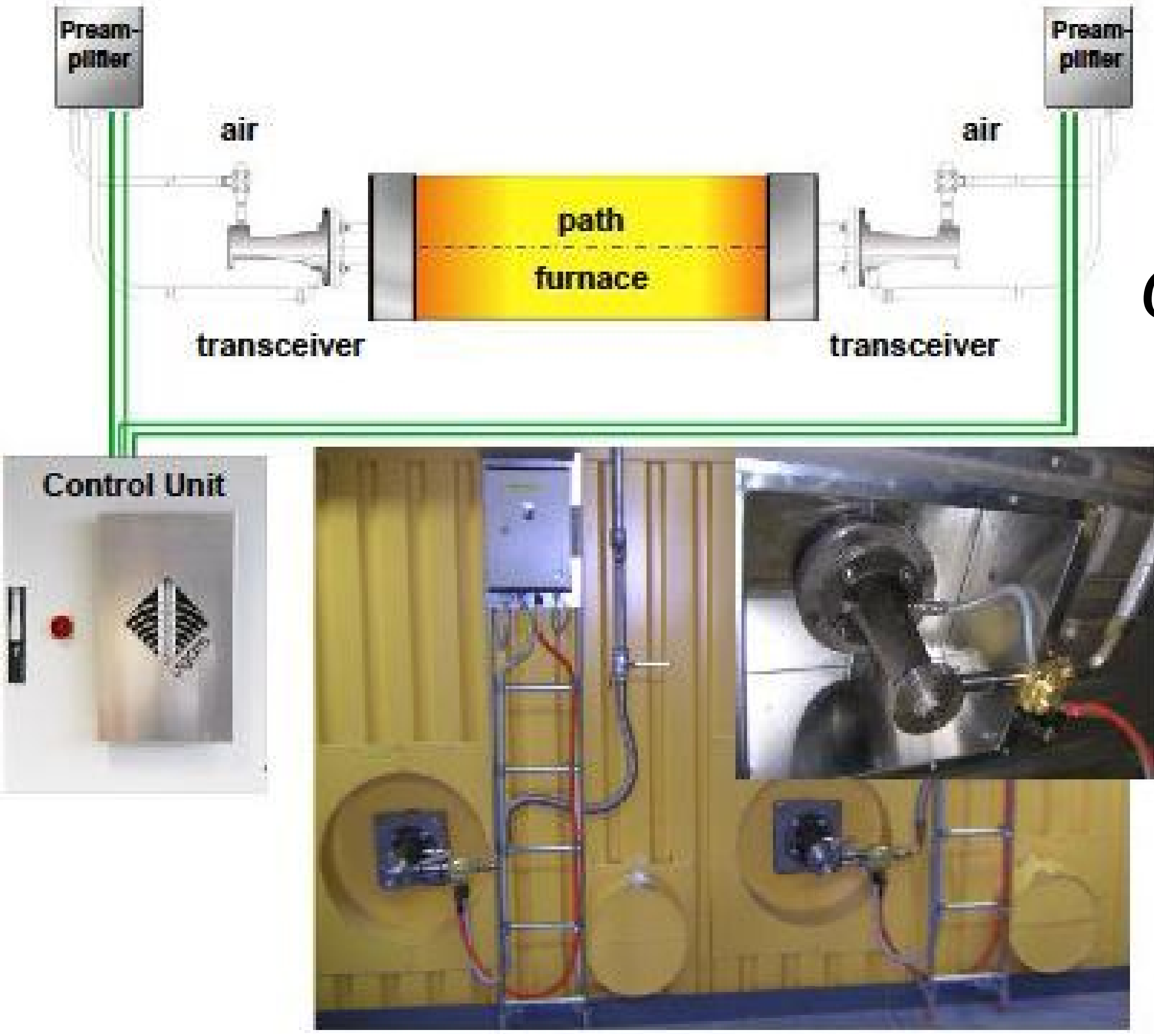


average temperatures in 4 symetrical zones



CO

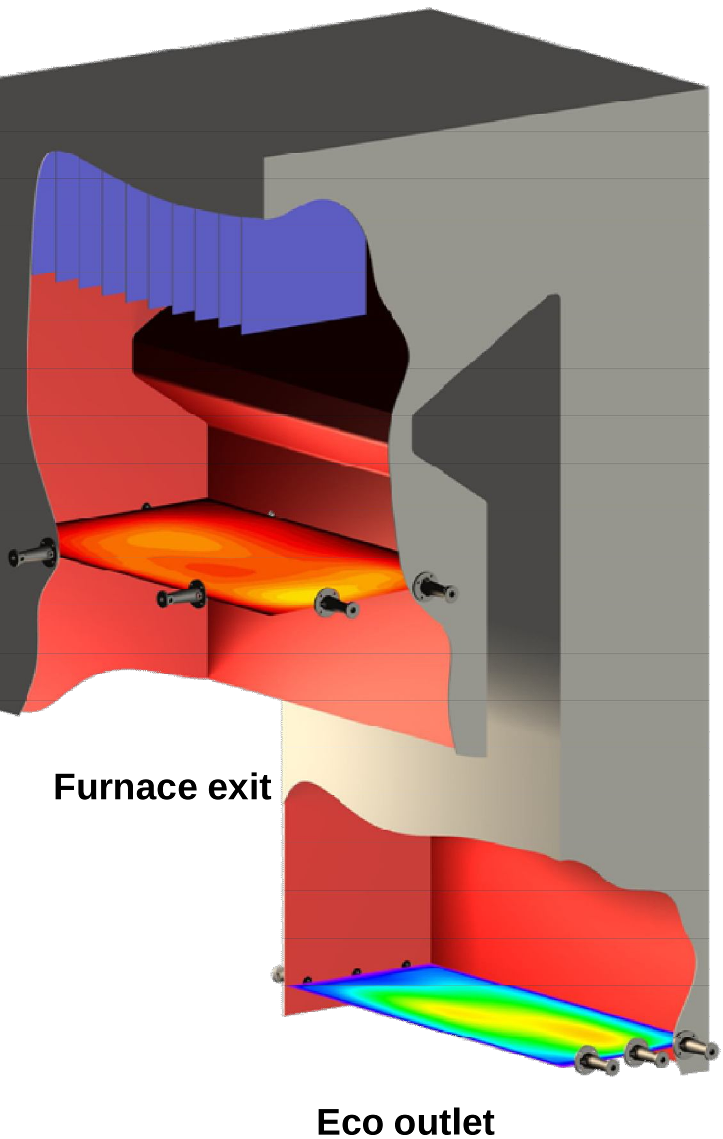
eduction of CO by temperature balancing (800 MW lignite)

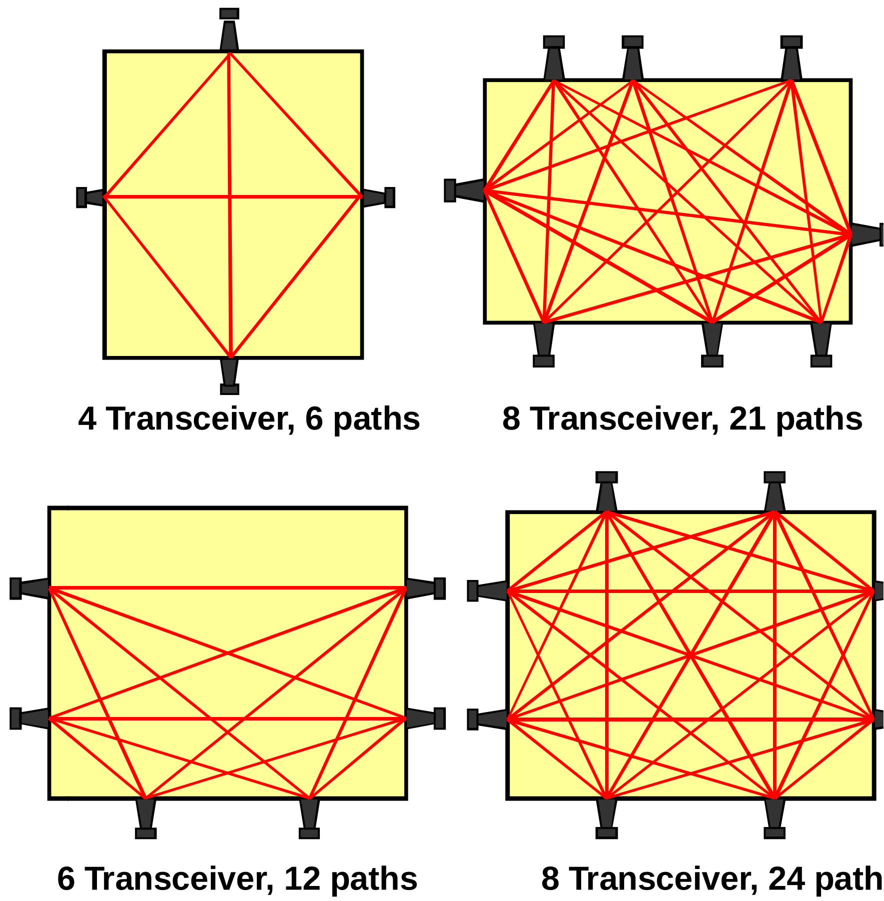


$$C = \sqrt{\frac{æ \, . \, R}{M} \, . \, T}$$

Acoustic gas temperature measurement system

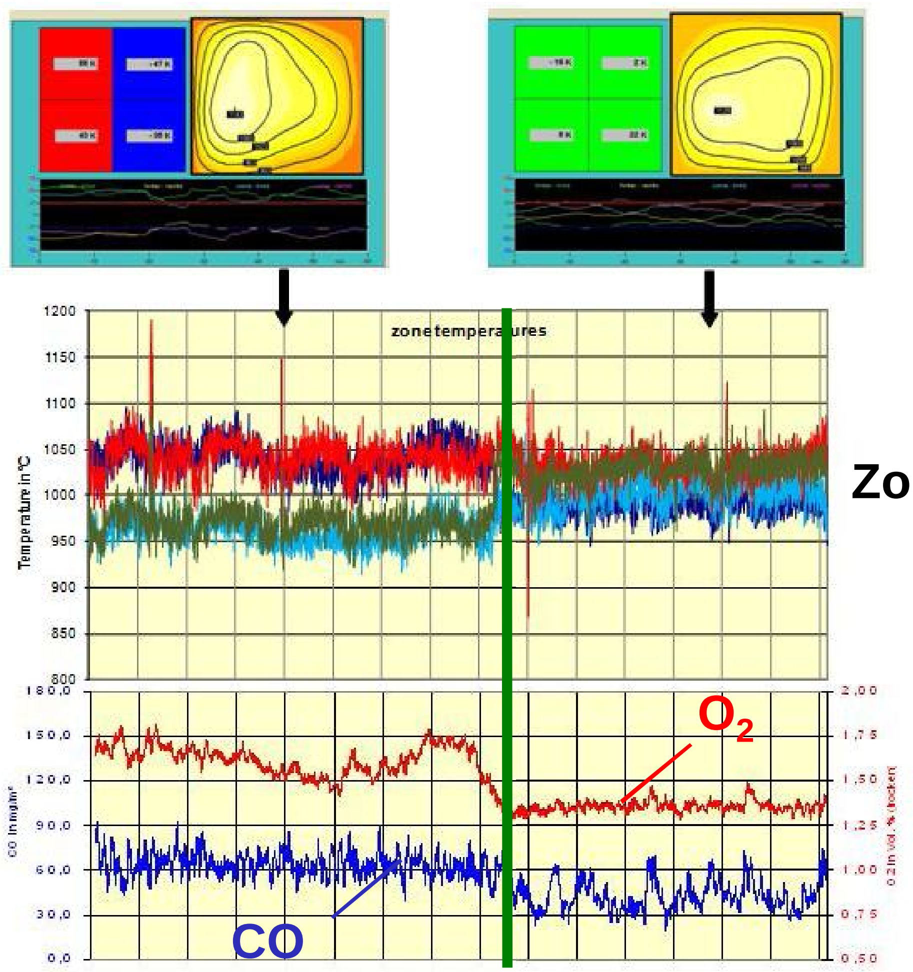
Acoustic Pyrometer



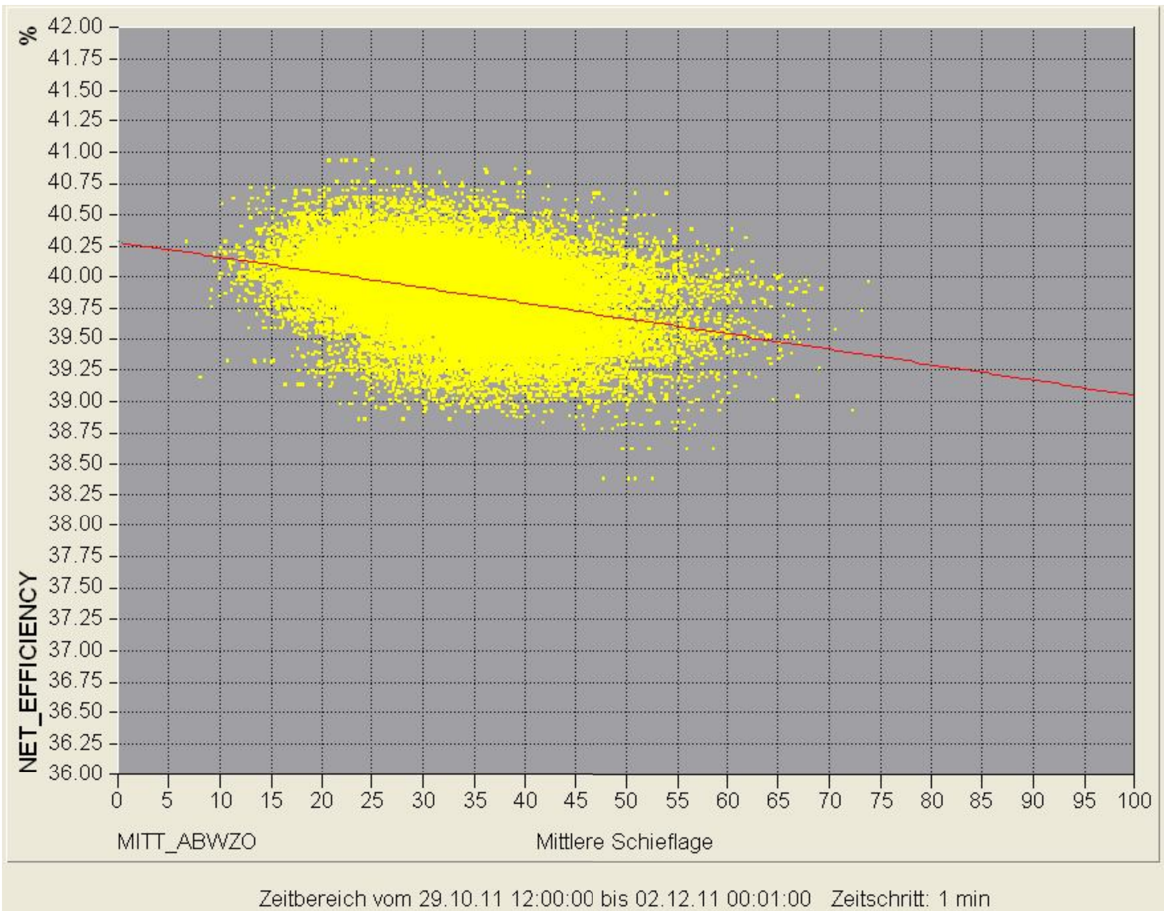


Multiple path configuration

Balancing and O_2



Effects of temperature balancing on O_2 (red) and CO (blue)

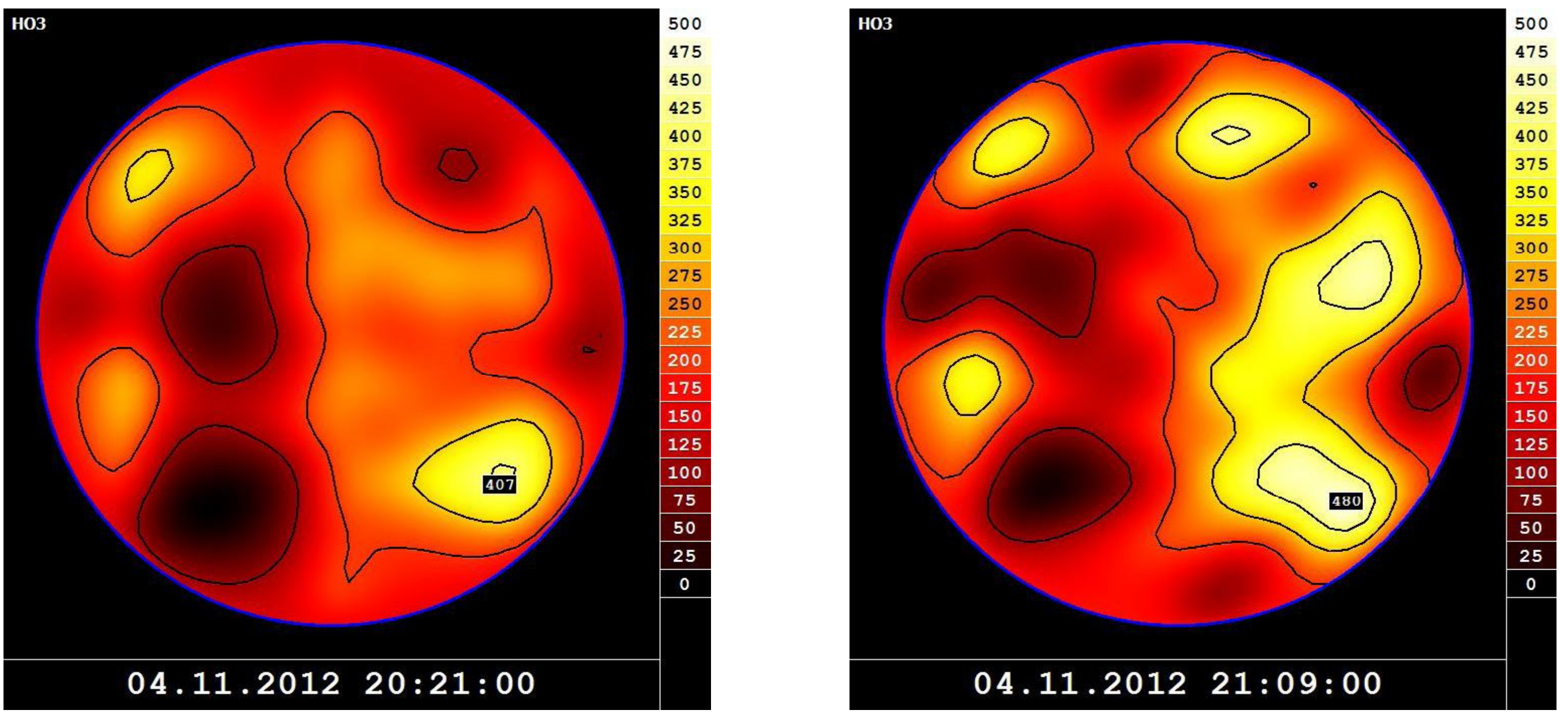


Net efficiency and temperature balancing (660 MW hard coal)

ew Developments for Future Requiremen

- ✓ **high resolution (> 100 paths)**
- ✓ **allways all path bidirectional**
- ✓ **increased measuring speed (< 20 sec. per complete cycl**
- ✓ **acoustic signal serveillance**
- ✓ **bi-directional data tranfer to DCS and redundancy**
- ✓ **3-dimensional determination between different levels**

New High Resolution Tomography



High resolution temperature distribution in the top of a blast furnace

Summary

diagnosis of the combustion and the operation of boilers with difficult fuels
e to comply with rapid temperature changes, high local imbalances and an
nown wide range of average temperatures.

required information about the fire is available since the introduction of the
ustic temperature measurement technology. The significant advantages resu
the fact that the measurement is not influenced by radiation.

perature balancing improves the local O_2-distribution and reduces CO-peak
this is particularly relevant for boilers with corrosion problems or slagging.
same time, an even temperature distribution leads to higher efficiency and i
ortant for a stable combustion at low load with difficult fuels or during start u
ne out prevention).

requirements from combustions with difficult fuels and with control applicati
e led to new standards for acoustic systems concerning resolution, speed a
bility.

Thank You

artners
progress

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$$C = \sqrt{\frac{æ \,.\, R}{M} \,.\, T}$$

C	=	*speed of sound*
T	=	*“true" gas temperature*
M	=	*molecular weight*
R	=	*universal gas constant*
æ	=	*specific heat*

T = 1000 °C **C = 686 ± ? m/s**

temperature = 1000 °c

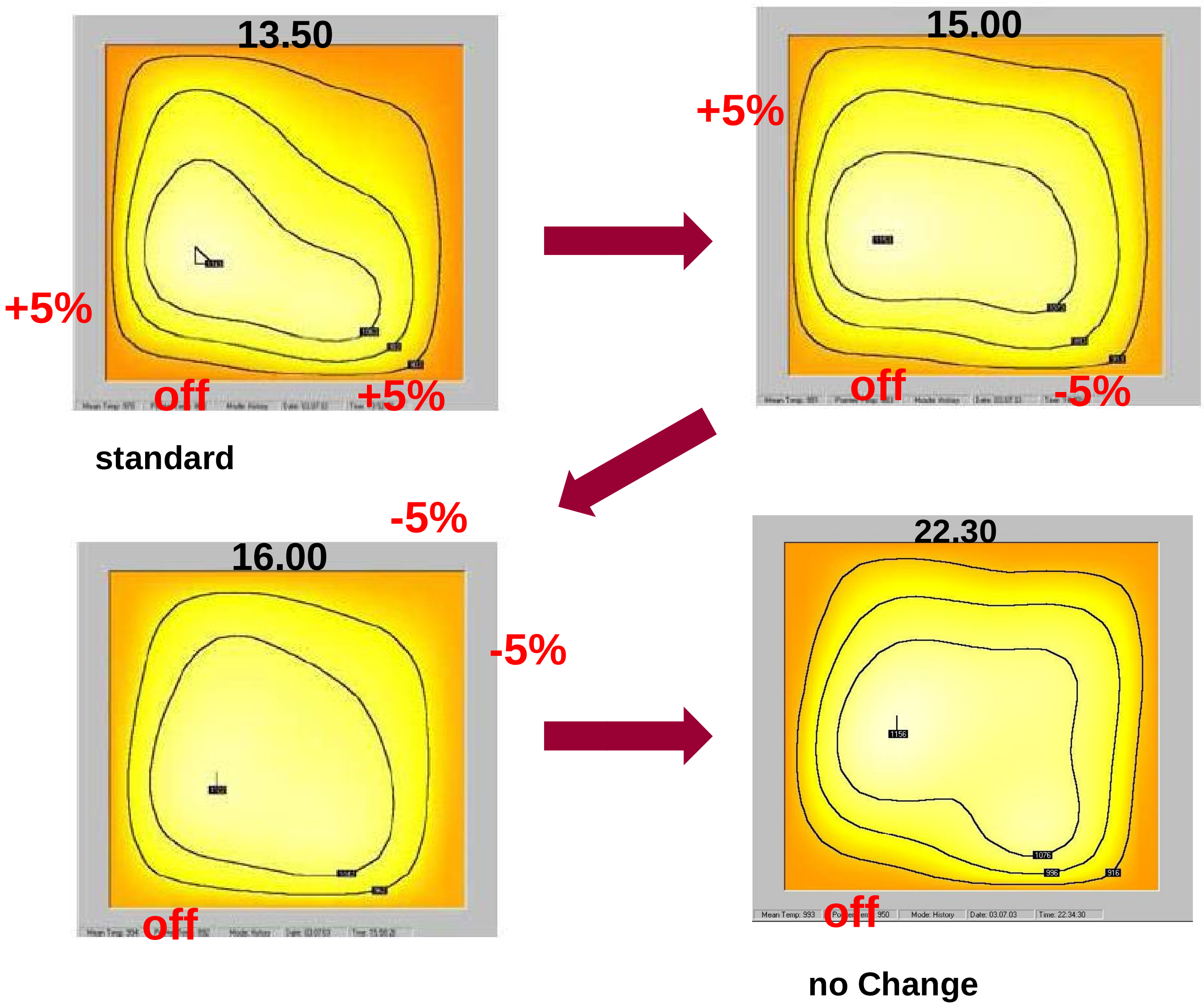
speed of sound = 686 ± **?** m/s

as composition (lignite)

CO_2 = 18-14 Vol. %
O_2 = 2 - 6 Vol. %
CO = 100-1000 mg/Nm^3
H_2O = 19-21 Vol. %
dust = 10-15 g/Nm^3

± **5 m/s**

unaccuracy < **1,5 %**


13.50
+5%
off
+5%
standard
15.00
+5%
off
-5%
-5%
16.00
-5%
off
22.30
off
no Change

MC-monitoring SA
Measuring - Consulting - Monitoring

Innovation in Condition Monitoring

Key benefits

Yvan Jacquat
Managing Director

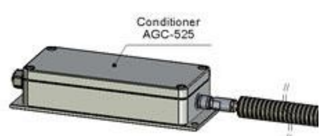
Think ahead, **Move** forward

Topics

Endwinding Monitoring

Airgap Monitoring

Partial Discharge Monitoring

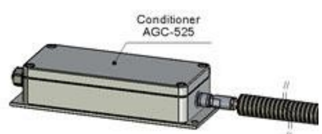


Topics

Endwinding Monitoring

Airgap Monitoring

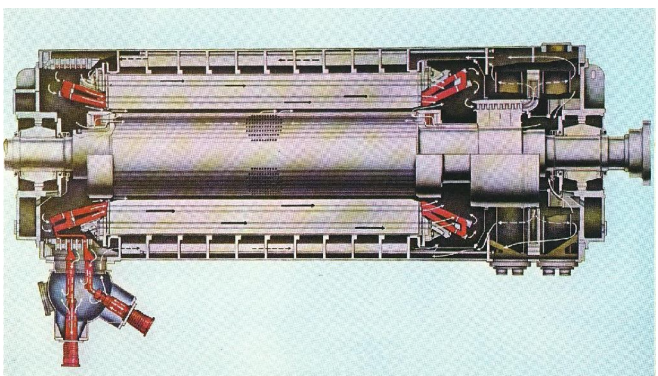
Partial Discharge Monitoring



Application

Endwinding Monitoring | Airgap Monitoring | Partial Discharge Monitoring

Turbo generators
Pump storage



Current practices:

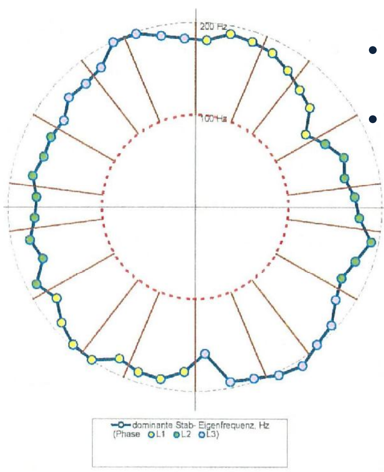
- Operation of the machine beyond its normal lifespan
- Operating costs reduction by increasing of the availability and reliability
- Operating of the machine closer to the real needs (leading to several run-up and run-down/day)

Premature ageing and winding deterioration

Dominant self resonance frequencies of the bars

Endwinding Monitoring | Airgap Monitoring | Partial Discharge Monitoring

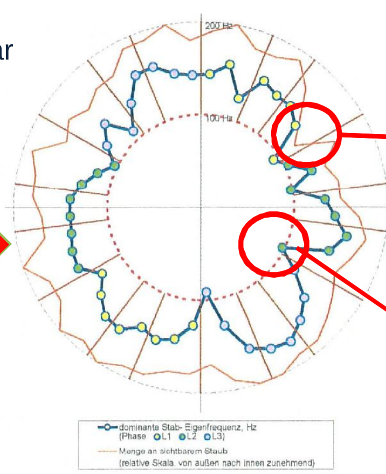
Original status:



- Progressive wear of insulation
- Structural weakness

Shift of the Resonance frequency

Endwinding deterioration:



Friction dust

Dominant self Resonance frequency at 2X – Heavy vibration

Source: Erweiterte Diagnoseverfahren für Kraftwerksturbosätze

Impact on PD activites

Endwinding Monitoring | Airgap Monitoring | Partial Discharge Monitoring

High level of Endwinding Vibration

⬇

Premature Aging of the Insulation

⬇

Increase of the Partial Discharges Activities

⬇

Increased risk of electrical discharges & short circuit

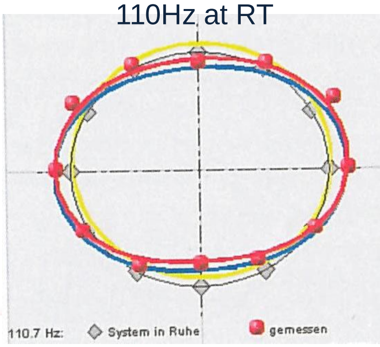
Insulation crack and abrasion between Endwinding and support elements

Online Endwinding Monitoring

Main advantages:

- Online Measurement takes into consideration the **temperature effect** on the stator bar dominant self resonance frequency
- In normal condition, the self resonance frequency of the 4-nodes model of the Endwinding may be reduced by -5Hz from 35°C to 65°C
- With the aging of the generator, the frequency shift rise up to -12Hz

4-nodes model:
110Hz at RT



Normal condition → 105Hz (-5Hz)

Deteriored Endwinding → 100Hz (-10Hz)

In operation
(+/- 65°C)

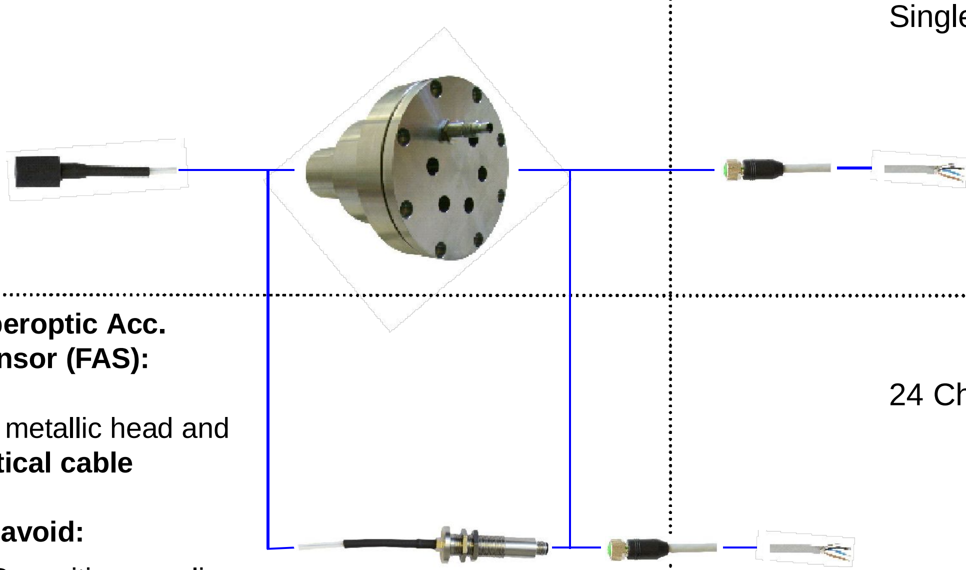
Source: Erweiterte Diagnoseverfahren für Kraftwerksturbosätze

On-line Monitoring System: Key components

Endwinding Monitoring | Airgap Monitoring | Partial Discharge Monitoring

FAS Sensor

Sensor & Flange	Transmitter & Monitoring System



Single channel module

Fiberoptic Acc. Sensor (FAS):

No metallic head and **optical cable**

To avoid:

- Capacitive coupling (LETHAL DANGER)
- Short circuit in the generator

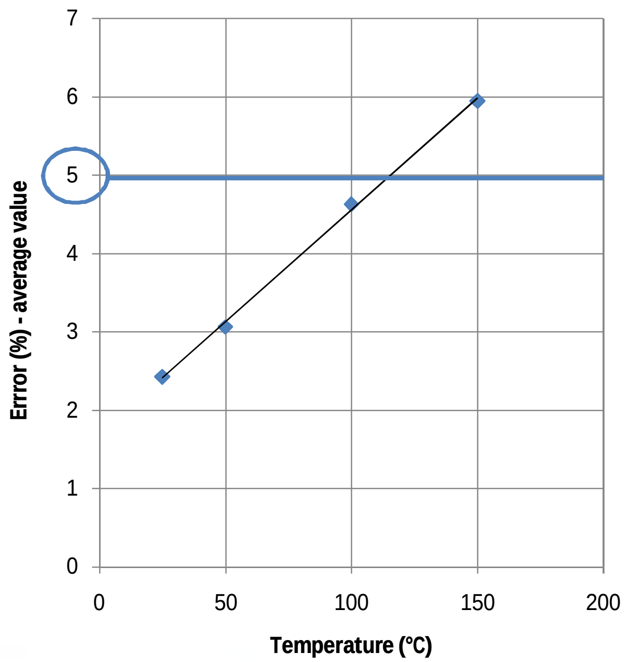
24 Channel monitor

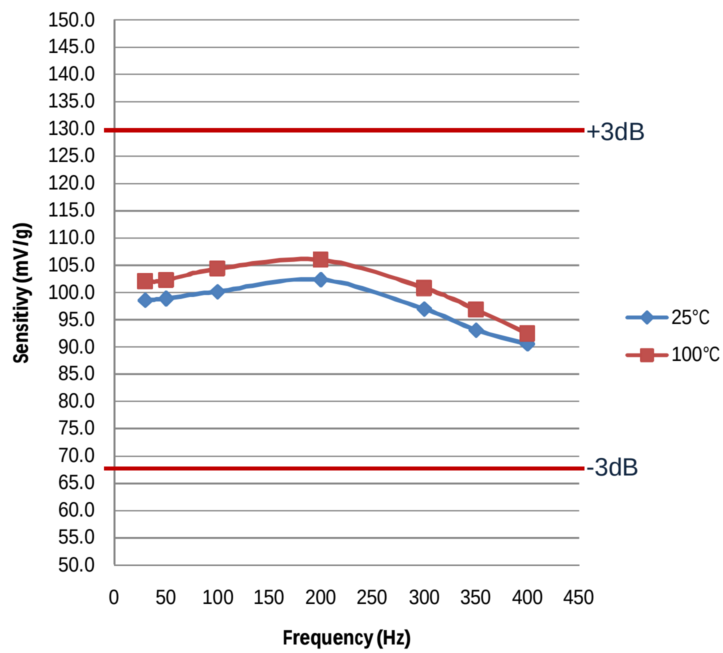
Key benefits of innovation

New **sensor generation** with:

- Improved temperature response
- Improved long term stability

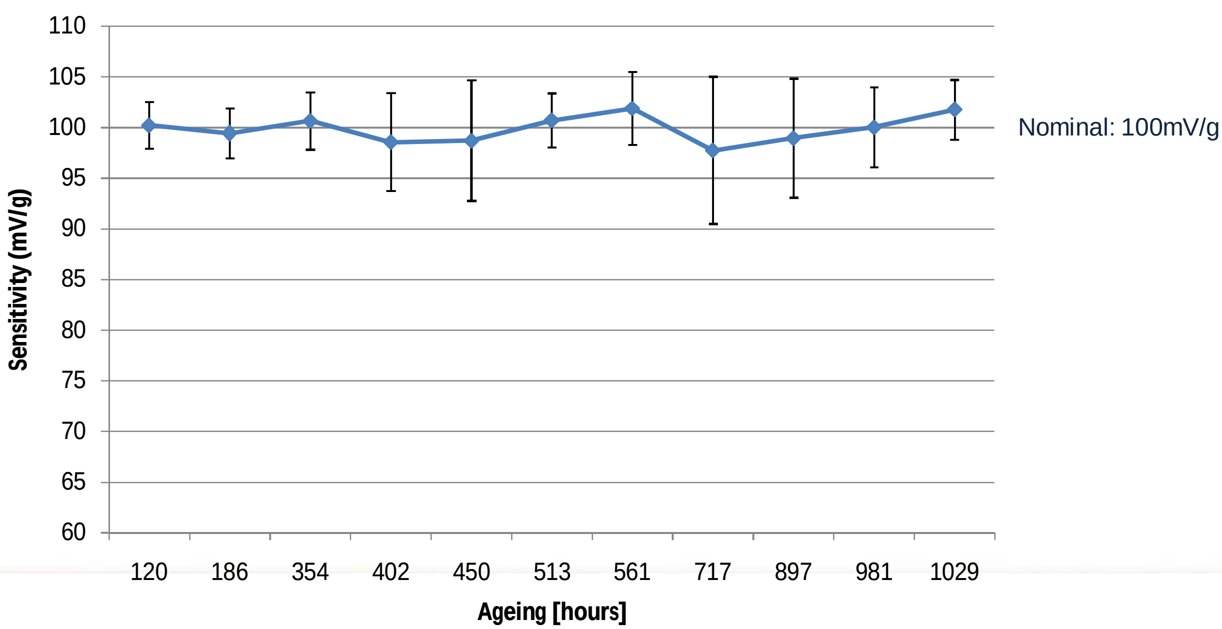
Sensitivity temperature response (@ 100Hz)





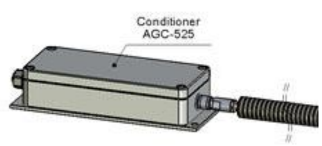
Long term stability

Sensitivity stability after aging cycles
(3h @ 100ºC and 3h cooling)



Topics

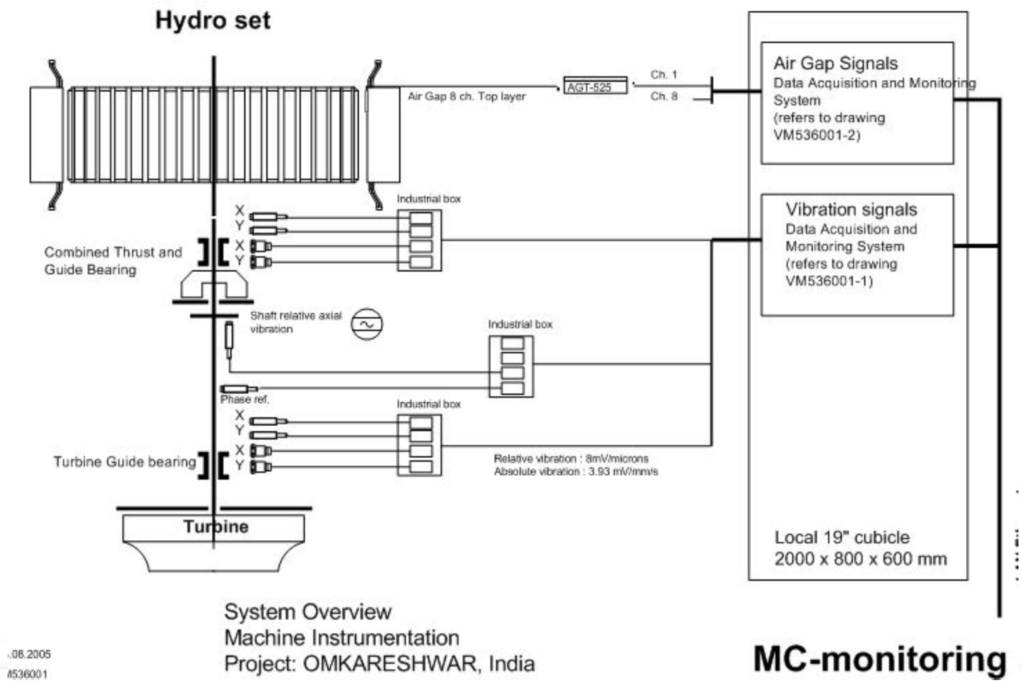
Endwinding Monitoring | Airgap Monitoring | Partial Discharge Monitoring

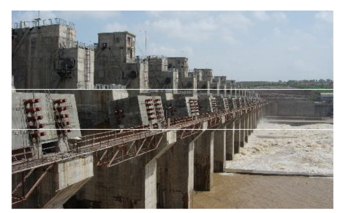


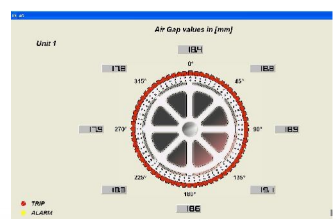
Application

Endwinding Monitoring | **Airgap Monitoring** | Partial Discharge Monitoring

Example - Omkareshwar – HPP Project 8x65MW







Application

The airgap variation is the result of mechanical deformation induced by forces on the rotor, on the stator and electromagnetic forces

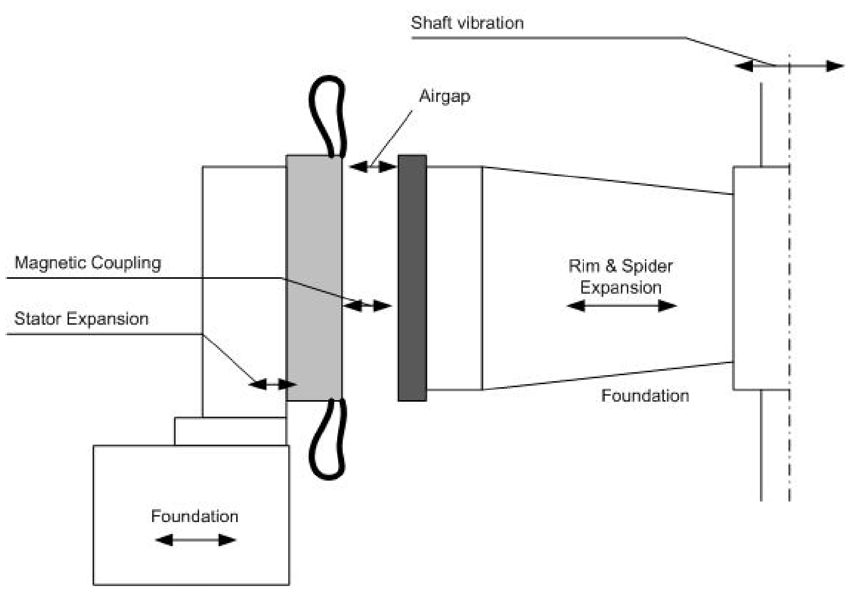
Forces acting on the rotor

- Centrifugal Force
- Thermal expansion of the rim
- Gravity
- Vibrations

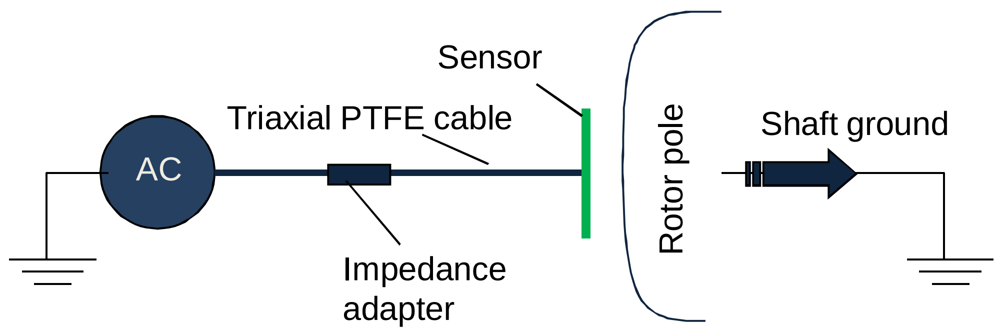
Forces acting on the stator

- Thermal expansion
- Gravity
- External forces, concrete growth
- Vibrations

Electromagnetic forces



Measuring principle



- Contactless, capacitive principle, no wear
- Reliable, no maintenance
- Immune to shocks/vibrations
- Immune to magnetic field, EMI
- Operating temperature up to +125 ° C
- Carrier frequency technique, amplitude modulated high frequency

Airgap Transmitter

Key benefits of innovation

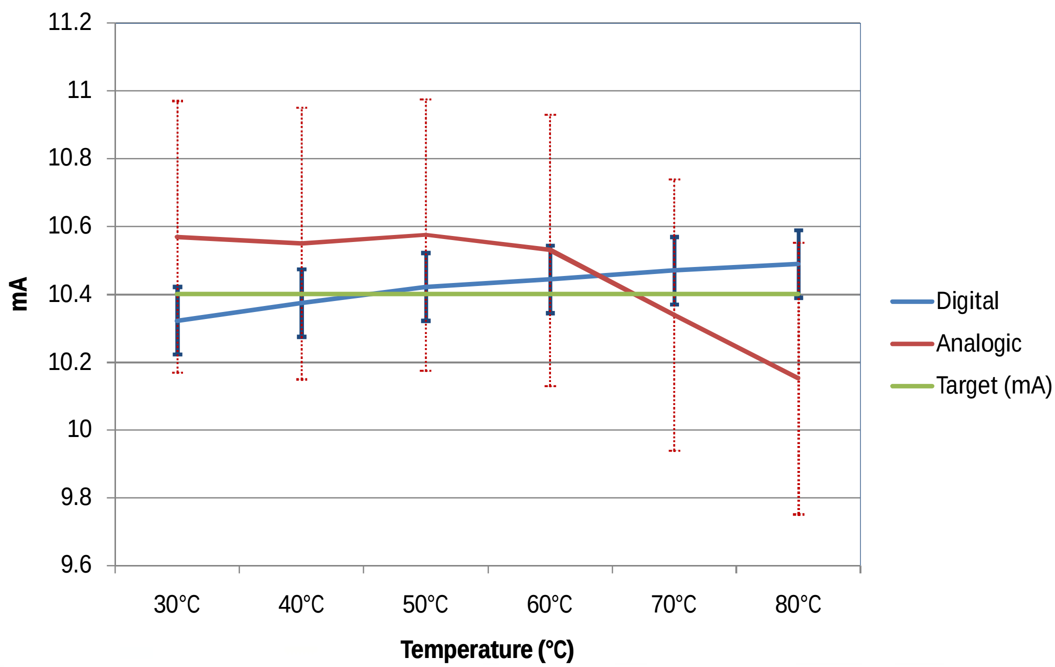
New **digital conditioner**

Digital conditioners

Key advantages:

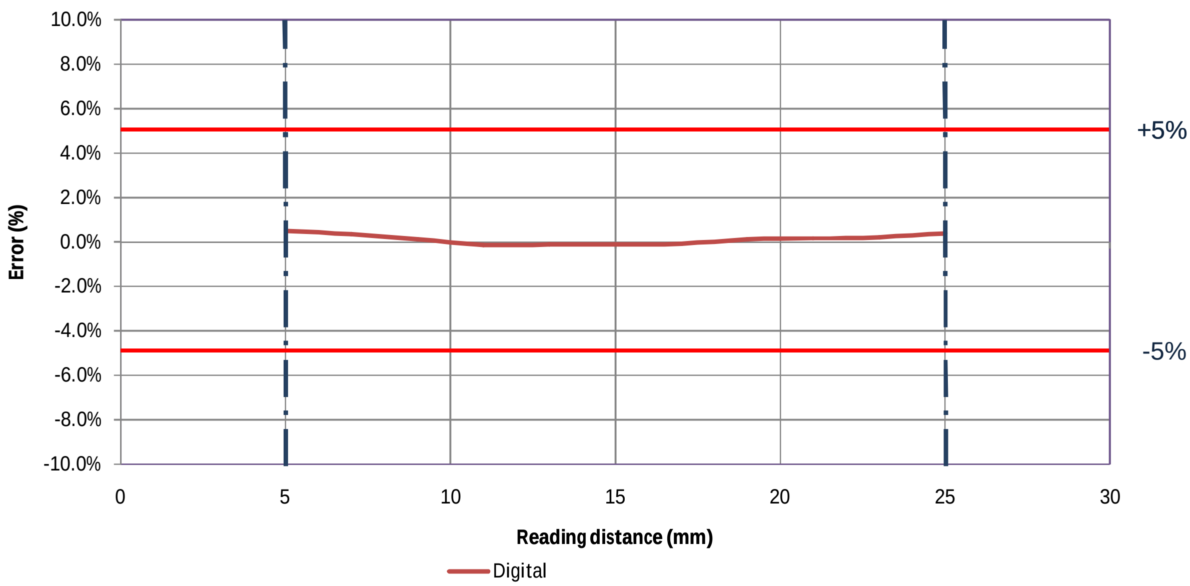
- Numeric linearization making it **stable** and **independent** from environmental conditions (temperature, humidity,…) due to less analogue components
- Numeric regulated carrier frequency making impedance measurements more **stable** and more **repetitive**
- Digital linearization allowing a **greater fineness** in linearization adjustment
- Digital calibration making it **stable** and **invariable** with the time
- Galvanic insulated output with internal power supply making possible the use of standard 4..20mA input cards and the whole system **less sensitive** to grounding effect in heavy noise environment

Digital conditioners: Temperature response



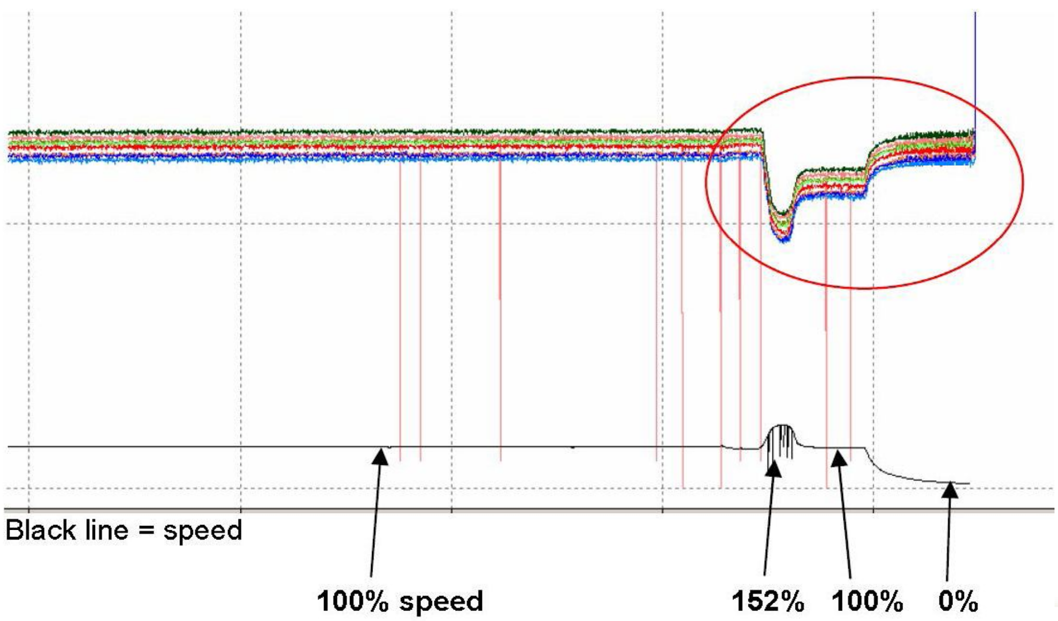
Error plot at +/- 3 sigma

Digital conditioners:
Linearity – 5..25mm



Case study

After overspeed testing, nominal airgap reduced from 12.9mm down to 9.3mm

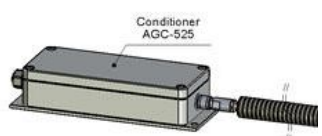


Topics

Endwinding Monitoring

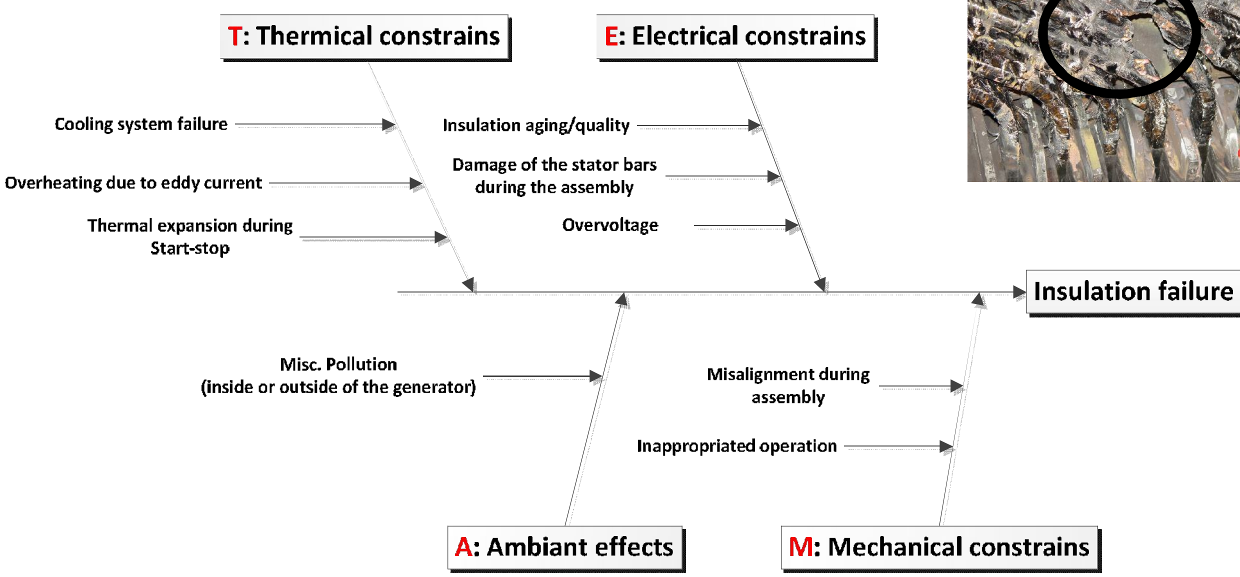
Airgap Monitoring

Partial Discharge Monitoring



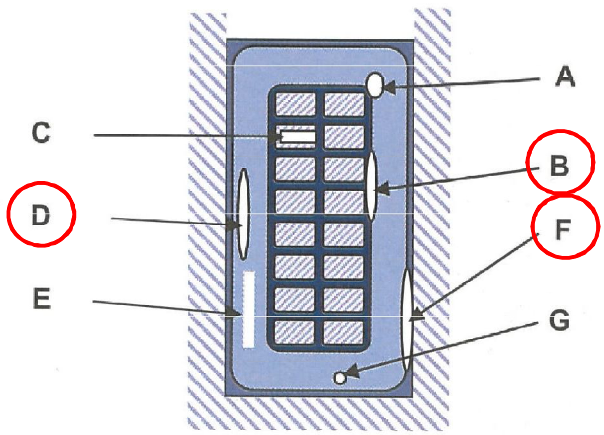
Application

Online PD Monitoring Systems are used to detect failure in winding insulation due to:

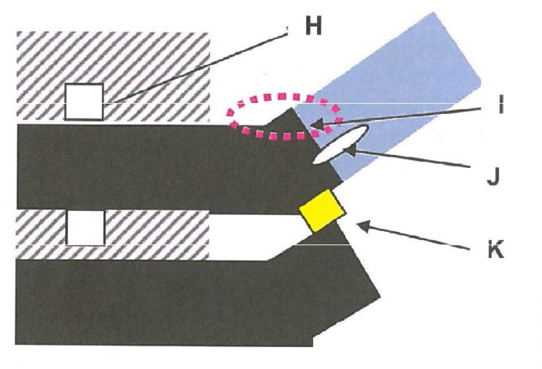


Typical failure

Slot area



Endwinding area



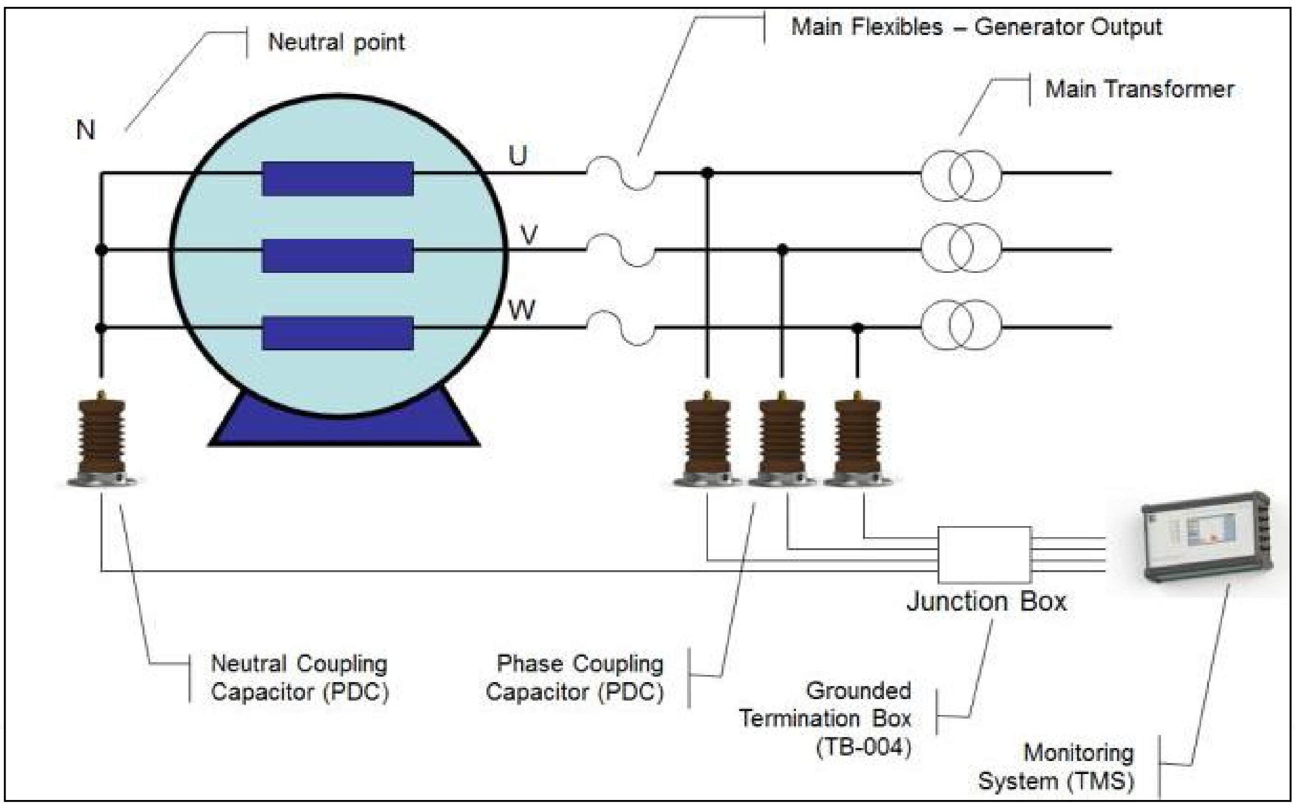
A: High electrical field due to sharp edge
B: Delamination of single conductor to main insulation
C: Broken conductors
D: Delamination of the main insulation
E: Electrical treeing
F: Abrasion of the corona slot protection
G: Gas inclusion

H: Problem in the cooling ducts
I: Splitting of the insulation (manufacturing)
J: Pollution on the surface
K: Defect or broken spacers

Risk level (IEC 60034-27):

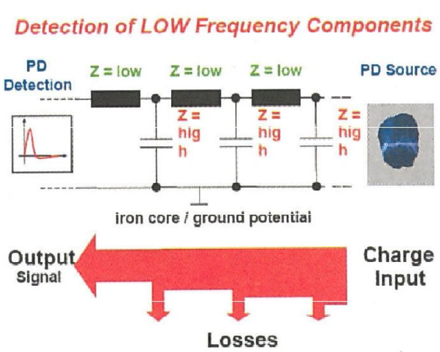
- High risk
- Normal risk
- Low risk

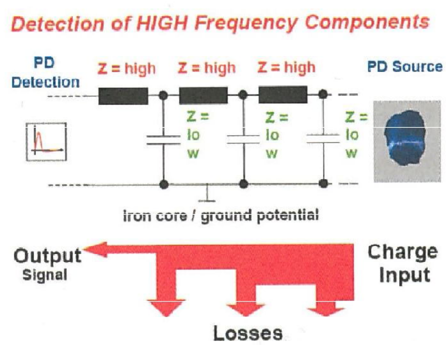
Typical installation

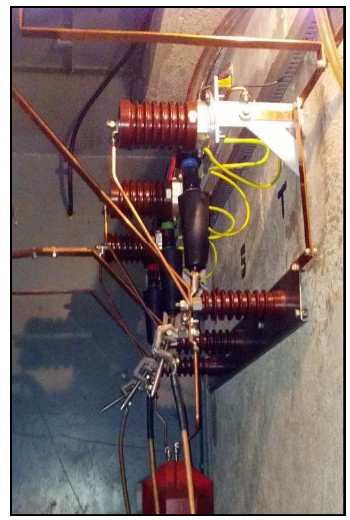


Benefits of 1000pF sensors

Detection of PD activities **deep inside the winding** of the machine requests low frequency PD measurements:







1000 pF sensors better adapted to
measure low PD frequencies as low capacity sensors (e.g. 80pF)

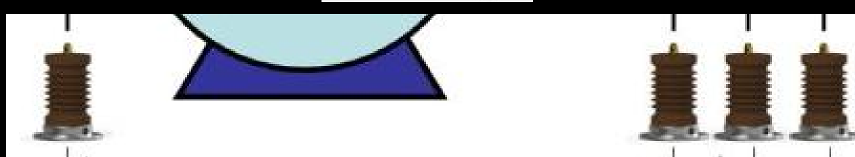
Key benefits of innovation

New **PD systems** according to IEC 60270 standard:

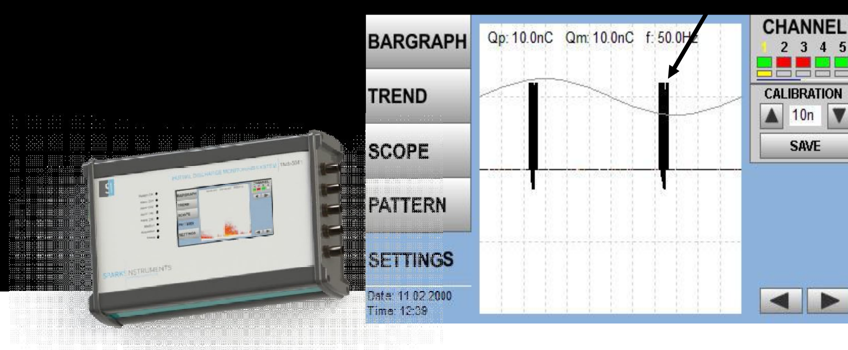
- Automated Calibration
- Standalone field-proven Portable system with built-in True Color Touch Screen display
- True simultaneous data acquisition for analysis of PD signals

Automated calibration

Calibration pulse generator according to IEC 60270

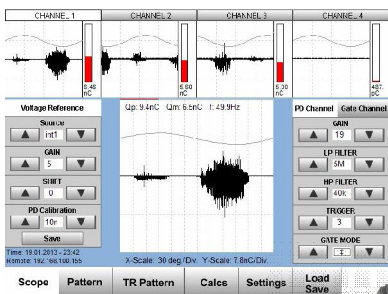


Typical response of a PD calibrator

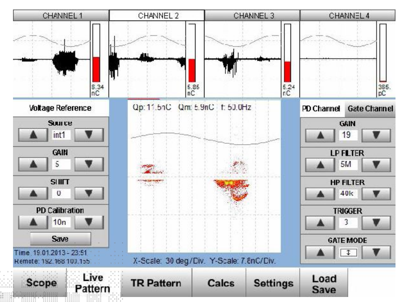


Standalone Portable PD System:

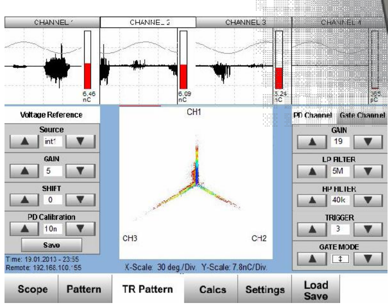
Endwinding Monitoring | Airgap Monitoring | Partial Discharge Monitoring



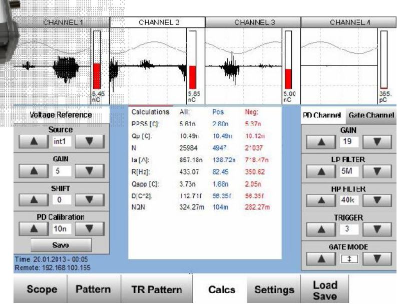
Oscilloscope view



Real time live phase resolved PD pattern



Time related pattern



IEC-60270 standard related measurement results

- Standalone PD measurement without computer for analysis

Many thanks for your attention

A Mahar

Real time Process Improvement & Diagnos

Thermal Power Pla

Expert Syste

Abhishek Kumar
Himanshu Pant
J S Chandok
NETRA-NTPC Limited

Presentation Outline

- Need & Objectives
  - Optimization Challenges
  - Impact & Potential Savings
- Applications
  - Background
  - Underlying Technologies
  - Efficiency Optimization System
  - Chemistry Diagnostic & Optimization System
  - Solution Architecture
- Conclusions

eed & Objective

inimizing Operating Cost

Coal & nsumption

Meeting Demands

Grid Load
Demand Fluctuations

Meeting Constraints & Disturbance

Sprays, Steam Temps,
Chemistry Parameters

onmental onstraints

&

Reliability

Equipment
Health & Ageing

Adaptability

Overhauls, Seasonal
variations, different
chemistry regimes

Optimiz
Challen

eed & Objective

Approx. 37 Lacs/Annum. of Coal Savings

prox 9 Lacs/Annum for 20% reduction in CBD

Approx 1165 Tonnes/Annum. of CO_2 Reduced

mprovement

prox. 2 Lacs/ Annum for 20% reduction in Chemicals used

KCal/KWHr

Approx 407 Tonnes/Annum. of Ash Reduced

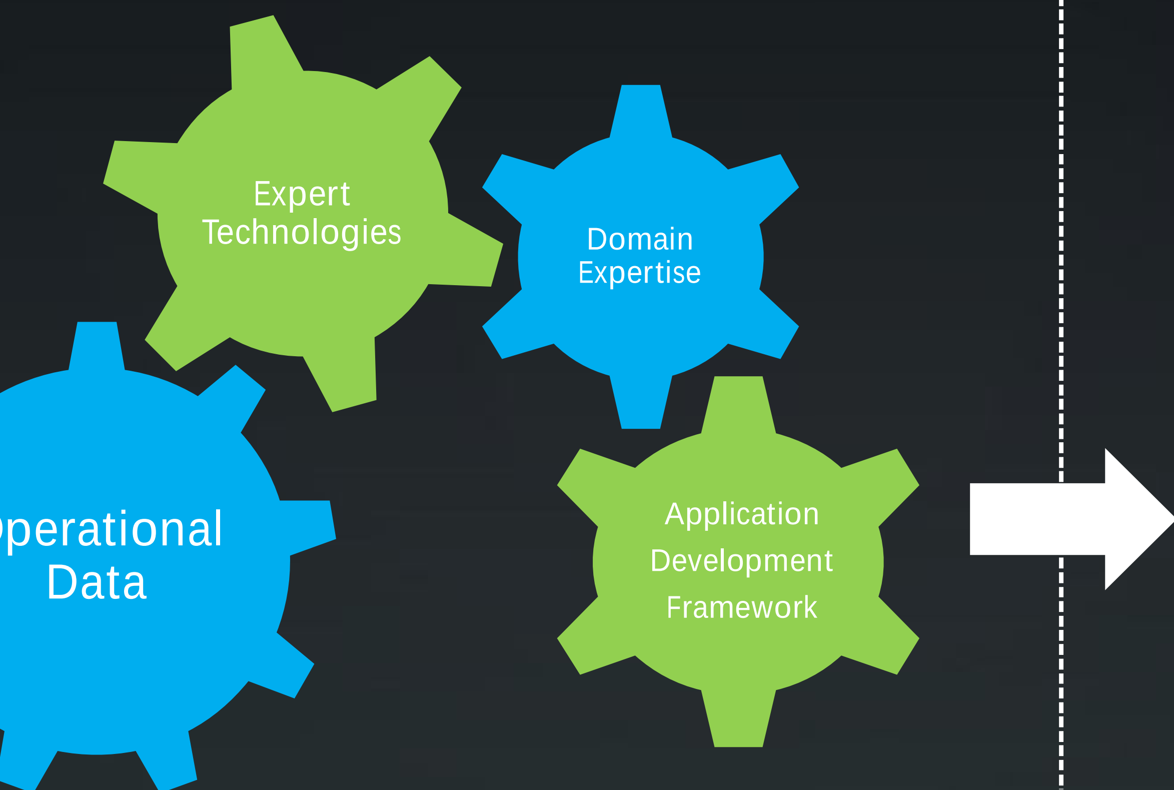
prox. 50 Lacs/Annum for increase in acid cleaning period

ear

Impact
Potent

- Plant Capacity: 500 MW Coal
- Coal price :. 3000/T
- Coal GCV : 3500 KCal/Kg
- Amount in INR

pplications



Backgr

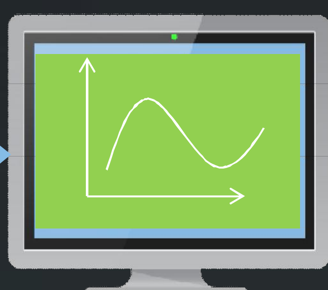
Optimizati
goals

pplications

Data

- eal time
- istorical
- ffline
- esign

010011100111...



Underl

Techno

pplications

Domain Expertise

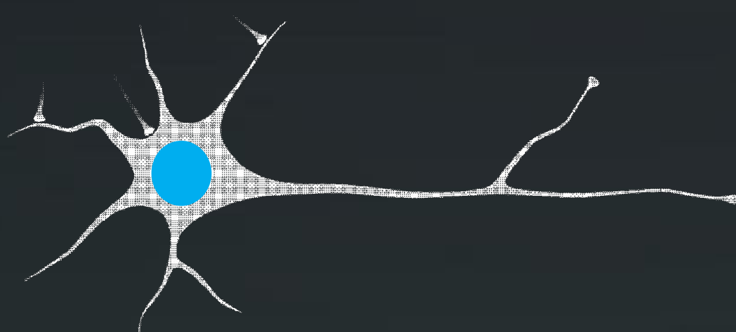
- Main Plant Op
- Chemistry Op
- Literature

Underlying Technologies

pplications

pert Technologies:
Artificial Intelligence

eural Networks
volutionary algorithms
uzzy logic
dvanced pattern
cognition

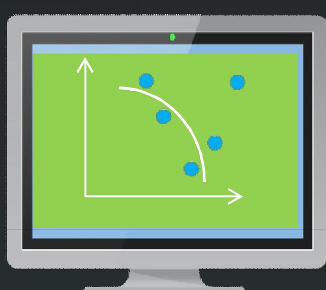


Underlying Technologies

pplications

pert Technologies:
Statistical Tools

- egression analysis
- urve fitting
- ustering &
- assification



Underlying Technologies

pplications

Application Development Framework

- ervice oriented
- chitecture
- DBMS
- ch User Experience

Underlying Technologies

pplications

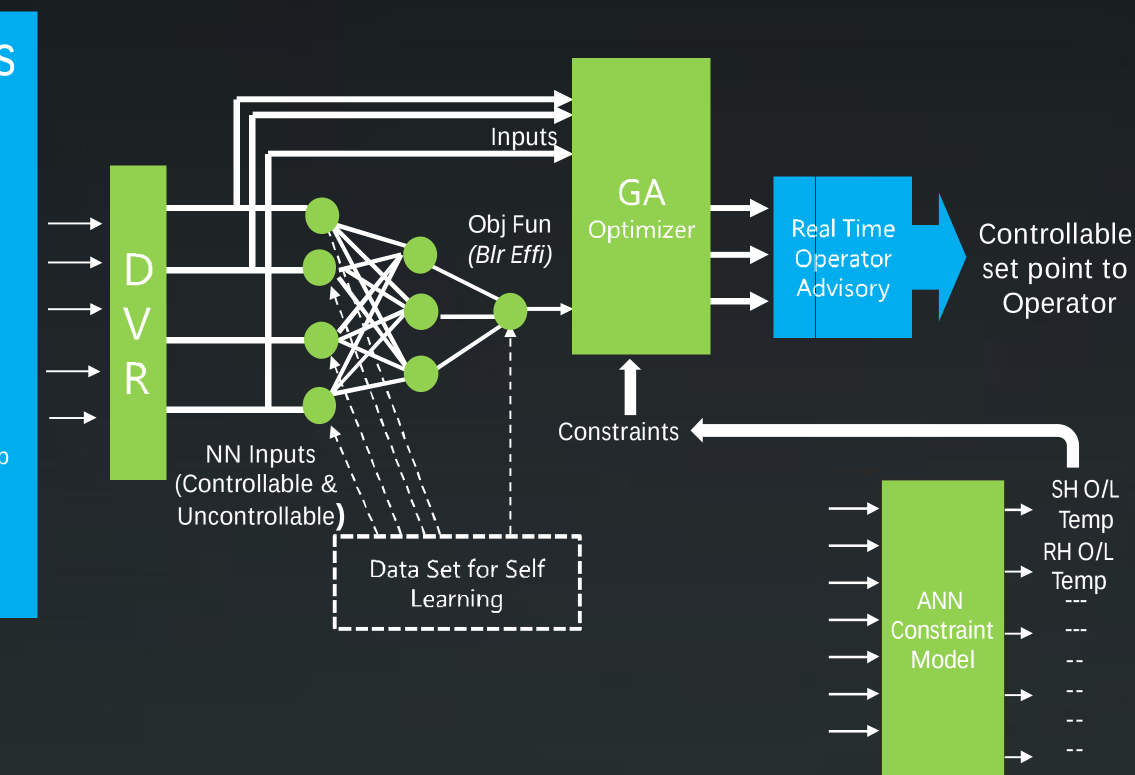
ime plant imization system	Operator advisory for controllable parameters	On the spot Plant Heat rate (HR) improvement	Constraint Handling
erage HR rovement 3-10 Kcal.	Self learning ANN models	Customizable GA Based Optimization system	Real time CV

Overview

Eff
Op
Sy

pplications

Core Engine Architecture



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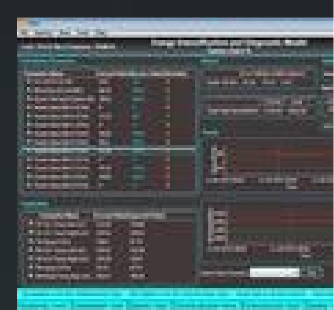

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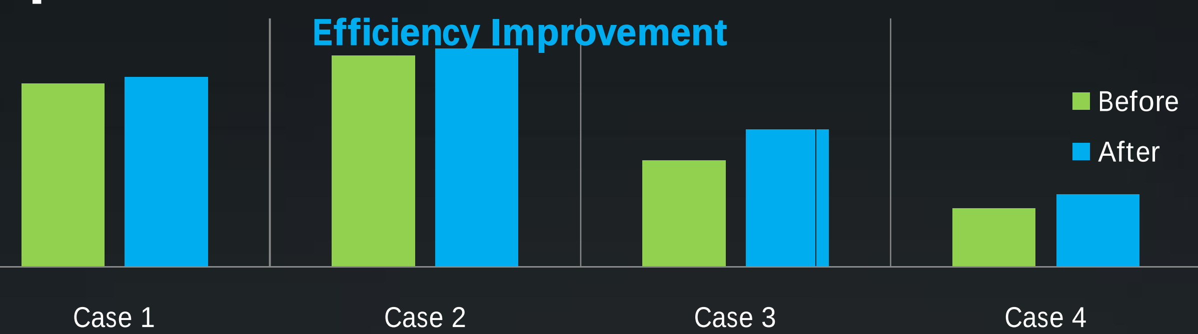
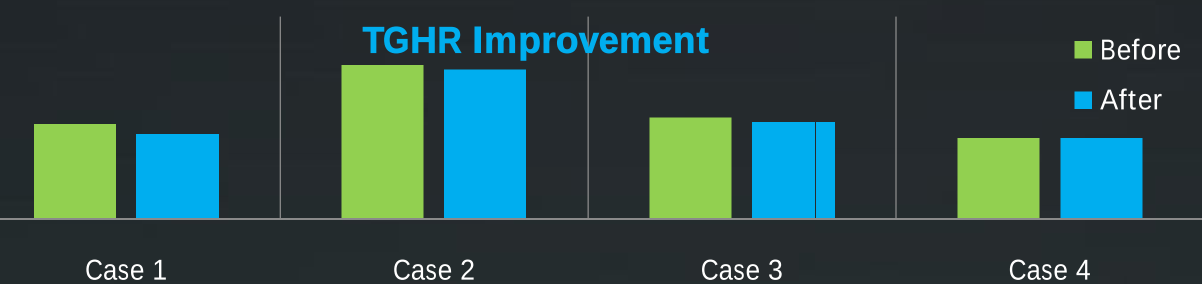


WB Pr Burner Tilt	WB Pr	WB Pr: Burner Tilt O2%	Burner Tilt O2%

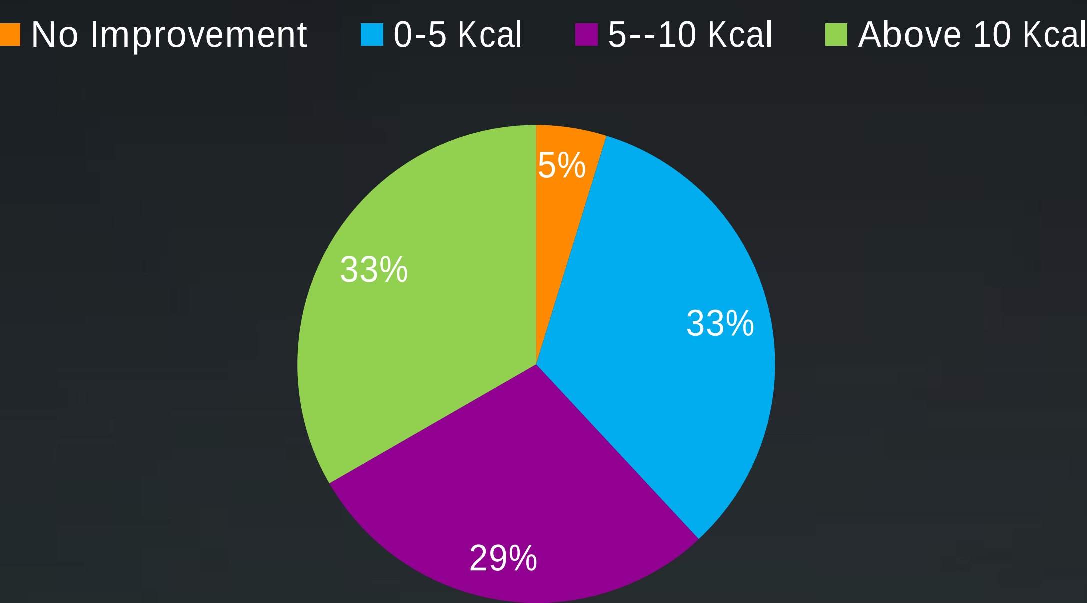


Case Studies

Eff…
Op…
Sy…

pplications

Unit Heat Rate Improvement for over 25 Cases



Case Studies

Eff
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pplications

Real time
etection of
chemistry
issues

Fine tuning of
chemical
parameters to
reduce
corrosion and
scaling problem

Optimization of
chemical
treatment

Single platform
for online as
well as offline
parameters

parameter
alization &
Fault Tree
analysis

learning tool for
plant
chemist, and
analyst

Platform for
converting
plant chemistry
expertise into
tangible form

Role based
dashboards
customized to
individual needs

Overview

Ch
Dia
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pplications

Boiler Drum

Cl & Si contamination
Free NaOH
Na-PO4 Ratio
Theoretical conductivity
Iron deposit rate

Feed Water

Ammonia
CO2

Main Steam

Steam Purity
Ammonia
CO2

Condensate

CEP cation column exhaustion
Condenser leakage
Condenser air-in leakage

Dozing

HP dozing
LP dozing

Others

Colloidal silica passing
CBD Advisory

Areas Covere

Ch
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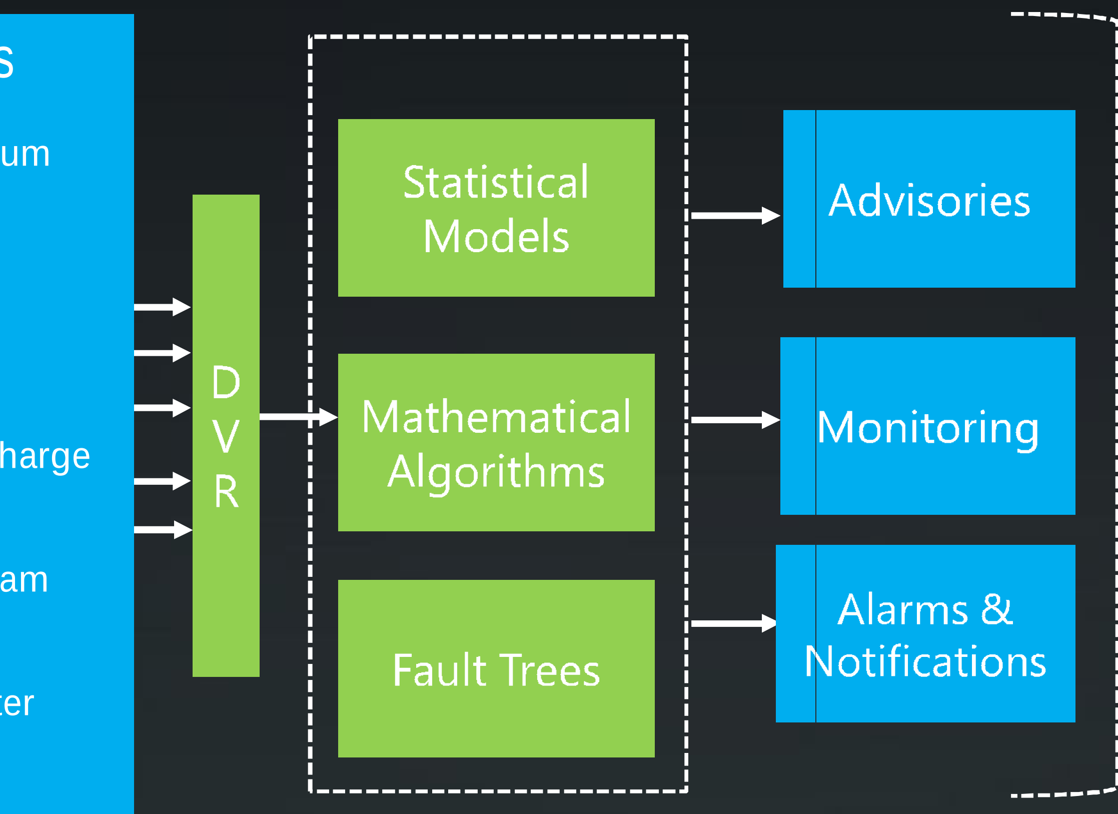
Op
Sys

pplications



Core Engine Architecture

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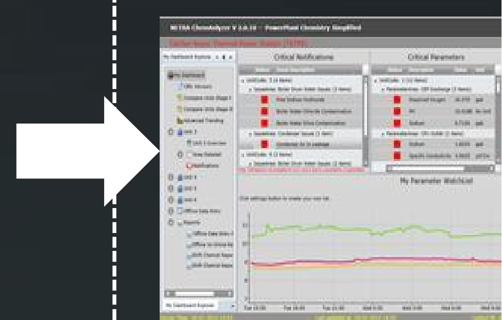

pplications

m/Issue	Chem Analyzer prediction	Actual condition	Action/benefit
olumn ustion	Detected	Column Exhaustion	replaced
denser kage	Detected	Problem occurred	Stabilized
ytical blem	Detected	Silica analyser faulty	Calibrated/ standards replaced
nser leak	Detected	Condenser leak	Appropriate action taken
silica	Blow down recommendation	High silica in off line data	100/50 T blow down
PO4	Detected	High boiler conductivity	B/D to reduce boiler conductivity
iler nination	Detected	High sodium	Normalized after B/D

Case Studies

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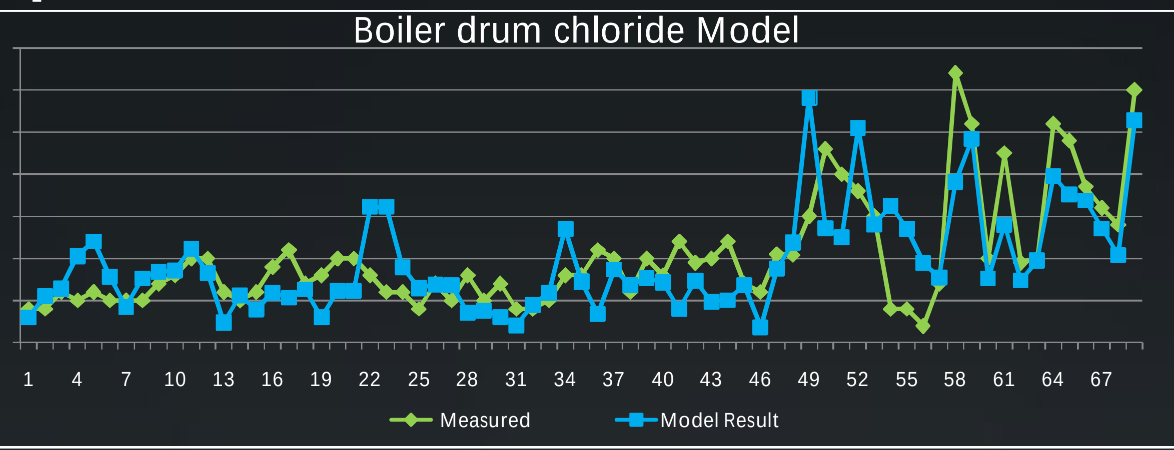

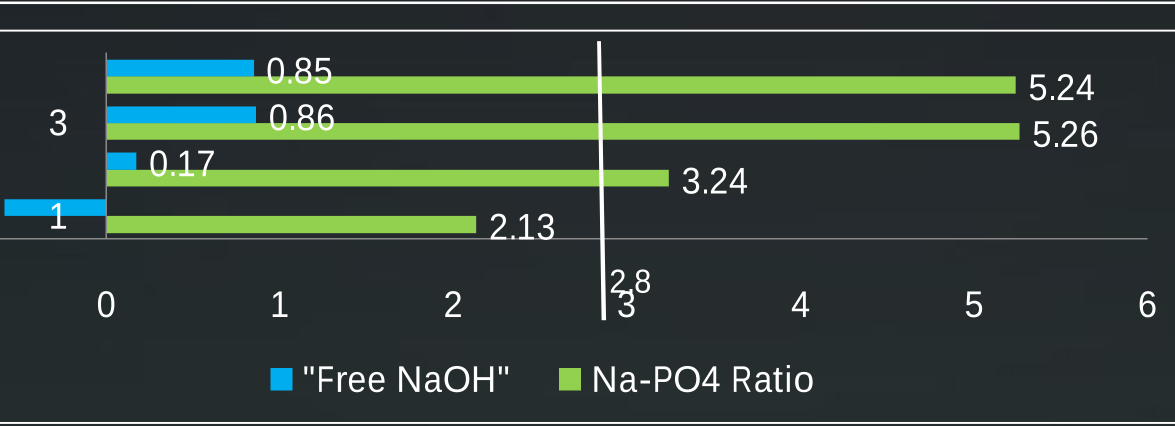

Case Studies

Ch

Dia

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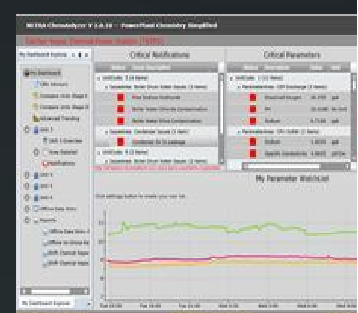
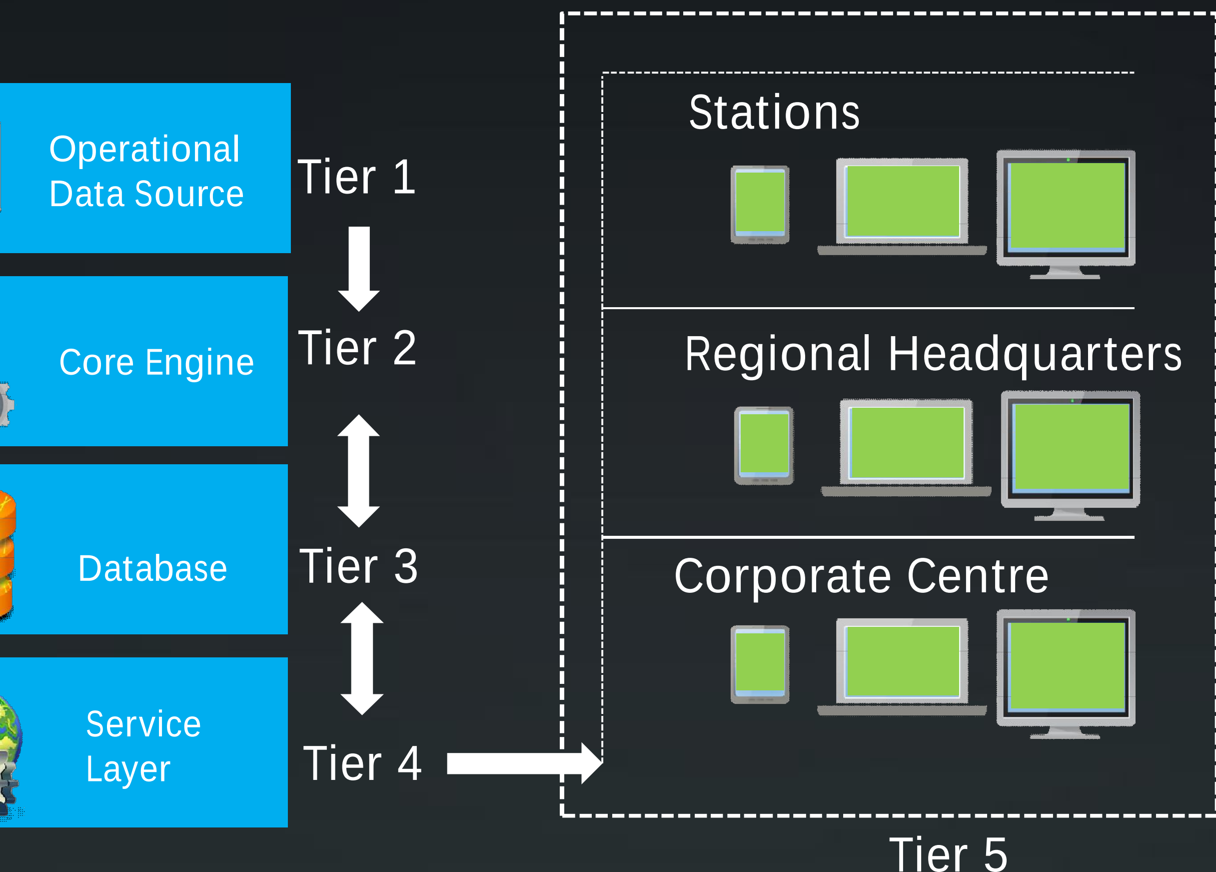


pplications



Sol
Arc

→ 5 Tier Industry Stand
Architecture
→ Service Oriented Ar

onclusion

→The combination of operational data, domain expertize and expert systen technologies can produce significant improvements in power plant performance anc reliability

→Real time monitoring and diagnosis can help to maintain equipment's health thu increasing plant operation lifetime

→With stringent environmental norms, such system can benefit power utilities i controlling emissions

→Efficiency improvement can help to achieve performance targets in PAT regime

→Such systems can be customized according to different utilities needs

→Service Oriented Architecture enables interoperability and seamless integration wit existing, legacy and future systems

Thank You

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Solar Simulators – Plant optimization

V.S.Sharma – GM Renewable Energies

Dated : 12/04/13

steag

STEAG – Operations full of energy

More than 75 years old company, based in Germany

Owns more than 11,000 MW plants

Planning – operation – supply – marketing – recycling

Project development, planning, operation and supply of power plants…

… in Germany and …

… abroad

… on the basis of fossil…

… and renewable energy sources.

Marketing of electricity and district heat, and…

…recycling of power plant byproducts.

Key figures (as of Dec. 2011)

External sales **3,066 € m** Capital expenditure on fixed assets **1,283 € m** Employees **5,800**

Steag's Activities

steag

Steag India Activities

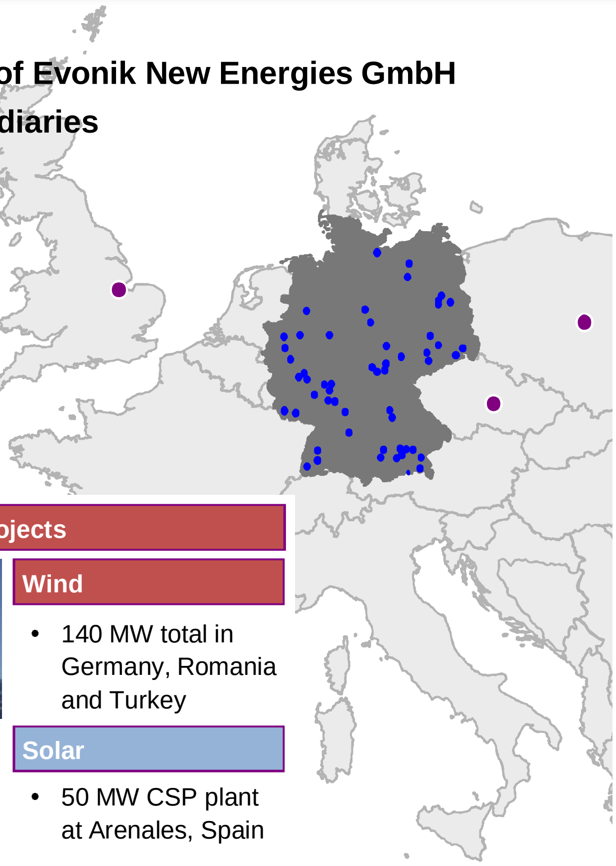
- Engineering Consultancy
- O&M services – ~ 5000 MW
- System Technology – Simulators and Plant optimization systems
- Training and advisory services

Steag India – Solar activities

- Several DPRs and feasibilities
- Ebsilon Solar
- Solar simulator - with Trax
- Owners Engineer NTPC Anta
- Training on Solar – With IITJ

STEAG holds a strong position in the renewable energy market

steag



Steag Projects

Wind

- 140 MW total in Germany, Romania and Turkey

Solar

- 50 MW CSP plant at Arenales, Spain

		Installed capacity		Plants
		MW_{el}	MW_{th}	
	**Biomass*** • since 2002 • #3 in Germany	66	154	13
	**Biogas** • since 2007 • First own biogas plant commissioned			
	**Mine gas** • since1908 • #1 in Germany	177	139	108
	**Geothermal** • since 1994 • #1 in Germany	--	71	2
	**Contracting** • since 1961 • #2 in Germany	77	905	100
Total		**319**	**1,271**	**223**

Topics for discussion

- Simulator types – Steady state, Quasi Steady state and Dynamic
- Applications of Dynamic simulators in Solar thermal
  - Dynamic simulators – Case studies – DLR, SESI
  - Basic applications – Training
  - Simulation studies – Correction factors for a Steady State simulator
  - Research on Operational Optimization
    - Startup time optimization
    - Plant trip risk minimization – Transients
    - Mirror cleaning frequency optimization
    - Thermal storage usage optimization
- Applications of Steady state simulators in Solar thermal
  - Design optimization - Field sizing and Annual electricity generation
  - Cost optimization - Field size and storage for minimum LCOE
  - Hybridization studies – Optimization of extraction and injection points
  - PG testing of plant and Daily performance monitoring

Types of simulation

- Steady state:
  - Simulations done at a particular point of time based on Algebraic equations
  - Simulations can be done over multiple time steps but the simulation at a particular step has no relation with the previous step. e.g. DNI at a particular time step would not consider the DNI of previous step
  - Mostly used as a design tool or cumulative output analysis tool but can not be used for the study of transients
- Quasi steady state :
  - Simulation is done in discrete time steps, but the input state for a particular time step can be taken from the calculated state in the previous time step.
  - Can take care of thermal inertia during start up / shut down, cloudy conditions , storage etc. to some extent

Types of simulation

Dynamic :

- A dynamic simulator runs like an actual plant
- Based on differential equations and is used to do the continuous analysis of transients
- It is able to consider thermal inertia during the start up and shut down and clouding conditions satisfactorily
- Used for comparatively short duration analysis since it needs a lot on computation power

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Case Study 1 - Modelica / Dymola based dynamic simulator by DLR

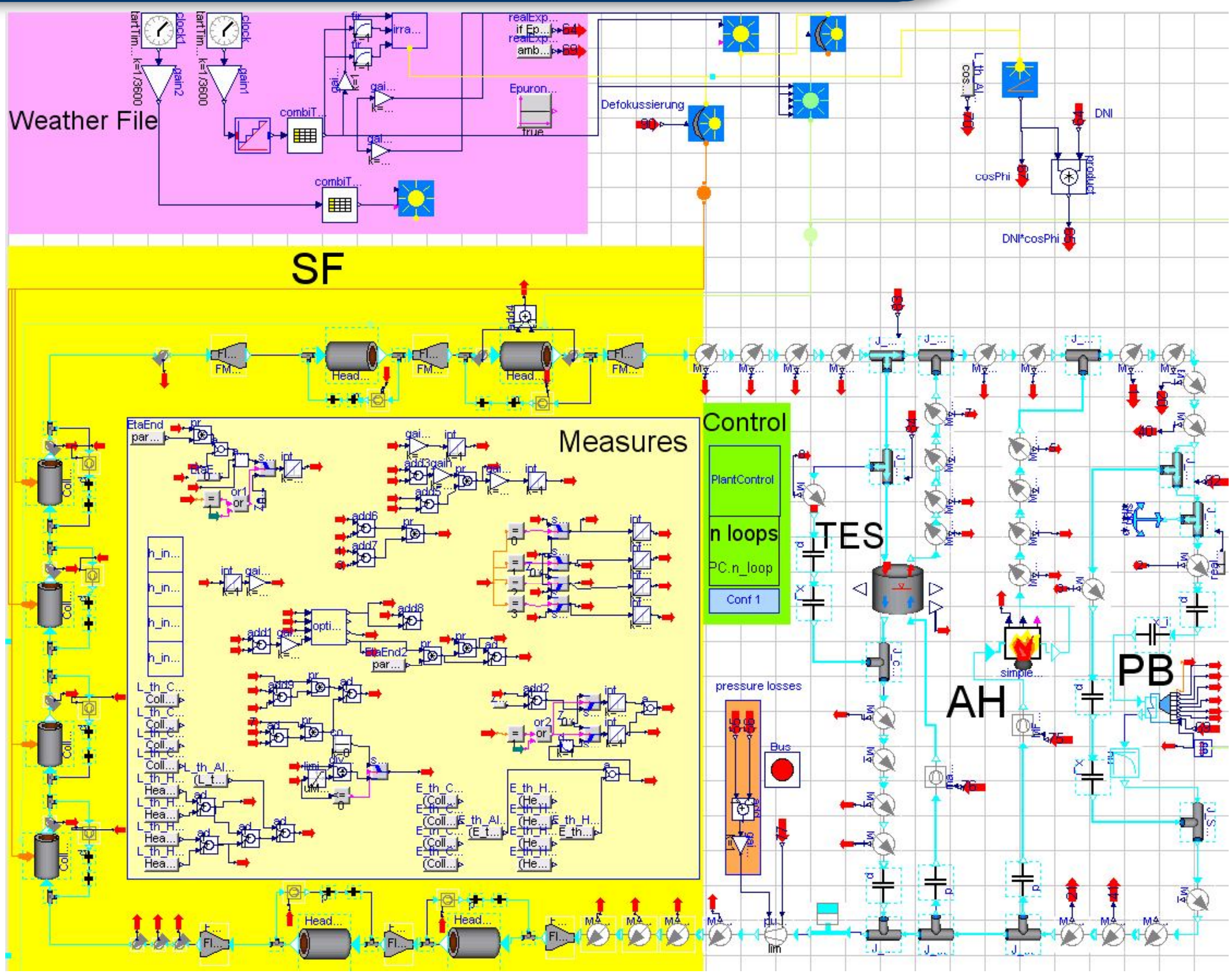
- A dynamic simulator has been created for a Parabolic trough plant in which numerous transient effects are accounted for which have an impact on the energy yield.

- The model possesses a control layer which is able to reliably cope with changing weather conditions.

- An automatic plant operation during one or even several consecutive days is possible.

- Due to the open layout of the model, submodels can easily be modified or replaced. Therefore more detailed submodels can be developed and tested.

Case Study 1 - Modelica / Dymola based dynamic simulator by DLR



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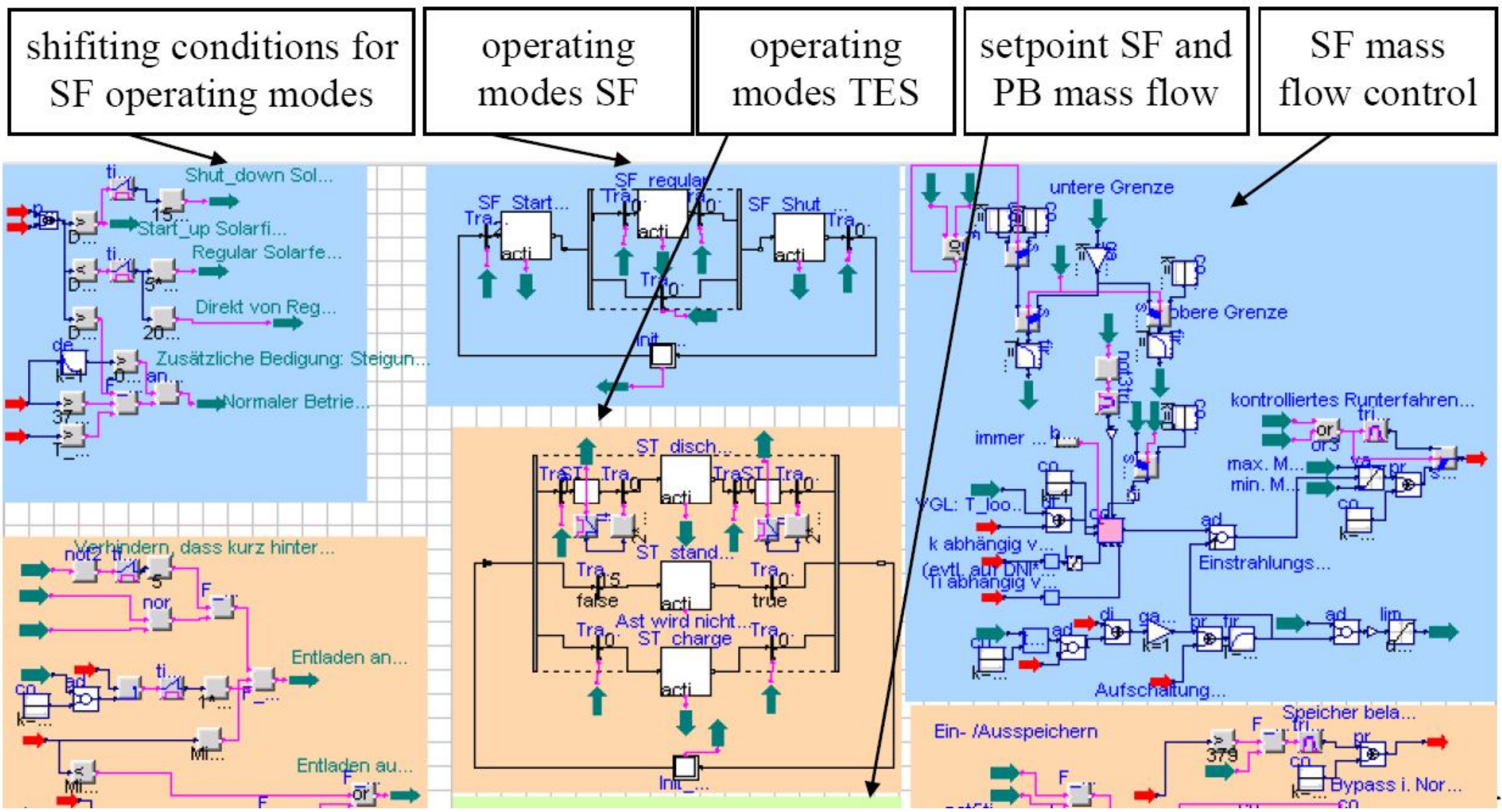
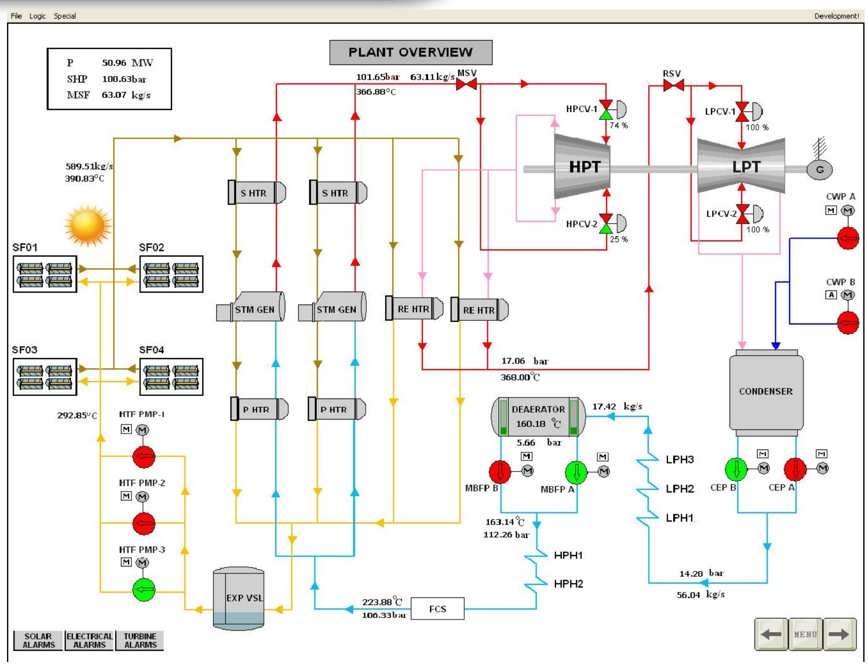


A complex control layer has been developed which is able to operate the plant automatically, even during bad weather periods.

Case Study 2 - Trax based simulator from Steag

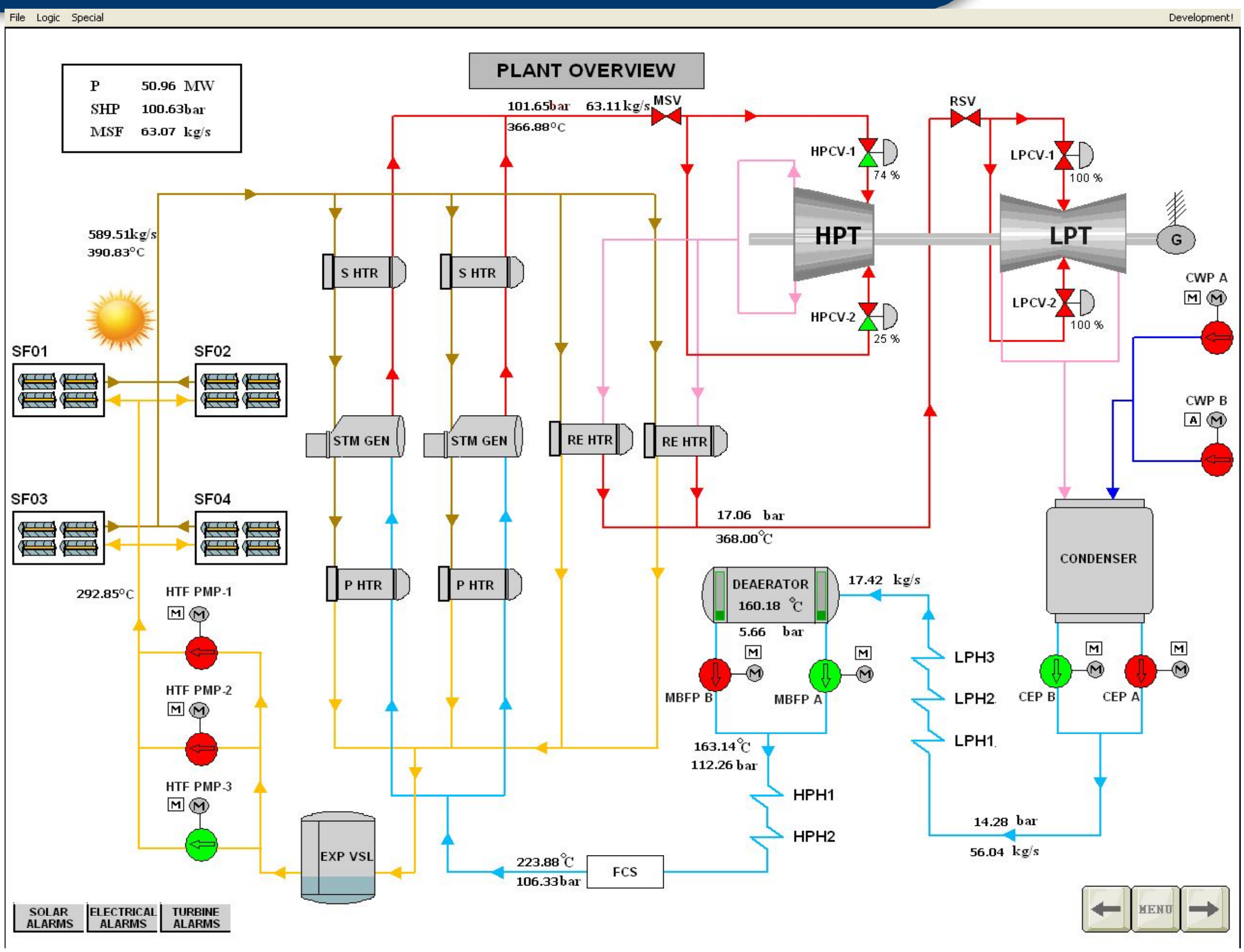
steag

- Based on 50 MW PT
- Joint development with Trax Inc. of USA
- Being used for training jointly with IITJ.
- Steag is using for various studies and Research



- Physical and control models developed using Trax toolkit, while the HMI is developed in Wonderware Intouch
- We understand that it is the first commercially available simulator for solar thermal power plants

Case Study 2 - Trax based simulator from Steag



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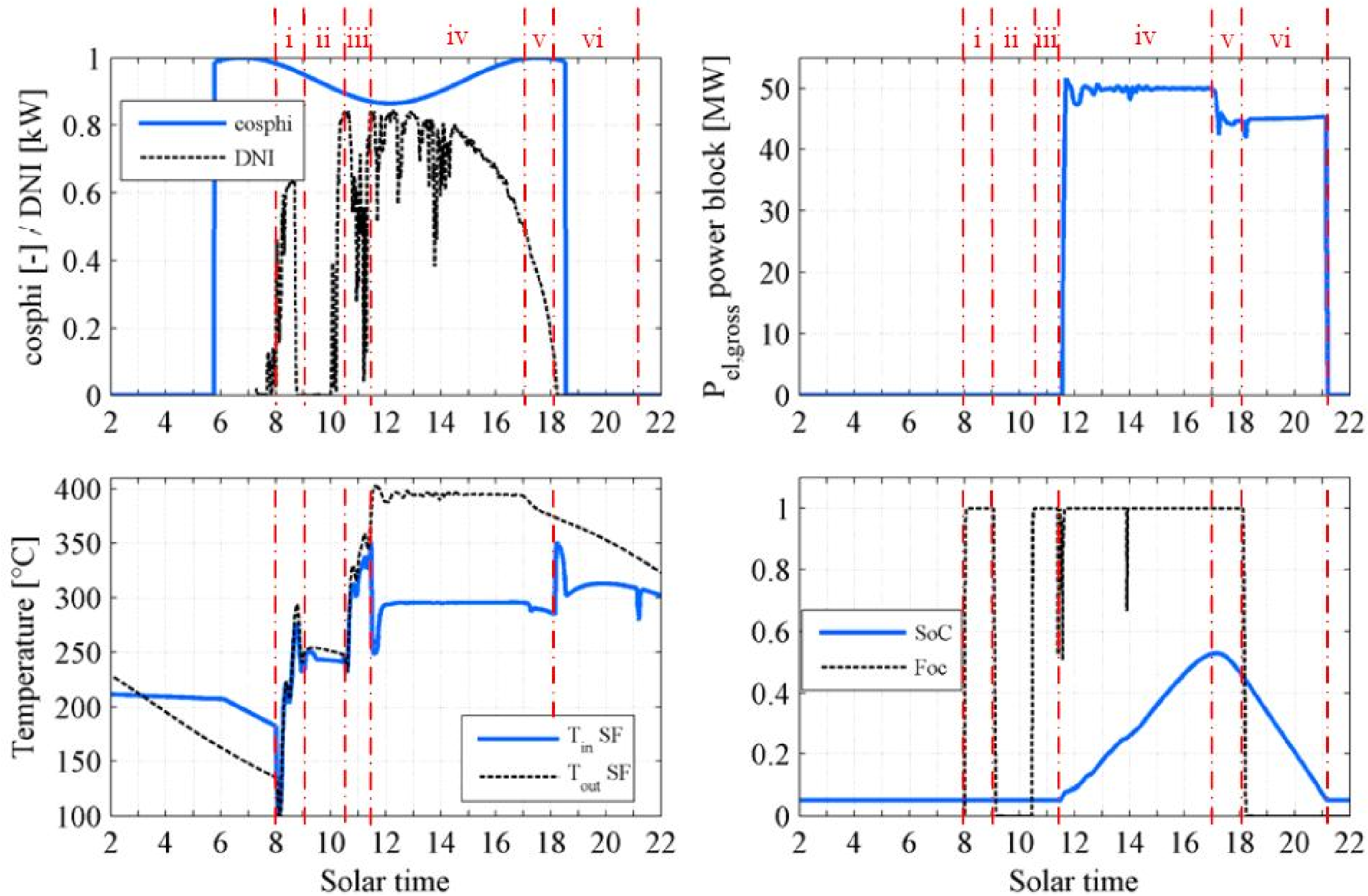
Simulation studies – Varying conditions, operational regimes and control strategies



Using the simulator various operation regimes and control strategies can be studied / designed and various types of transients can be studied