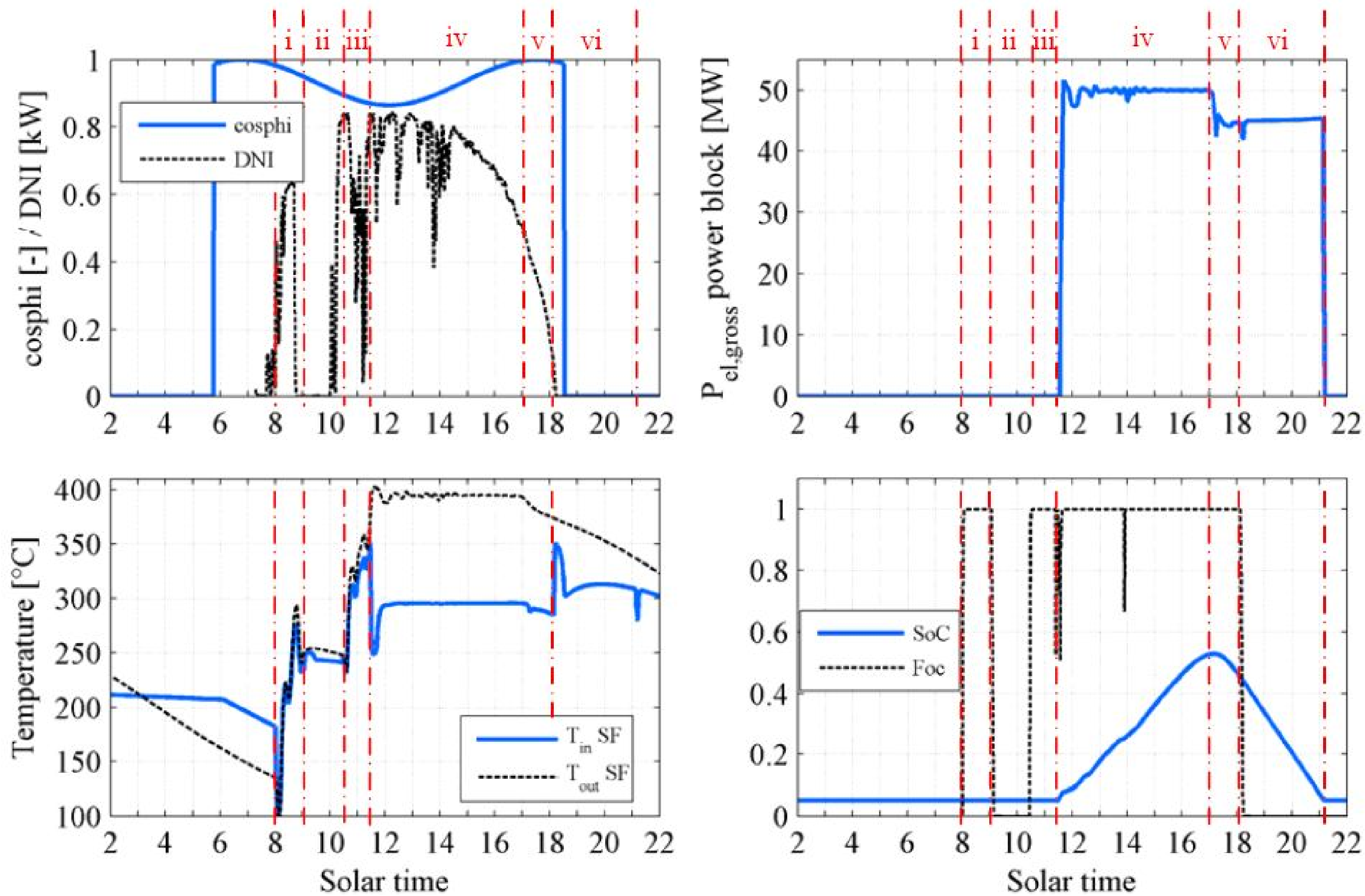
Simulation studies – Varying conditions, operational regimes and control strategies

steag



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

Use of Dynamic simulator for developing correction factors for transients for a Steady state simulator

- Electricity yield calculations are generally done by steady-state simulation, in hourly time-resolution, using at least one year data.
- Such calculations are fairly quick, but fail to capture the ill effects of Start-up and interruptions due to broken clouds.
- Such effects can only be handled by a dynamic simulator, but the use of a dynamic simulation is not feasible for such long term data in an iterative mode. Its feasible only for short term analysis.
- DLR has therefore developed certain correction factors, that can account for such dynamic effects in a quasi-static simulator, thus ensuring that the calculations are quick as well as close to reality.
- For developing these correction factors, DLR has used their dynamic simulator which was presented in the previous slides.

The minimum start-up energy is the difference between the Energy level (required to start the power production) and Energy level of the system in the morning.

The ratio of theoretically available energy during the start-up process to the minimum start-up energy is called start-up effort ratio

$$\psi_{\text{start-up}} = \frac{\Delta E_{\text{avail}}}{\Delta E_{\text{min}}} > 1 \ .$$

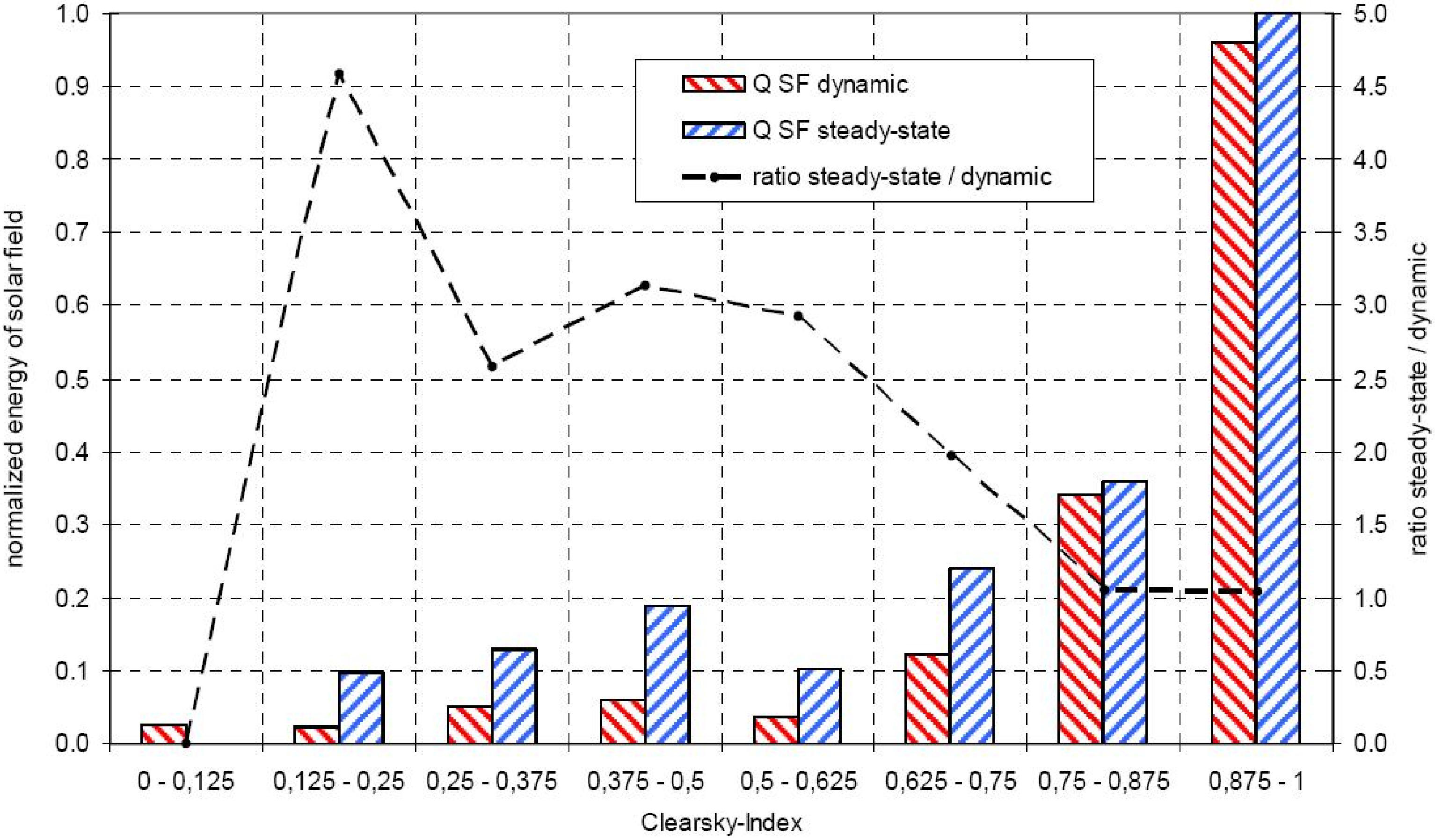
A value close to 1 indicates a good quality of start up.

By simulating start ups on enough number of days with varying conditions, it is possible to get start up effort ratios.

Use of Dynamic simulator for developing correction factors for taking care of reduction due to clouding

- For studying the impact of short-term fluctuations (clouds) on the electricity yield, simulations with the same dynamic model were performed as were done for Start up effects.
- Simulations have been performed over a number of days including all kinds of cloud situations
- Based on the above, an appropriate reduction factor for the steady-state model could be derived in the form of a clear sky factor as shown in the graph on the next slide.

Use of Dynamic simulator for developing correction factors for taking care of reduction due to clouding

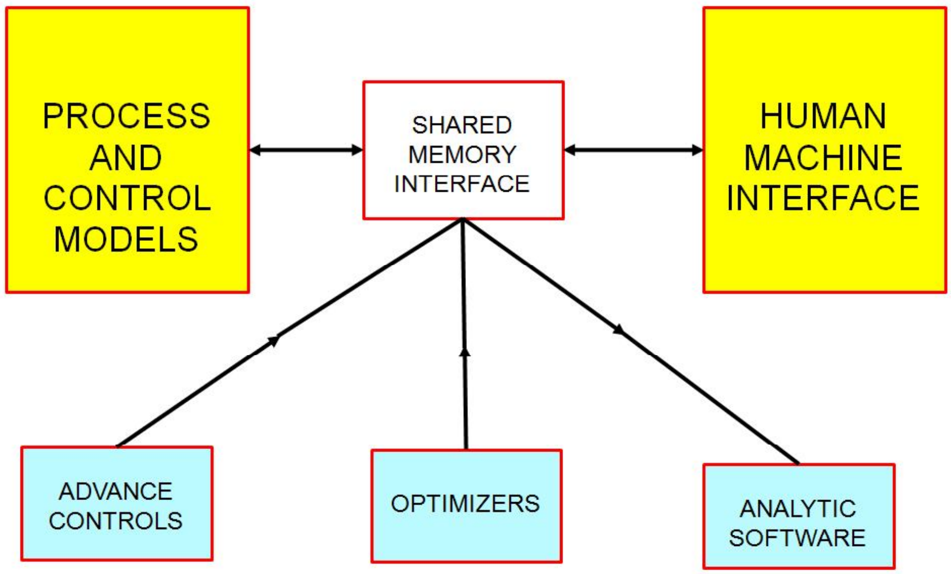


The derived reduction factors would be only applicable for the considered steady-state model.

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

R&D on operational optimization on simulator platform



- It is possible to write interface software to exchange data between simulator and other softwares such as optimizers and Advanced control software like Model Predictive Control.
- With this interface it is possible to writing the setpoints generated by external software simulator fields and test the results.

Startup time optimization :

- A solar plant needs a daily start up and shut down.
- Since it has to be done daily, a small reduction in the startup time can be a big additional revenue
- Startup under different DNI conditions is different and so is the startup strategy and the startup optimization challenge.

Mirror cleaning optimization:

- The mirrors in the solar field need cleaning periodically and each cleaning process is very resource intensive.
- It is therefore required to optimize the frequency of cleaning by comparing the cost of cleaning to the loss being incurred by the dirty surfaces.

R&D on operational optimization on simulator platform

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Optimization of Thermal Energy Storage Operation

- This process of thermal storage operation has to be scheduled and optimized such that it maximizes the power production while meeting ramp rates and other process/ equipment constraints.

Minimizing the risk of plant trip during transients

- Transients like cloudy conditions can sometimes trip the plant
- The plant can sometimes sustain the operations by reducing the load sometimes without tripping.
- This is also an important research problem and an important application of such simulators.

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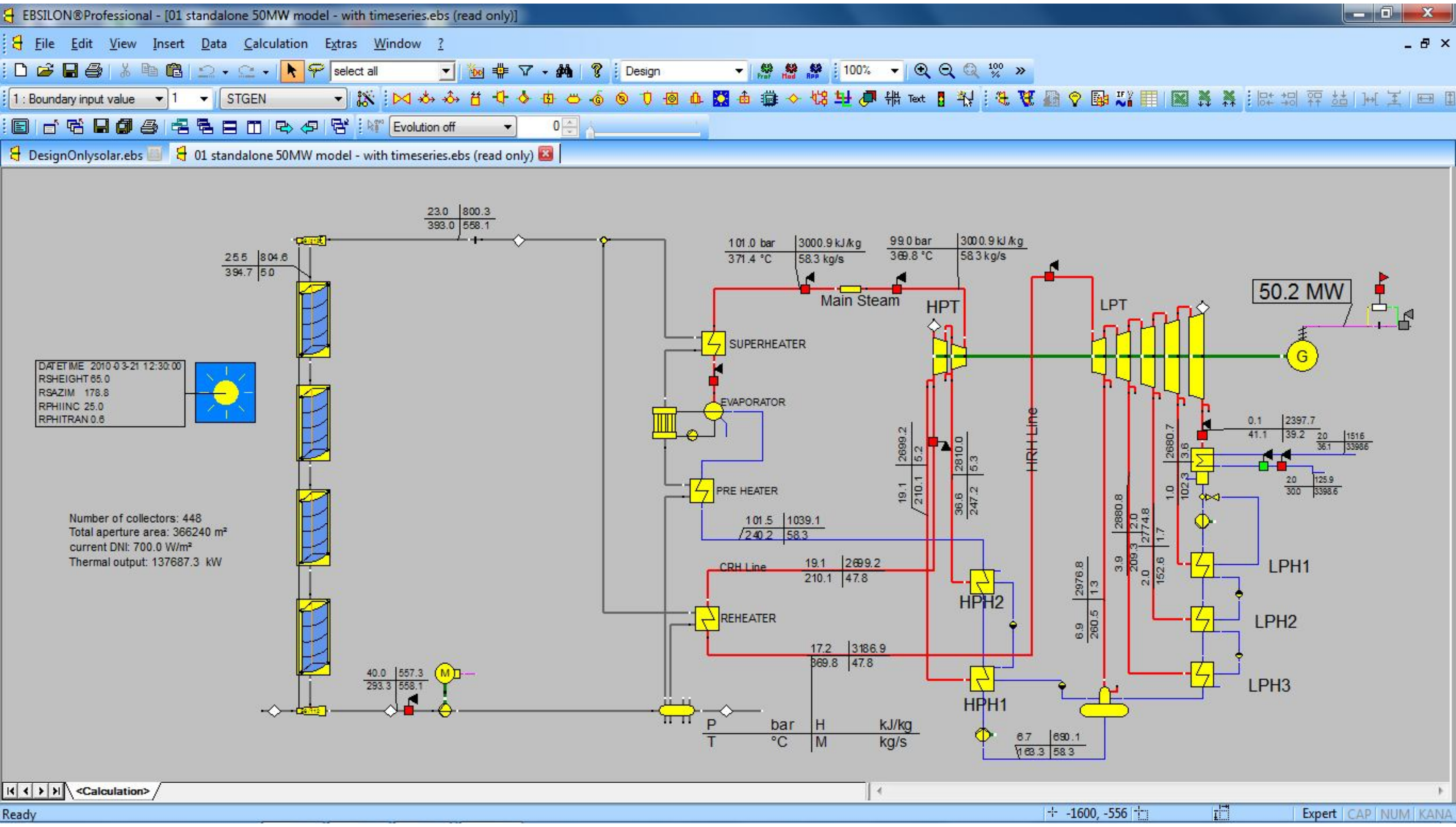
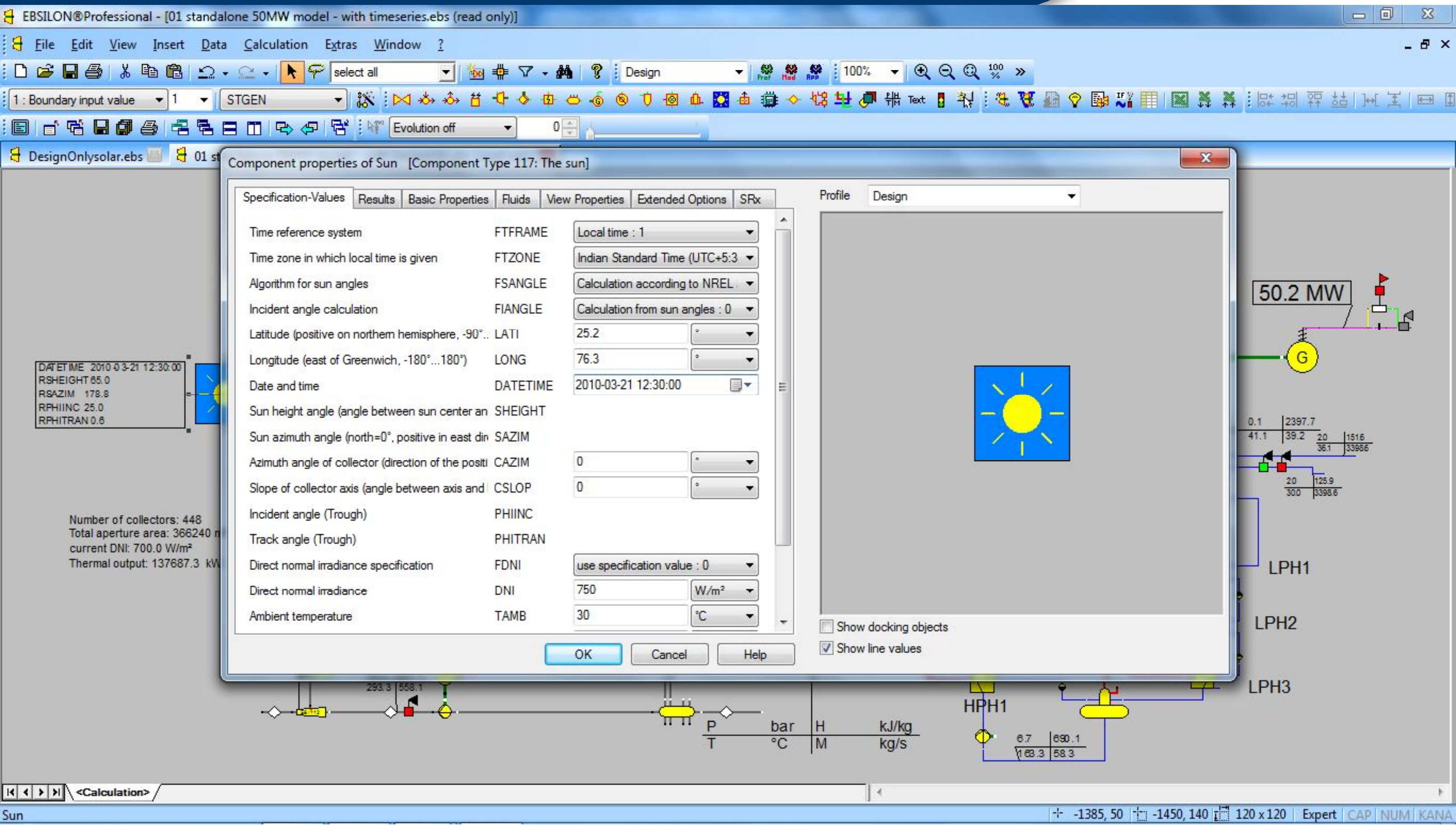
Solar plant design



Step 1 - Creation of the components of solar field as well as the power block

Solar field sizing



Step 2 – Initial sizing of the solar field based on a design point at a specific day

Annual power output

Anmerkung		DNI	Tamb	generator po...	Sur
Typ	auto-inserted	spec	spec	result	res
Definition		Sun.DNI	Sun.TAMB	Gross_OP.Q	Sur
2010-01-01 06:30:00		0	15.3	0.00300896	-2
2010-01-01 07:30:00		0	15.6	0.00339918	3.2
2010-01-01 08:30:00		259	17.9	8733.37	14
2010-01-01 09:30:00		482	20.3	23152	25
2010-01-01 10:30:00		585	22.6	26306.8	33
2010-01-01 11:30:00		718	24.7	31144.1	39
2010-01-01 12:30:00		701	26.2	29073.4	41
2010-01-01 13:30:00		797	27.2	35915.4	39
2010-01-01 14:30:00		772	27.7	38397.2	33
2010-01-01 15:30:00		764	27.5	43136.6	24
2010-01-01 16:30:00		345	26.4	13843.7	14

Step 3 – Linking the DNI (tmy file) and computing the yearly power output

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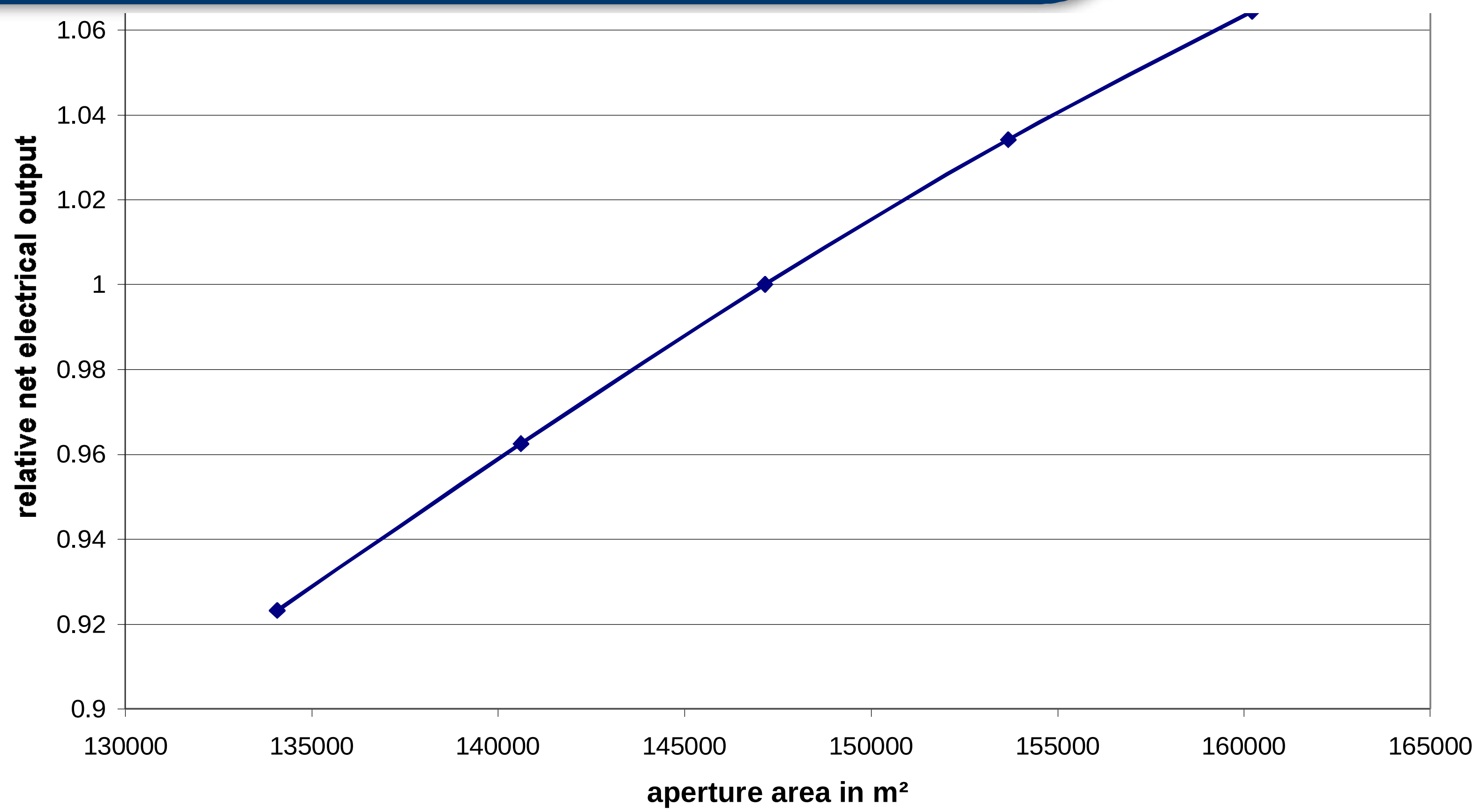
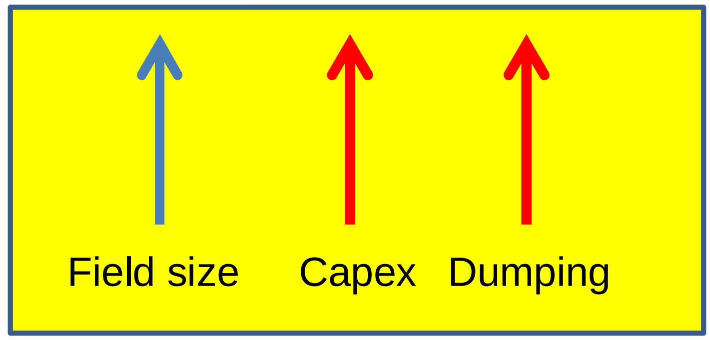
Calculation of field size for minimum LCOE



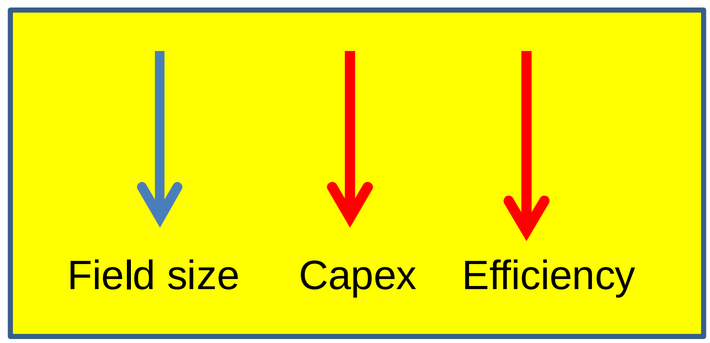
An increase in the field size increases the power output because the full load operating hours increase for a given DNI pattern but …

Calculation of field size for minimum LCOE

- In addition to the power output, an Increase in field size also increases the Capex and dumping of steam (since power block capacity is fixed)

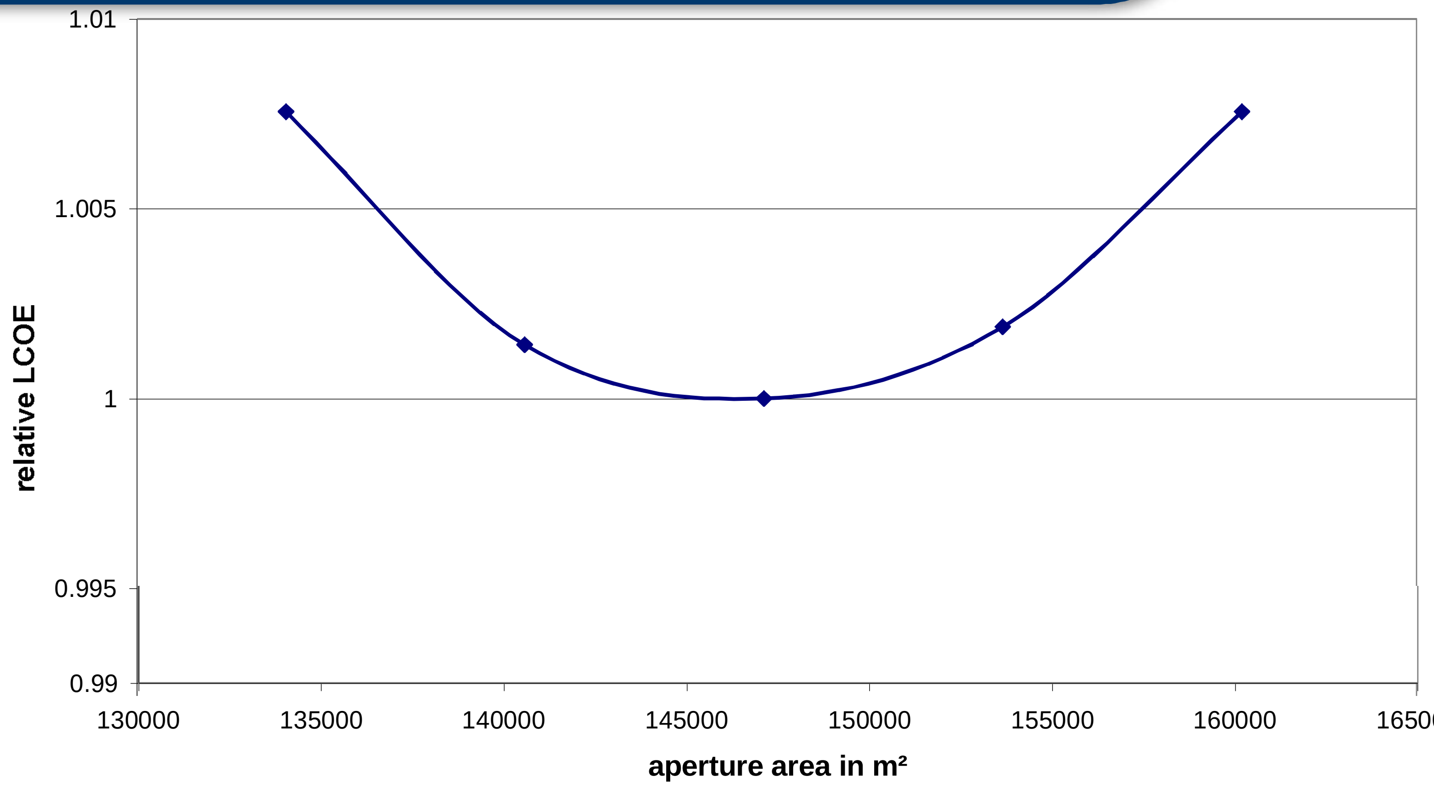


- A decrease in the field size decrease the Capex and Steam dumping but also increase the number of part load hours that reduces the efficiency and hence the power output.



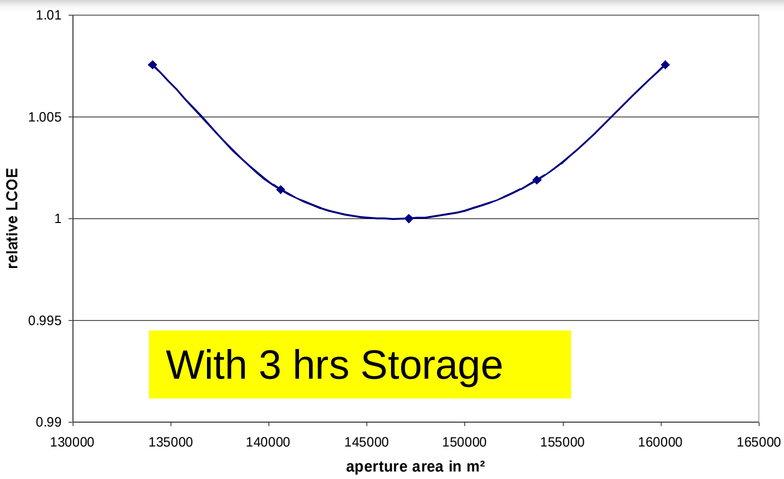
- These dependencies are nonlinear and thus for given costs of the solar field and fixed power block size, an LCOE-optimal solar field size exists.

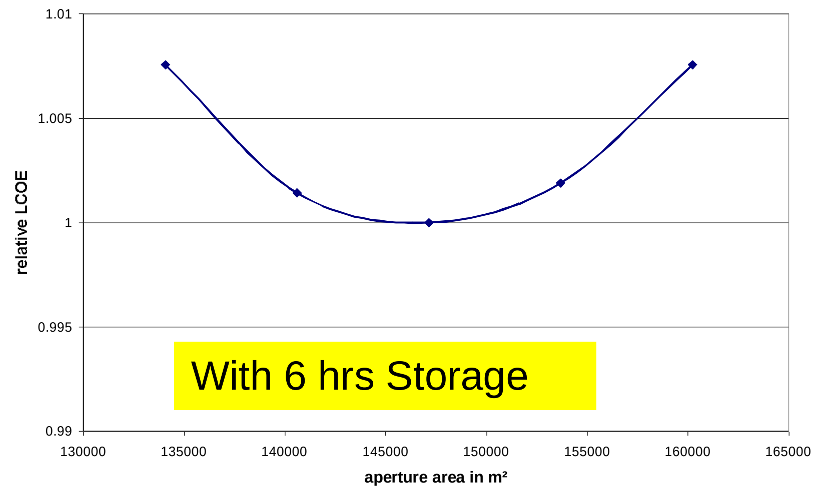
Calculation of field size for minimum LCOE



To arrive at this optimum size, iterative simulations have to be done by varying the solar field size and running the simulation model (with tmy) and calculating LCOE repeatedly.

Calculation of field size and storage for minimum LCOE (MVIS)





- To consider the storage, Multi Variable Iterative Simulation is to be done
- For this first a value of storage is fixed say 3 hours and iteration for different solar field sizes leading to different LCOE are done.
- The storage size is then changed and the process is repeated.
- This is done for the entire range of storage hours that is possible
- Finally the Storage hours and the field size is fixed based on the absolute minimum out of all the above results.

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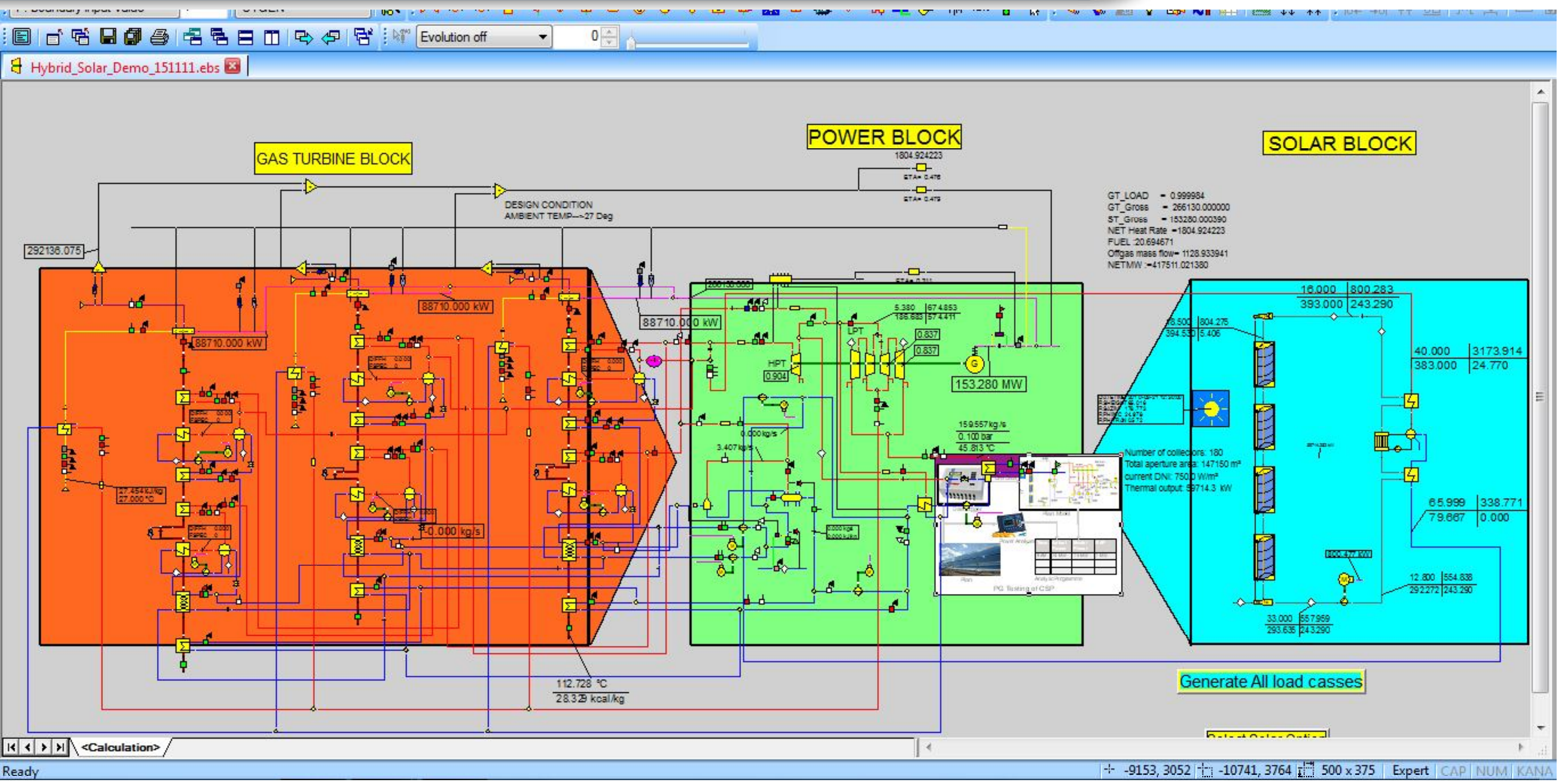
Simulation of Hybridization schemes
Developing HBD of the integrated plant

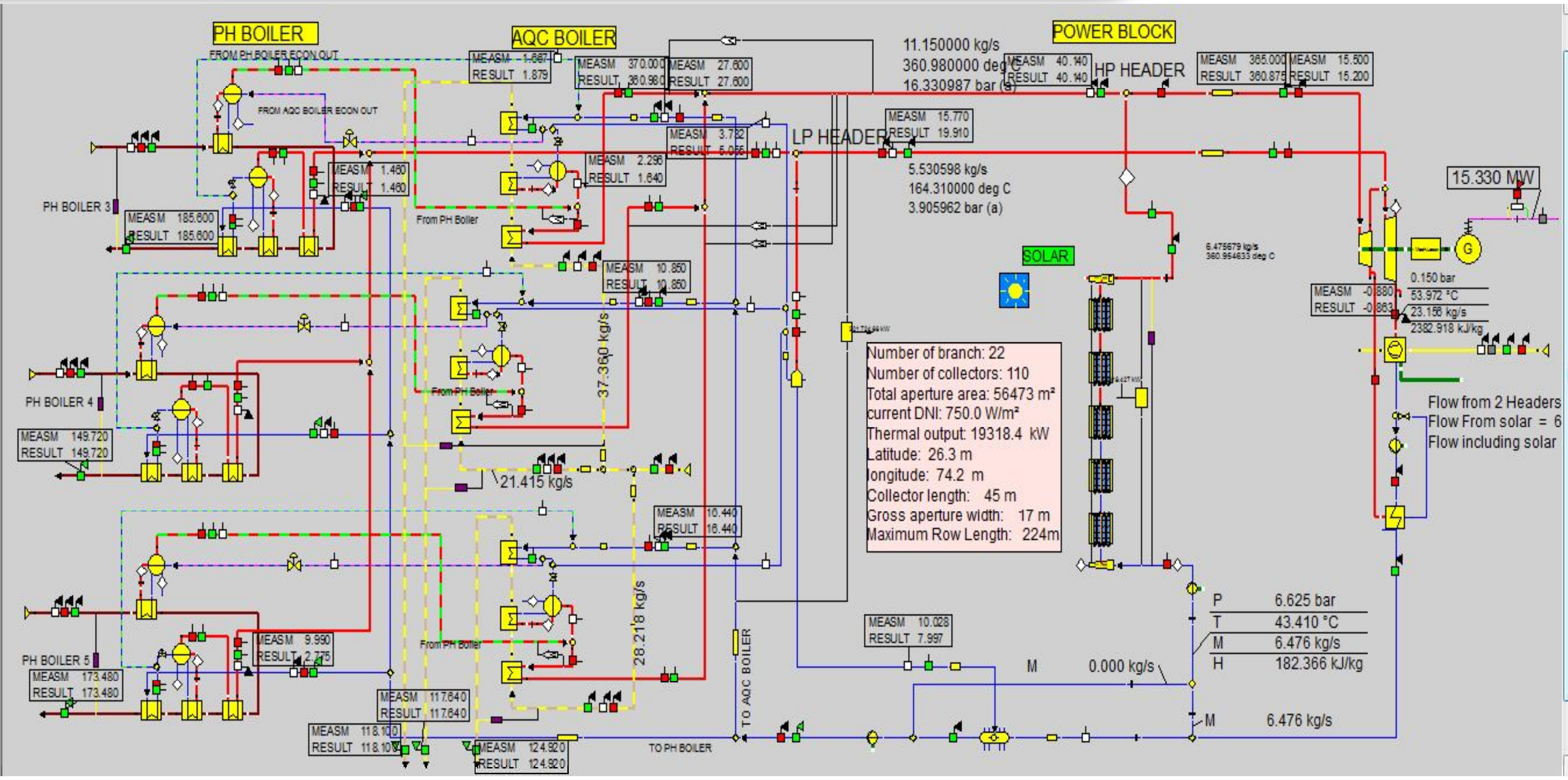


NTPC Anta 419.38 MW CCPP – Model for integration of 15 MW PT Solar field in 153 MW ST.

Steam injection options considered

1. To integrate the solar steam into the HP-drums of the existing HRSGs
2. To integrate the solar steam between two super heaters of the existing HRSGs
3. To integrate the solar steam of 370°C into the main steam (of 485°C) pipe via new mixing arrangement.
4. To superheat the solar steam of 370°C in a separate fired superheater to bring it to 485°C before integrating it into the main steam (of 485°C) pipe.
5. Solar steam to be used in a new Back-pressure Turbine Generator and exhaust of the BPST to be mixed with LP steam at LPT inlet.
6. Solar steam to be used in a new Condensing Turbine Generator and exhaust of the CST to be connected to condenser of the existing power plant.

Simulation of Hybridization schemes
Finding the best extraction point



A cement plant in Rajasthan - Model for integration of a 5 MW Solar field into 14 MW WHRB

Water extraction points explored are CEP outlet and BFP inlet

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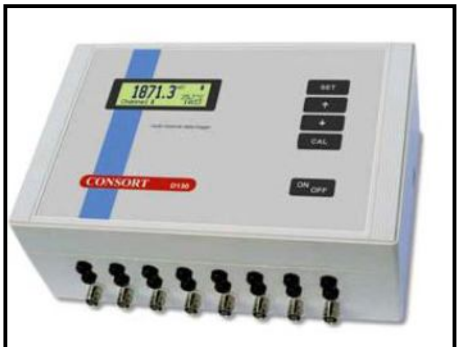
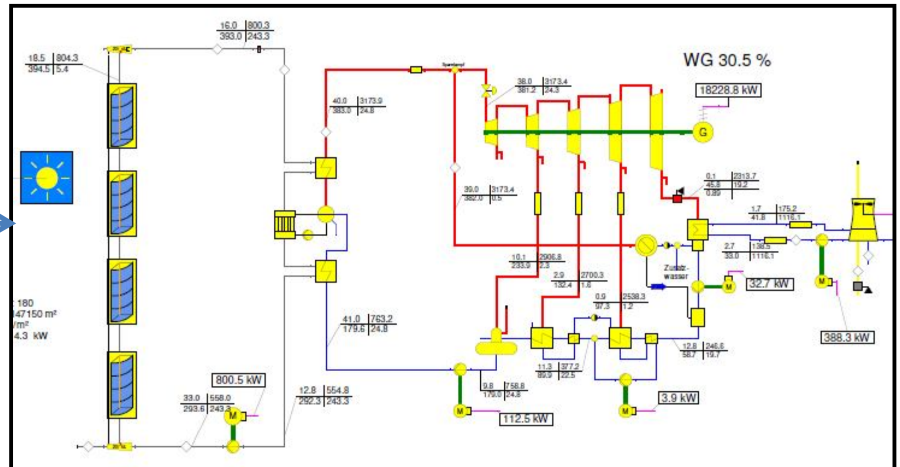


Data Logger

DNI Data



Plant Model

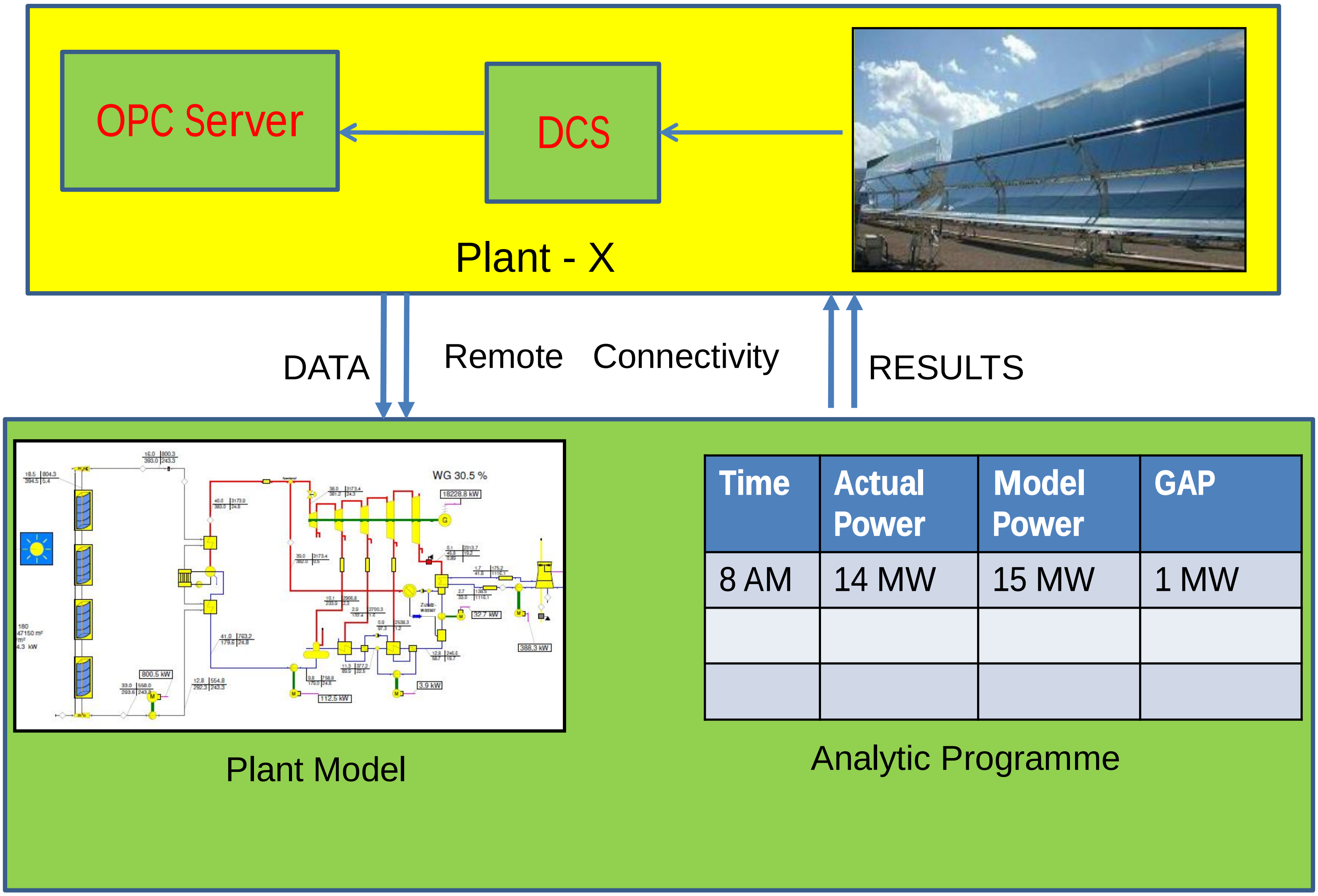
Power Analyzer

Plant

Time	Actual Power	Model Power	GAP
8 AM	14 MW	15 MW	1 MW

Analytic Programme

Simulations during PG Testing of CSP



Time	Actual Power	Model Power	GAP
8 AM	14 MW	15 MW	1 MW

Simulation for Daily Performance monitoring of a Solar thermal plant

Case Study from DLR - Comparative study of PT and CLFR costing using Greenius S/W

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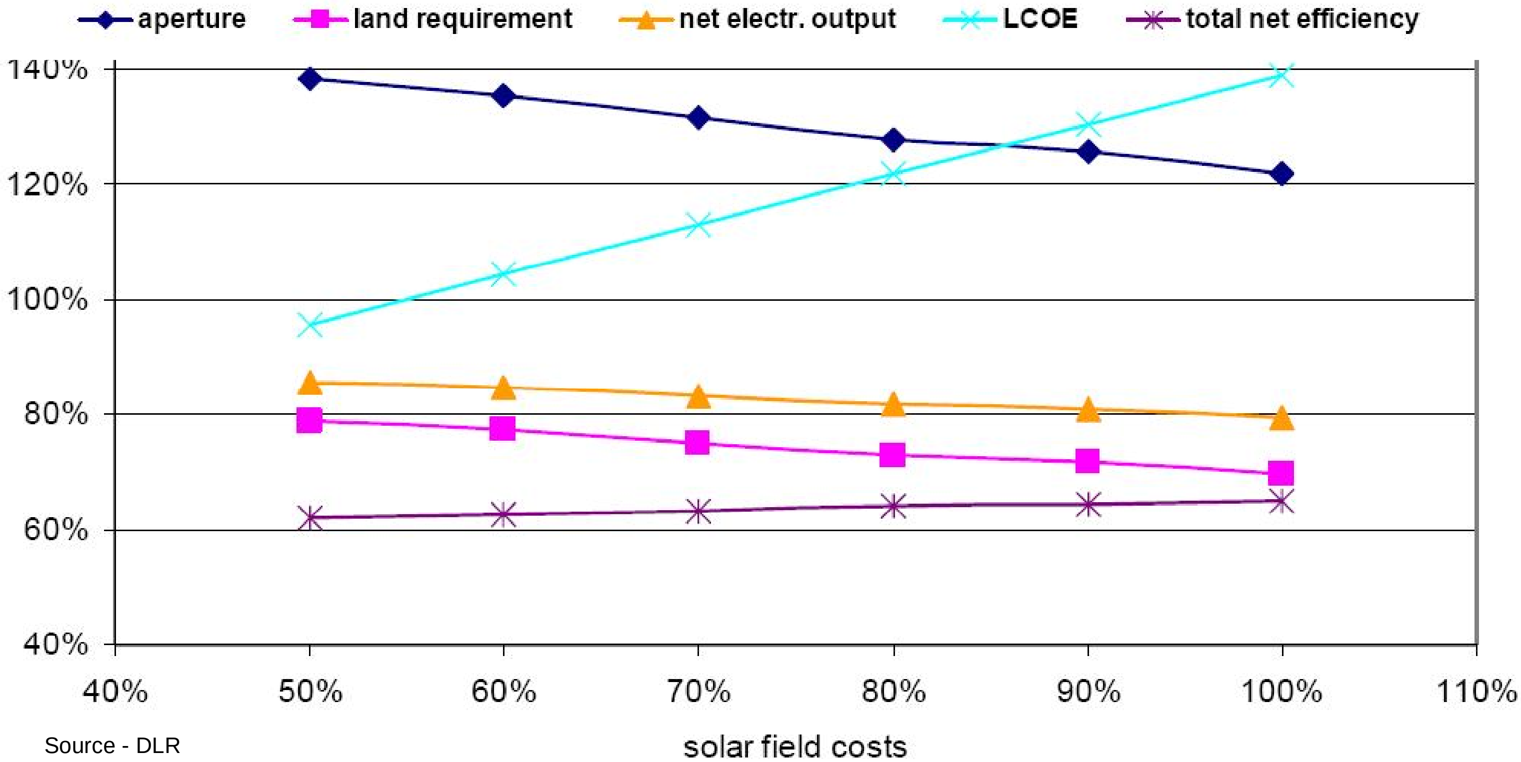

Source - DLR

Influence of the relative solar field costs of the linear Fresnel collector field (reference value is in each case the parabolic trough field with direct steam generation on the same site)

... Ideas & Solutions for Tomorrow

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Intelligent Combustion Optimisation as reaction to changing pulverised fuel properties – A Case Study

Dr .Peter Deeskow

12.04.2013

ISA Delhi Section

- Plant details
- CO system „PIT Navigator“
- Targets
- Design of CO Solution
- Project execution
- Performance Test
- Results

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Customers Targets

Increasing boiler efficiency

- by reduction of average excess O_2
- by reduction of average flue gas temperature

- but keeping global and local CO level below certain limits to prevent wall corrosion

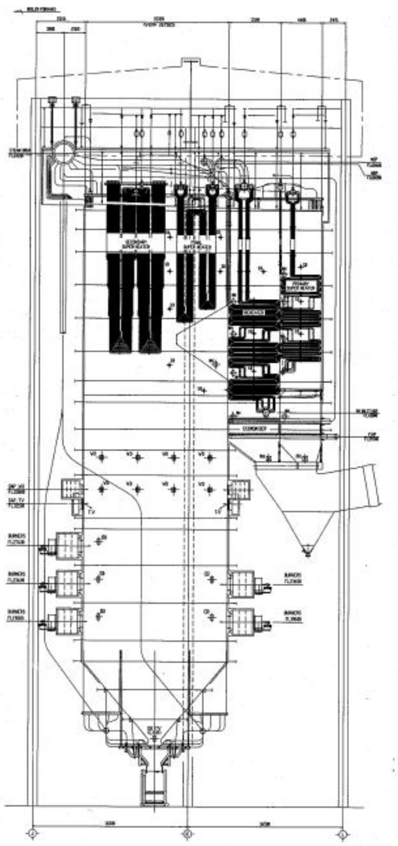
- for different mill combinations
- for different load demands
- for different coal blends

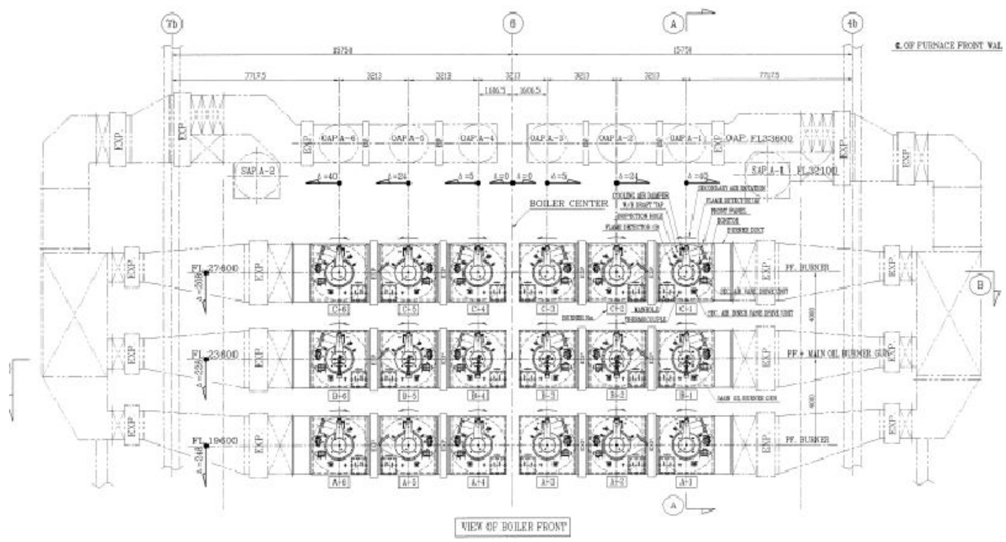
Plant Details

MALAKOFF Tanjung Bin Power station

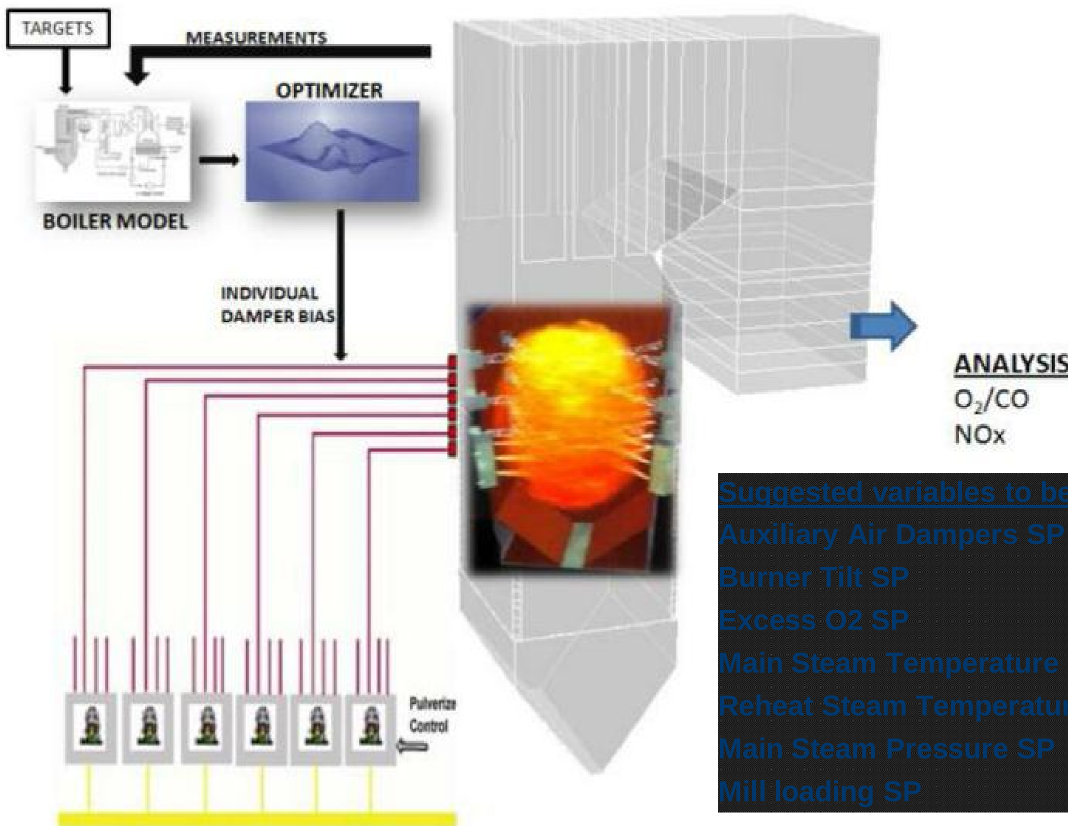
- **Unit #30 commissioned 2007**
- **748MW_{el}**
- **2350t/h steam**
- **IHI natural circulation single drum with reheater 27.7m x 15.3m x 48.5m**
- **30 LowNO_x Burners each 13.4t/h pulverized coal from different sources**

Boiler and Burner / Air arrangement





Approach to Closed Loop Optimization



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Plant Audit

- **On-site inspection**
  - **mills**
  - **coal pipes**
  - **burners**
  - **boiler**
  - **control system**
    - available measurements
    - available actuators
    - process interface
    - automatic vs. manual operation
  - **.........**
- **Data Mining on available process data**
  - **estimation of controllability of combustion**
  - **identification of existing „weak“ control loops, e.g. steam temperature control**
  - **evaluation of optimisation potential**
  - **.........**

Design of CO
Deliverables / Guarantees

Optimization core

- reduction of average excess O_2 (>= 0.6% abs.)
- reduction of average flue gas temperature (>= 2.5°C)
- keeping certain (1st RH) metal temperatures below given limit

Online CFD

- visualisation of the impact of different coal types on combustion
- visualisation of combustion unbalances

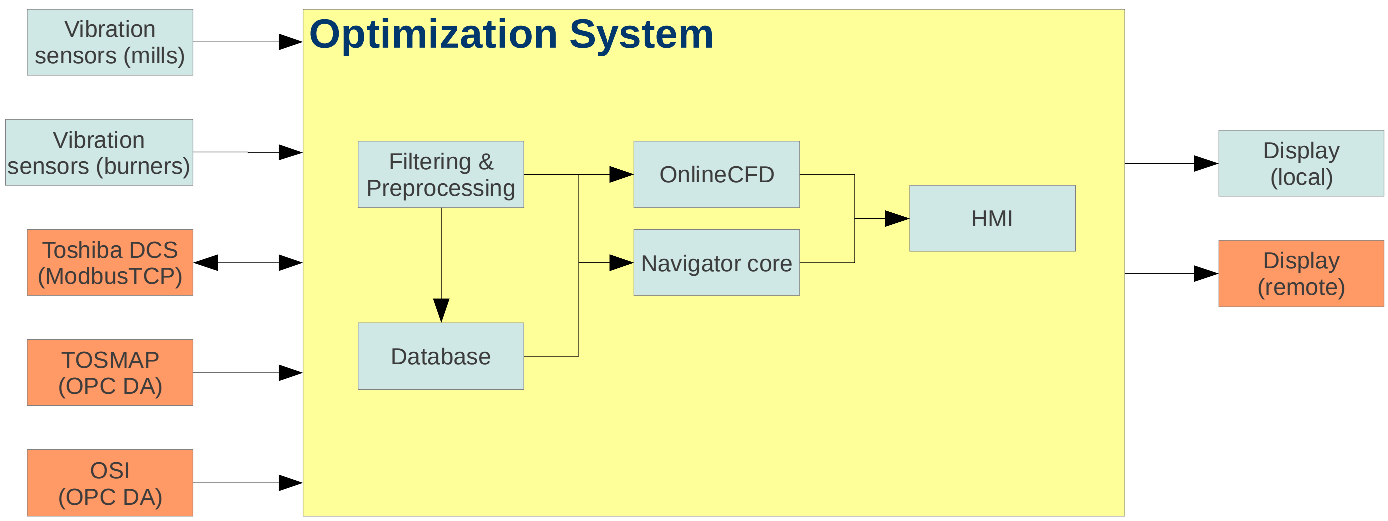
Interfaces

- process interfaces to DCS and OPC servers
- necessary changes in DCS for set-point biases
- setup of remote maintainance

Hardware

- mounting and connecting necessary computer hardware
- mounting and connecting vibration sensors and cabinets for mills and burners

Implementation
Overview system setup



Implementation
Process interface

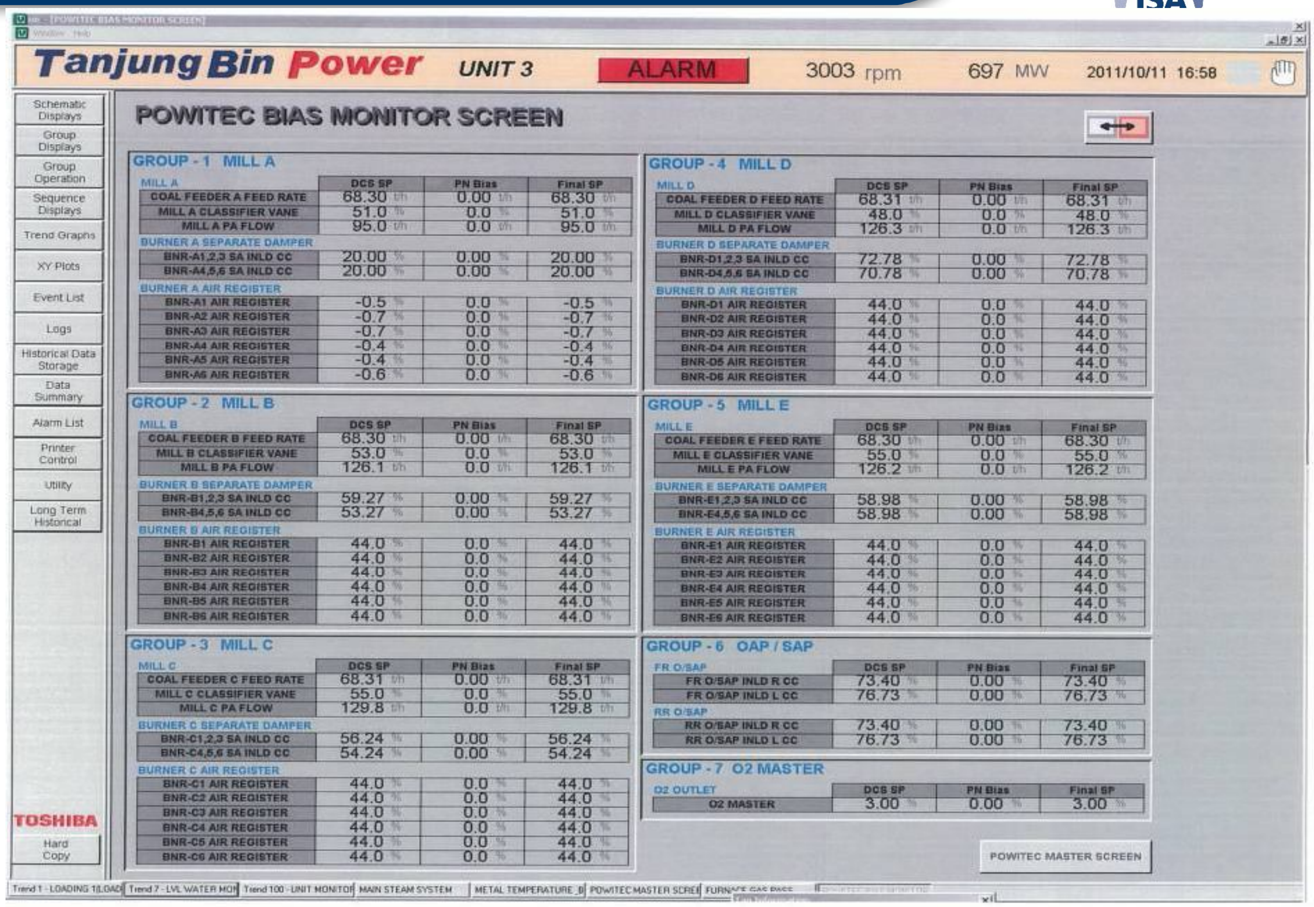
DCS -> Optimization system

- air flows related to the boiler (burner + mills +OFA)
- coal flows into the mills
- emissions (furnace + chimney)
- flue gas temperatures in the furnace
- metal temperatures of super heaters and reheaters
- steam parameters of boiler (superheaters, reheaters, boiler)
- burner settings (swirl)
- mill parameters (motor amps, temperatures, pressure, speed, ...)
- …

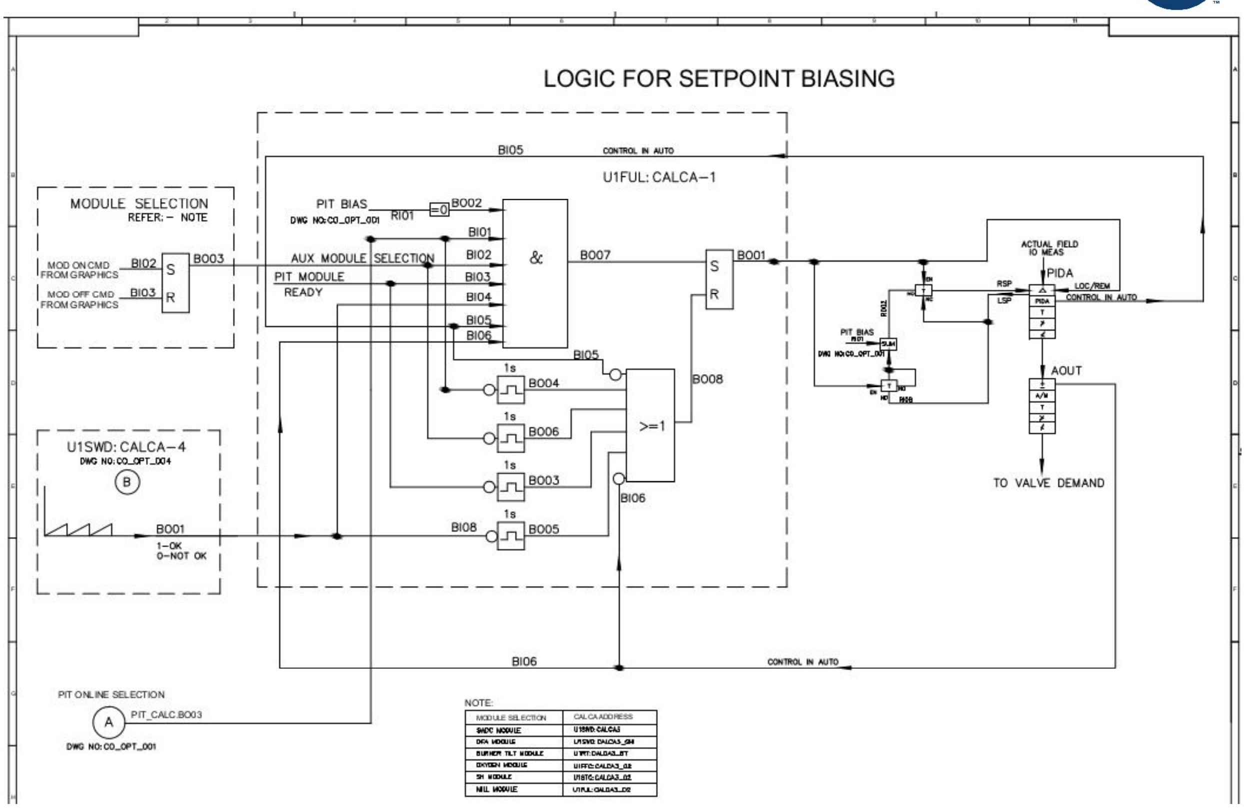
Optimization system -> DCS (biases)

- coal distribution between mills
- secondary air distribution between 10 groups feeding three burners each
- over fire air
- classifier vane of all mills
- o2 setpoint
- …

Implementation
Bias Monitor

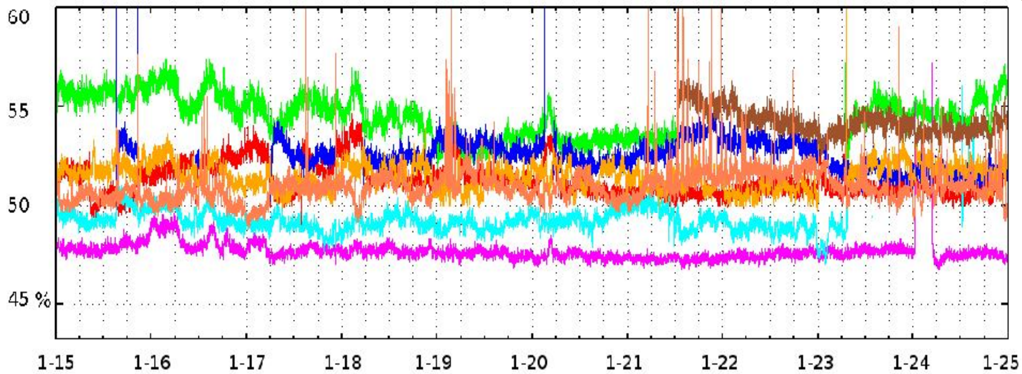


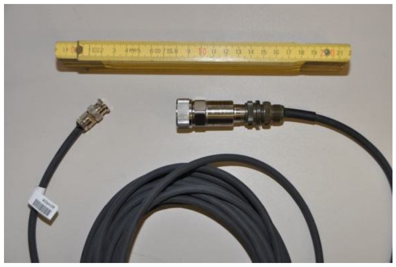
Implementation
Biasing & Loop tuning



Implementation
Vibration sensors (here: burners)

- **Fast sampling of vibration (better noise) sensors**
- **Vibration spectrum (frequency domain) instead of intensity used**
- **Result: Distribution of coal feed at each single burner at one mill**

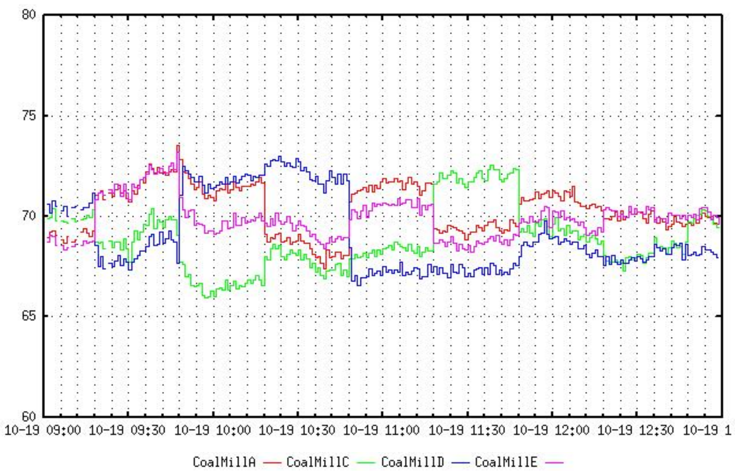


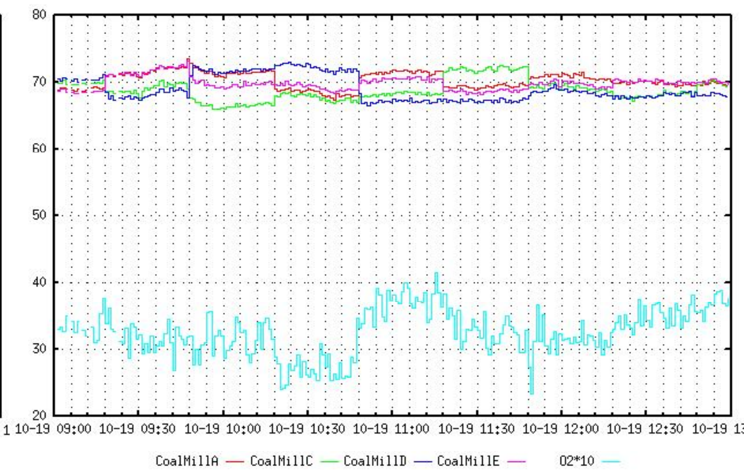


Implementation
Process exploration

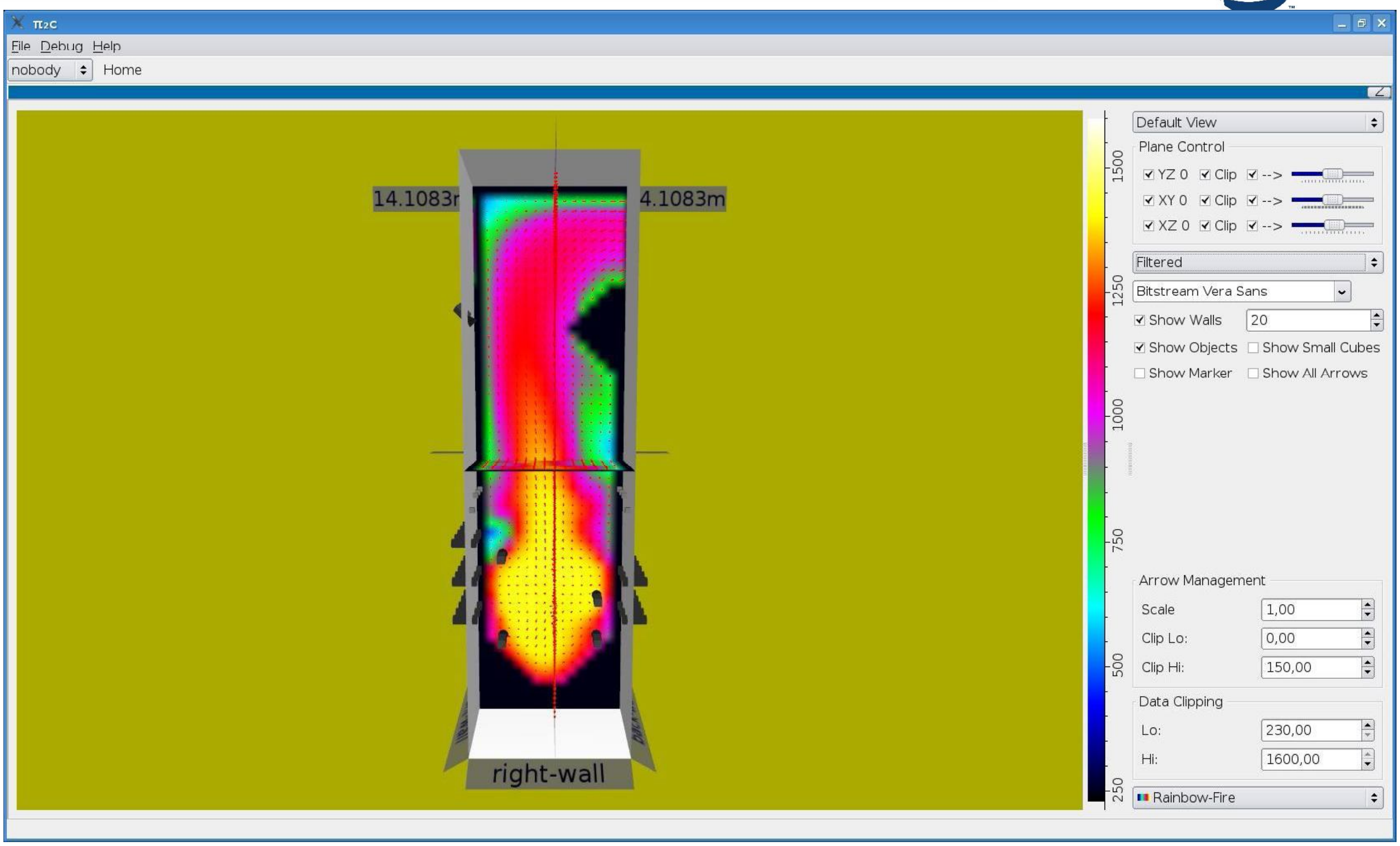
Optimization system should contain a module to carry out full automatic process exploration

- to aquire process data apart from normal operation following characteristic curves
- does not disturb „normal“ operation by maintaining production, limits, ...
- base of process data is expanded by potentially favourable working points





Implementation
CFD



Implementation
Advanced Process Control (APC)

- **A multi dimensional, model based controller is required**

- **The model is not „hand made“, but „teached“ from process data, e.g.**
  - **existing process data (temperatures, volume & mass flows, pressures, ...)**
  - **coal distribution (see: vibration sensors at burners)**
  - **coal properties (not mentioned: vibration sensors at mills, ...)**
  - **targets (reduction of excess O2, reduction of flue gas temperature, ...)**

- **A ready to use model can be used for simulation**
  - **What will happen if I would change a single set-point or a group of set-points?**

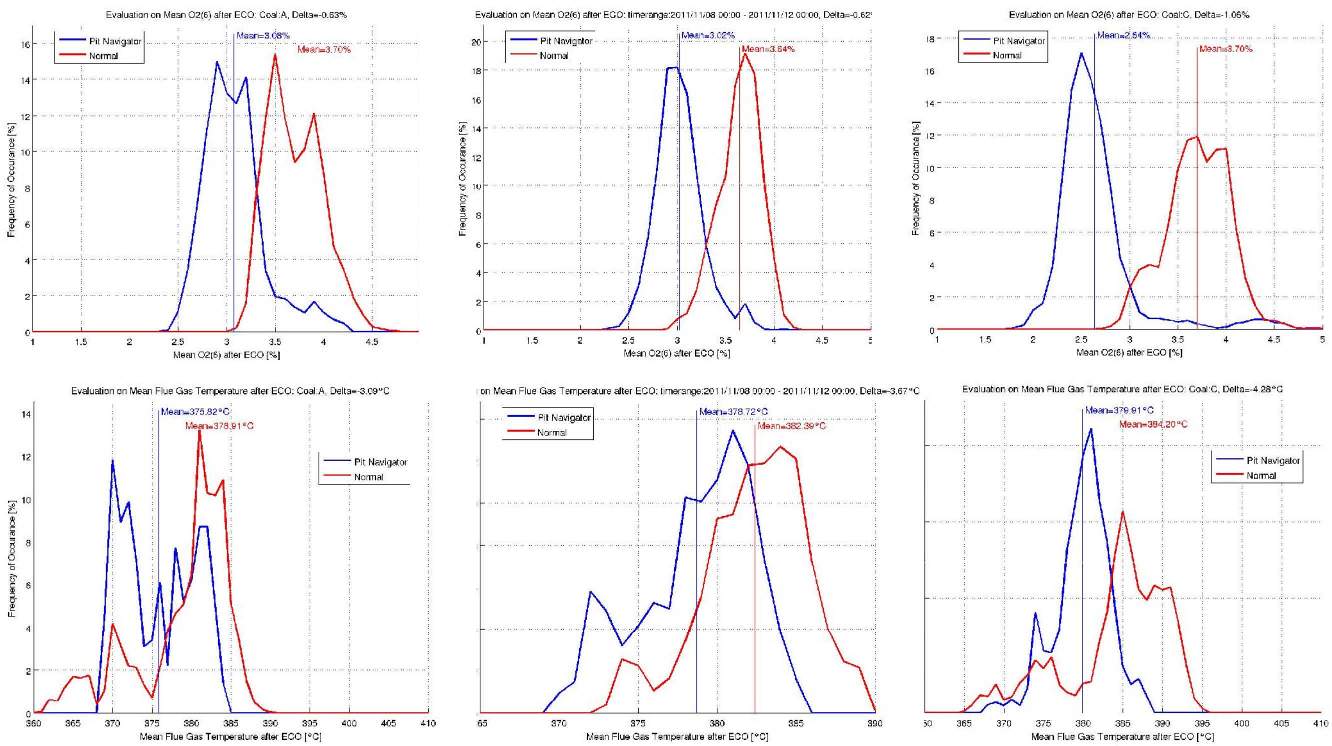
- **Optimiser uses model to find best possible action plan with regards to targets**

- **Safety layer passes or blocks action plan to be carried out online**

Performance Test
Choosing comparable periods

Label	Coal type (Nav on)	Coal type (Nav off)	Gross power ~ΔMW	Deactivated Mill	Comparable
I	40% MSJ 60% DRY	30% PQ 70% DRY	7	D D	Yes
II	40% MSJ 60% DRY	40% MSJ 60% DRY	0,3	D D	Yes
III	20% MSJ 80% BYN	20% ENVB 80% BYN	10	B, C C	Yes
IV	40% KYN 60% DUI	40% PQ 60% DUI	13	C, A D	No, because of incompatible mill constellation
V	40% KYN 60% WHN	40% ADM 60% WHN	20	A D	No, because of incompatible mill constellation

Performance Test
Distribution of O2 and exit gas temp.



Performance Test
Results for comparable periods

Label	ΔO2/%	ΔT/°C	CO/mg/Nm³
I	-0,63	-3,09	91
II	-0,62	-3,67	72
III	-1,06	-4,28	90

Performance Test
Overall Results

- O_2 reduced by 0.6% to 0.8% abs.
- Flue gas temperature reduced by up to 4°C
- Coal Flow decreased by 0.5 t/h/mill = 15.600t/a
- IDF/FDF savings = 2700 MWh/a

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SUBSTATION AUTOMATION SYSTEM ESSENTIALS

SUBSTATION AUTOMATION SYSTEM
TOPICS OF DISCUSSION

Current Industry Focus

System Architecture

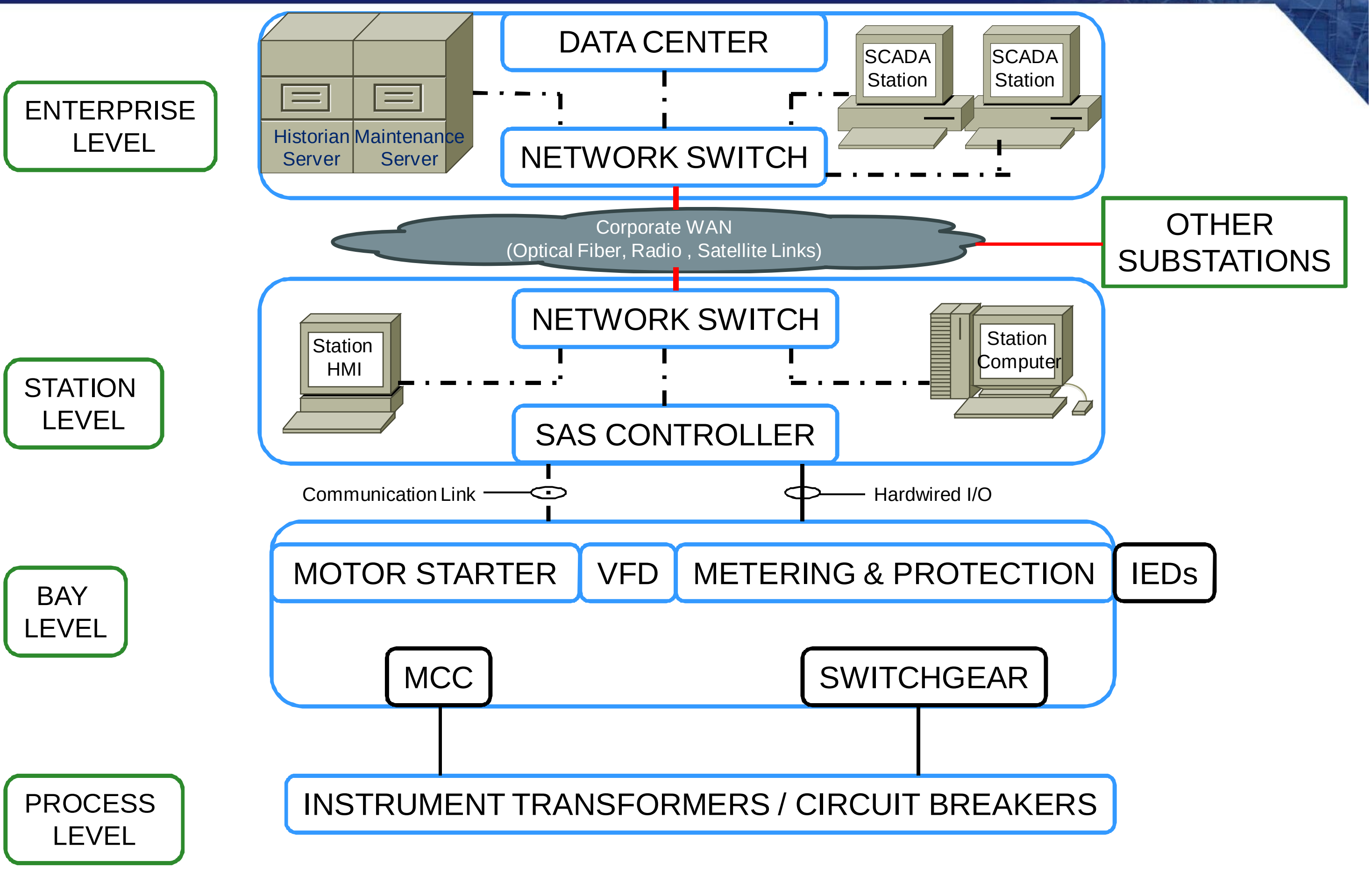
Elements of SAS

Challenges

SUBSTATION AUTOMATION SYSTEM
INDUSTRY FOCUS

- Enhanced Reliability
  - Power available at all times
- Asset Management
  - Predictive Maintenance
- Improved Operation and Maintenance
  - Minimum Downtime
- Life Extensions
  - Better utilization of resources
- Smart Grid

SUBSTATION AUTOMATION SYSTEM
SYSTEM ARCHITECTURE

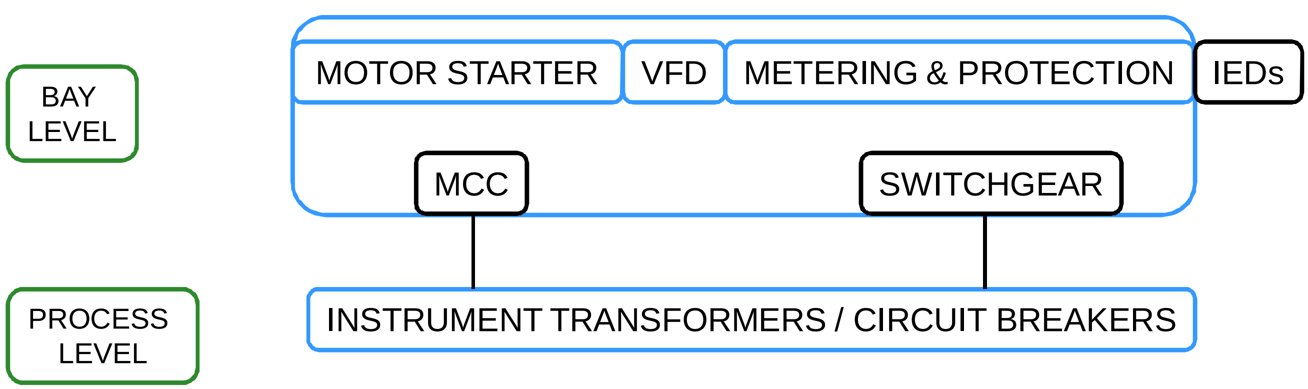


SUBSTATION AUTOMATION SYSTEM
SYSTEM ARCHITECTURE

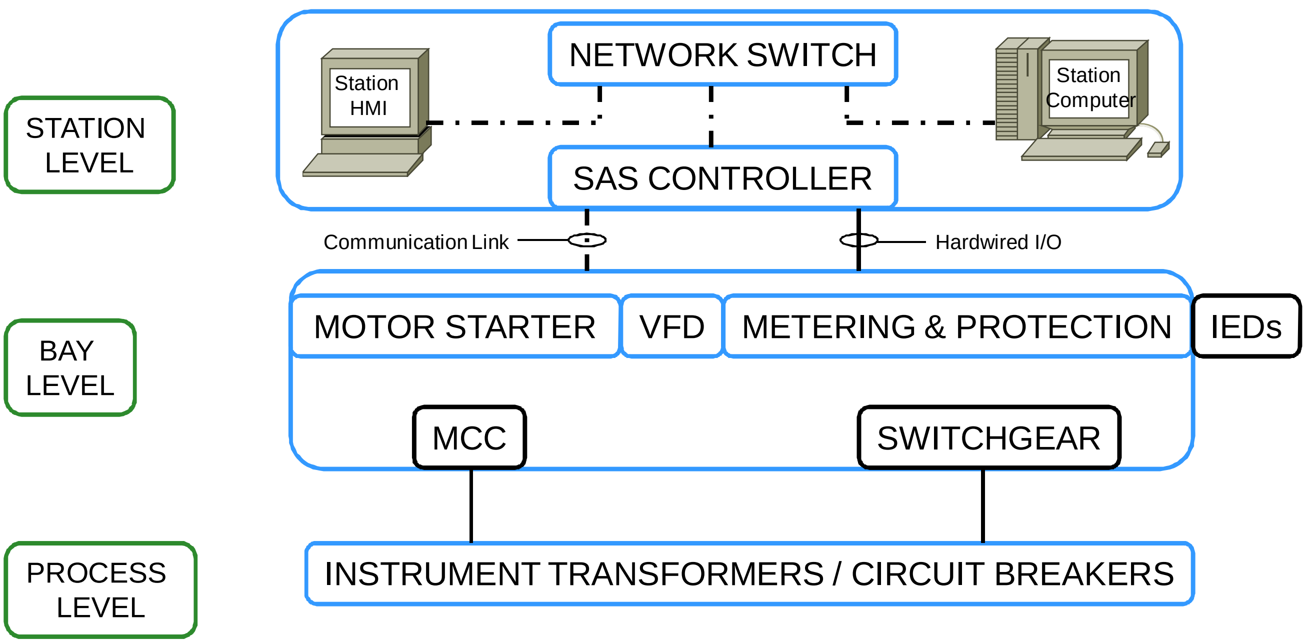
PROCESS LEVEL

INSTRUMENT TRANSFORMERS / CIRCUIT BREAKERS

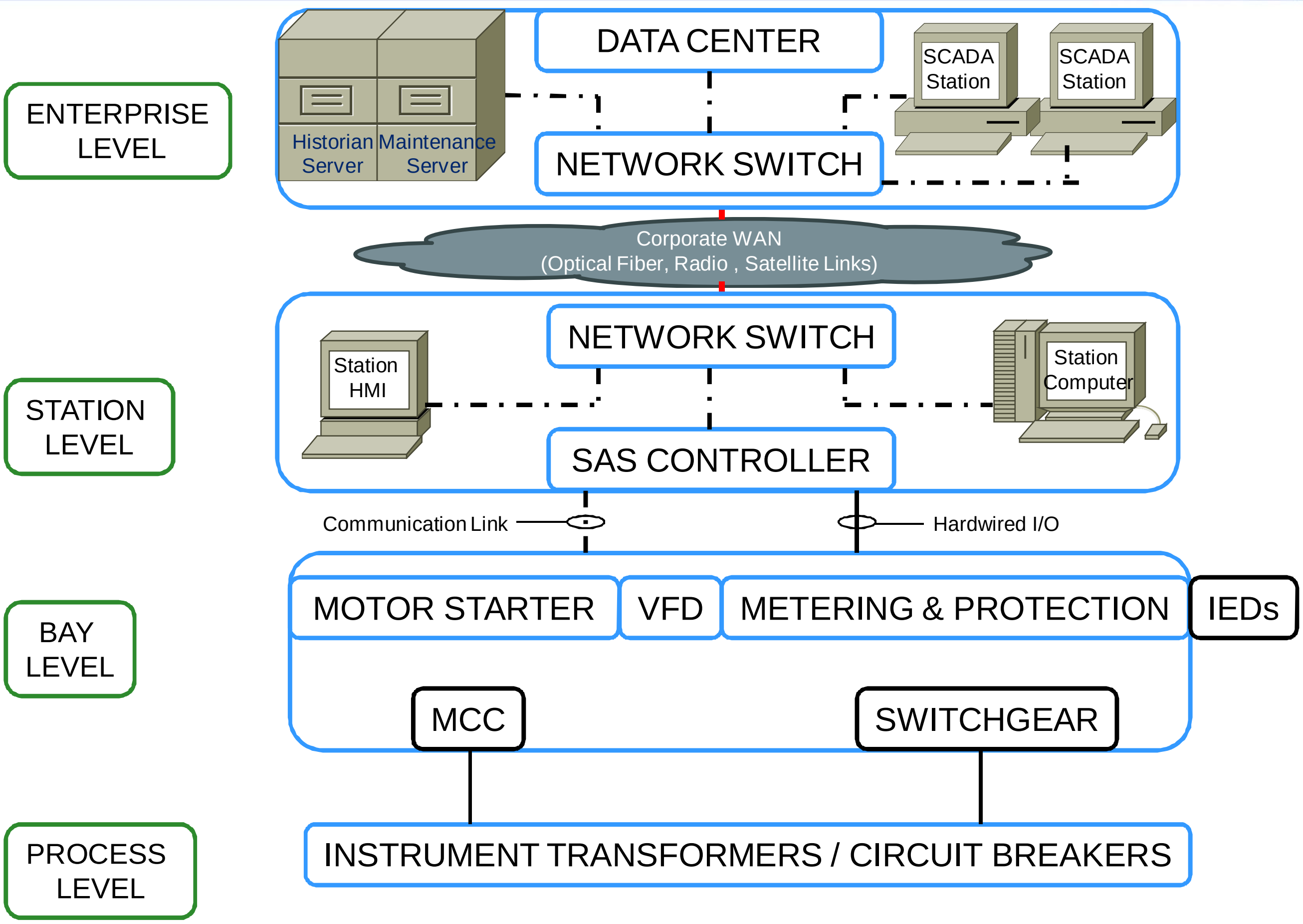
SUBSTATION AUTOMATION SYSTEM
SYSTEM ARCHITECTURE



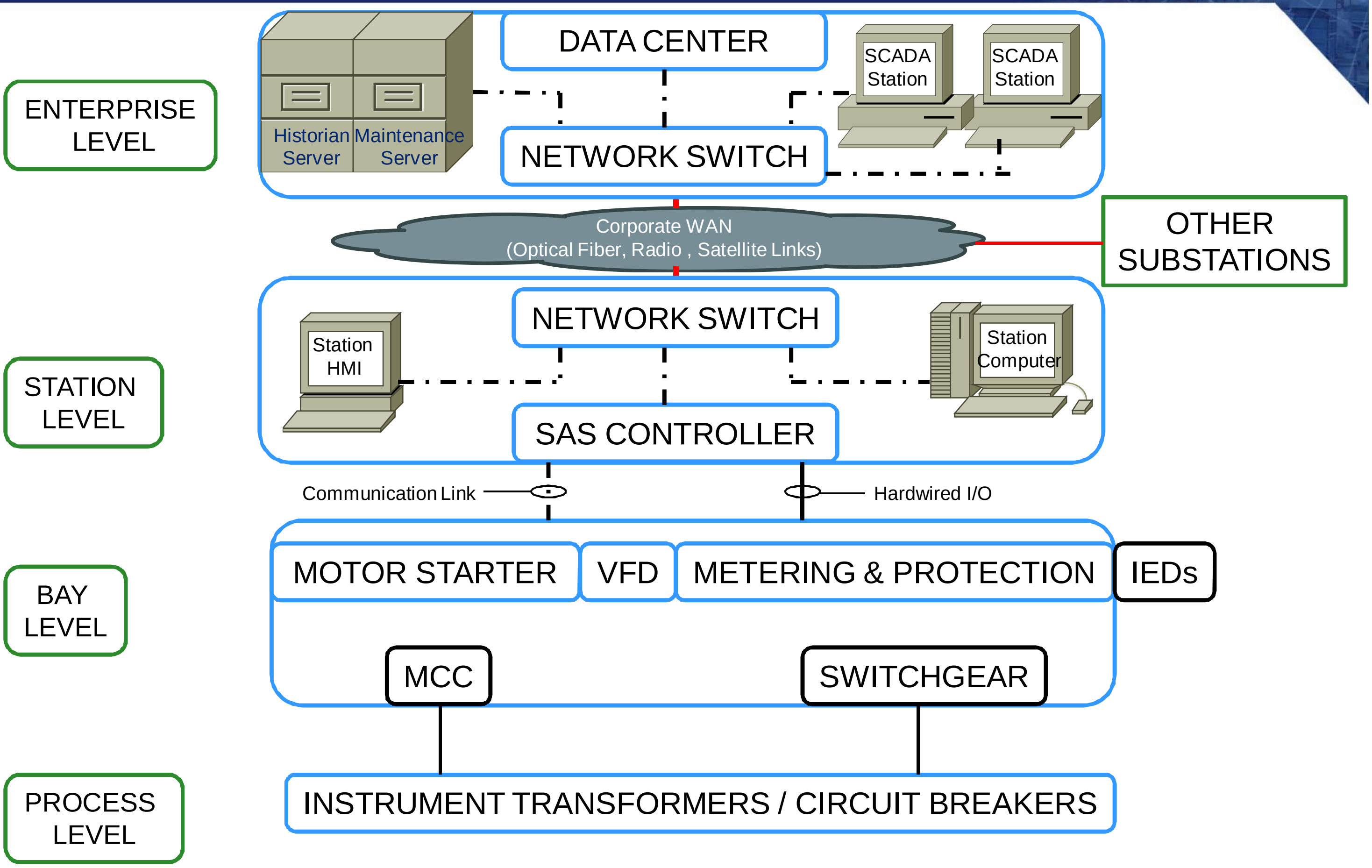
SUBSTATION AUTOMATION SYSTEM
SYSTEM ARCHITECTURE



SUBSTATION AUTOMATION SYSTEM
SYSTEM ARCHITECTURE



SUBSTATION AUTOMATION SYSTEM
SYSTEM ARCHITECTURE



SUBSTATION AUTOMATION SYSTEM
ELEMENTS OF SAS

- Intelligent Electronic Device (IED)
  - Key Element of SAS
  - Microprocessor based
  - Capability to integrate various functions (control, metering, protection and data acquisition) into a single device
  - Electronic Multifunction Meters, Digital Relays

- SAS Controller
  - PLC or RTU based
  - Polls IEDs for analog and status signals for monitoring and control of the substation
  - Data concentrator for the overall SCADA
  - Hardwired Input / Output for the primary equipment control and protection
  - Manages Communications

SUBSTATION AUTOMATION SYSTEM
ELEMENTS OF SAS

- Station Computer
  - Server grade computer
  - Accompanies SAS Controller

- User Interface HMI
  - Provides view of essential information and activities in hierarchical displays
  - Client to the Station Computer

SUBSTATION AUTOMATION SYSTEM
ELEMENTS OF SAS

- Supervisory Control and Data Acquisition (SCADA) System
  - Resides at the Enterprise level of SAS
  - Collects time Critical operational data for monitoring and control of the substation
  - Instantaneous values and status like Volt, Ampere, KVA, KW, breaker status etc

SUBSTATION AUTOMATION SYSTEM
ELEMENTS OF SAS

- Data Center
  - Resides at the Enterprise level of SAS
  - Collects time Critical operational data for monitoring and control of the substation
  - Instantaneous values and status like Volt, Ampere, KVA, KW, breaker status etc
  - Also collects non operational data like event summaries

- Communication
  - Most important element of SAS
  - Key requirements of communication systems include, but not limited to,
    - High Speed IED to IED communication
    - Networkable throughout the enterprise
    - High availability
    - High reliability
    - Standards based
    - Multi vendor interoperability
    - Support for file transfer
    - Plug and Play
    - Support for security

◆ Communication Contd…

- Several factors for selecting right protocol
  - The communicating devices SCADA to SAS controller or IED to IED etc.
  - Data requirements, Speed and reliability
  - Technology developments
  - Continuous vendor support for the life time
  - Non proprietary

SUBSTATION AUTOMATION SYSTEM
CHALLANGES

- Meeting Performance Requirements
  - Response time, Safety and Reliability
  - Compromise between Cost and Performance
- Communication Protocol and Topology
  - Communication needs are different
  - Various available options with inherent constraints

SUBSTATION AUTOMATION SYSTEM
CHALLANGES

- Technological Advances
  - Fast changing technology
  - Timing of installation
- Cyber Security
  - ANSI/ISA 99 and IEC/ISA 62443 recommendations
  - Firewalls, DMZ, Conduits, Defense in Depth security policies

SUBSTATION AUTOMATION SYSTEM
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SUBSTATION AUTOMATION SYSTEM
QUESTIONS

THANK YOU

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IFFCO

Analysis of Power System Failure at IFFCO Aonla and subsequent measures to enhance reliability—a case study

--By A.K.Bhaduri
Sr. General Manager

Introduction—the IFFCO Aonla Complex

IFFCO-Aonla Fertiliser complex consists of

•Two streams of Ammonia Plants and

•Four streams of Urea Plants. (approx 6600 MTPD product)

•Two nos. of Gas Turbine Generators (GTGs)

• Total Electrical power requirement of about 30MW

•Additionally there is back-up connection of capacity 4.5 MW. with the State Grid (UPPCL).and 2 nos. Auxiliary Mains Failure(AMF) DG sets 1MW each(approx)

•Ammonia Plants are highly energy intensive & critical

•Outage of Ammonia Plants are extremely costly.

•However Urea Plants outage are much less costly.

The Failures of Power System :

- There has been instances of failure of one GTG.
- This in turn caused tripping of second GTG as well as UPPCL feeder on overload
- This has caused major power outage at the complex including tripping of not only the Urea Plants but also the Ammonia Plants .
- By system design such power outage and tripping of both Ammonia plants are not supposed to happen,
- Such situation is very unsafe for plants and
- It was found attributable to the slow response of the Load Management System(LMS) PLC.

Actions Required :

For such power crisis condition it was felt prudent to ensure healthiness/running of

- at least one GTG,
- both Ammonia Plants (at least the Primary Reformers in worst case),
- Cooling water system and Lube oil system of major rotary machines.
- Tripping of all Urea Plants may be allowed to save one GTG and Ammonia Plants.
- Also actions to take place automatically through interlocks and communication gap/confusion and delays thereof are to be avoided for manual actions.
- Steam crisis must not get superimposed on power crisis.
- Plant operating procedures would be updated accordingly.