Intergration Options and need for metering in Solar Thermal Hybridization with Conventional plants

Topics for discussion

- Steag and it’s services
- Integration options used in some existing plants
- Simulation study for finding the Solar share
- Need for metering

Steag's Activities

Steag Germany - Key figures (as of Dec. 2011)

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

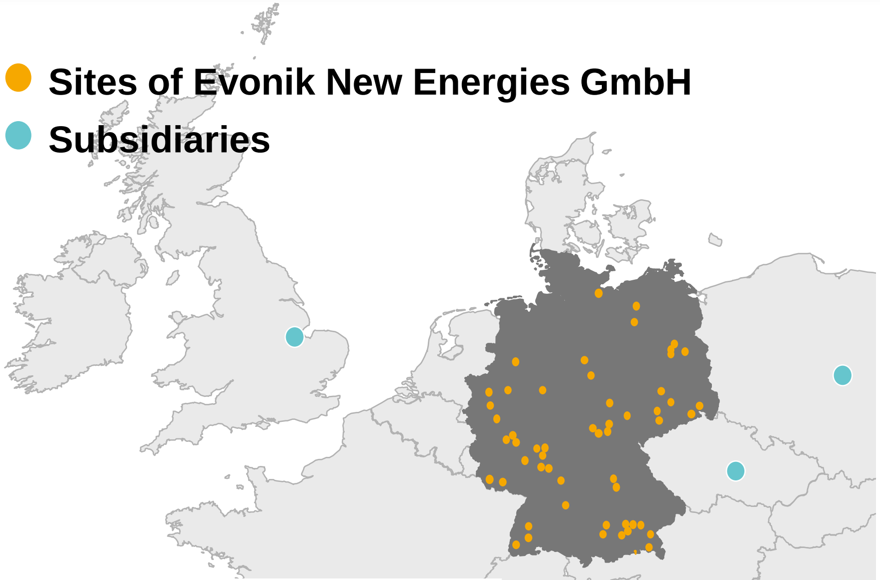
Steag India Activities

- 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 – Proprietary thermodynamic design software
- Solar simulator - with Trax
- Owners Engineer NTPC Anta
- Training on Solar – With IITJ

STEAG holds a strong position in the renewable energy market



- Sites of Evonik New Energies GmbH
- Subsidiaries

Steag Projects

Wind

- Identification of specific projects

Solar

- 50 MW plant at Arenales

Biomass*

- since 2002
- #3 in Germany

Biogas

- since 2007
- First own biogas plant commissioned

Mine gas

- since1908
- #1 in Germany

Geothermal

- since 1994
- #1 in Germany

Contracting

- since 1961
- #2 in Germany

	Installed capacity		Plants
	MW_{el}	MW_{th}	
Biomass* / Biogas	66	154	13
Mine gas	177	139	108
Geothermal	--	71	2
Contracting	77	905	100
Total	**319**	**1,271**	**223**

Steag's Arenales 50 MW plant in Spain

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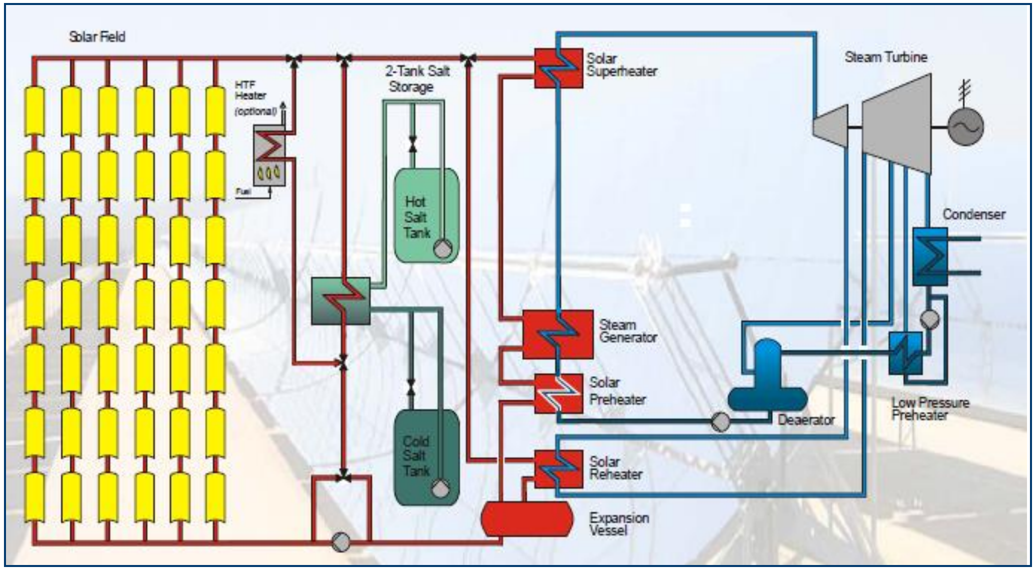
- Steag has a 26% stake
- O&M shall be done by Steag themselves
- Technical concept comparable to Andasol 3
- Capacity of the plant: 49.9 MW
- Wet cooling tower implemented
- Solar field with 156 Loops Parabolic Collectors
- Thermal Storage (salt) for up to 7h of full load operation
- Gross electricity production: about 170 GWhel p.a.
- Planned operation period: 40 years



➢ The implemented technical concept is state of the art for CSP plants in Spain

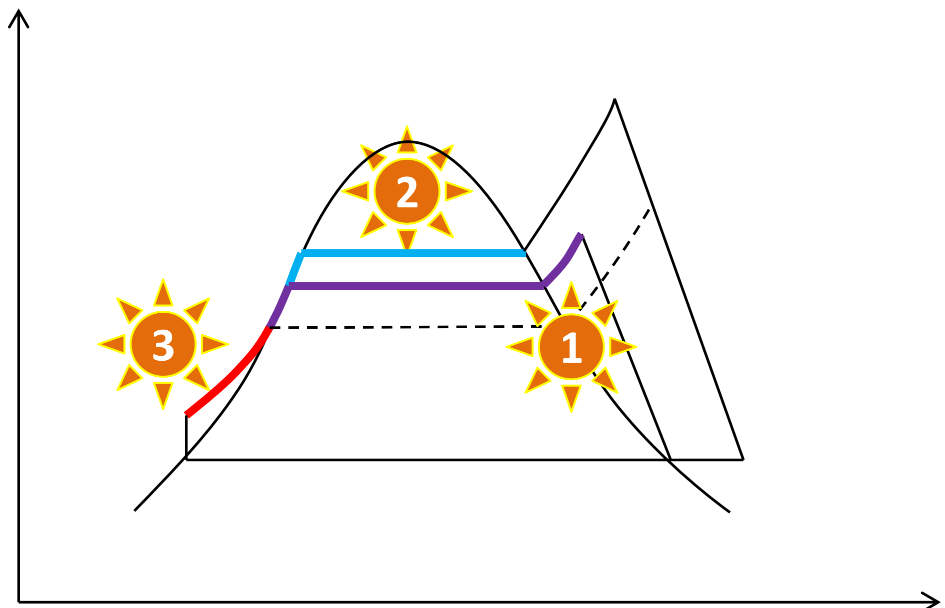
Approaches to hybridization

ISCC

1. **Solar heat → LP stage of turbine**
   Superheated Steam of low P, T
   - replacing extractions from ST

2. **Solar heat → steam generator**
   saturated steam
   - fossil fired superheating

Shams 1 – UAE



ISST

3. **Solar heat (300°C) → Feed-water pre-heaters**

Kuraymat – Egypt
Agua Prieta II – Mexico

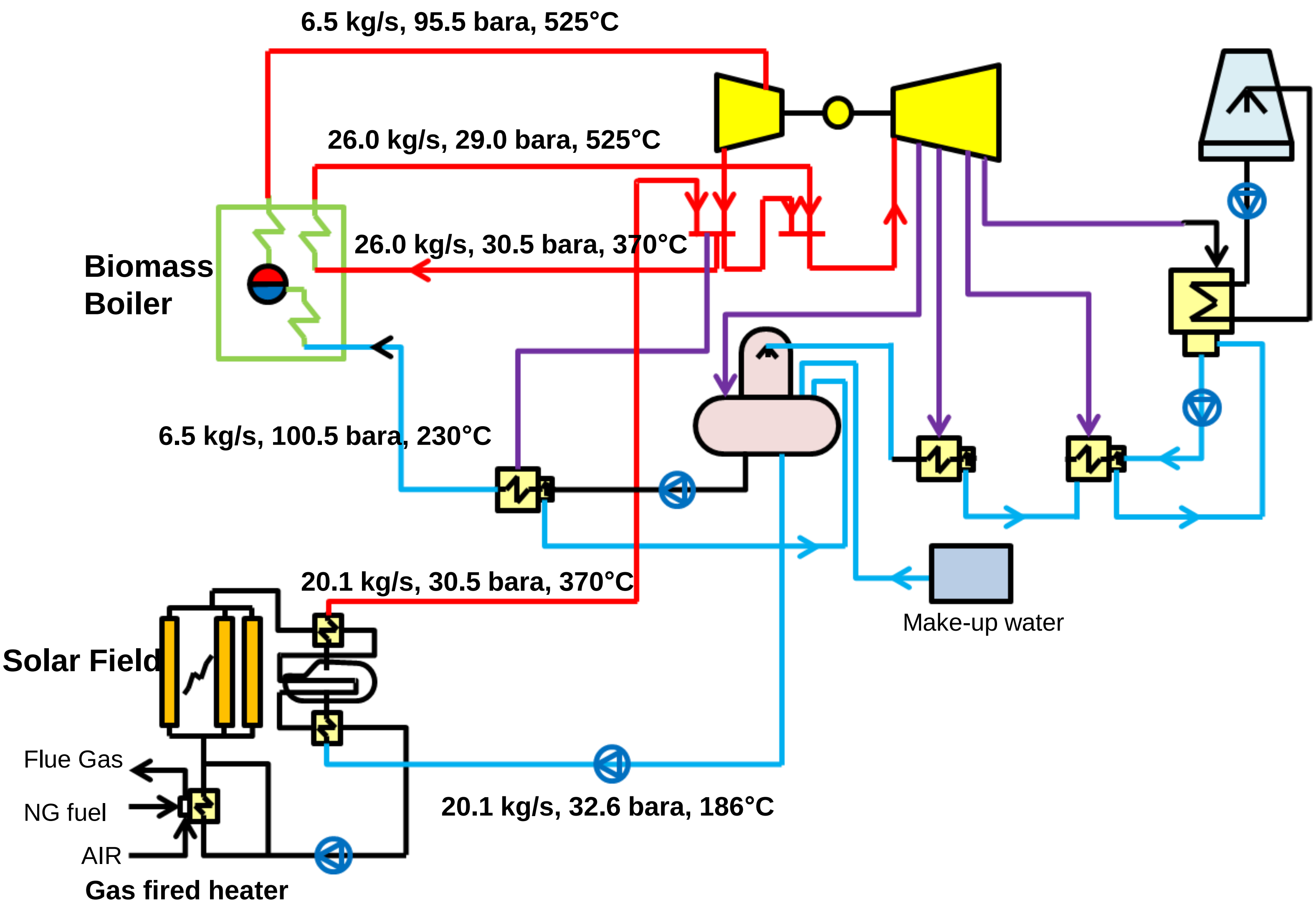
Solar thermal hybrid plants in the world

Location	Start Production	Hybridization scheme		Method
Borges Termosolar Spain	Dec 2012	**Biomass**	**Solar**	Solar steam in CRH line
		2 X 22 MW_{th}		
ISCC Kuraymat Egypt	Jun 2011	**Nat. gas**	**Solar**	ISCC
		120 MW	20 MW	
Liddell Power Station Australia	Oct 2012	**Coal**	**Solar**	270°C, 55 bar fed into the existing coal plant
		4X500 MW	9 MW_{th}	
Agua Prieta II Mexico	2014	**Nat. gas**	**Solar**	ISCC
		464 MW	14 MW	
Shams 1 UAE	Mar 2013	**Solar**	**Nat. gas**	380°C steam boosted to 540°C by gas augmentation
		100 MW	Augmentation and backup	

Borges Termosolar – SPAIN
Biomass + Solar

- **Participants**: Abantia, Comsa EMTE
- **Scheme**: 2 x 22 MW_{th} biomass (main fuel)
  183,120 m^2 solar-field aperture area
- **Turbine capacity**: 25 MW (gross); 22.5 MW (Net)
- **Solar-field inlet**: 293°C
- **Solar-field outlet**: 393°C
- **Advantage**: -reduction in biomass consumption
  -reduction in fuel-transport expenditure
  -easier integration in agro-land

Borges Termosolar - Layout



ISCC Kuraymat – EGYPT
Nat. gas + Solar

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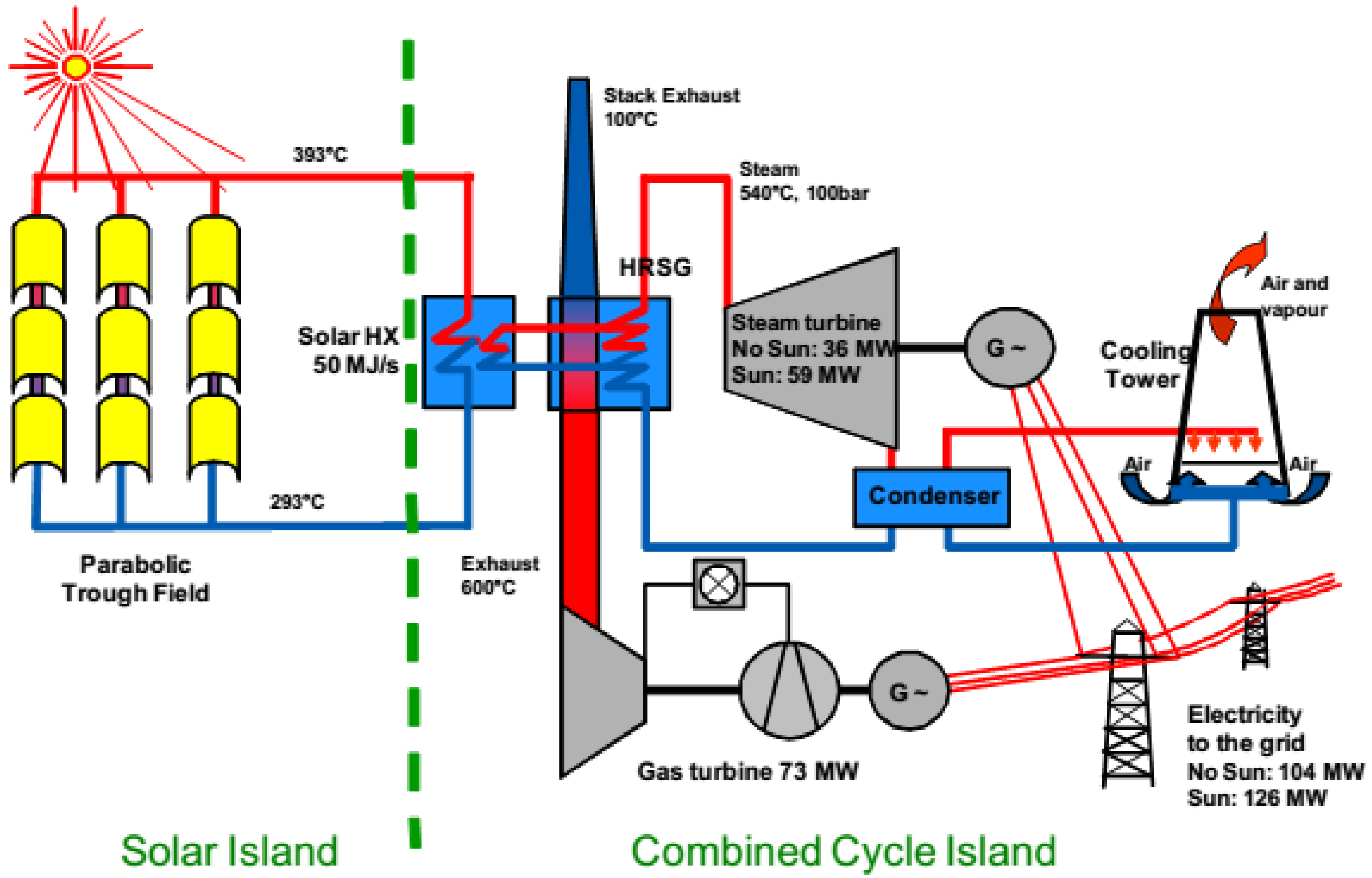
• **Participants**:	NREA, Orascom/Flagsol	
• **Scheme**:	120 MW combined cycle (Nat. gas)	
	20 MW solar input	
	131,000 m^2 mirror area	
	61 MW_{th} max.	
• **Method**:	Integrated solar combined cycle	
• **HRSG and Solar HX**:	Steam generation by solar HX (pre-heater + evaporator) fed into HP steam drum	
• **Turbine capacity**:	gas turbine:	74 MW
	steam turbine:	60 MW @ 50 MJ/s solar heat
		36 MW without solar heat
• **Solar-field inlet**:	293°C	
• **Solar-field outlet**:	393°C	

ISCC Kuraymat
Scope split and general concept



Source: “Construction of ISCC Kuryamat”, G. Brakmann, F.A. Mohammad et al, Fichtner Solar GmbH SolarPACES 2009.

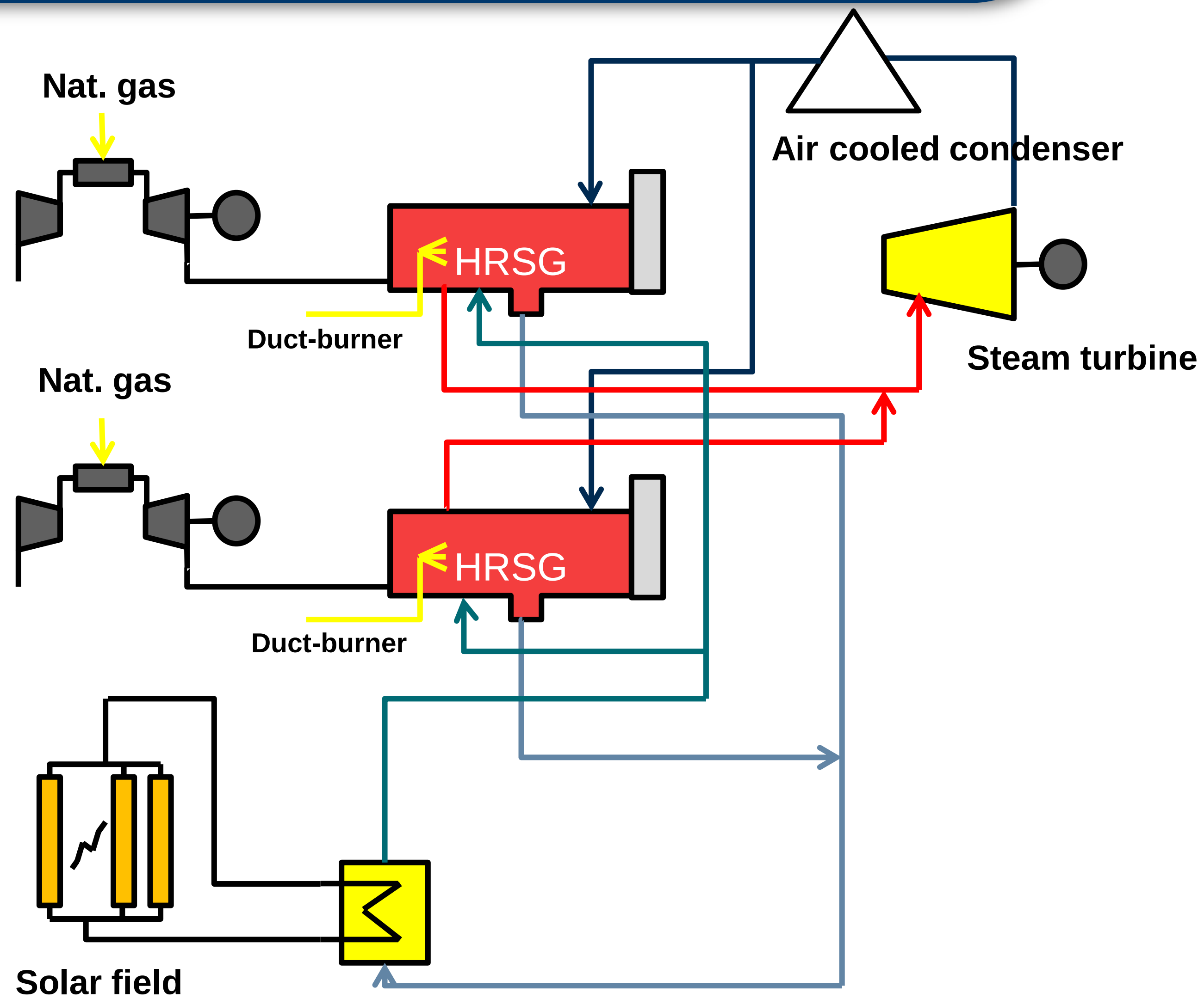
Liddell Power Station – AUSTRALIA
Coal + Solar

- **Participants**: Novatec Solar, Macquarie Generation
- **Scheme**: 2000 MW coal
  9 MW_{th} solar input
  18,490 m^2 mirror area
- **Method**: 270°C, 55 bar from the 9 MW_{th} solar boiler fed into the existing 2000 MW coal fired power station
- **Technology**: LFR
- **Solar-field inlet**: 140°C
- **Solar-field outlet**: 270°C

Agua Prieta II – MEXICO
Nat. gas + Solar

• **Participants**:	Abengoa Solar, Federal Electricity Commission Abener/Teyma
• **Scheme**:	464 MW combined cycle (Nat. Gas) 14 MW_{el} solar input 85,000 m^2 mirror area
• **Method**:	ISCC 330°C, 130 bar saturated steam from solar Additional nat. gas duct burner included in CC when solar field not in operation
• **Technology**:	Parabolic trough

Agua Prieta II - Layout



Source: Shukla, S. – Abengoa Solar India, World Future Energy Summit – 2013, Abu Dhabi

Shams 1 – UAE
Solar + Nat. gas

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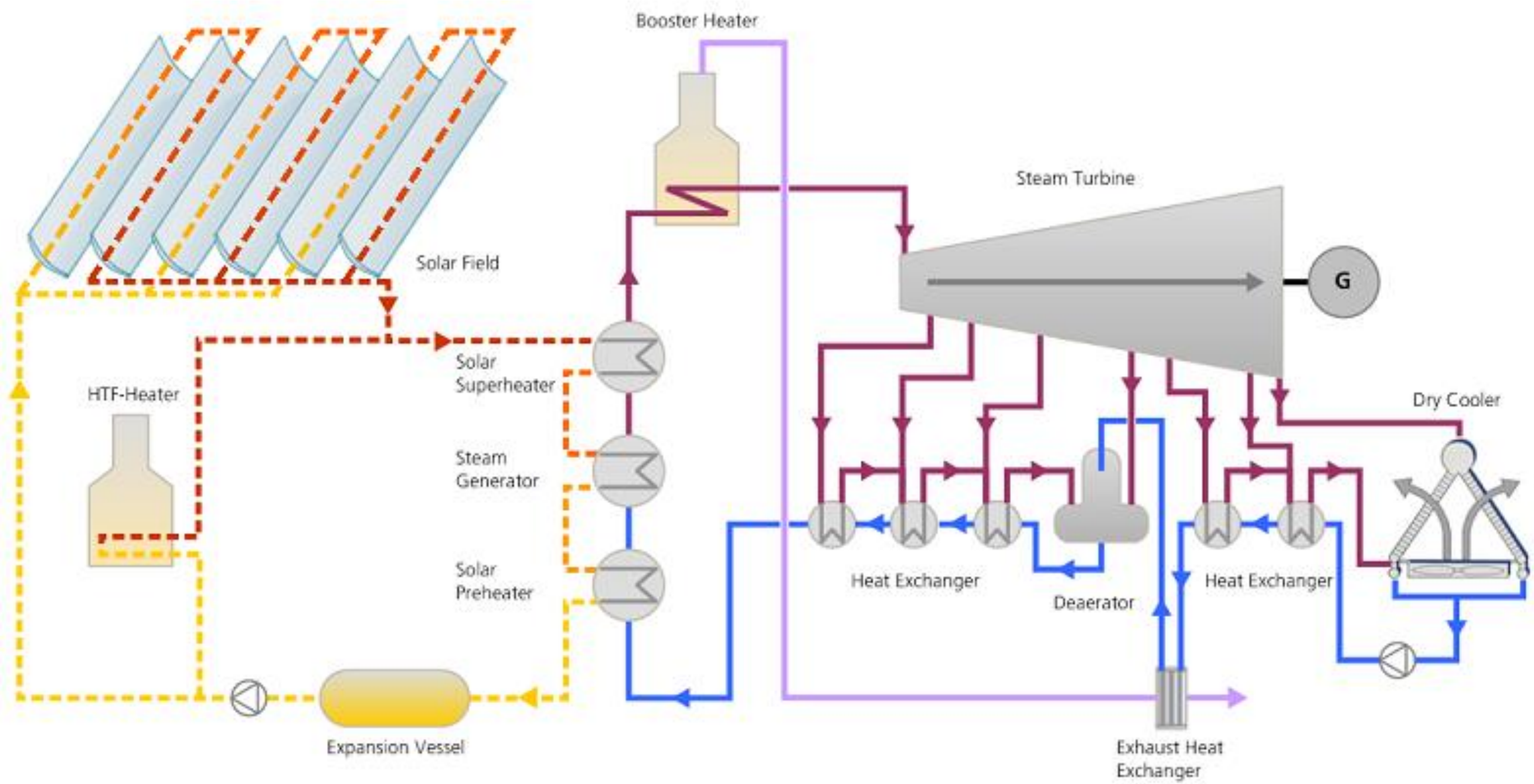
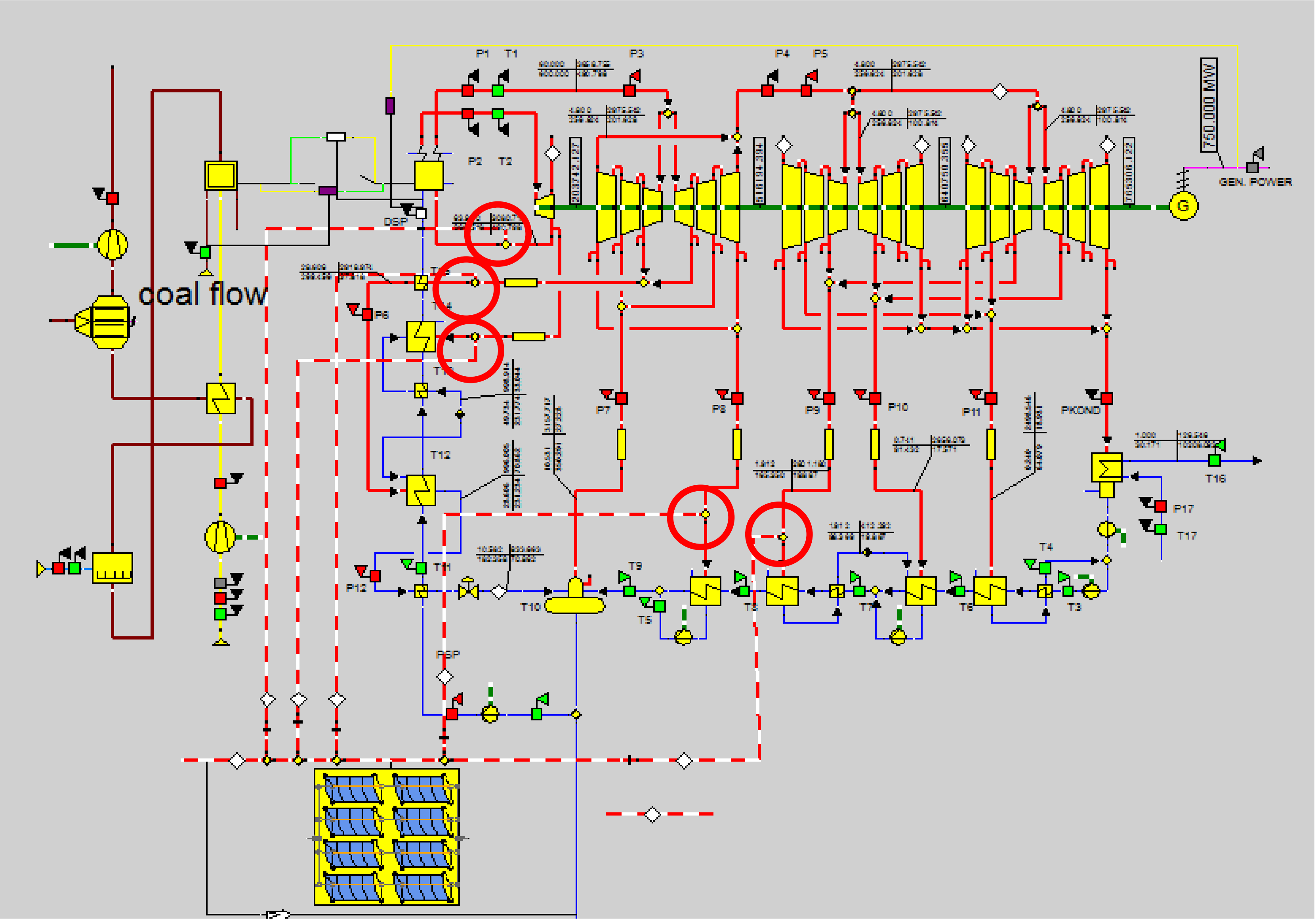
• **Participants**:	Masdar, Total, Abengoa Solar, Abener/Tyma, ADWEC
• **Scheme**:	100MW solar
	627,840 m^2 mirror area
	Nat. gas backup
• **Method**:	Gas augmented solar thermal
	380°C steam boosted to 540°C by gas powered heater
• **Technology**:	Parabolic trough
• **Solar-field inlet**:	300°C
• **Solar-field outlet**:	400°C

Shams 1 - Layout



Source: Goebel, O., and F. Luque. "Shams one 100 MW CSP plant in Abu Dhabi: update on project status." Concentrating Solar Power & Chemical Engineering Systems (2012).

Simulation done for finding the solar share at different points of injection



Simulation results – Coal saving

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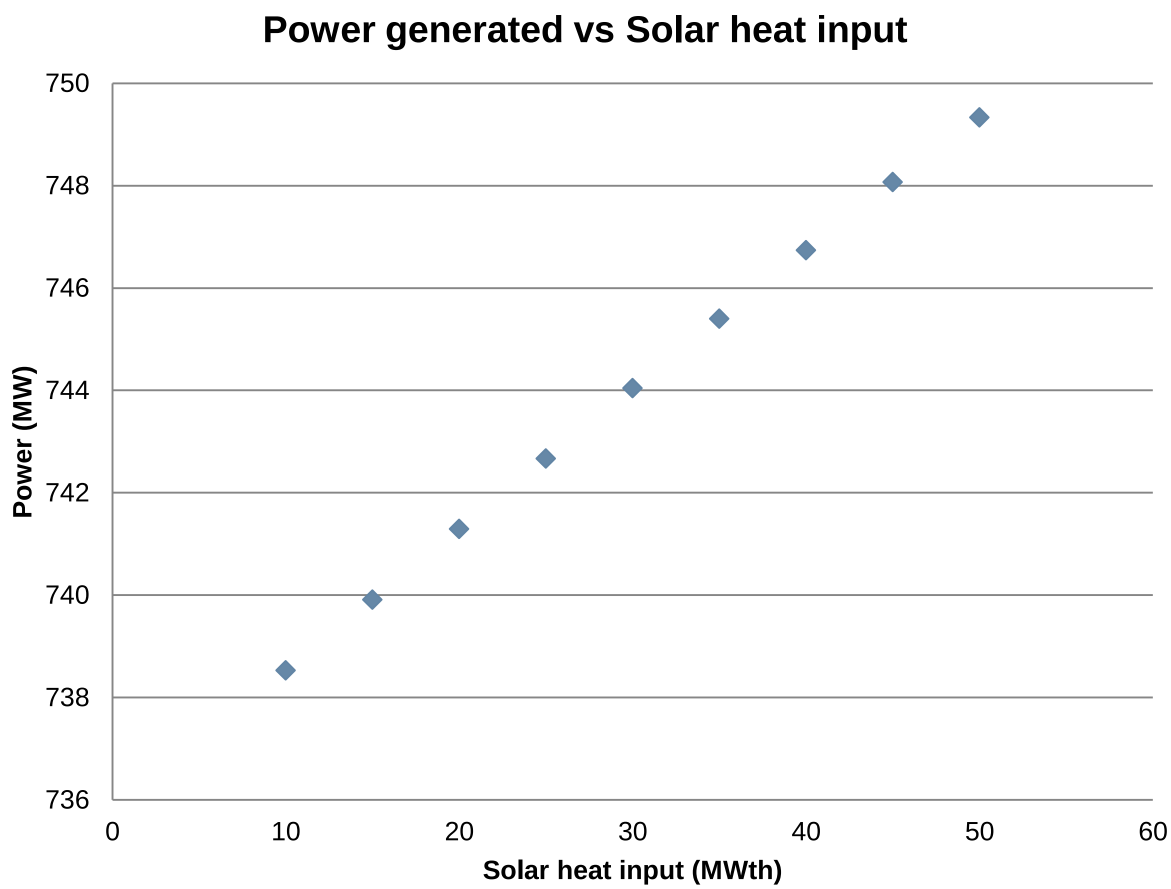
Case	Coal Consumption (kg/s)	Reduction (kg/s)	Reduction (%)
Base Case	52.115		
LPH 3	51.907	0.21	0.40
LPH 4	51.691	0.42	0.81
HPH 1	51.207	0.91	1.74
HPH 2	50.691	1.42	2.73
CRH	51.193	0.92	1.77

Simulation results – Power reduction

Case	Coal Consumption (kg/s)	Power (MW)	Reduction (MW)	% reduction
Base Case	52.115	750.00		
LPH 3	51.907	746.95	3.05	0.41
LPH 4	51.690	743.73	6.27	0.84
HPH 1	51.207	736.47	13.53	1.80
HPH 2	50.691	735.76	14.24	1.90
CRH	51.193	736.27	13.73	1.83

Simulation results – Varying heat at a particular point

q solar (MW)	Power (MW)
50	749.333
45	748.068
40	746.738
35	745.400
30	744.042
25	742.669
20	741.292
15	739.912
10	738.530



Need for Metering

- Injection of same amount of heat at different places has different equivalent power.
- There can be no standardized calculation for the equivalent power as it depends upon the HBD of the plant.
- The equivalent power at a particular injection point may or may not vary linearly with the changing heat input. This means that with varying DNI, the equivalent power conversion ratio would be different.
- The plant load percent also changes the solar equivalent power as the cycle efficiency varies with load.
- The special tariff / subsidy / RPO would be permissible only for the power produced and not for the heat produced.
- So a methodology is required for accurately calculating the equivalent power.
- We present a model based approach for this based on our Ebsilon software.

Thank You

... Ideas & Solutions for Tomorrow

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