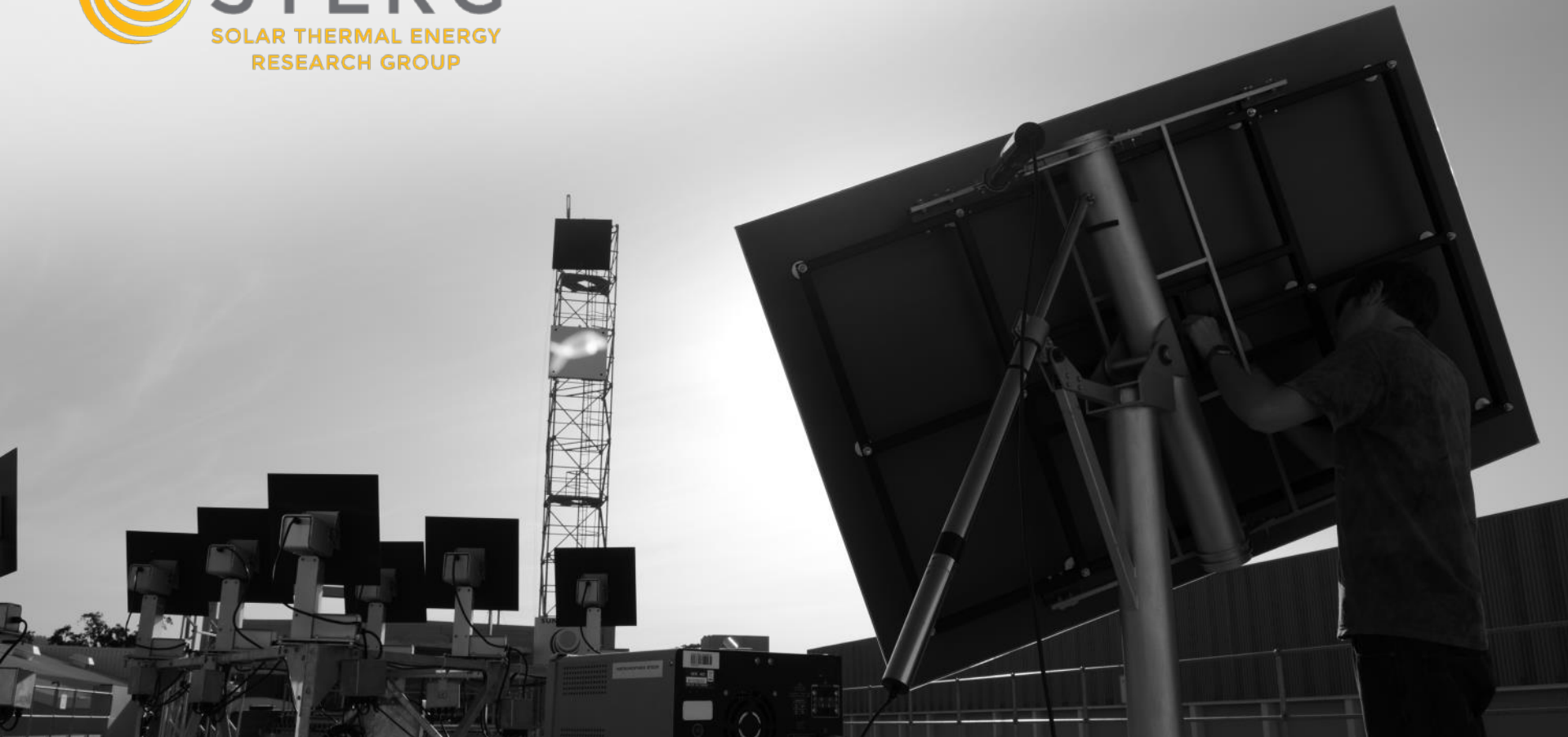
STERG

SOLAR THERMAL ENERGY RESEARCH GROUP



Performance Modelling, Verification and Operational Feasibility of a Parabolic Trough Plant

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Content

Presentation Overview

- Introduction
- Power Plant
- Modelling
- Simulation Output
- Verification
- Conclusion – Operational Feasibility

Introduction

Outline

- Develop a Parabolic Trough Power Plant (PTPP) **Simulation Program** for Performance Analysis

a) **Investigation & Analysis** (Operational Strategy)
b) **Model**
c) **Verify**
d) **Operational Feasibility**

Andasol 3 Power Plant

Plant used: Andasol 3

- 50 MW ~ Power plant
- 180GWh ~ Forcast gross electricity volume

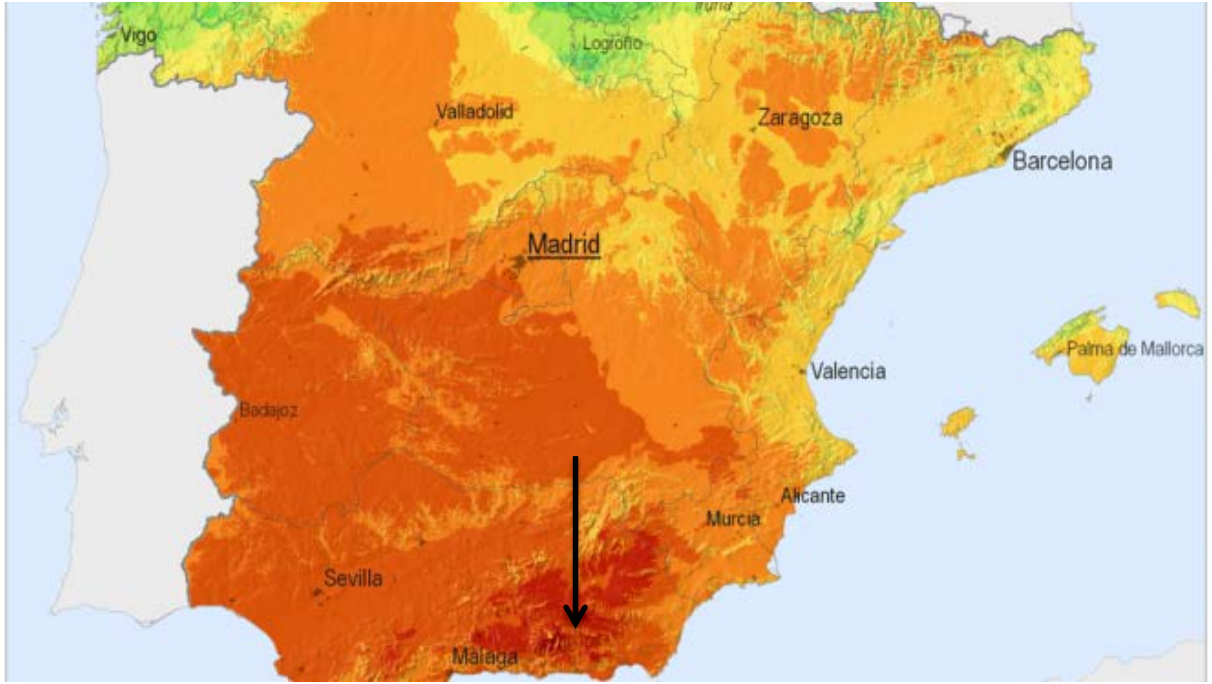
- <u>Plant efficiency:</u>

  28% ~ Peak

  15% ~Annual Average

Andasol 3 Power Plant

Location and Resource



Aldeire, Granada (Spain):

~ 37°13′ 42.7″ N

~ 3°4′ 6.73″ W

Annual DNI:
2136 kWh/m²

Andasol 3 Power Plant

Technical Data

Power Plant Information	
Kind	Parabolic Trough Technology
Power Output	50 MW
Solar Field Aperture Area	497 040 m^2
Storage Design	2-Tank Indirect Thermal Storage
Thermal Storage	28 500 t Molten Salt
Storage Capacity	7.5 Full Load Hours

Modelling

Simulation Program

- MATLAB (Prepare variables and simulation inputs)
  - ~ 2017 academic License
- Simulink Toolbox (Dynamic performance model)
- Excel (DNI data, ambient temperature data and lookup tables)

Modelling

Techniques

- **Solar Geometry:** Power from the Sun (Ch 3)
- **Solar Field Output Temperature:** NREL Model [SAM]
- **Storage Operation:** Power from the Sun (Ch 11) & Andasol 3 data analysis
- **Plant Control:** Power from the Sun (Ch 14) & data analysis

Modelling

Simulation Input

1. Simulation Timestep
2. Solar Time and Geomtery
3. DNI
4. Ambient Temperature
5. Constants, parameters & limitation conditions.

Modelling

Control Systems

- **Solar Field**
- Mode 0: No DNI
- Mode 1: Low DNI
- Mode 2: Design DNI

- **Thermal Storage**
- Mode 1: Charging
- Mode 2: Storage Full
- Mode 3: Discharging
- Mode 4: Storage Empty

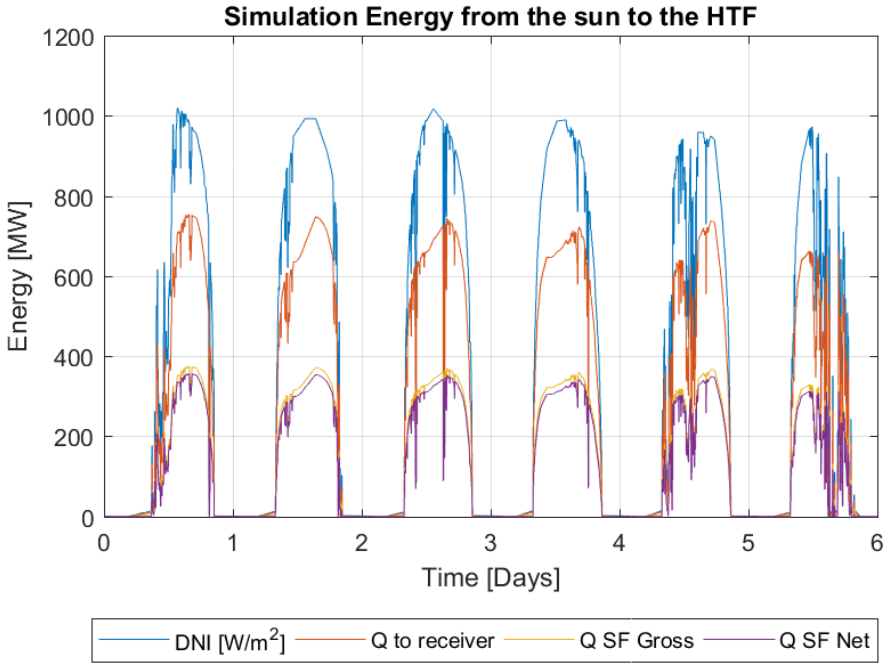
Modelling

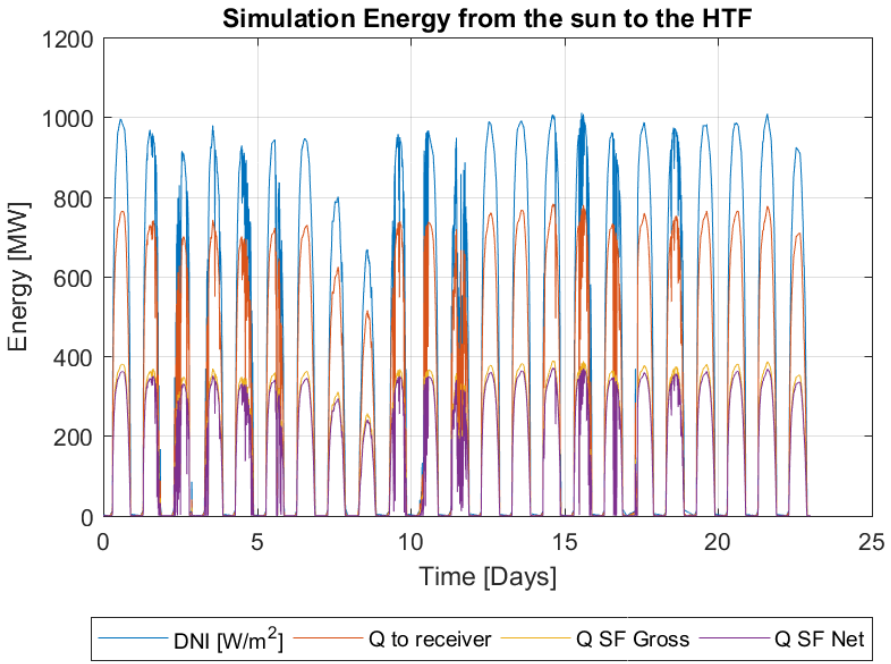
Control Systems Cont...

- **Power Block:**
- Mode 1: Shut-down (No electricity generation)
- Mode 2: Start-up (Preheating)
- Mode 3: Design-point (Electricity production)
- Mode 4: Cool-down (After electricity production)
- **Mass Flow Rates(Pump Control)**
- Solar field
- Molten Salt Storage Pumps
- Steam Cycle Pumps

Simulation Output (11-16 April 2016) & (1-23 June 2016)

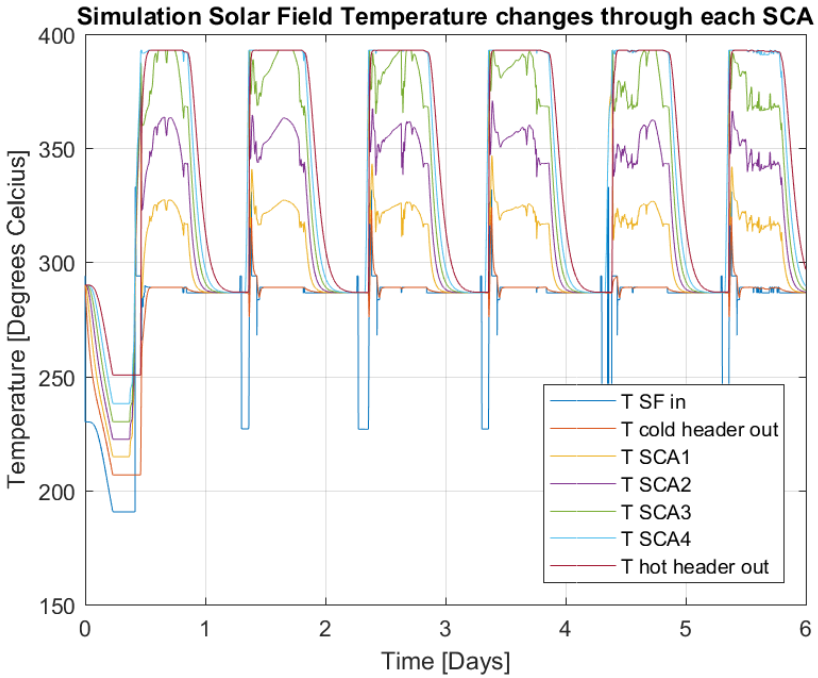
Solar to Thermal Energy

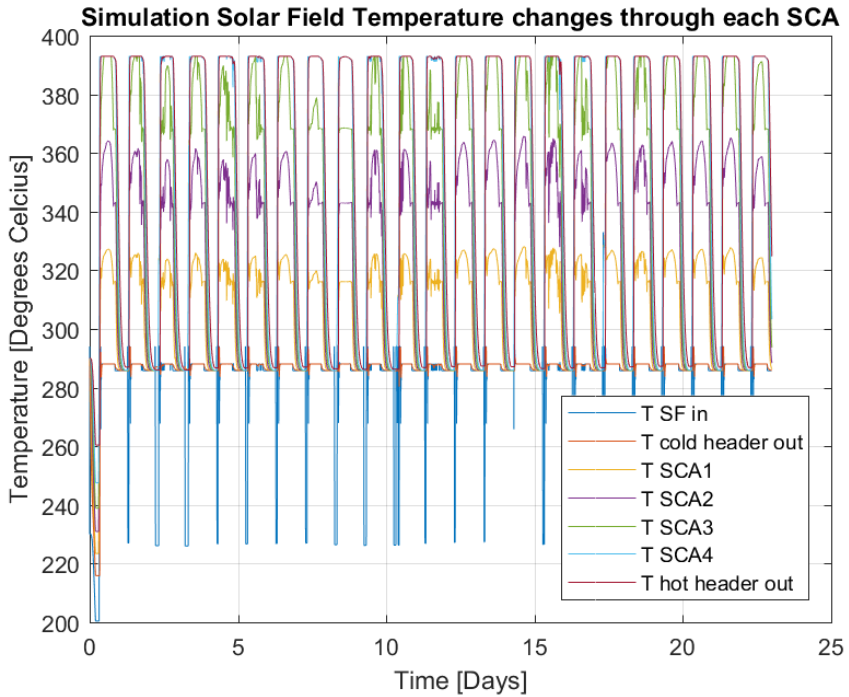




Simulation Output (11-16 April 2016) & (1-23 June 2016)

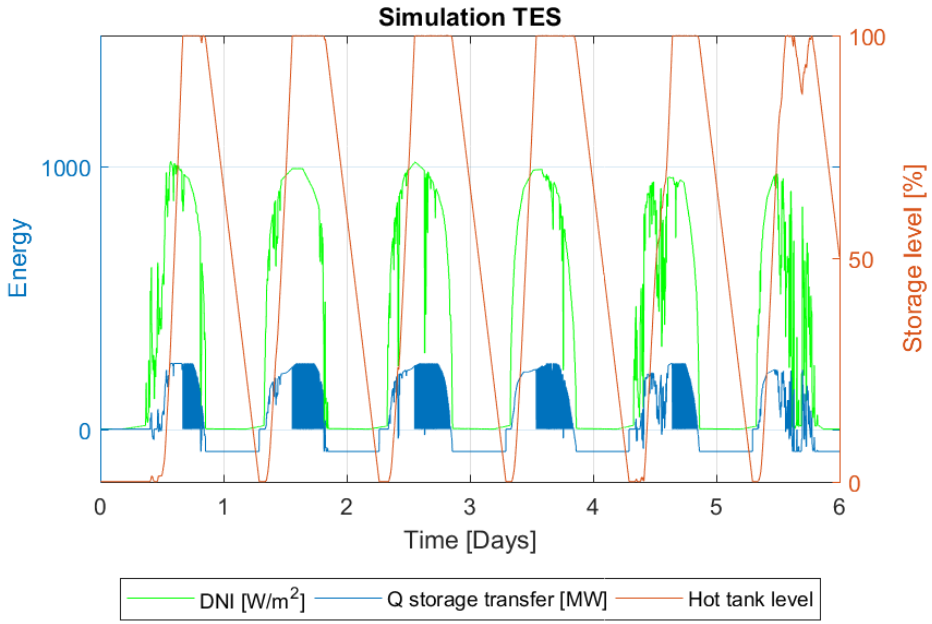
SF Output Temperature

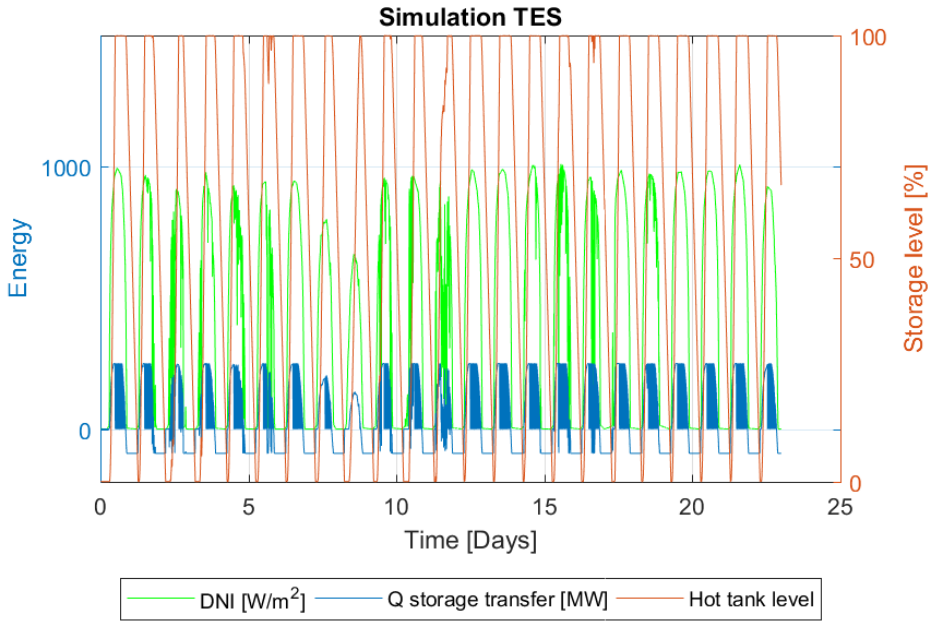




Simulation Output (11-16 April 2016) & (1-23 June 2016)

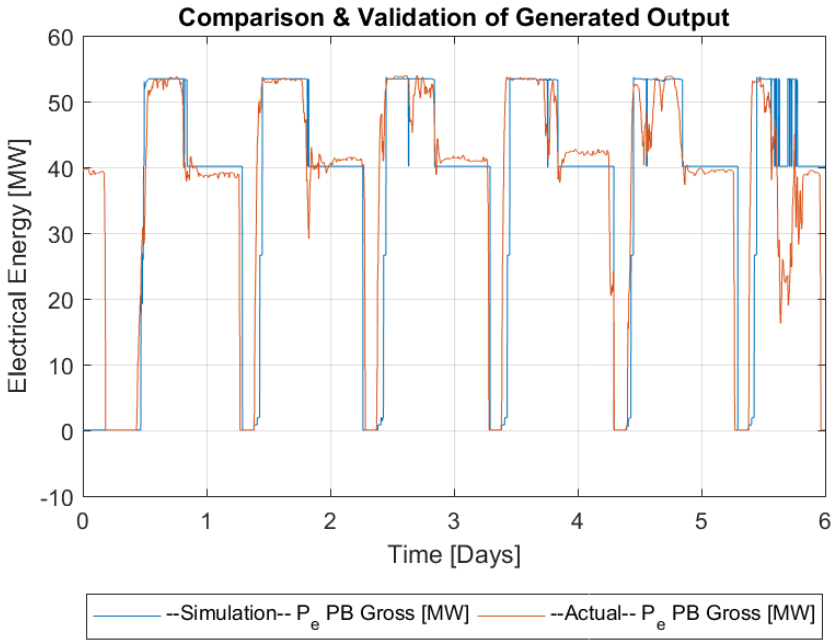
Storage

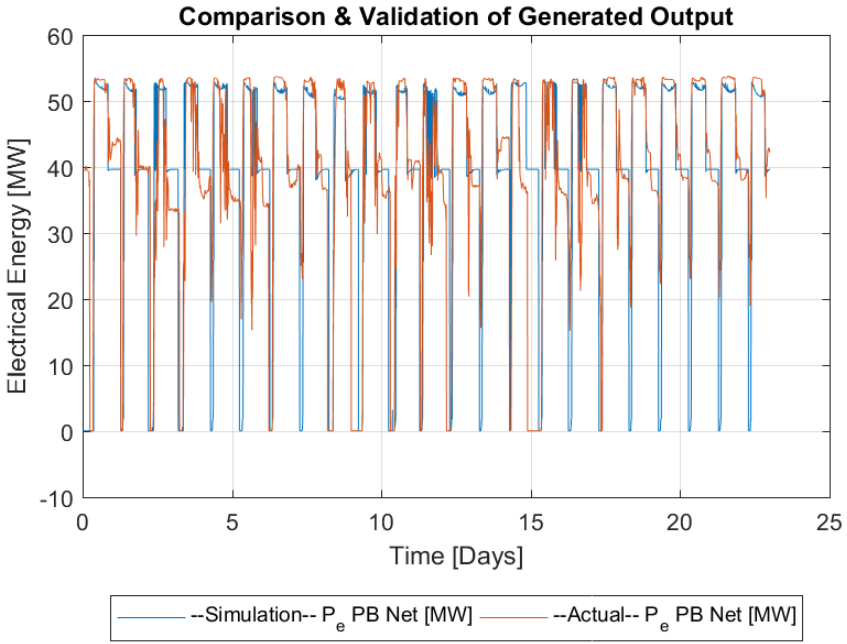




Verification (11-16 April 2016) & (1-23 June 2016)

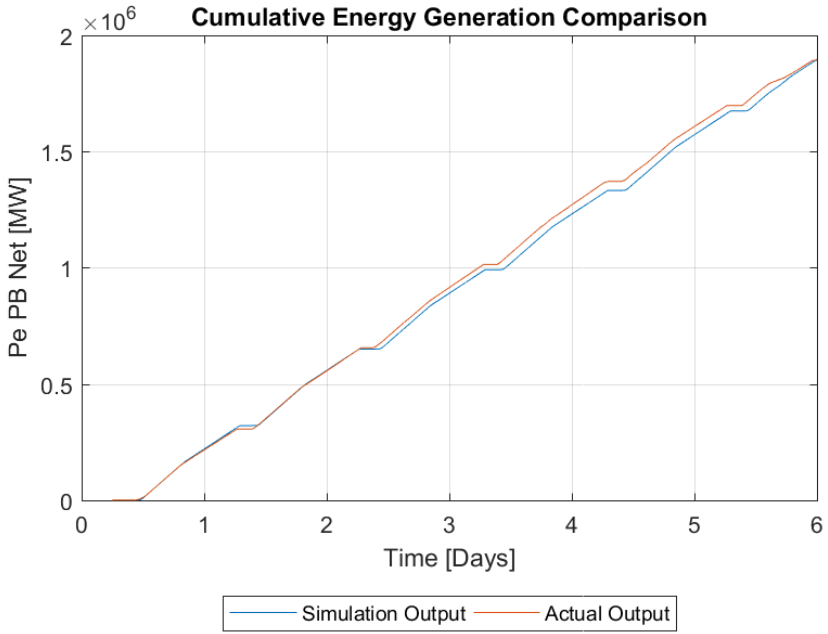
Simulation vs Actual

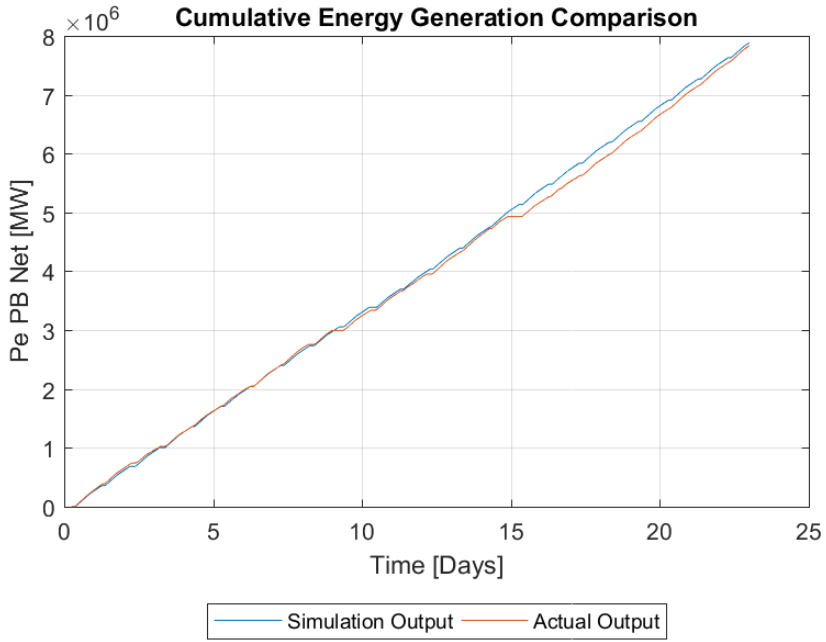




Verification (11-16 April 2016) & (1-23 June 2016)

Cumulative (6am-6am)

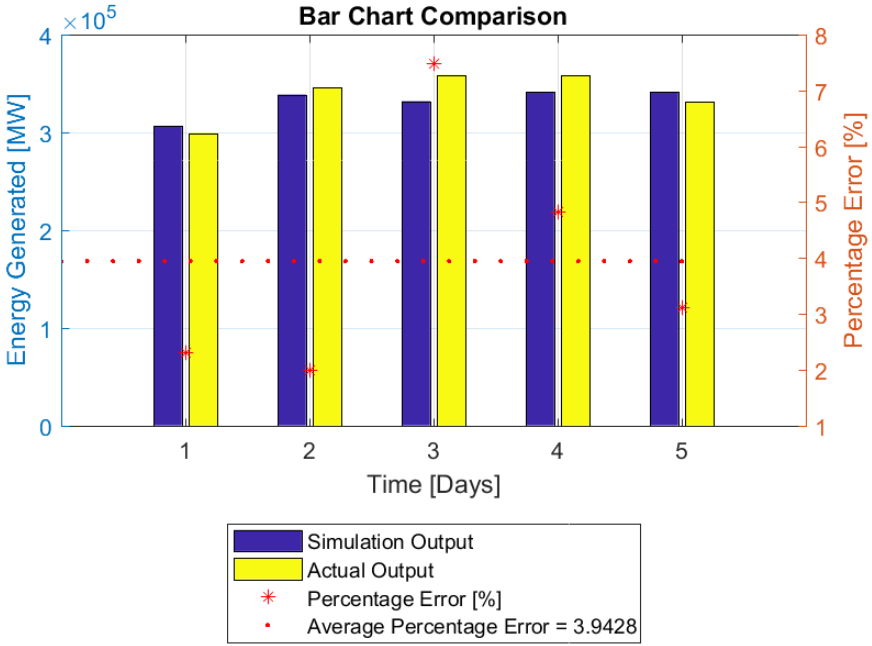


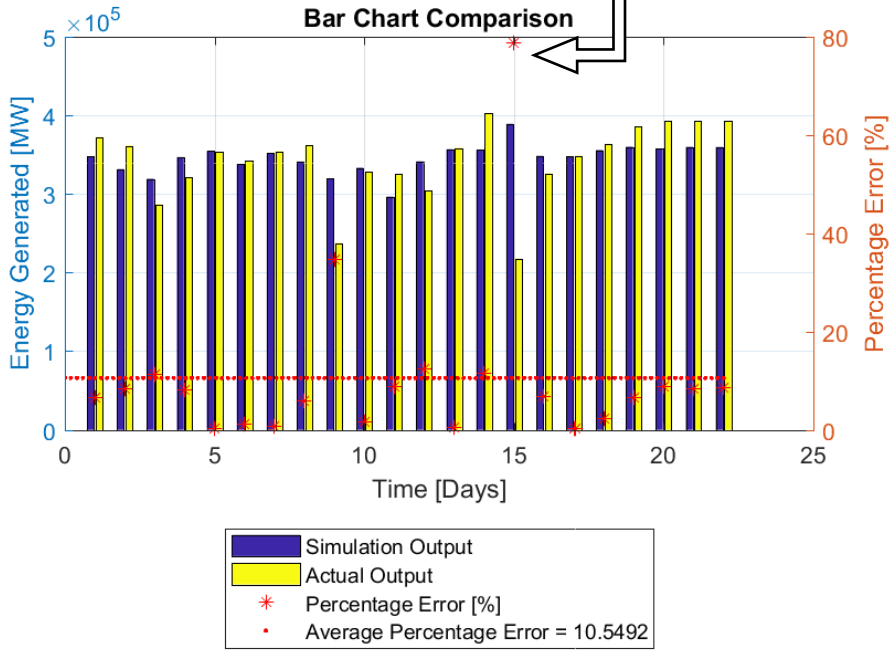


Verification (11-16 April 2016) & (1-23 June 2016)

Percentage Error (6am- 6am)

Sunny
Plant in operation
Failure in HP Turbine Seal System





Conclusion

Operational Feasibility

- **Simulation Tool for Operation:**

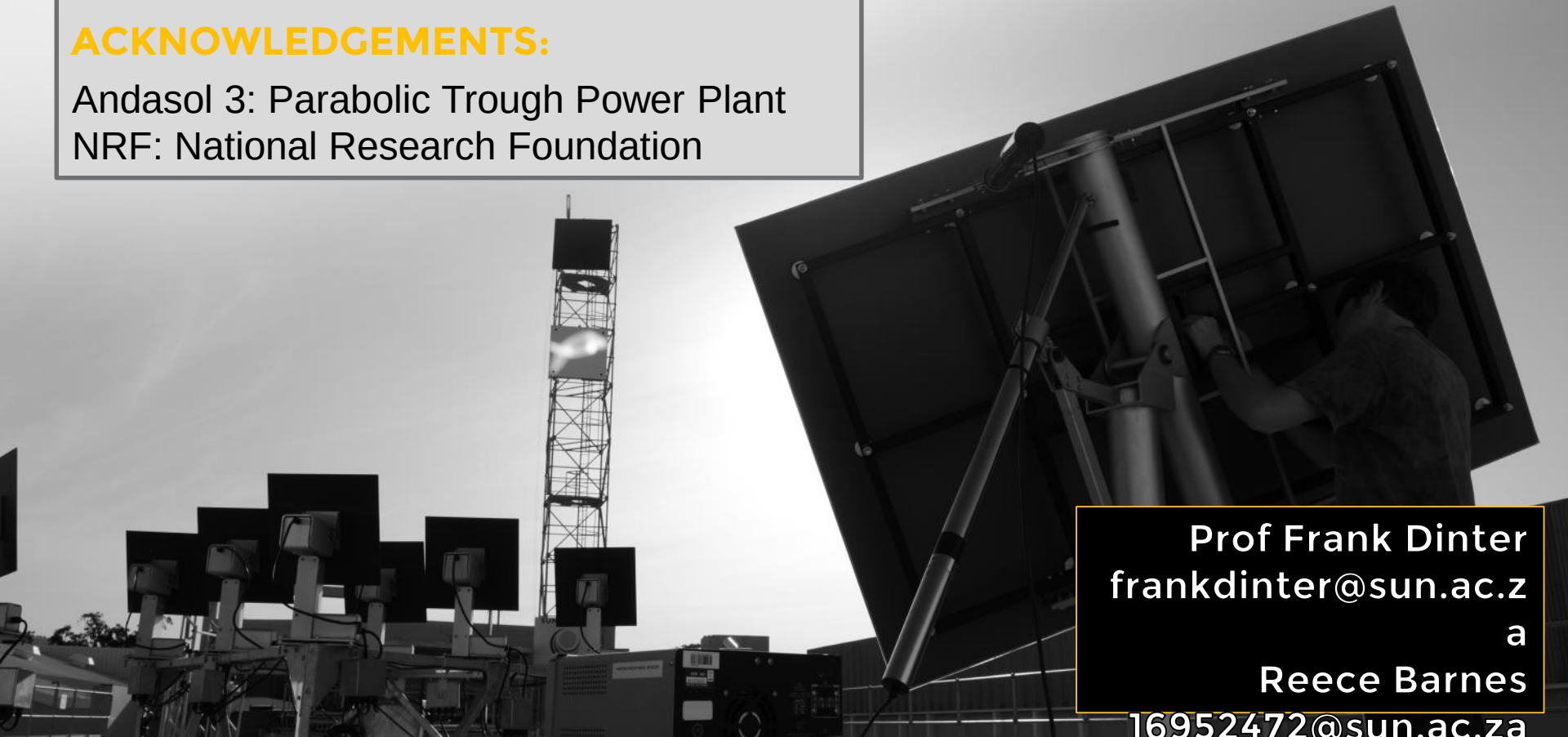
- Use the simulation program as a tool to adjust/optimise operations depending on the output the operator desires.

- The program functions as a “quick check” or as an evaluation tool for different scenarios regarding operational strategy .

THANK YOU

ACKNOWLEDGEMENTS:

Andasol 3: Parabolic Trough Power Plant
NRF: National Research Foundation



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