Overview on Direct Steam Generation (DSG) and Experience at the Plataforma Solar de Almería (PSA)

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Overview on Direct Steam Generation
&
PSA experience

- Advantages and disadvantages of the DSG process
- R+D activities related to DSG since 1980
- State-of-the-art of the DSG technology

The Direct Steam Generation Process

Comparison between the DSG technology and the HTF (oil) technology

Advantages of the DSG technology:

- Smaller environmental risks because oil is replaced by water
- Higher steam temperature (maximum steam temperature with oil = 380ºC)
- The overall plant configuration is more simple
- Lower investment and O&M costs and higher plant efficiency

DSG-related potential problems:

- Solar field control under solar radiation transients
- Instability of the two-phase flow inside the receiver tubes
- Temperature gradients at the receiver pipes

The Direct Steam Generation Process

DSG-related projects and studies since 1980

- Theoretical studies by SERI (1982)
- The ATS (Advance Trough System) project by LUZ,(1987-1991)
- Experiments by ZSW at the HIPRESS test facility (1992-1994)
- The GUDE project experiments at Erlangen (1992-1995)
- The project PRODISS
- The project ARDISS (1994-1997)
- R+D activities at UNAM (Mexico, 1976- up to date)
- The DISS project (1996-2001)
- The INDITEP project (2002-2005)

The Direct Steam Generation Process

State-of-the-art of the DSG technology

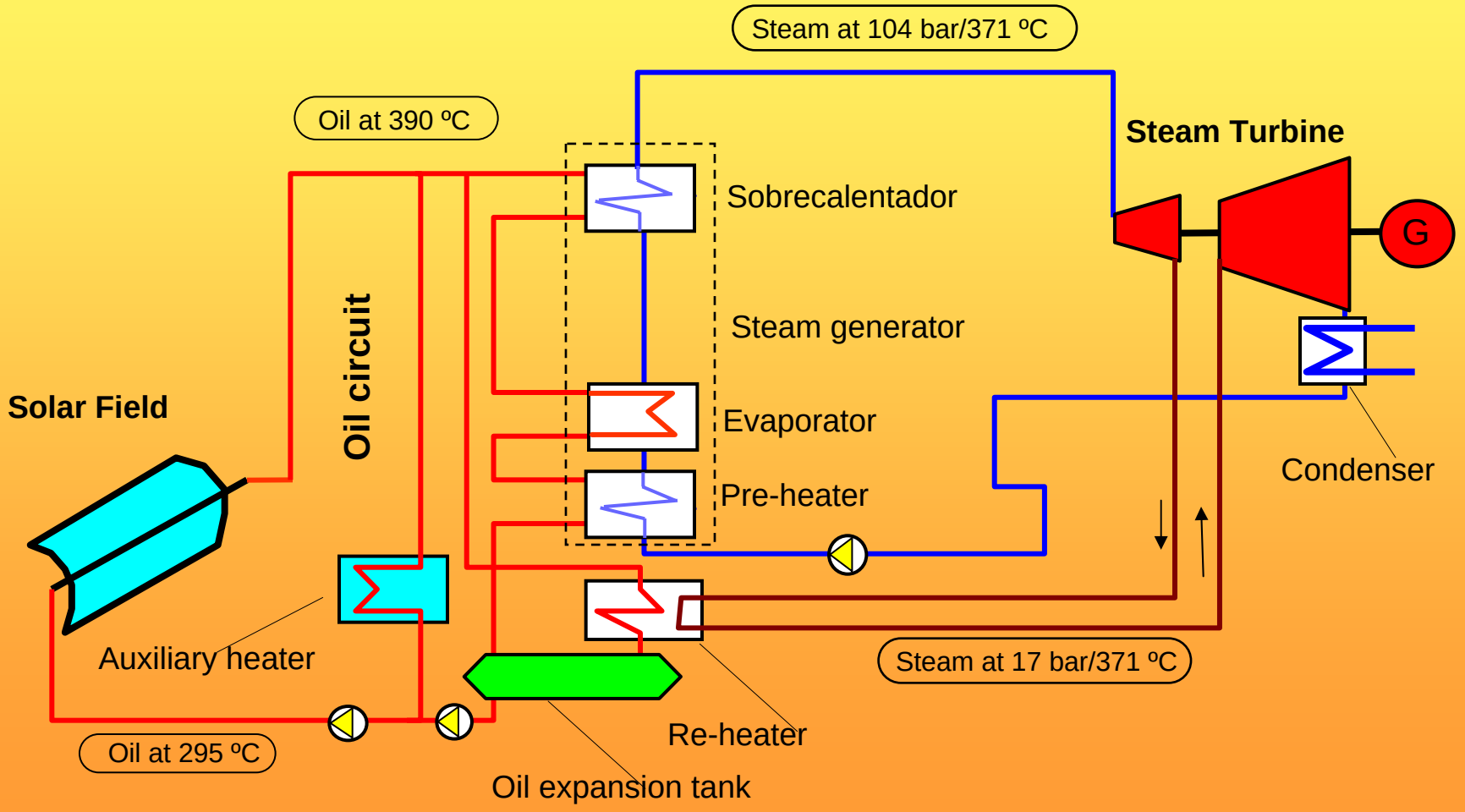
- Technical feasibility of the DSG process in horizontal PTs has been proven. More than 5500 hours of operation have been accumulated at the DISS test facility
- Accurate simulation&design tools for DSG solar fields have been developed
- Ball-joints for water/steam at 100bar/400ºC have been successfully tested. Testing of ball-joints for steam at 100bar/550ºC currently underway.
- The best configuration for commercial DSG solar fields is a mixture of injection and recirculation. This configuration has been experimentally evaluated at PSA
- It is easy to keep the temperature gradients in the receiver pipes within safe limits. Maximum stress obtained at PSA during operation has been 47% of the limit allowed
- Compact and cost-effective water/steam separators have been developed
- A Spanish Consortium is promoting a 3 MWe DSG power plants to be installed at PSA
- Several projects related to DSG are currently underway in Europe
- A suitable thermal energy storage technology for DSG still to be developed

End of Presentation

! Many thanks for your attention ¡

Direct Steam Generation

Typical Temperature profile in a HTF Solar thermal Power Plant



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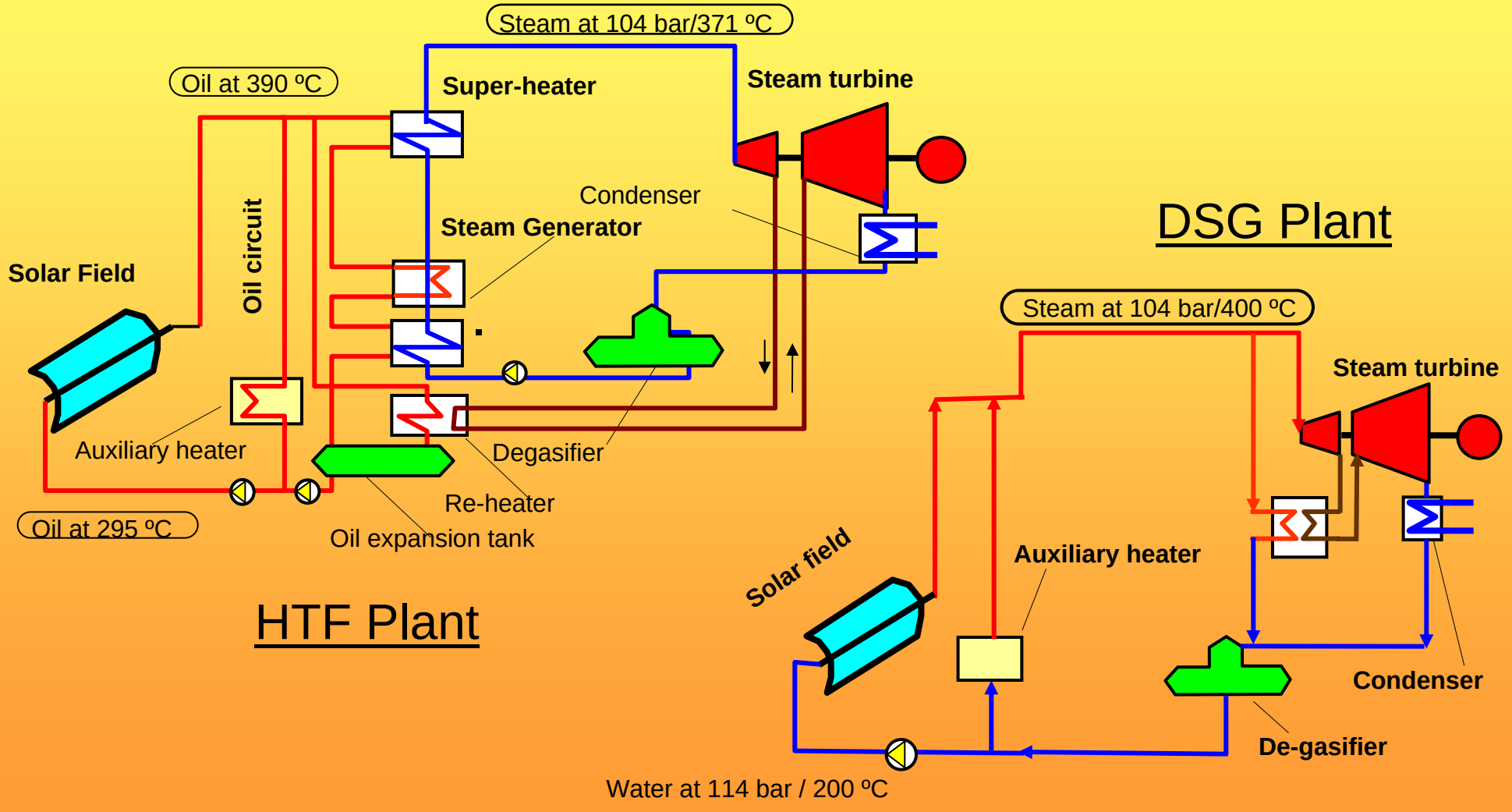
Simplified Scheme of typical HFT and DSG solar thermal power plants



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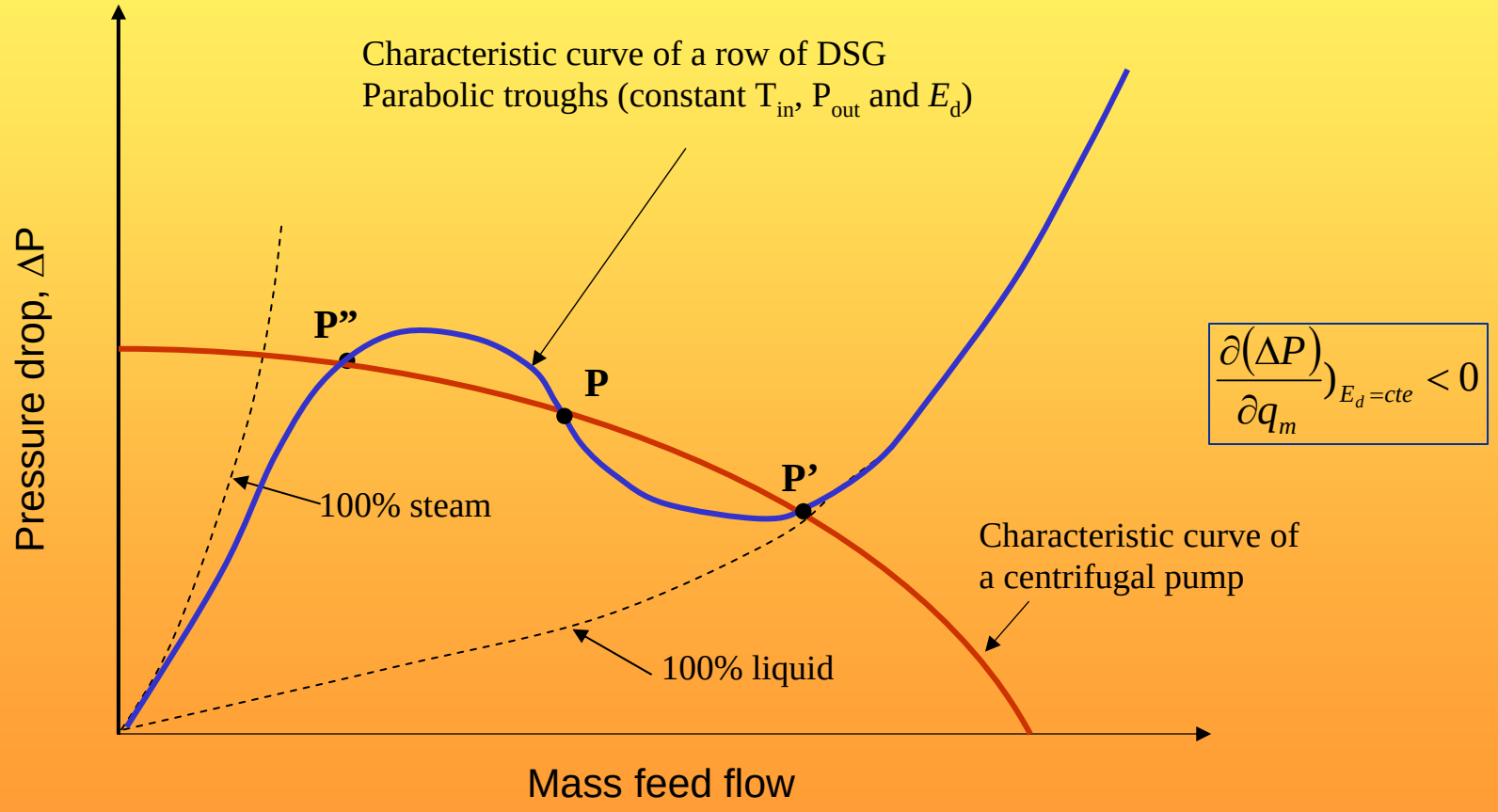
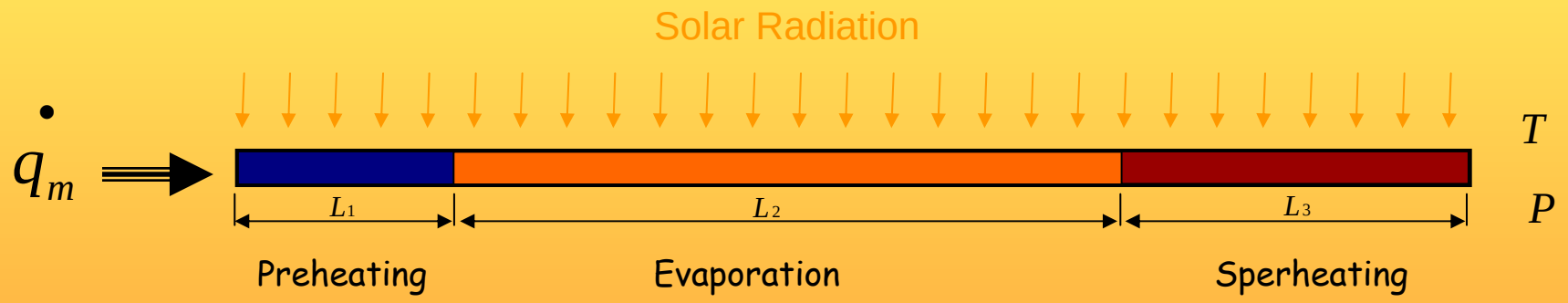
The Ledinegg instability



$$\left(\frac{\partial(\Delta P)}{\partial q_m}\right)_{E_d=cte} < 0$$

Direct Steam Generation

Different sections in the rows of a DSG solar field



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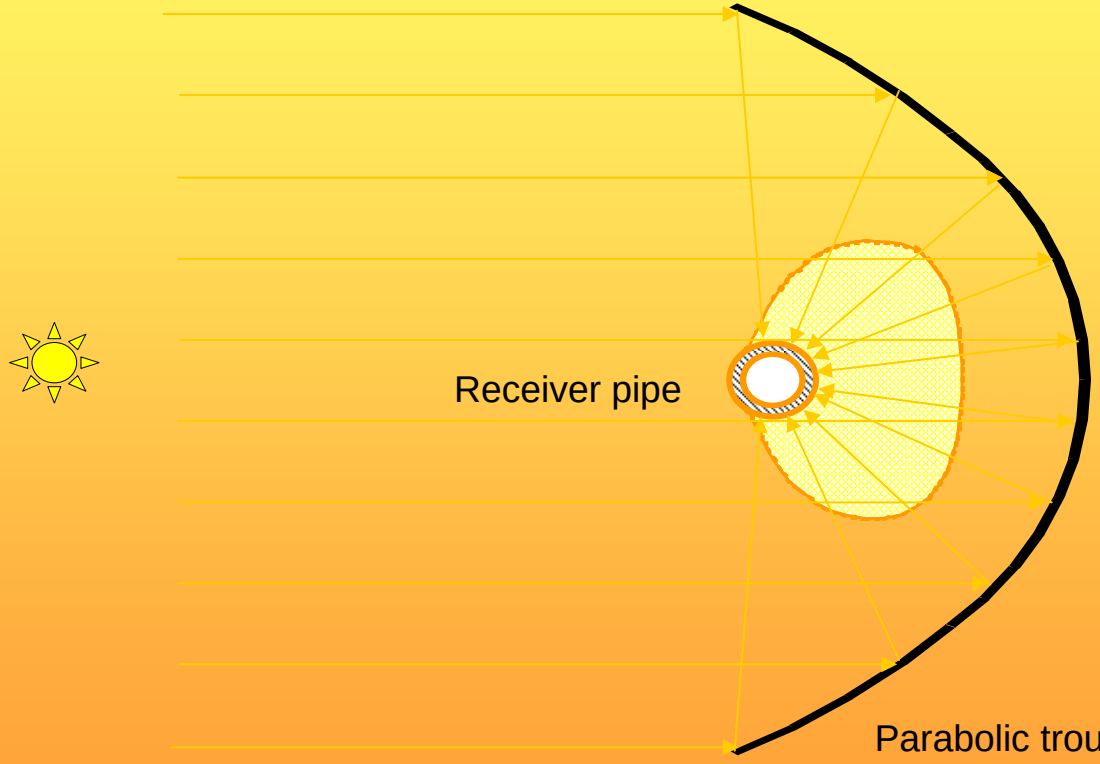
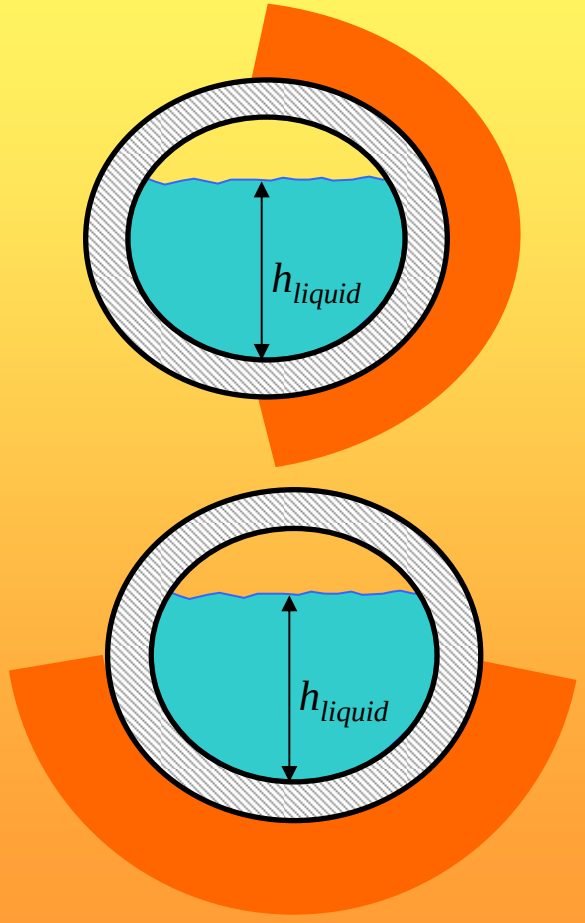
Uneven heat transfer at the steel absorber pipe





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The DSG test facility implemented by LUZ for the ATS project

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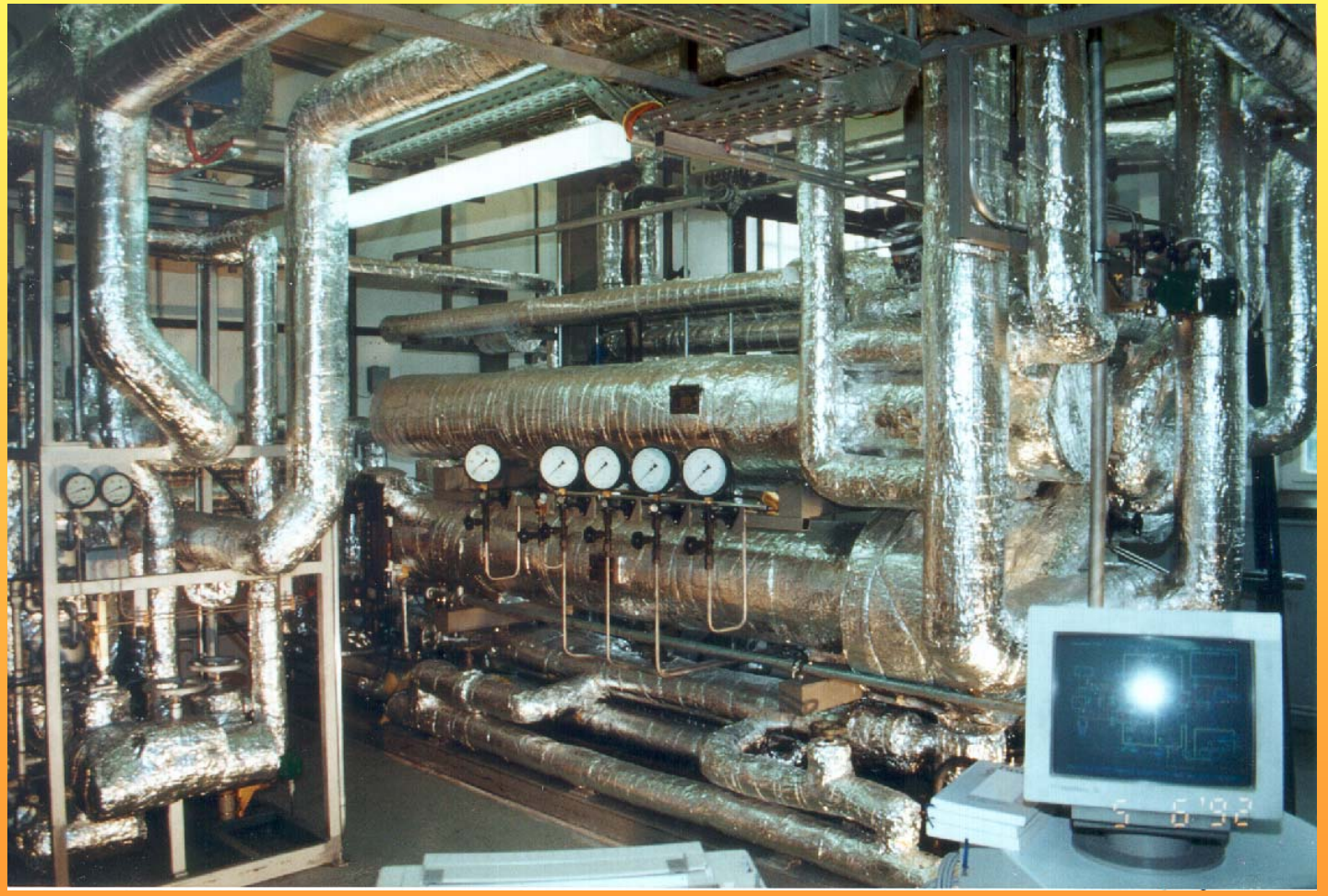
The HIPRESS test facility implemented by ZSW to study the DSG process



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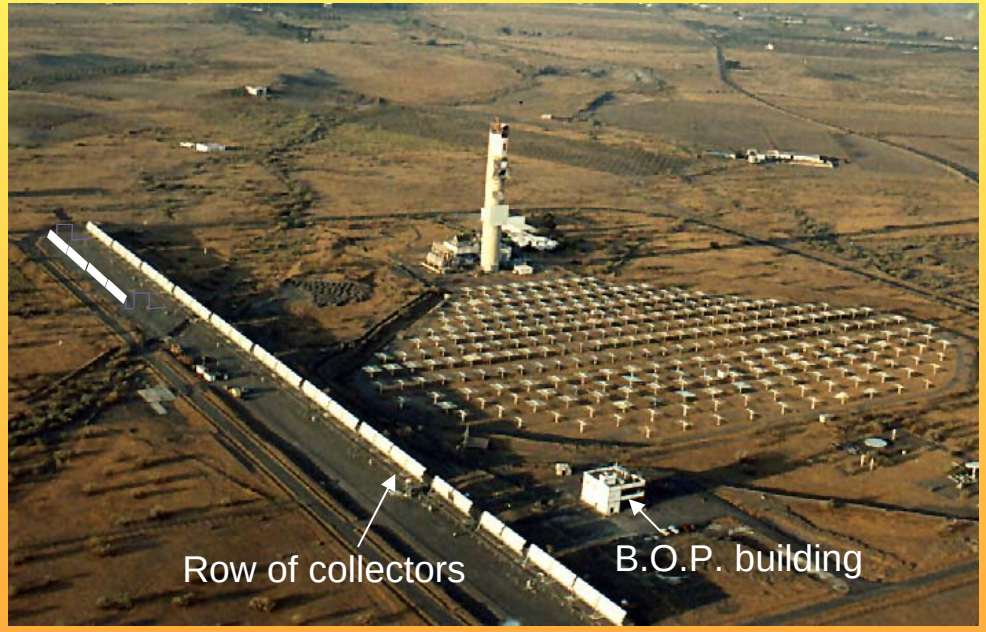
The DSG test facility implemented by SIEMENS for the GUDE project

Direct Steam Generation

The DISS test facility implemented at the PSA

Aerial view of the DISS facility



The DISS solar field (south)

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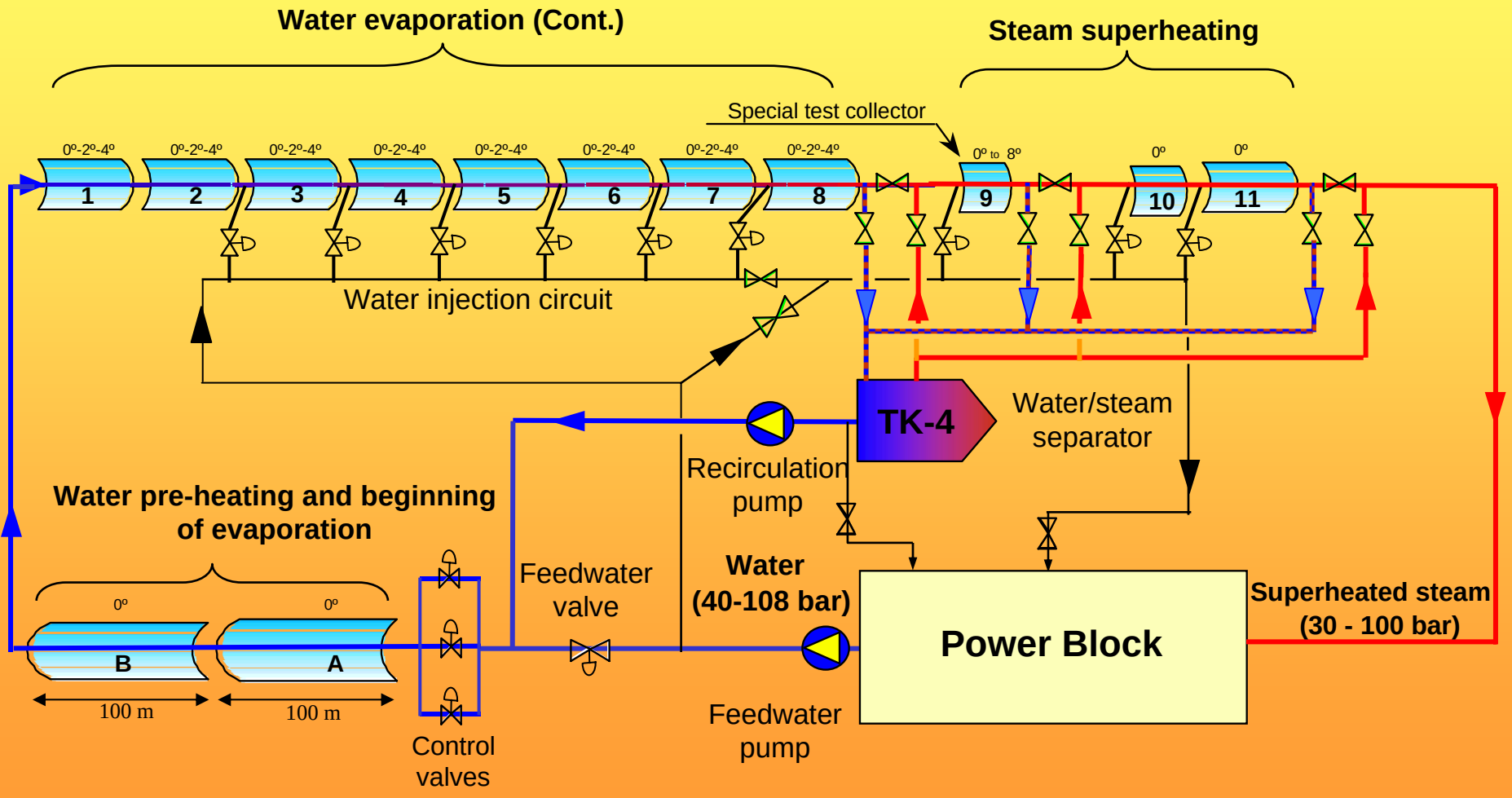
The DISS test facility implemented at the PSA



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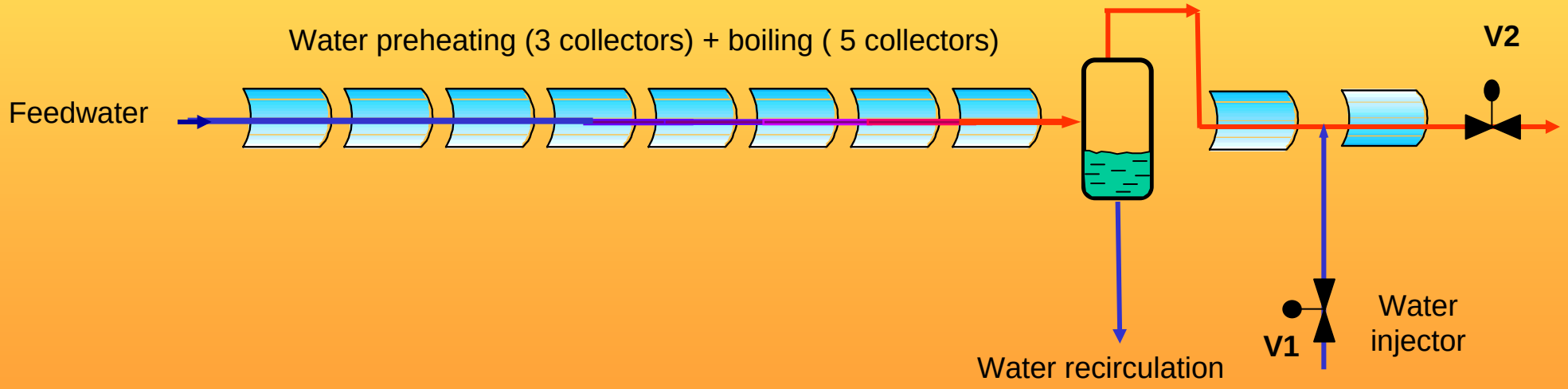
Scheme proposed for commercial DSG solar fields



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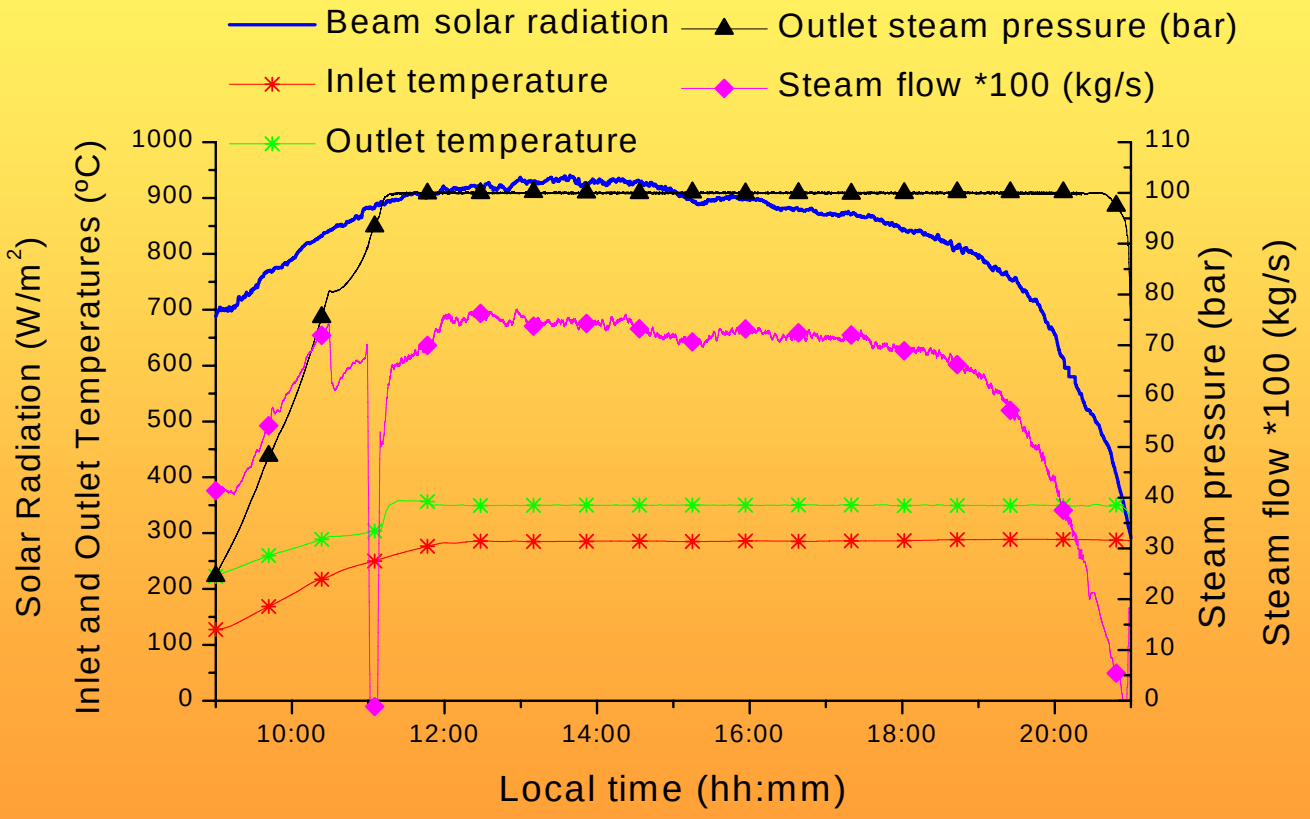
Experimental data collected at the DISS facility



Steam Production at 100bar/350ºC (05/07/2001)

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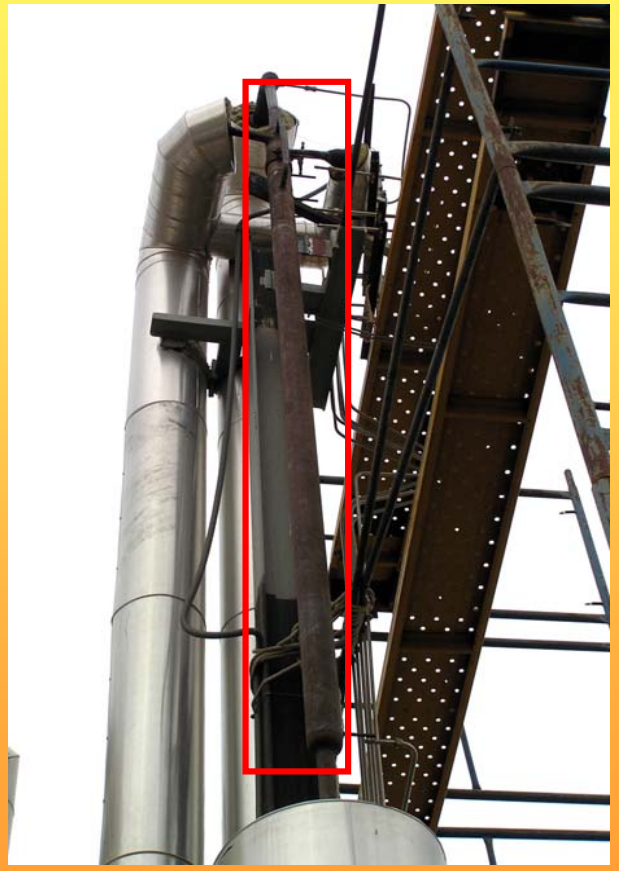
Water/steam separators for DSG

Classic water/steam separator



Compact water/steam separator

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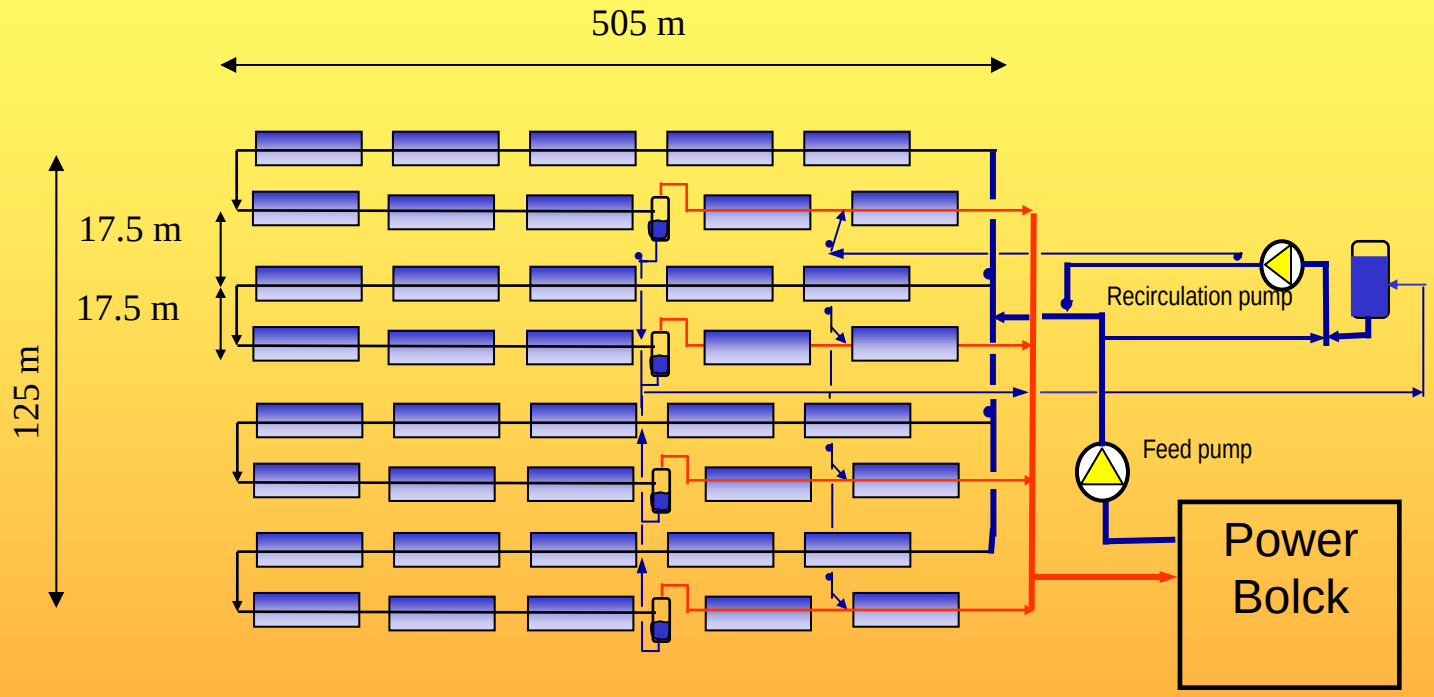
Simplified Scheme of the DSG Solar Field to be installed at PSA



Technical parameters

- Number of parallel rows: 4
- Lenght of every collector: 98,5 m
- Total aperture area: 21934 m²
- Number of collectors per row: 10 ET-100 collectors
- Parabola width: 5.76 m
- Peak Thermal power (E_d=1kW/m²): 14,3 MW

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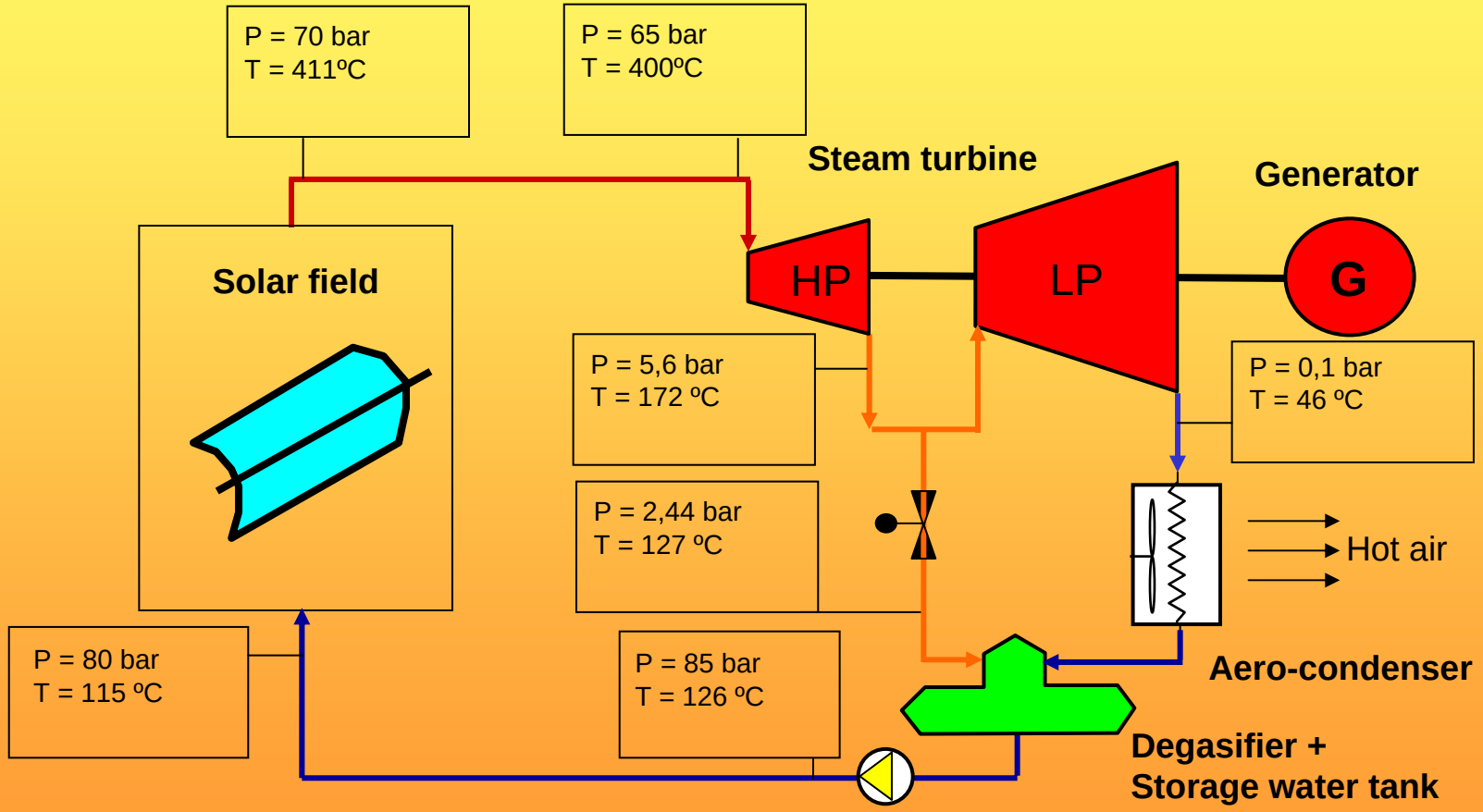
Simplified Scheme of the Power block for the PSA DSG plant



Direct Steam Generation

Temperature gradients in the steel absorber pipes