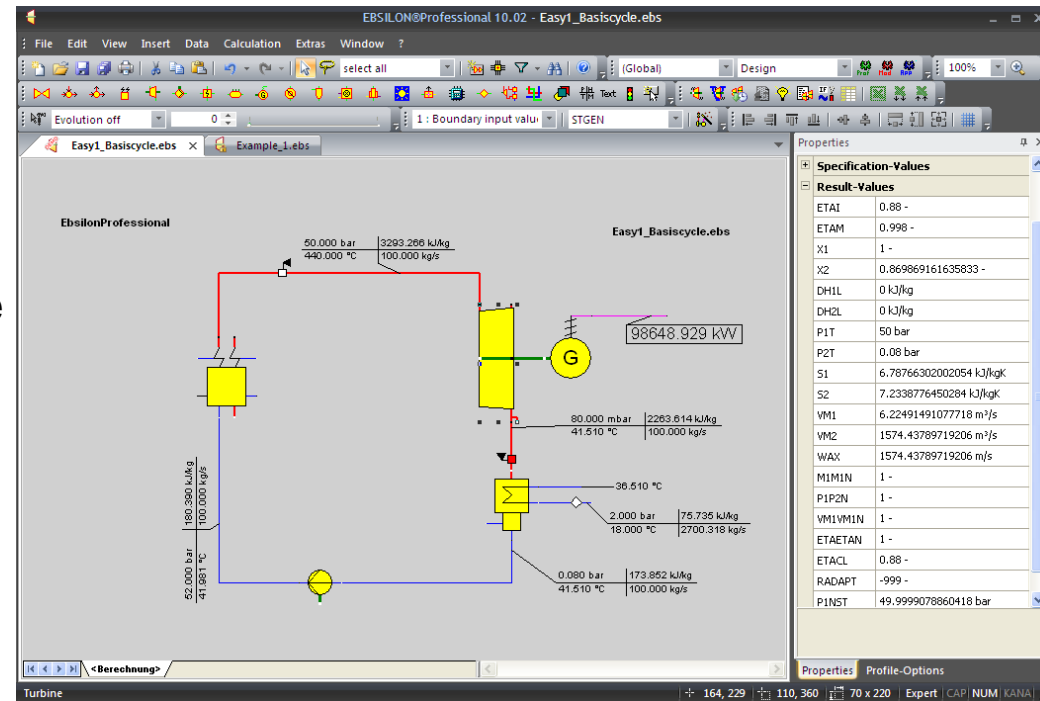


Solar Thermal hybridization of conventional power plants and hybrid CSP feed-in metering

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steag

- Leading program for thermo dynamical calculations of power plants in Germany
- Fully flexible system
- convenient graphical user interface
- Interfaces for data exchange and programming
- Multilingual user interface (De, En, Tr, Fr, It, Es, Zh)
- Professional service, training and workshops



Simple sketch of a model
(Few minutes working time)

20 years of experience, successful use and improvement.

CSP components in EBSILON

- **Parabolic trough / linear fresnel**



- **Solar tower with heliostat field**



- **Detailed geometric model** accounting for mirror efficiency, pressure. shading, atmospheric losses...
- **Storage system** applicable with all kind of thermo liquids
- **Comprehensive thermo liquid data base**
- **Time-series-calculation** enables annual yield calculations

Developed in cooperation with the German Aerospace Center (DLR)

Offline solar applications

- **Solar topping studies**

- Hybridization of existing conventional power plants with solar heat input
- Studies on different plant types and heat input concepts: preheater string / reheat

- **CSP plant design and annual yield calculation**

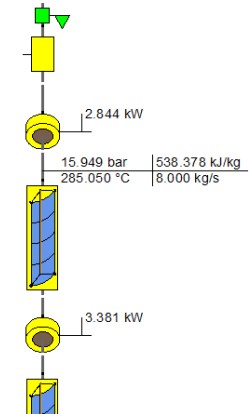
- Detailed solar field with comprehensive power block simulation
- Annual yield calculation based on physical model of designed plant

- **Optimal control of plant elements**

- Decision-making algorithm that determines state of operation
- Optimal synchronization of solar field / storage / burner / power block

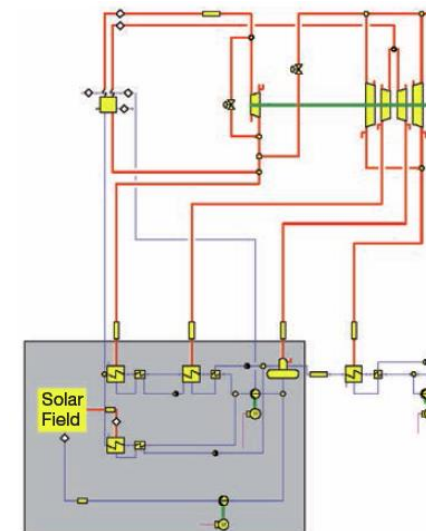
Clients

- **Areva Solar, Abengoa, ACWA, Flagsol, STEAG (Arenales), DLR etc.**



Collector string with transient storage

Hybridization study



Online applications in CSP

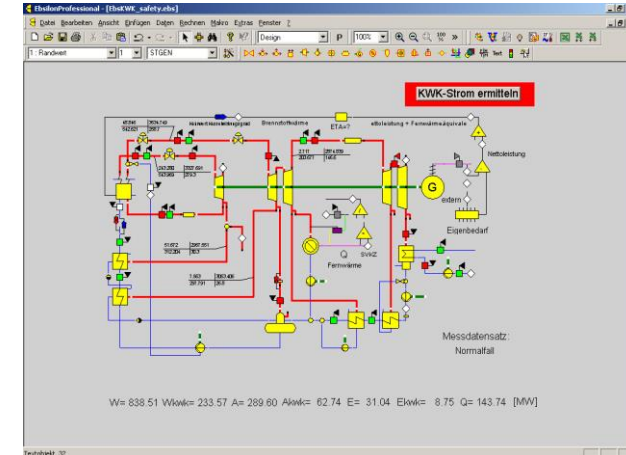
- **Process Quality monitoring**

- Turbine efficiencies, heat exchanger quality ratios
- Degradations of components
- Solar collector performance
- Auxilliary system monitoring

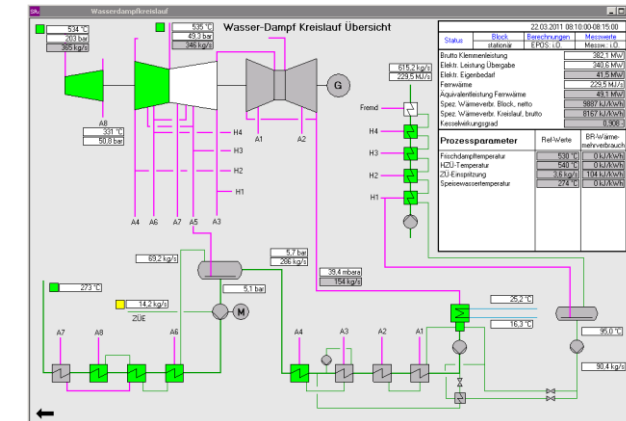
- **Fatigue and degradation due to CSP fluctuations**

- Evaluation of stress on boiler components e.g. piping
- Additional load on turbines (see case study)

- **CSP fraction metering ...**



WSC in EBSILON



SR::EPOS interface

Metering concept



- **Electricity from**

- Convent
- Subsidiz

- **Challenge**

- CSP fra
- Grid de

Requirements:

- Scientifically sound and comprehensible approach
- Providing right incentives for plant operator
- Easy to use with feed-in tariffs

Estimation of CSP fraction

- **Heat input**

- Comparison of coal consumption / heat input with and without CSP at same duty
- Only coal equivalent, not expressed in electrical power
- Permanent availability of coal's NCV / cycle's efficiency necessary

- **Electrical output**

- Electrical output with steady coal input neglecting CSP
- Efficiency of turbines, preheaters, condenser come into play
- Periodical calculation based on temperature / mass flow measurements

Requirements:

- Scientifically sound and comprehensible approach
- Providing right incentives for plant operator
- Easy to use with feed-in tariffs

Online solar metering: What-if scenario approach

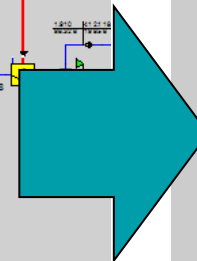
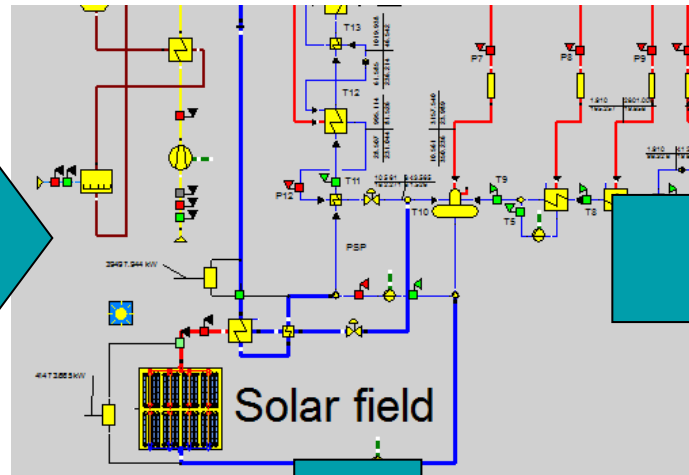
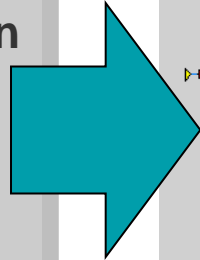
DCS / data historian

Measurements:

P, T, M

DNI

P_{hybrid}



Results

$Q_{\text{solarfield}}$

$Q_{\text{conventional}}$

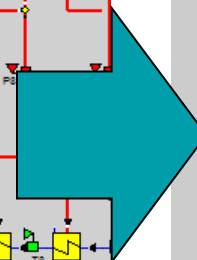
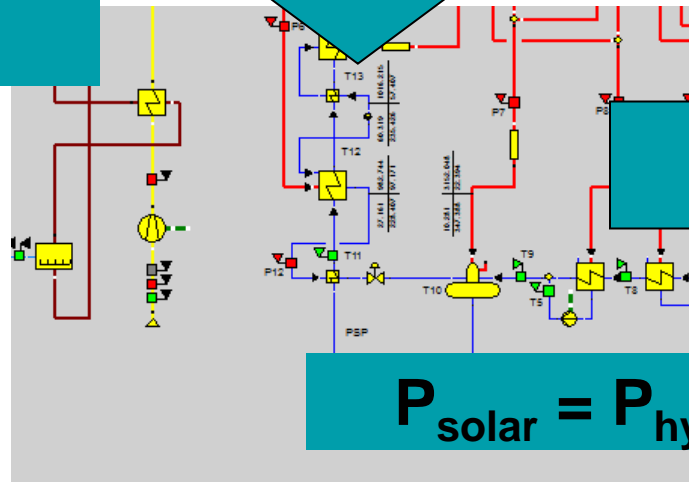
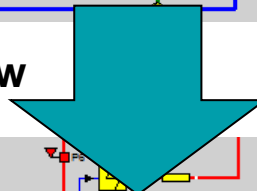
ETA_{hybrid}

$ETA_{\text{collector}}$

...

$Q_{\text{conventional}}$ / Coal mass flow

$$Q_{\text{solar}} = 0$$



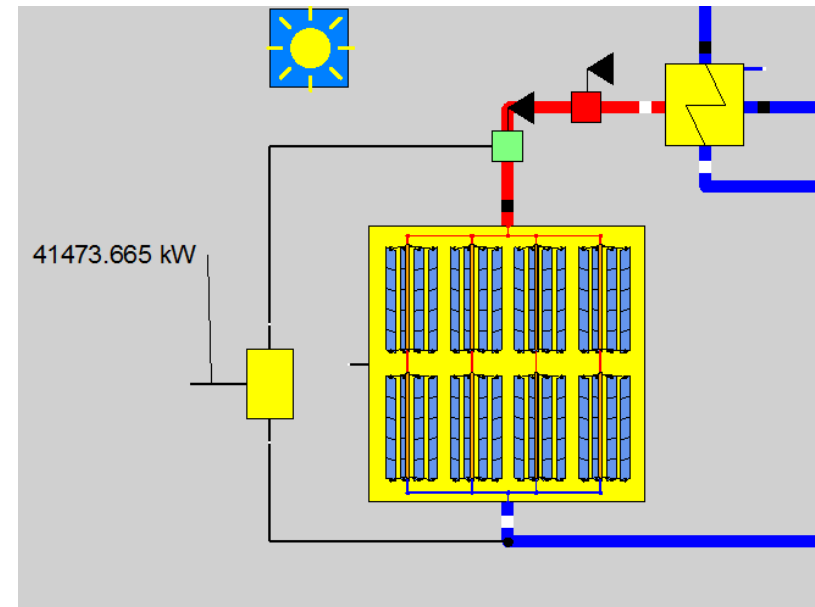
$P_{\text{conventional}}$

...

$$P_{\text{solar}} = P_{\text{hybrid}} - P_{\text{conventional}}$$

Case-study's assumptions

- Coal fired power plant (750 MW gross)
- Solar heat input after the last HP preheater
- Linear-fresnel type field 127500 m² (60 coll.)
- Direct evaporation (5K superheated)
- Steady generator power output
- Steady DNI
- One day calculation



- **Online scenario approach**

- Practical results for hybrid CSP metering → easy to use with feed-in tariffs
- Based on the plant's thermodynamic → comprehensible/transparent
- Final concept open for discussion

- **Additional benefits**

- Comprehensive process quality monitoring
- Taking into account solar part e.g. collectors
- Data reconciliation used for improvement of measuring system
- Life-time-monitoring (necessary due to volatile CSP input)

Worldwide proven technology

- More than 50 SR::EPOS systems: RWE, E.ON, Vattenfall...
- 70 PADO systems in India: BHEL, NTPC...

stead