SAM Linear Fresnel solar boiler model
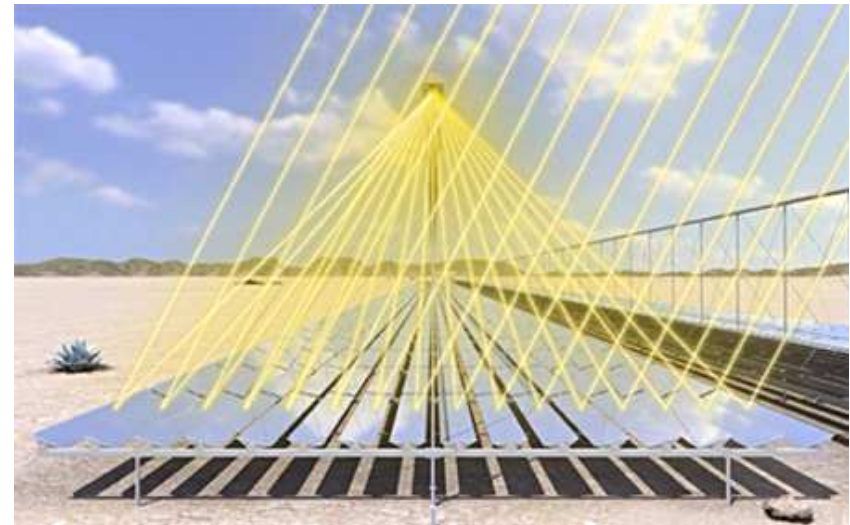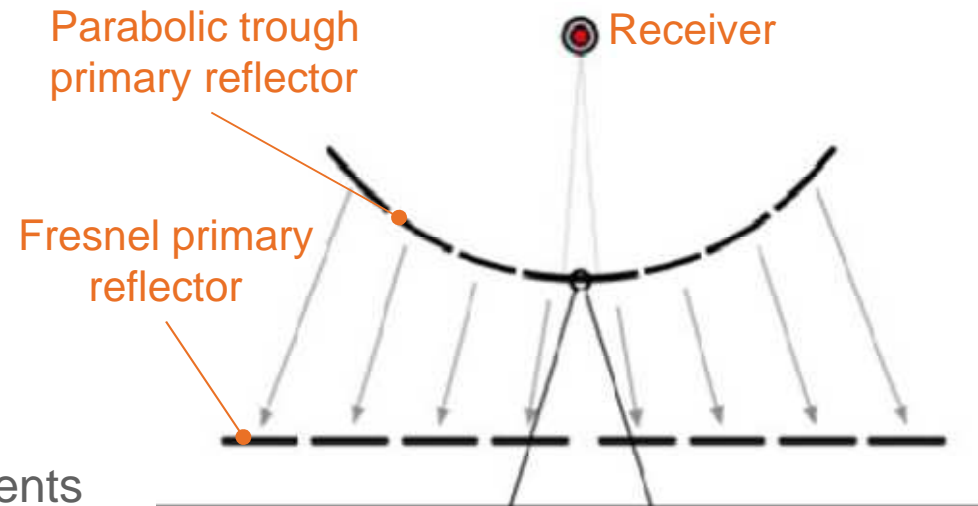
SAM Webinar

NOVATEC SOLAR

23.07.2013

Introduction

- Since version 11.05.2012, a Linear Fresnel performance model is integrated in SAM, based on state of the art linear Fresnel technology

- Presentation outline
  - Linear Fresnel technology
  - Fresnel performance model and integration in SAM
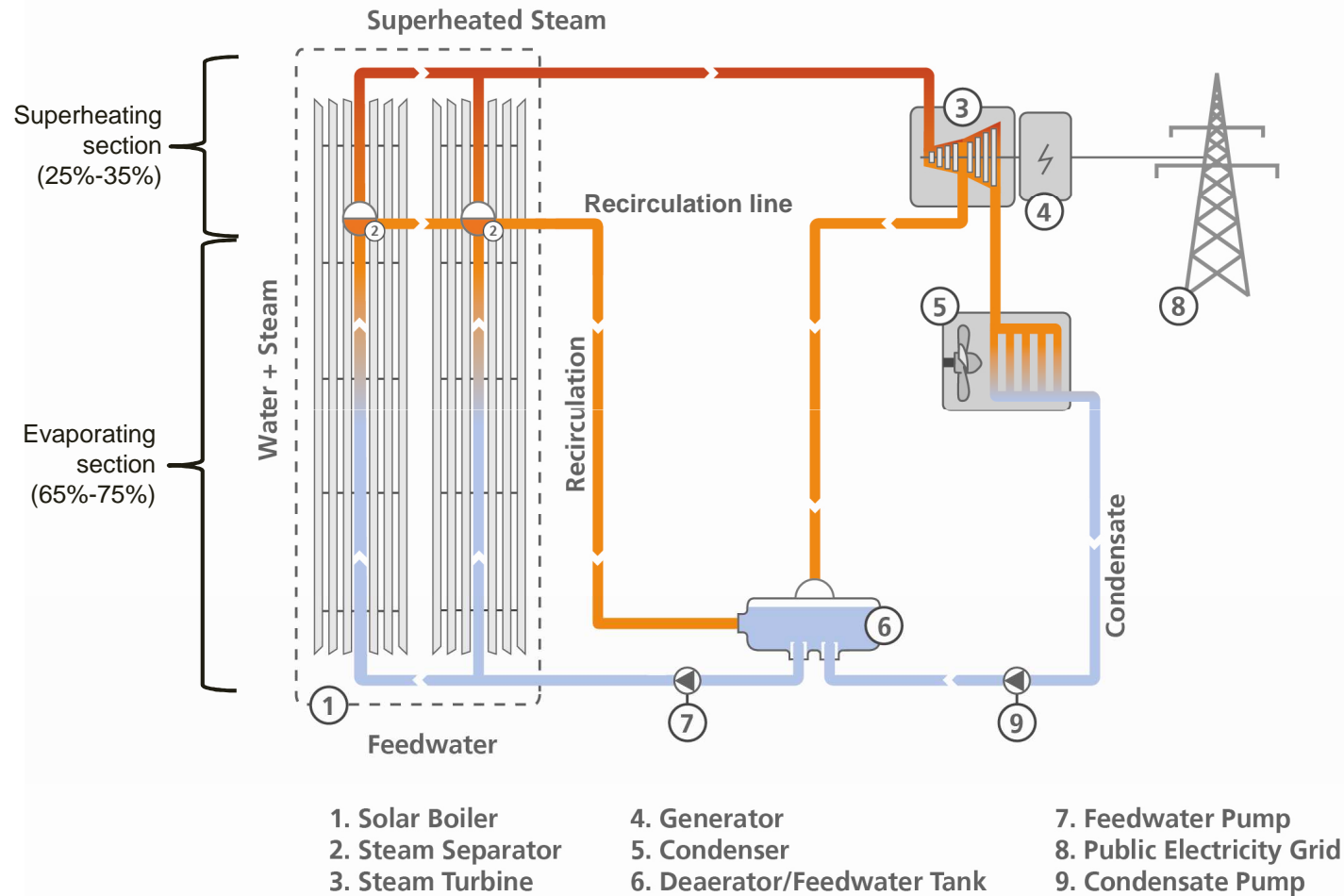 - Comparison SAM/Novatec Solar models

LINEAR FRESNEL TECHNOLOGY

Linear Fresnel Basic Principle

- Similar to parabolic trough
  ...but simplified reflector

- Fresnel design:
  - Lower optical efficiency
  - Significant cost reductions:
    - Less sensitive to wind
    - Light weight reflector
    - More standard components
    - Lower land use
  - Cost reductions > efficiency loss

- Flexible choice of heat transfer fluid:
  - Direct Steam Generation (DSG)
  - Direct Molten Salt (DMS, currently under development)

Parabolic trough primary reflector

Receiver

Fresnel primary reflector

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Typical Fresnel DSG solar power plant layout

Superheated Steam

Superheating section (25%-35%)

Recirculation line

Water + Steam

Recirculation

Evaporating section (65%-75%)

Condensate

Feedwater

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

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

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

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Novatec Solar Boilers

- Low cost turnkey solar boilers based on Fresnel technology

- Direct steam generation: water is the heat transfer fluid

- Non vacuum tube collector
  - Usually used as evaporator
  - Saturated steam
  - Up to 310°C – 100 bar

- Vacuum tube collector
  - Usually used as Superheater
  - Superheated steam
  - Up to 550°C – 150 bar

**Puerto Errado 1, Turnkey Solar Boiler, Southern Spain**

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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	In commercial operation since August 2012	
Liddell Power Plant	9 MW$_{th}$	18,500 m^2	Solar augmentation of a coal fired power plant	In commercial operation since October 2012	

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# FRESNEL PERFORMANCE MODEL

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Core thermal power formula

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

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

  A = aperture area (cumulated aperture area of mirror lines) [m²]

  DNI = direct solar irradiance [W/m²]

  f_{cl} = mirror cleanliness factor

  η_{opt} = optical efficiency

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

- $\eta_{opt} = \eta_o \times K_\perp (\Theta_\perp) \times K_i (\Theta_i)$
  - $K_\perp$ transversal angle modifier factor
  - K_i incident angle modifier factor
- q_{loss} = $u_0 \Delta T + u_1 \Delta T^2 + u_2 \Delta T^3 + u_3 \Delta T^4$
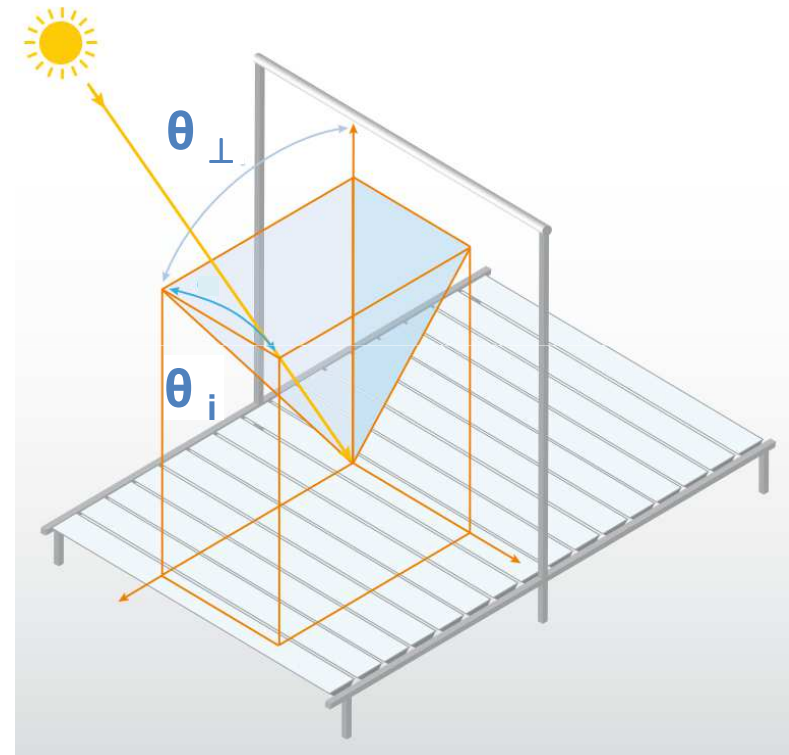
Novatec Solar Key Performance Indicators (Used in SAM)

Collector type	Non vacuum	Vacuum	Unit
Nominal optical efficiency (η_0)	67%	64.7%	-
Heat loss coefficient u0	0.671	0.15	$W/(m.K)$
Heat loss coefficient u1	0.00256	0	$W/(m.K^2)$
Heat loss coefficient u2	0	0	$W/(m.K^3)$
Heat loss coefficient u3	0	7.5E-09	$W/(m.K^4)$

Angle modifier dependency on sun position
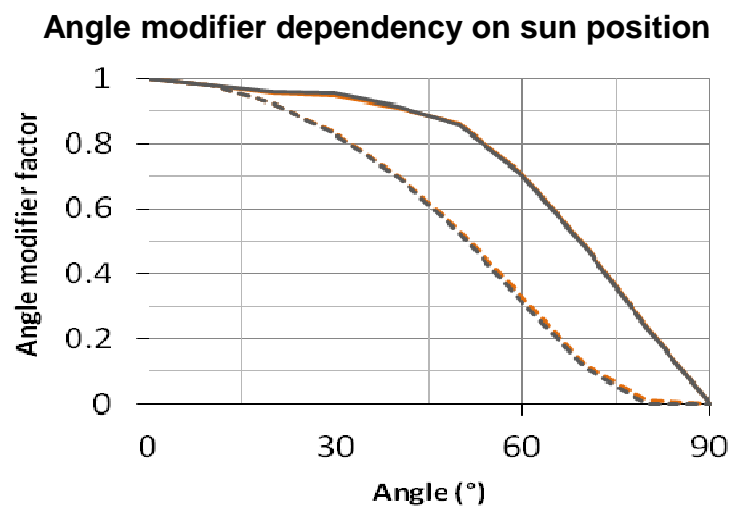
—— Non vacuum - transversal
- - - - Non vacuum - incident
—— Vacuum - transversal
- - - - Vacuum - incident
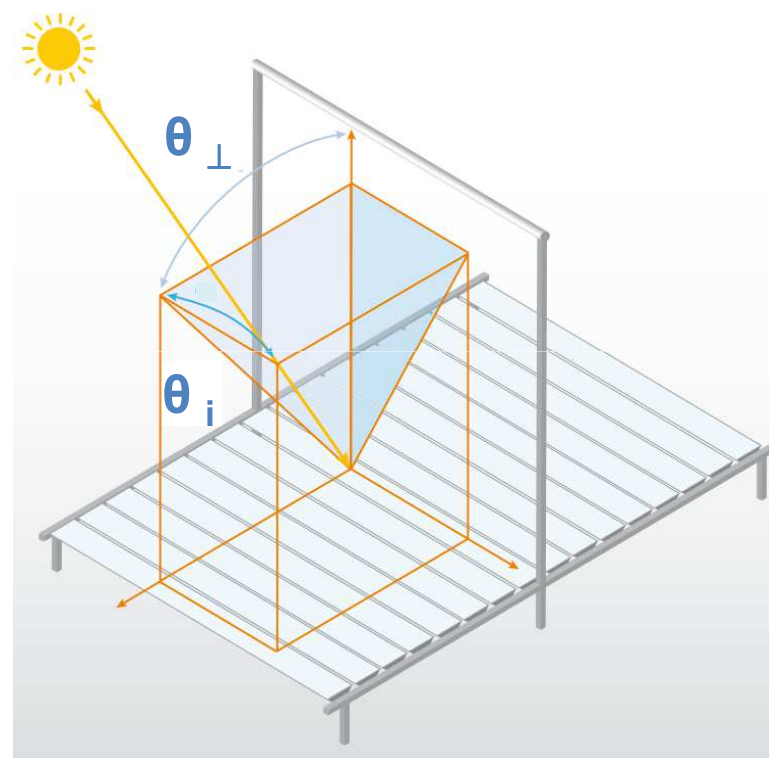
# Linear Fresnel Solar Boiler Model in SAM

- Sample file integrated in SAM:
  - On welcome screen: click on "Open a sample file"
  - Select "Novatec solar boiler"
  - Follow instructions

- This model is pre-configured:
  - Some inputs can be changed (solar field size, pressure, temperature,...)
  - ...but some **must not be changed** (e.g. optical efficiency, angle modifiers, heat loss coefficients)
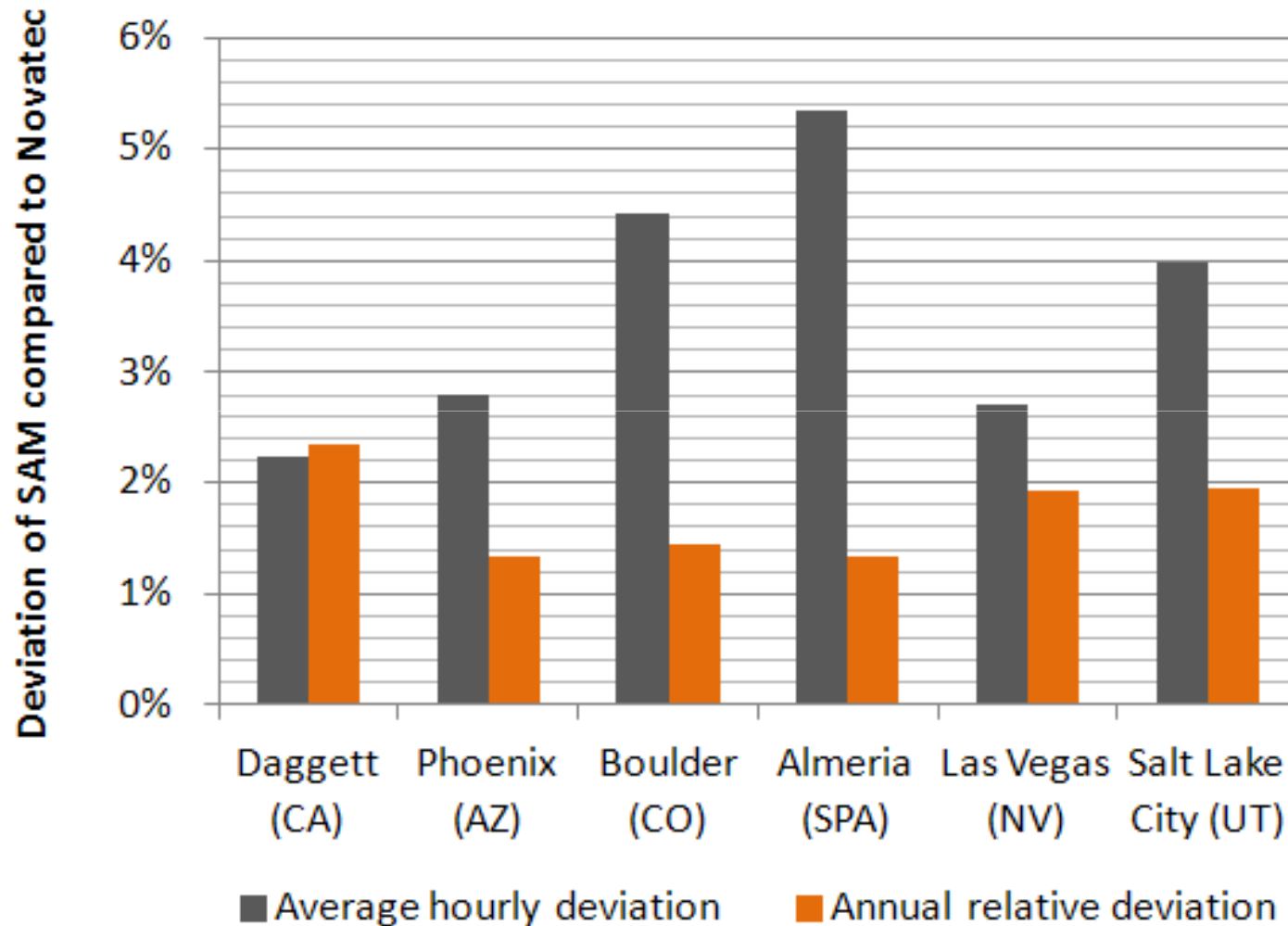
SAM/Novatec results comparison

Main Results: Hourly Results Comparison

Daggett (CA), June 21st (SAM weather data)
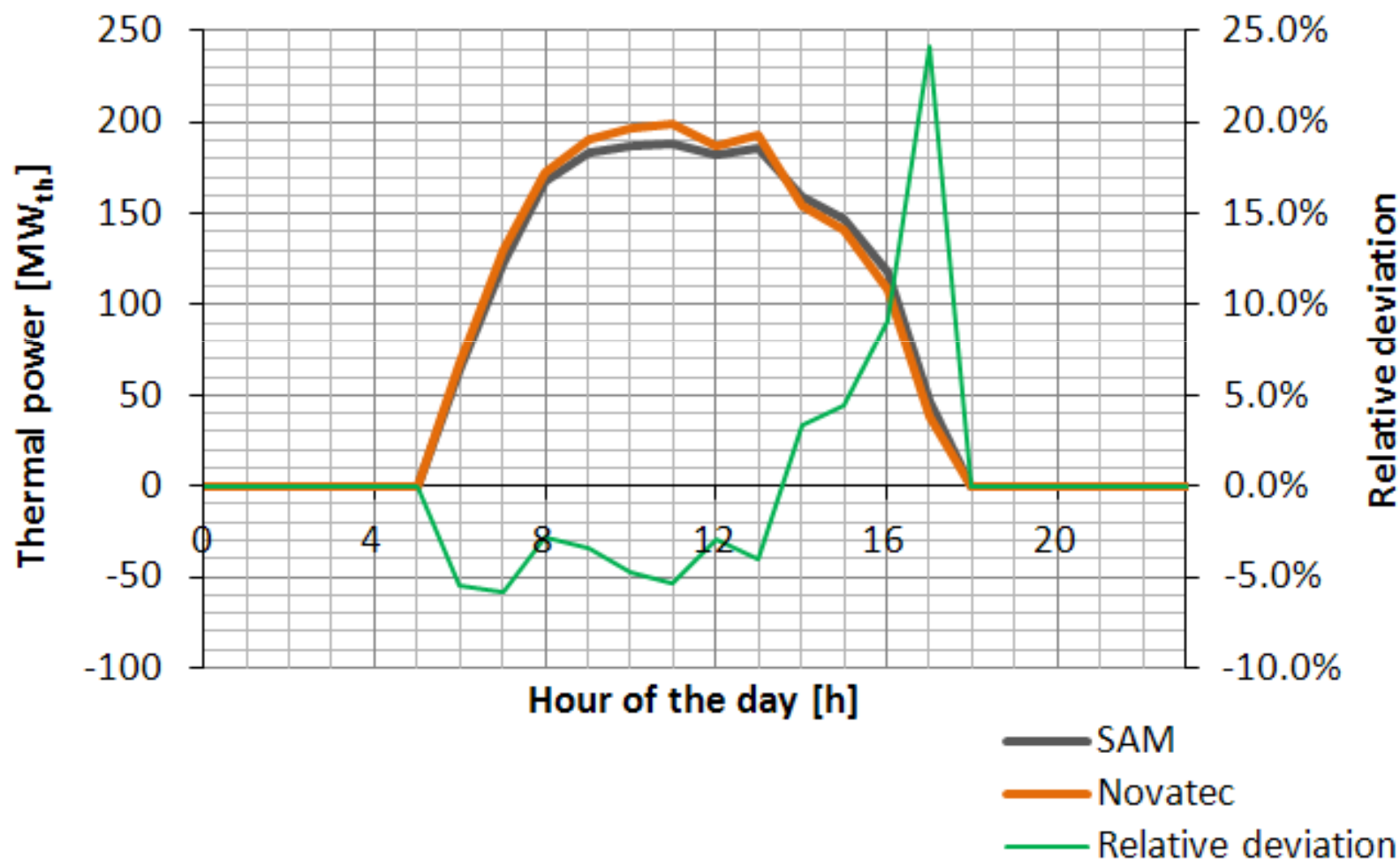
Main Results: Multiple Location Annual Results Comparison

Conclusions

- Relatively good match between SAM and Novatec Solar
  - Usually around +/- 5% deviation
  - Comparison have been done for the solar field **thermal** energy yield only

- For sake of results correctness, technology specific inputs should not be changed:
  - All inputs of the "Collector and Receiver" tab
  - Solar field layout: recirculation configuration with an unique geometry for Superheaters
  - Superheater/Evaporator ratio can be carefully adapted to the aimed steam parameters

THANK YOU FOR YOUR ATTENTION

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