

**SAM Linear Fresnel solar
boiler model: Novatec solar
boiler sample file**
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About the speaker



- **Camille Bachelier**
camille.bachelier@novatecsolar.com
(+49) 721 255 173 41
www.novatecsolar.com

- Applications engineer - Product and market development department
- Working since 2010 at Novatec Solar GmbH
- Academic background:
 - Master thesis at the Deutschen Zentrums für Luft- und Raumfahrt (DLR) in the solar research department (German Aerospace Center, Stuttgart, Germany)
 - MSc in Sustainable Energy Engineering from the Kungliga Tekniska Högskolan (Royal Institute of Technology, Stockholm, Sweden)
 - Masters degree in engineering in Energy System Engineering from the Ecole des Mines de Nantes (Nantes, France)

Presentation outline

- Novatec Solar profile
- Novatec solar boiler technology
- Novatec Solar linear Fresnel solar boiler sample file
- Comparison SAM/Novatec models

NOVATEC SOLAR PROFILE




Novatec Solar

- Novatec Solar profile:
 - Leading supplier of turn key linear Fresnel solar boilers
 - Founded in 2006 in Karlsruhe, Germany
 - Since 2011, partially owned by the ABB group
- Collaboration with NREL: review of linear Fresnel solar boiler model in SAM



Novatec Solar PE-2, Solarthermal Power Station, Southern Spain

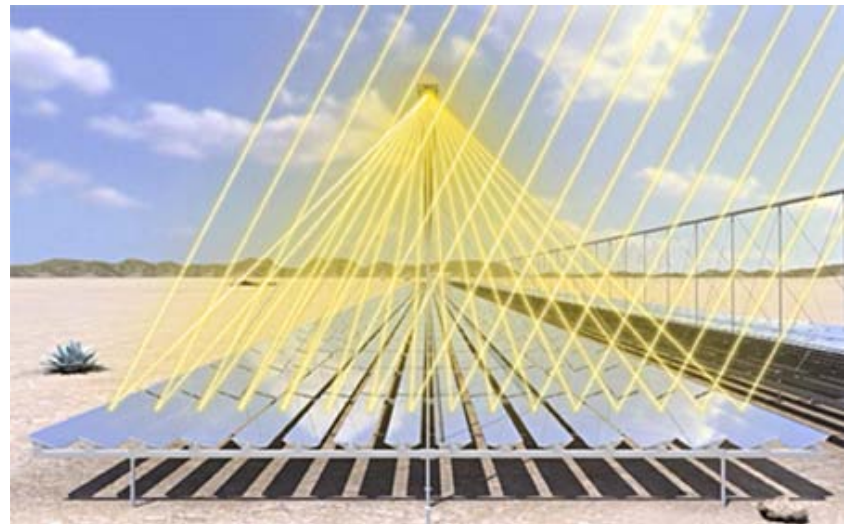
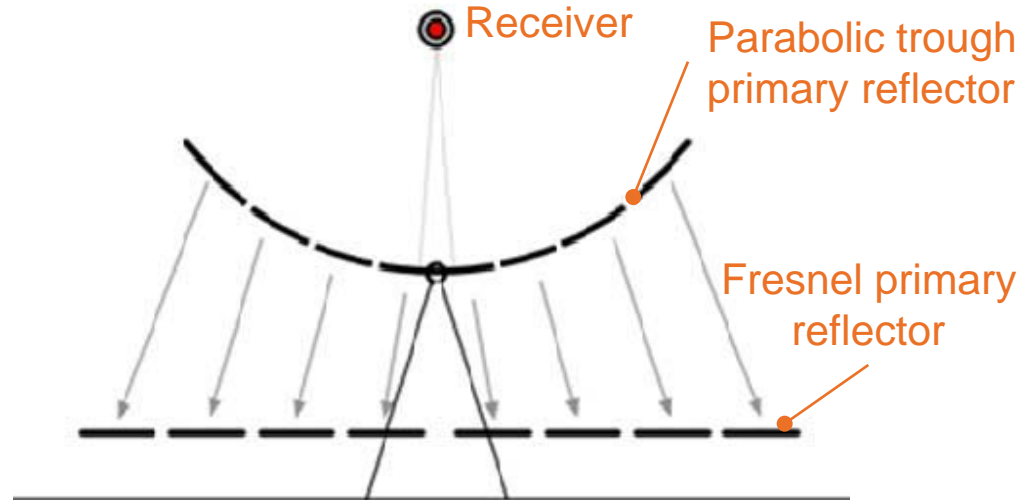
Novatec Solar references

Project Name	Power output	Aperture area	Type of Project	Status	Picture
Puerto Errado 1 (PE 1)	1.4 MW _{el}	18,500 m ²	Demonstration plant	In commercial operation since March 2009	
Puerto Errado 2 (PE 2)	30 MW _{el}	302,000 m ²	Power generation plant	Final commissioning	
Liddell Power Plant	9 MW _{th}	18,500 m ²	Solar augmentation of a coal fired power plant	Final commissioning	

NOVATEC SOLAR TECHNOLOGY

Linear Fresnel basic principle

- Collects sun radiation on a large mirror area and concentrates it on a tiny area
- Similar to parabolic trough, but the primary reflector design is different
- Fresnel design:
 - Lower optical efficiency
 - Significant cost reductions
 - Cost reductions compensate efficiency losses



Novatec solar boilers

- Low cost turnkey solar boilers based on Fresnel technology
- Direct steam generation: water is the heat transfer fluid
- Evaporating solar boiler
 - Saturated steam
 - Up to 300°C – 90 bar
- Superheating solar boiler
 - Superheated steam
 - Up to 500°C – 100 bar



Puerto Errado 1, Turnkey Solar Boiler, Southern Spain

Key differences to other CSP technologies

- Direct steam generation ⇔ no costly and hazardous heat transfer fluid, no intermediary heat exchanger
- Structure close to the ground ⇔ lighter structure (lower required mechanical strength), light foundations, lower land requirement
- Fixed receiver ⇔ simple receiver connection even at high pressure, simple thermal expansion compensation system
- Mostly made of standard components ⇔ cost reduction, streamlined production process, potentially high local content in the construction
- Patented automated cleaning system ⇔ almost waterless operations, reduced O&M costs
- Performance guarantees

NOVATEC SOLAR LINEAR FRESNEL SOLAR BOILER SAMPLE FILE IN SAM

Linear Fresnel solar boiler in SAM

- Sample file integrated in SAM:
 - On welcome screen: click on “Open a sample file”
 - Select “Novatec solar boiler”
 - Follow instructions
- Pre-configured model of state of the art, commercially available linear Fresnel solar boiler
- Based on Novatec Solar Key Performance Indicators, used for performance guaranteeing



Novatec Solar performance guarantee model

- $P_{th} = A \times (DNI \times f_{cl} \times \eta_{opt} - q_{loss})$

P_{th} = thermal power output [W_{th}]

A = aperture area [m²]

DNI = direct solar irradiance [W/m²]

f_{cl} = mirror cleanliness factor

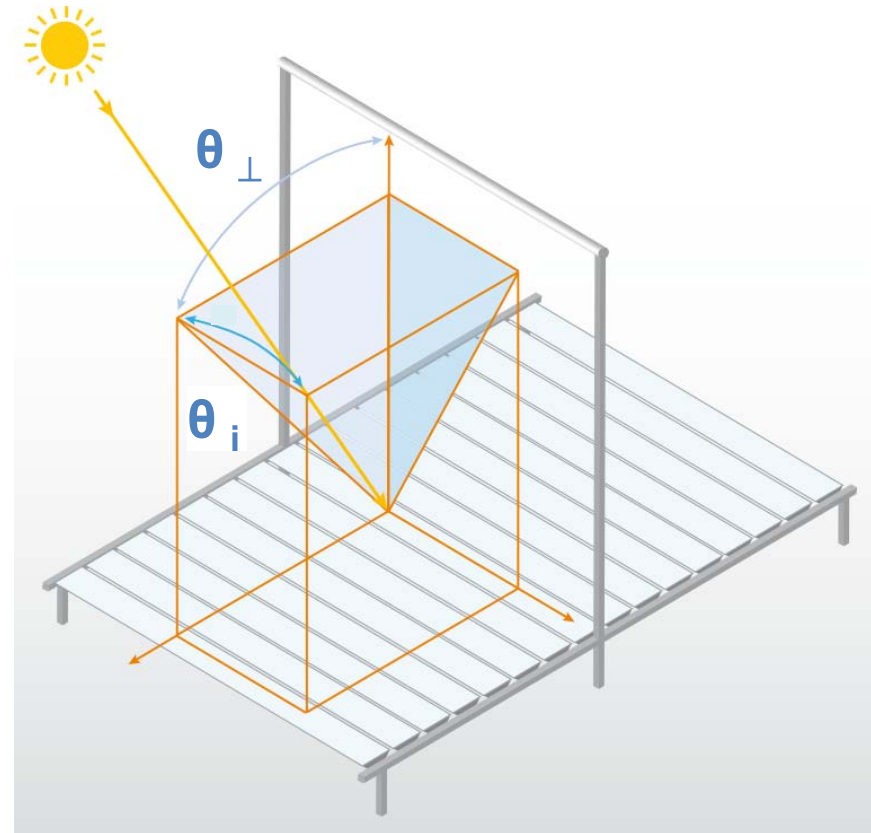
η_{opt} = optical efficiency

q_{loss} = specific heat losses [W/m²]

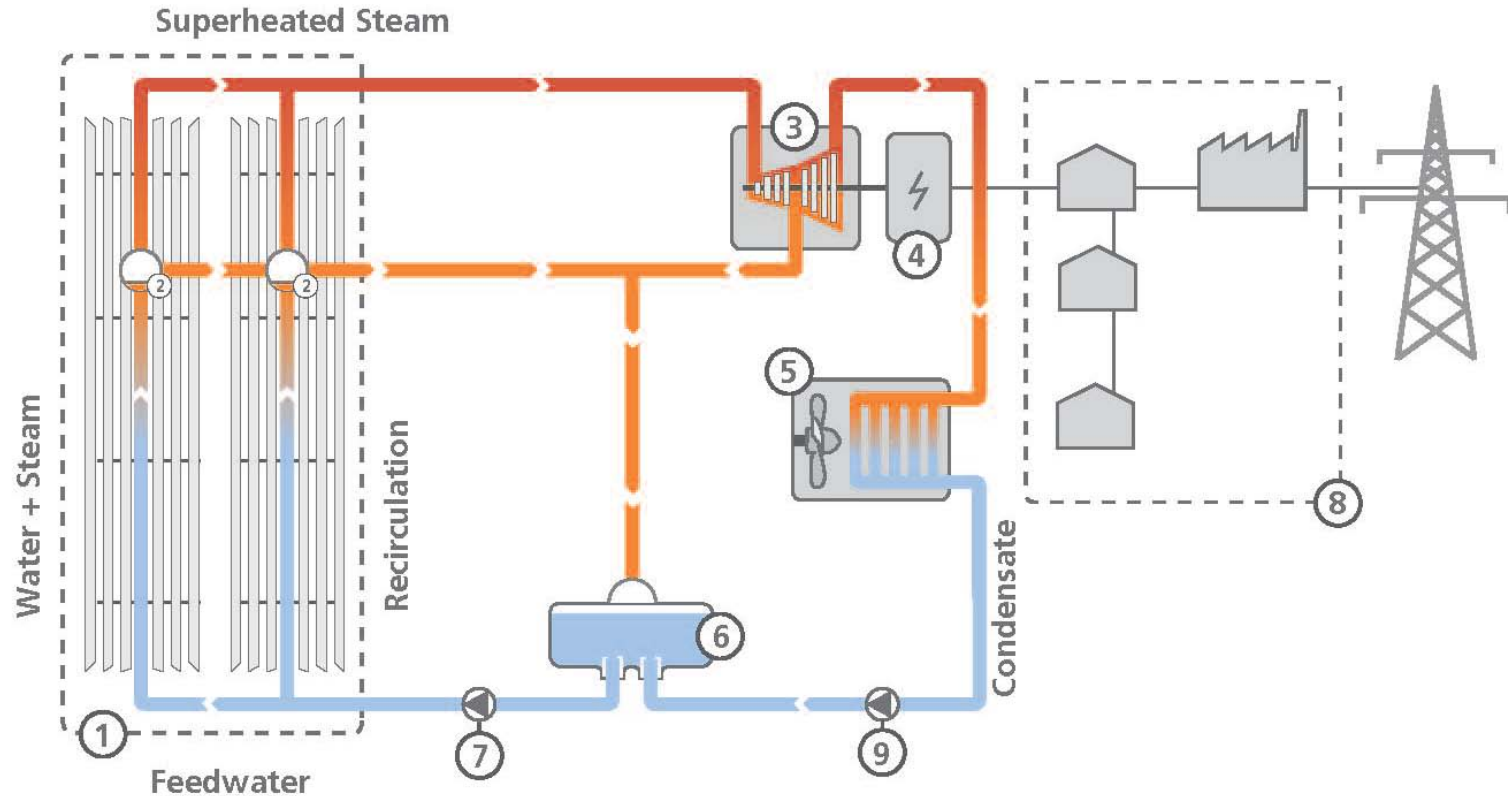
- $\eta_{opt} = \eta_o \times K_{\perp}(\Theta_{\perp}) \times K_{\parallel}(\Theta_i)$

- $q_{loss} = u_0 \Delta T + u_1 \Delta T^2 + u_2 \Delta T^3 + u_3 \Delta T^4$

- In orange: guaranteed values



Typical solar power plant based on Novatec solar boiler



- 1. Solar Boiler
- 2. Steam Separator
- 3. Turbine

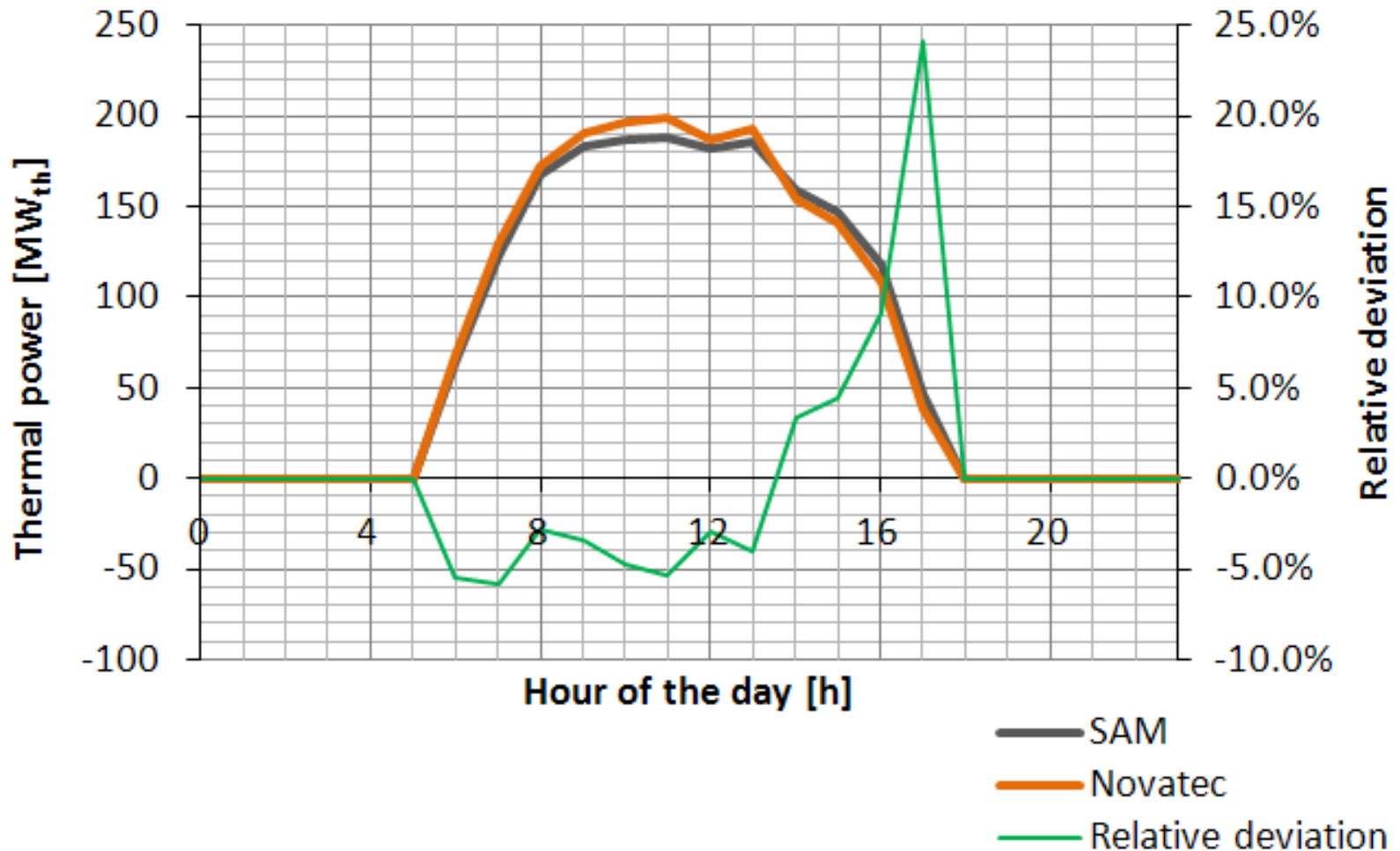
- 4. Generator
- 5. Condenser
- 6. Deaerator/Feedwater Tank

- 7. Feedwater Pump
- 8. Public Electricity Grid
- 9. Condensate Pump

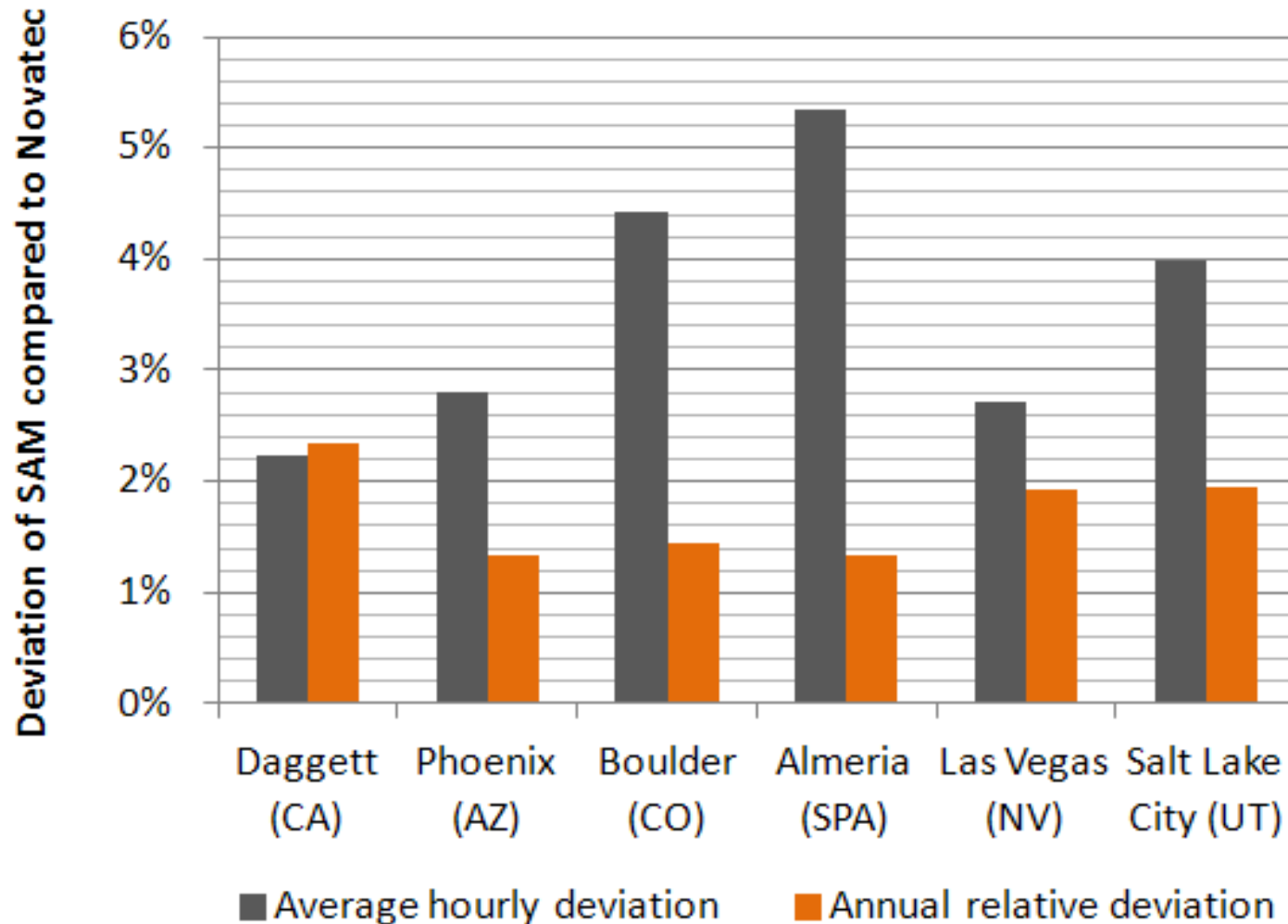
COMPARISON SAM/NOVATEC MODEL

Main results: hourly results comparison

Daggett (CA), June 21st (SAM weather data)



Main results: Multiple location annual results comparison



Conclusions

- Good match between SAM and Novatec solar results for annual thermal energy yield calculations
- Still some deviations due to the modelling detail level and assumptions
- SAM provides a good first estimate model for linear Fresnel solar boilers

THANK YOU FOR YOUR ATTENTION