



# ABENGOA

## Case Study: !Xina Solar One

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# !Xina Solar One Insights

## 1 Project Development

- REIPPP – Tough Regulation Framework
- Experience in South Africa
- !Xina Solar One: Abengoa's role as key of success
- PPA – Singularities
- Lessons Learned: Design Improvements

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## 2 Construction & Commissioning

- Safety Indicators
- Planning and Key Milestones
- Official Project Presentation

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## 3 Performance & Operation

- Facility Acceptance Tests
- O&M Capabilities
- Daily Performance – Optimal operation for any kind of day.
- Guarantee Period Figures

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Project  
Development





## South Africa - Renewable Energy Independent Power Producer Procurement Program

### National Target

- South Africa has a high level of Renewable Energy potential.
- National commitment to transition to a low carbon economy.
- 17 800 MW of the 2030 target are expected to be from renewable energy.
- Socio-economic and environmentally sustainable growth

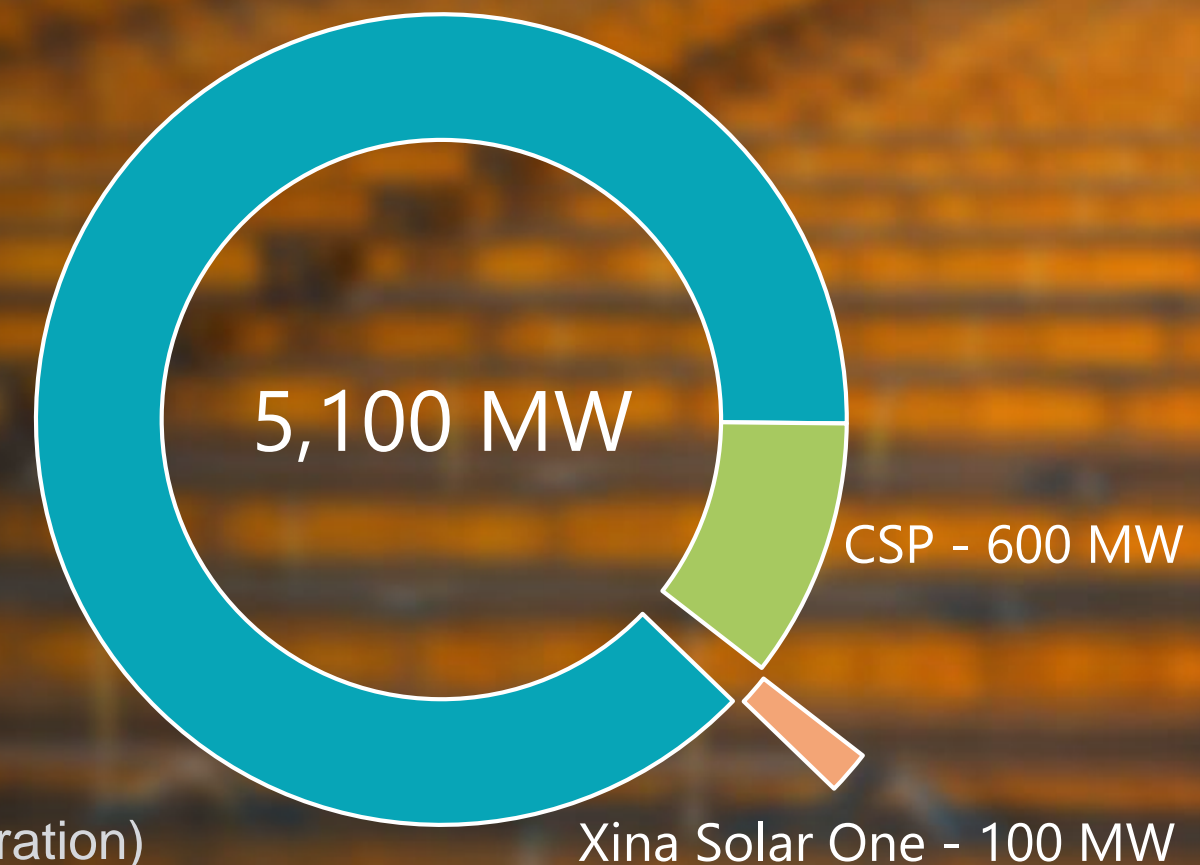
### Bid Windows

- A total of 4 Bid Windows have been deployed until 2018
- BW 1 – 1,4 GW Total; CSP 150 MW (Kaxu Solar One and Khi Solar One)
- BW 2 – 1,0 GW Total; CSP 50 MW
- BW 3 – 1,5 GW Total; CSP 200 MW (Xina Solar One)
- BW 3.5 – 200 MW; CSP 200 MW
- BW 4 – 1,0 GW; No CSP

### CSP Technology Used

- Parabolic Trough + Molten Salt Storage (4 Power Plants, 350 MW)
- Superheated Steam Tower + Steam Accumulators (1 Power Plant, 50 MW, in operation)
- Molten Salts Tower (1 Power Plant, Financial Closure)

Renewable Installed Capacity





## South Africa Experience

Abengoa has its own Solar Thermal Technology and has become a world leader in the Design, Construction and Operation of Solar Thermal Plants, with 35% of the installed capacity worldwide

Since 2011 Abengoa has successfully built three of the largest solar plants in Africa



### Kaxu Solar One

PTC Plant Kaxu Solar One is the first Project developed by Abengoa in South Africa, with a total installed capacity of 100 MW with 2,5 h TES



80.000 South African Households



315.000 tons of CO<sub>2</sub> emissions prevented



### Khi Solar One

Superheated Steam Tower Plant Khi Solar One, first Plant of its kind in the world, with a total installed capacity of 50 MW with 2 h TES



45.000 South African Households



18.000 tons of CO<sub>2</sub> emissions prevented



### Xina Solar One

PTC Plant Xina Solar One is the last Project developed by Abengoa in South Africa, with a total installed capacity of 100 MW with 5,5 h TES



95.000 South African Households



348.000 tons of CO<sub>2</sub> emissions prevented

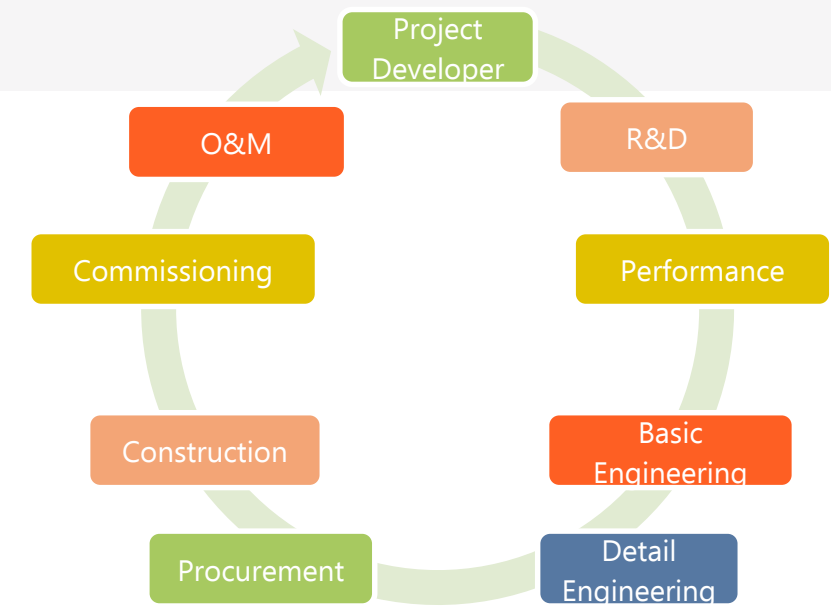


# Abengoa's roles as key of success

Abengoa participated at all stages of the Project throughout many different roles: Developer, Project Company, EPC, Commissioning and O&M.

## Abengoa as key player along all the stages in Xina Solar One Project

- Developing, since the RFQ in 2013 – Sponsor
- Financial Process in 2014 – Sponsor + Project Company
- Construction 2015 – 2017 - EPC Contractor + Project Company
- Operation 2017 – 2037 - O&M Contractor + Project Company



**Sponsor - Project Company**

Abengoa is the main partner in the Project Company with 40% of the shares

IDC, PIC and Xina Community Trust own 60%

**EPC Contractor**

Abengoa was the EPC Contractor

The Project was executed successfully within time and budget

**O&M Contractor**

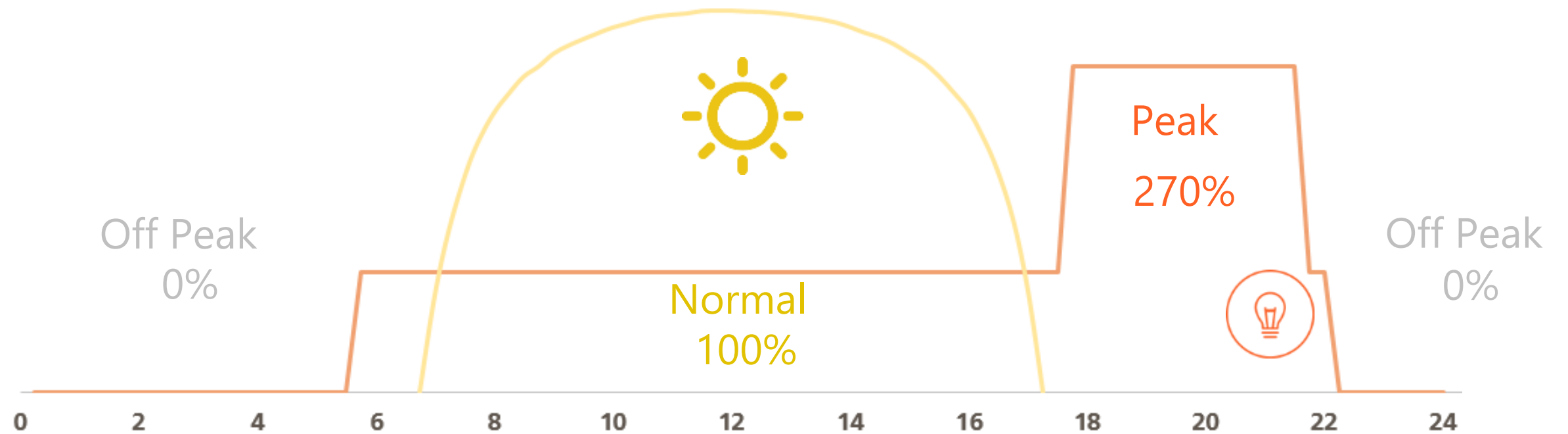
Abengoa is the O&M Contractor. The Plant is currently under operation achieving the expected performance with a reliable operation

# Power Purchase Agreement - Singularities



**Dispatchability strategy:** For this window, Off-Taker (Eskom) encouraged bidders to offer solutions to maximize electricity generation during the evening

Bid Window 3 - Tariff Scheme



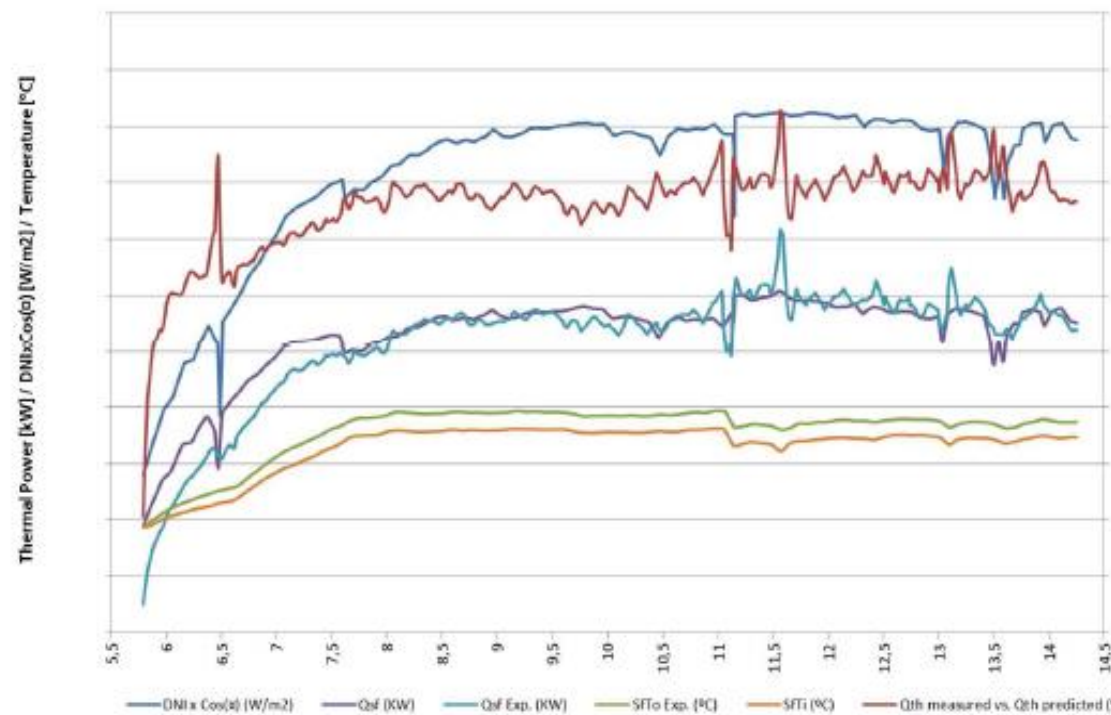
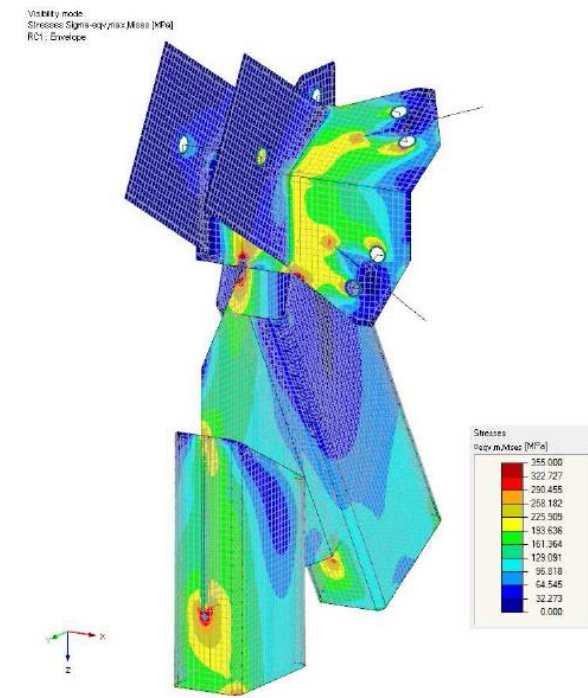
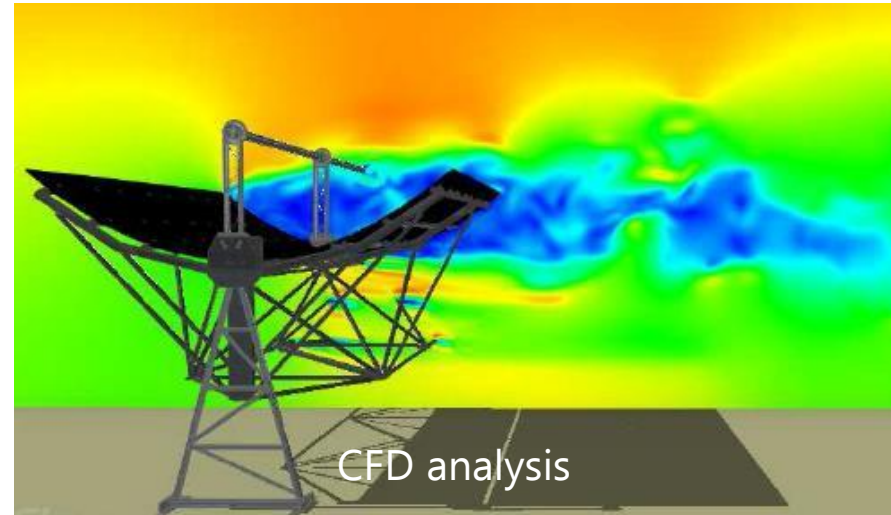
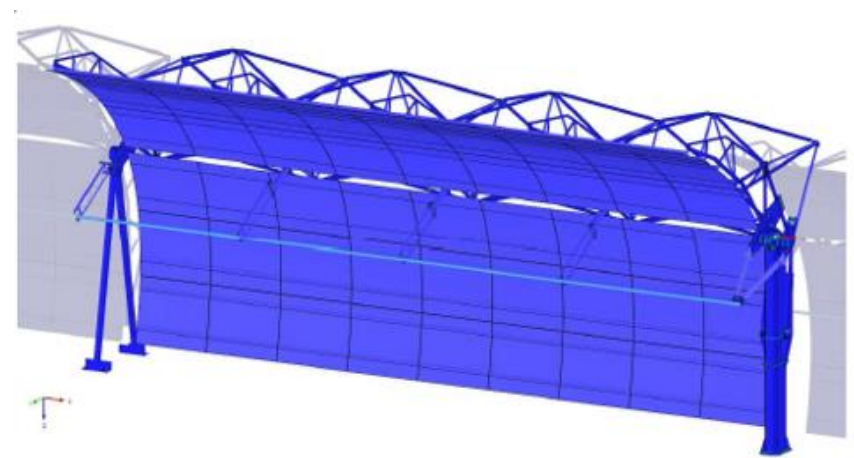
**Energy rate:** The commercial energy rate resulted in a reduction of 10% for previous Bid windows





# Main Design Improvements

## Solar Field - New Trough Design (Space Tube ST8.2+ +)



Efficiency [%]

- Abengoa selected the newest and most innovative Trough ever design to optimize the final Plant configuration.
- Main difference with previous designs is the aperture: 5,7m<sup>2</sup> (standard Trough) vs 8,2m<sup>2</sup> (largest of the market)
- The design was tested and approved during Due Diligence process

Stress analysis

Performance evaluation

New design results in a **reliable cost-effective solution**



## Main Design Improvements

### Solar Field – Design and Construction Strategies



Huge Continuous slope without terraces allowing an important **cost reduction on earth movement**



**New erection tools** to reduce the installation times and thus to erection costs



## Main Design Improvements

### Power Block – Design of TES and HTF systems



HTF Pumps process modifications to accommodate and improve the start up from TES System in normal operation.



Low pressure overflow system design to reduce HTF inventory



2

Construction & Commissioning







36 Months Project



Around 1,000 workers per month average



More than 3.8 millions of man hours



ZERO Fatalities or serious injuries



Safety indicators	Total
Reports	1244
Near Misses	13
First Aid Cases	44
Medical Treatment Cases	7
Lost time Cases	5
Fatalities	0

One of the areas of focus for Abengoa's management is safety in the workplace

All the safety index of the projects were below the initial targets







# Planning and Key Milestones

## 1 Earlyworks

- Earthworks and main equipment procurement started on August 2014 under pre-agreement with the SPV
- Significant number of milestones were achieved during this period
- Project reached 20% progress before official Notice to Proceed (NTP)

## 2 Construction milestones

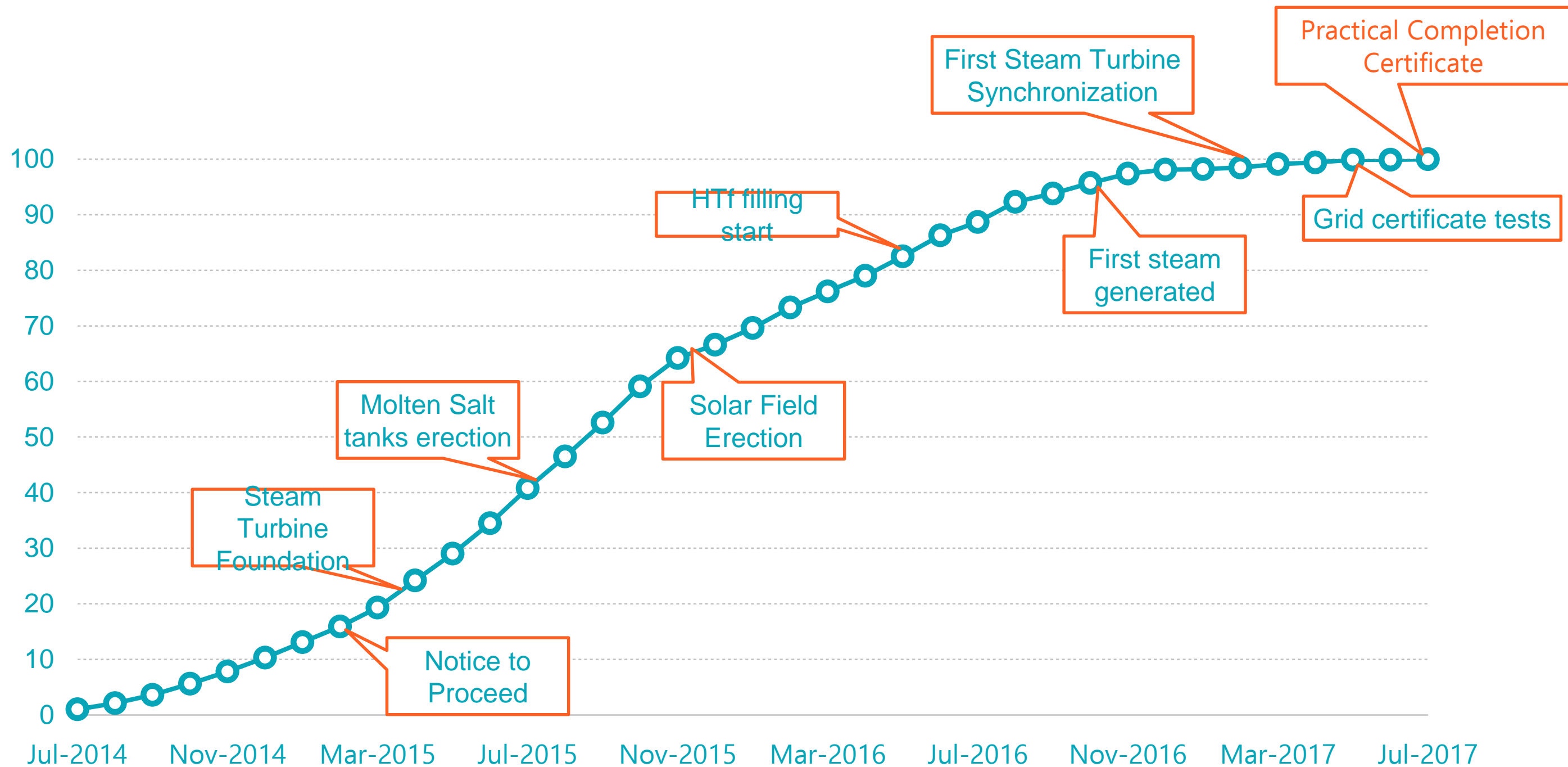
- All the key milestones of the Project were achieved on time with no relevant delays
- Equipment procured locally in South Africa and worldwide.
- Eskom upgraded the existing substation as well as T&D lines to accommodate Xina's generation. These critical works were monitored and supported by Abengoa (Project Company and Main Contractor)

## 3 Commissioning

- System blowing and chemical cleaning
- Hot commissioning and tests of all equipment. Suppliers on site to assist the works. Steam turbine (Siemens), ACC (SPX), SSG (Lointek)...
- Generation tests with utility (Eskom) to fulfill with the grid requirements for IPP. Active & Reactive Power quality, voltage and frequency control.
- EPC Contract Acceptance Tests passed. Practical Completion Certificate granted by the Project Company



# Planning and Key Milestones – Project Execution Schedule



Project Completed before deadline (31st July 2017)



# !Xina Solar One – Official Presentation to National Authority





# 3

## Performance & Operation





Facility Acceptance Tests is final milestone of the Project before granting Practical Completion Certificate. Those tests are enforced to be fulfilled within a period of 7 days in a row.

- Test 1 – Maximum Net Capacity Test (2 hours)
- Test 2 – Operation Mode 1. Solar Operation + Energy Stored discharge (1 hour)
- Test 3 – Operation Mode 2. Plant start from Thermal Energy Stored System (2 hours)
- Test 4 – Discharge Capacity Test (1 day)
- Test 5 – Charge Capacity Test ( 1day)
- Test 6 – Total energy Output (7 days)

<b>ABEINSA EPC XiNa</b>	Document:	0341-INF-AEPC-132-091-0001		
	Revision:	1	Date:	31/07/2017
	Page: 1 of 17			

**Acceptance Test Report**

<b>Title:</b>	Performance Test Report		
<b>Client:</b>	XiNa Solar		
<b>Project:</b>	XiNa Solar One		

<b>Document No.:</b>	0341-INF-AEPC-132-091-0001		
<b>Revision:</b>	1		
<b>Date:</b>	31/07/2017		

<b>Prepared by:</b>	Juan Ramon Vaquero Sanchez de Ibarquen / Jose Manuel Muñoz de Escalona	Electronic Signature
<b>Reviewed by:</b>	Jose Javier Callejon Romero	Electronic Signature
<b>Approved by:</b>	Santiago Lopez Perez	Electronic Signature

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If for exceptional reasons, due to specific aspects of the project (eg. project confidential information, legal requirements or local regulations and/or contractual requirements of the client), there was a need to modify the requirements included in this procedure, these changes must be properly documented in the quality, environment and health and safety plan of the project, prior approval from the company headquarters management system department.

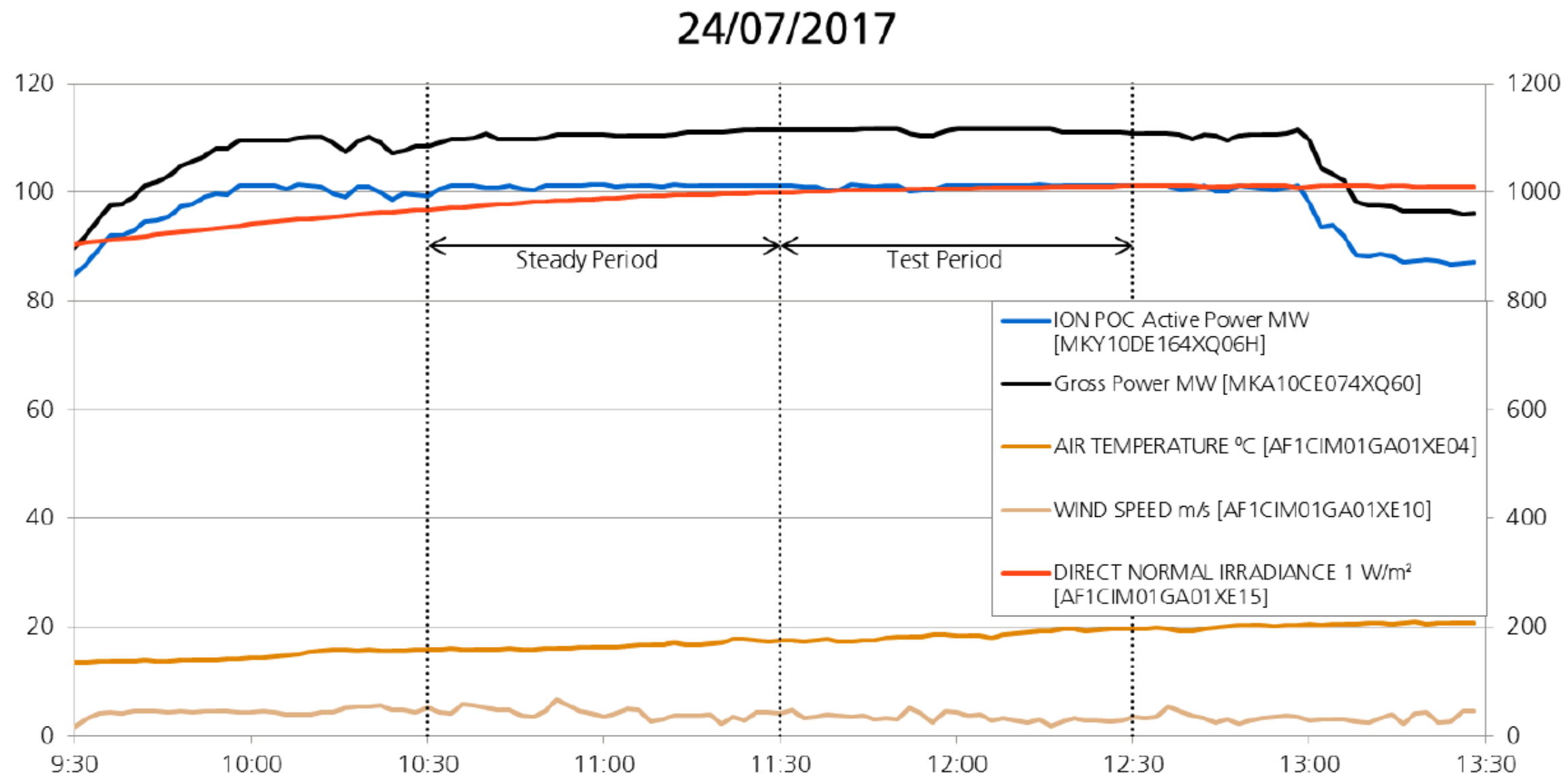


Plant successfully passed all Facility Acceptance Tests on 30<sup>th</sup> July 2017



## 1 Maximum Plant Net Capacity

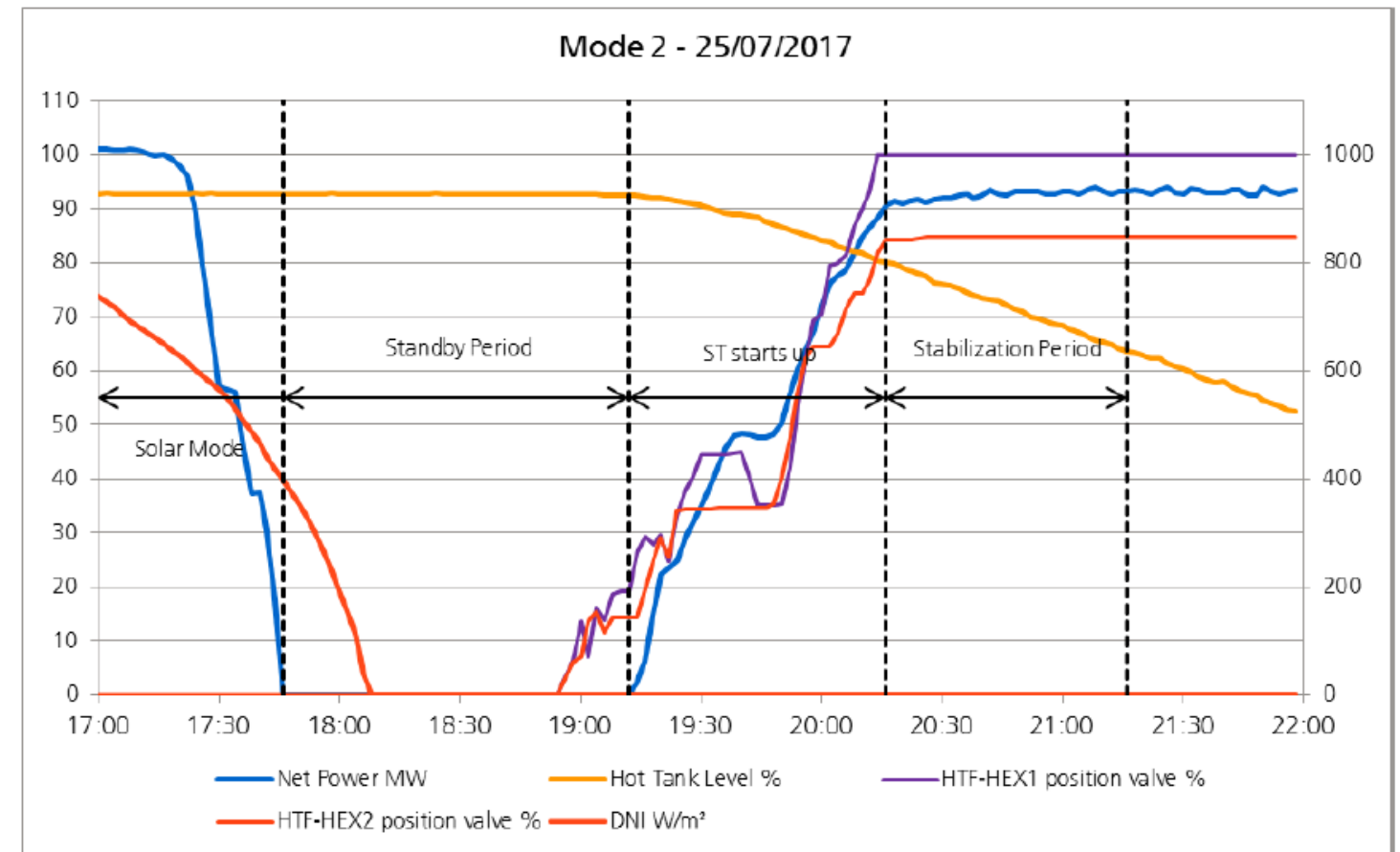
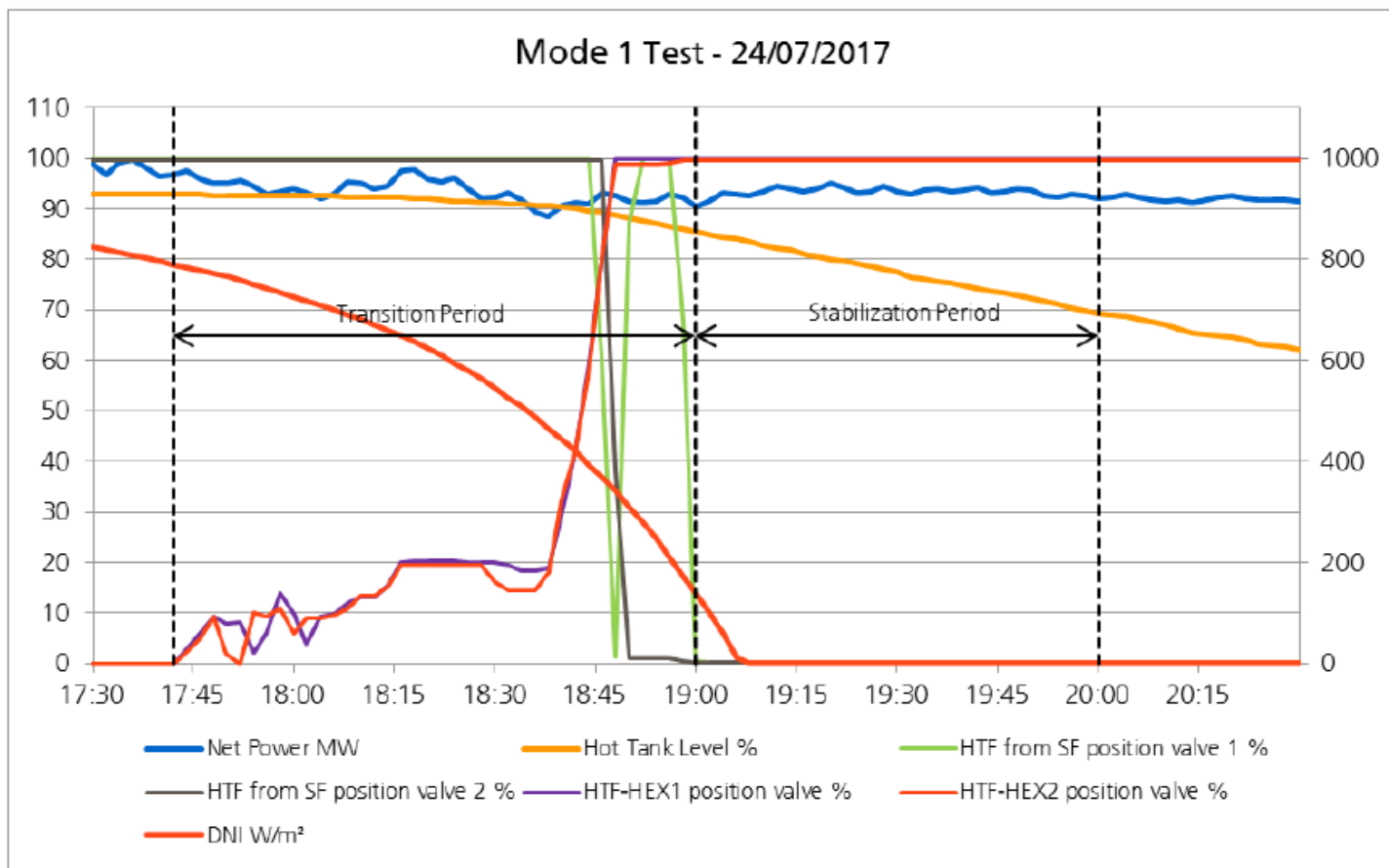
- The Maximum Plant Net Capacity measured at Delivery Point must be at least 100 MW
- Test duration is 2 hours. 1 hour Stabilization Period + 1 hour Test Period





## 2-3 : Operation Mode 1 & 2

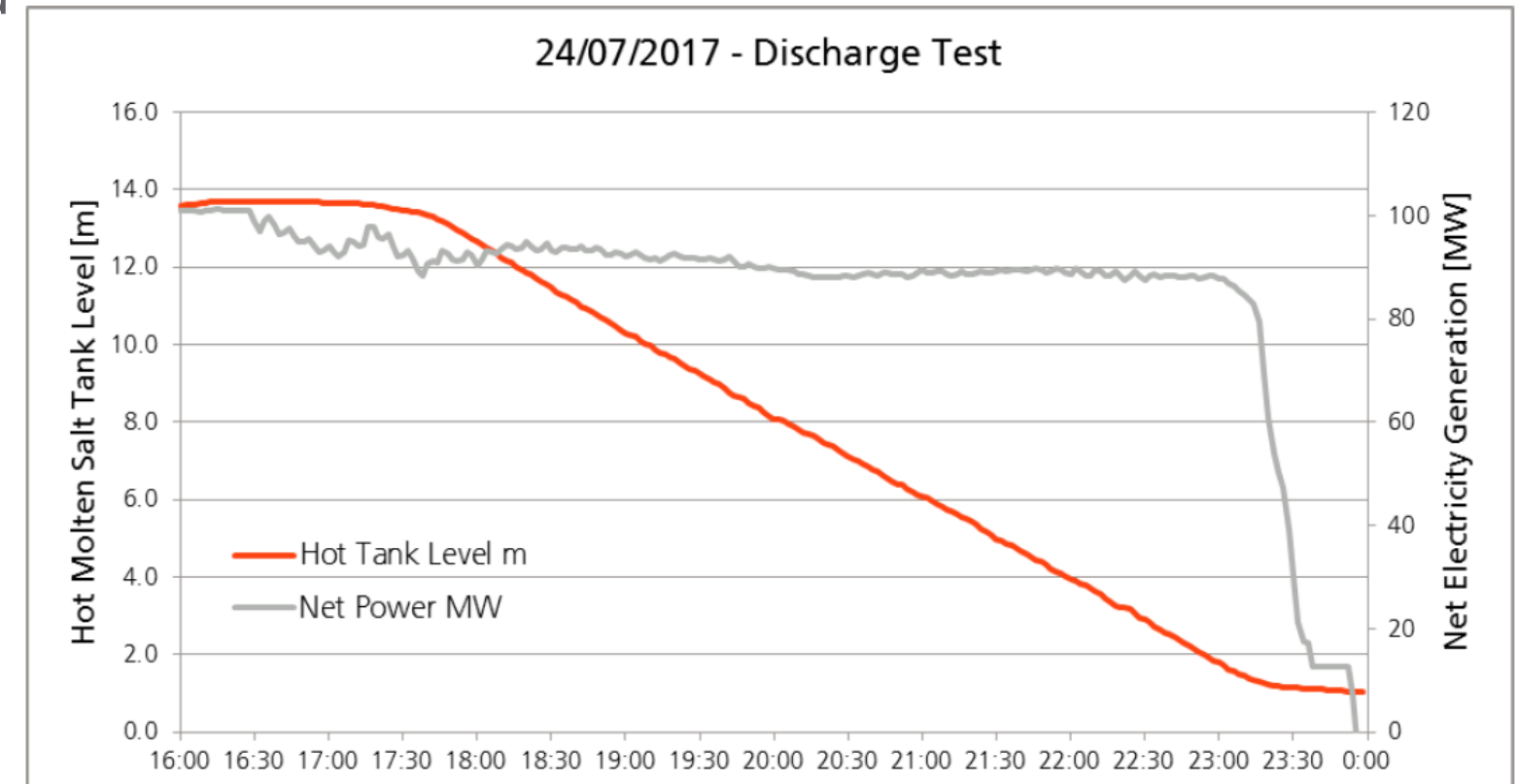
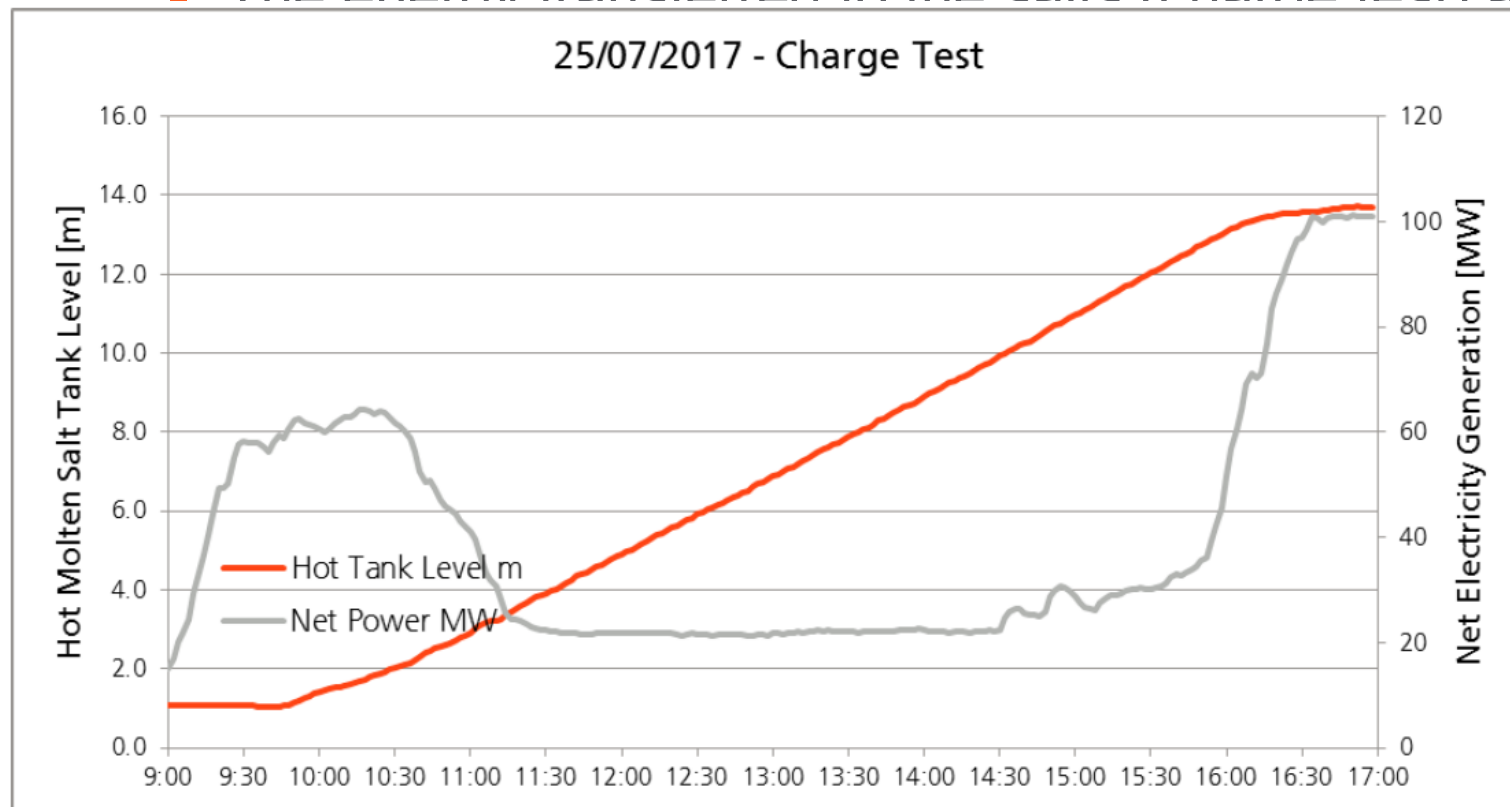
- Mode 1: Plant running on solar generation + charging mode. Once DNI decreases the thermal energy is provided from storage system and the Plant is capable to keep generation for at least 1 hour.
- Mode 2: Plant running on solar generation + charging mode. The Plant is shutdown for 2 hours and started up from storage system and operated in steady conditions for 1 hour.





## 4-5 TES Capacity

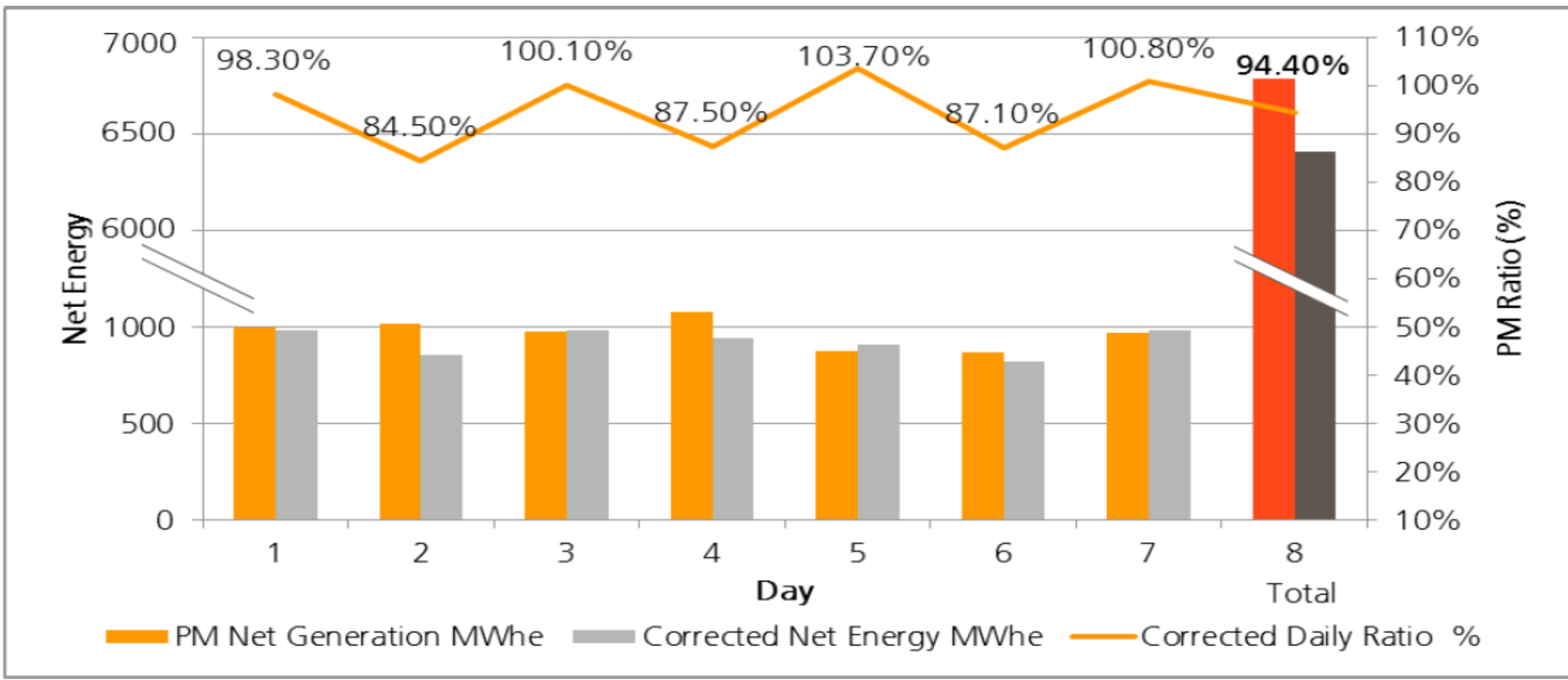
- Thermal Energy storage capacity to be proved
- Charge capacity test. Cold salts are heated up with hot HTF while are transferred from cold salt tank to hot salt tank.
- Discharge test. HTF is heated up with hot molten salts while the salts transferred from hot salt tank to cold salt tank.
- The energy transferred to the salts (charge test) and to the salts (discharge test) is evaluated to accept the test





## 6 Total Energy Output Test

- Total Generation during the 7 test days need to be at least 80% of the expected output
- All the Acceptance Tests to be performed during the 7 days test



Acceptance Tests passed succesfully at the 1st attempt

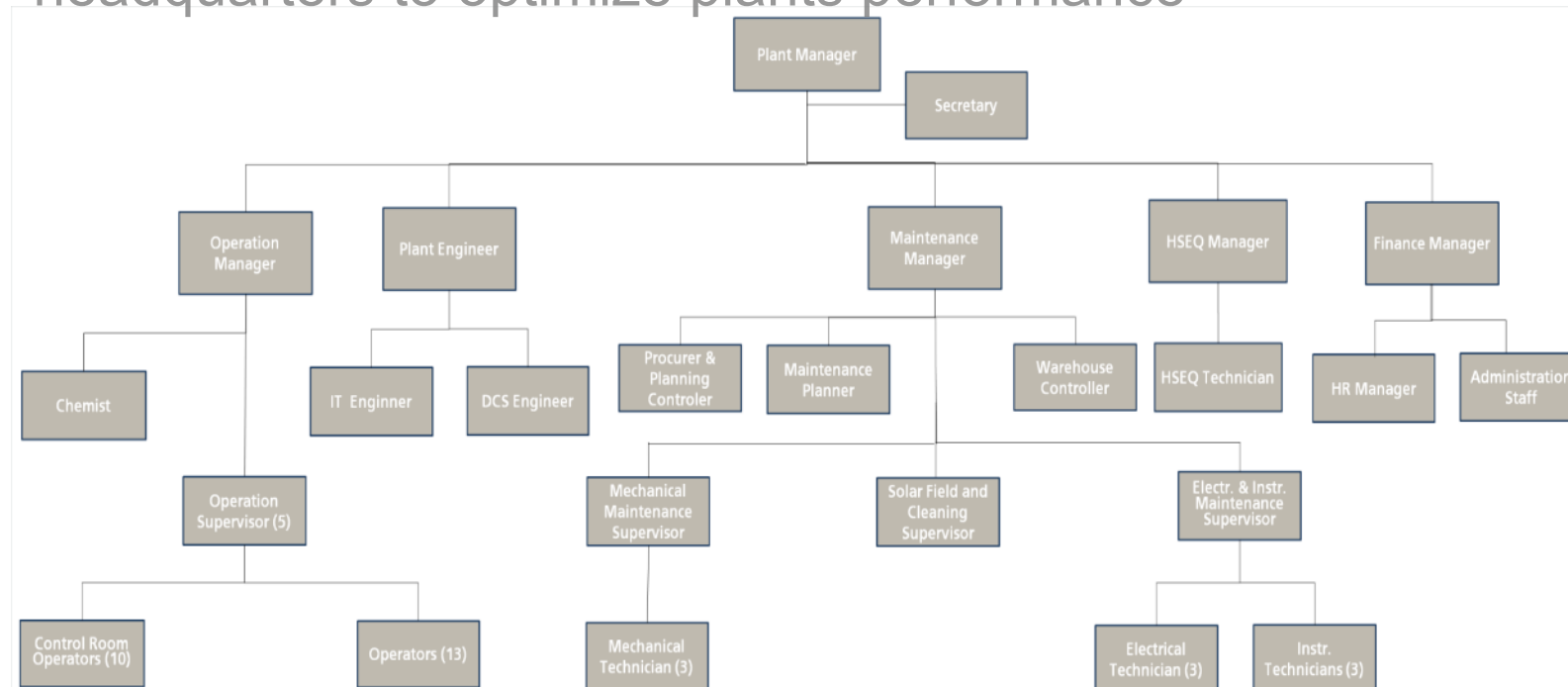


## Personnel

+50 Personnel for the Operation & Maintenance of the Plant

Financial controller, administration, purchasing, human resources services provided from local central services in South Africa

Technical and Management support from Abengoa headquarters to optimize plants performance



## Training

On site training provided from EPC Contractor and suppliers before Practical Completion

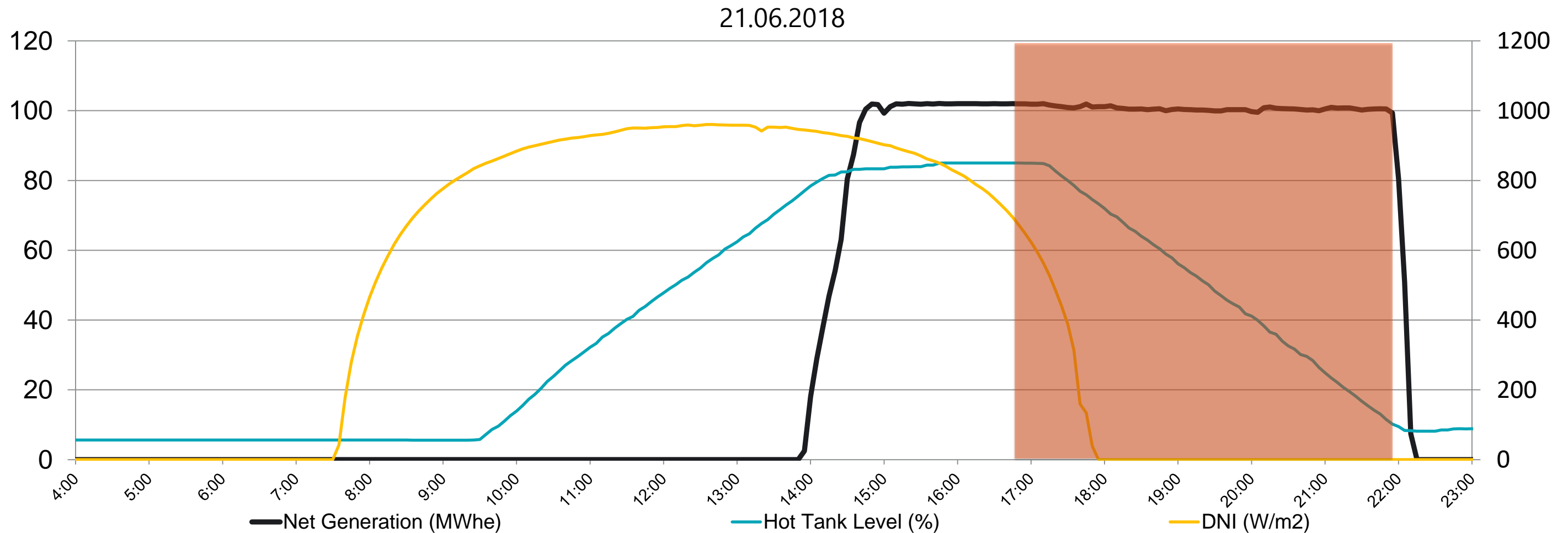
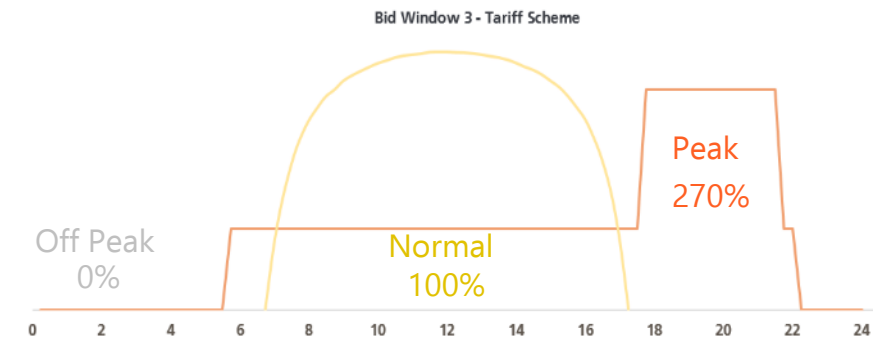
In house training provided during 4 months by experienced operators from other assets

Febrero						Marzo						Abril						Mayo					
L	M	X	J	V	S	L	M	X	J	V	S	L	M	X	J	V	S	L	M	X	J	V	S
		1	2	3	4	27	28	1	2	3	4	27	28	29	30	31	1	1	2	3	4	5	6
6	7	8	9	10	11	6	7	8	9	10	11	3	4	5	6	7	8	8	9	10	11	12	13
13	14	15	16	17	18	13	14	15	16	17	18	10	11	12	13	14	15	15	16	17	18	19	20
20	21	22	23	24	25	20	21	22	23	24	25	17	18	19	20	21	22	22	23	24	25	26	27
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## Winter Clear Day

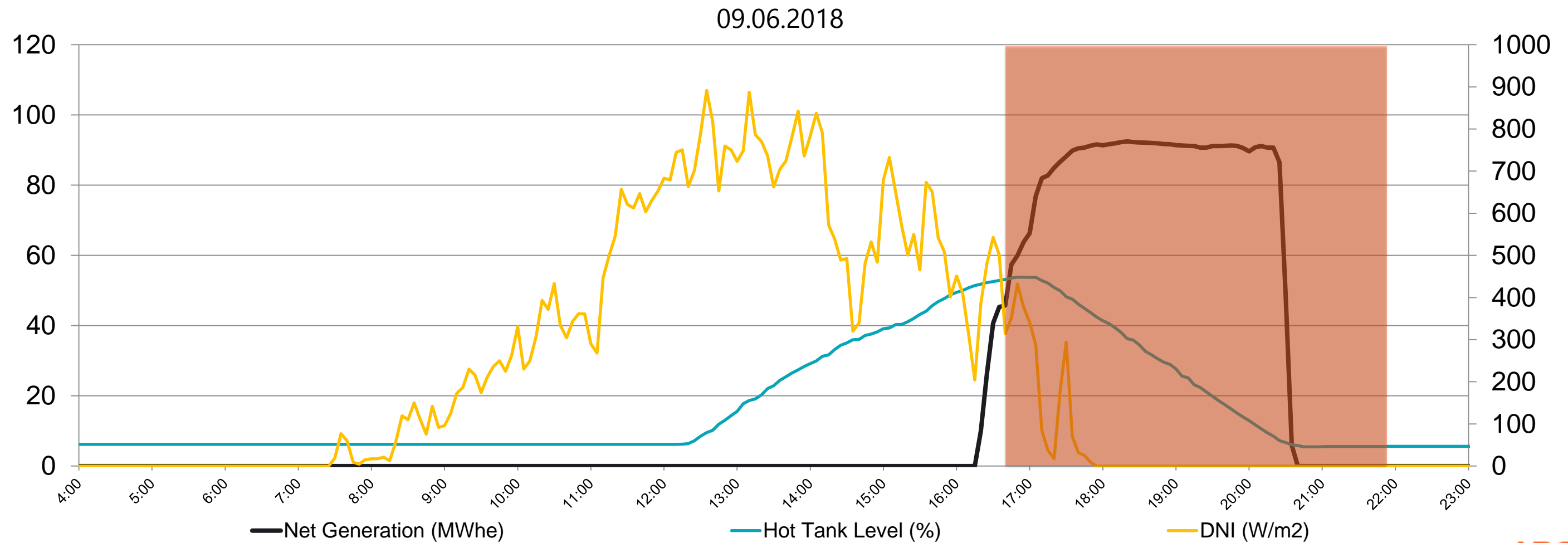
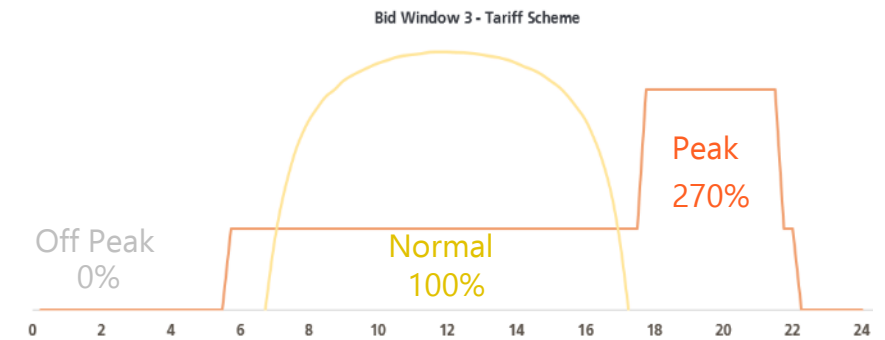
- During winter the solar resource is limited. Generation prioritized at peak hours.
- Start up: Solar source
- Operation: Charging mode + Delayed Start up + Solar Generation + Discharging mode
- Peak hours: Maximum load





## Winter Transient Day

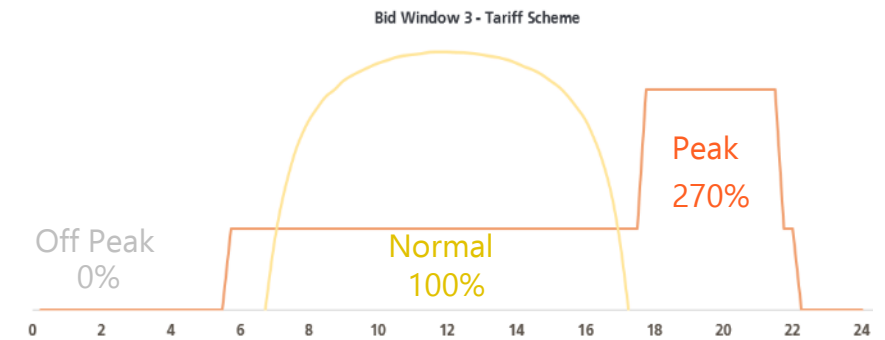
- Solar resource is limited and not stable. Generation prioritized only at peak hours.
- Start up: Solar source
- Operation: Warm up + Charging Mode + No Load until peak hours
- Peak hours: Maximum Energy. Partial load to maximize energy stored at TES system



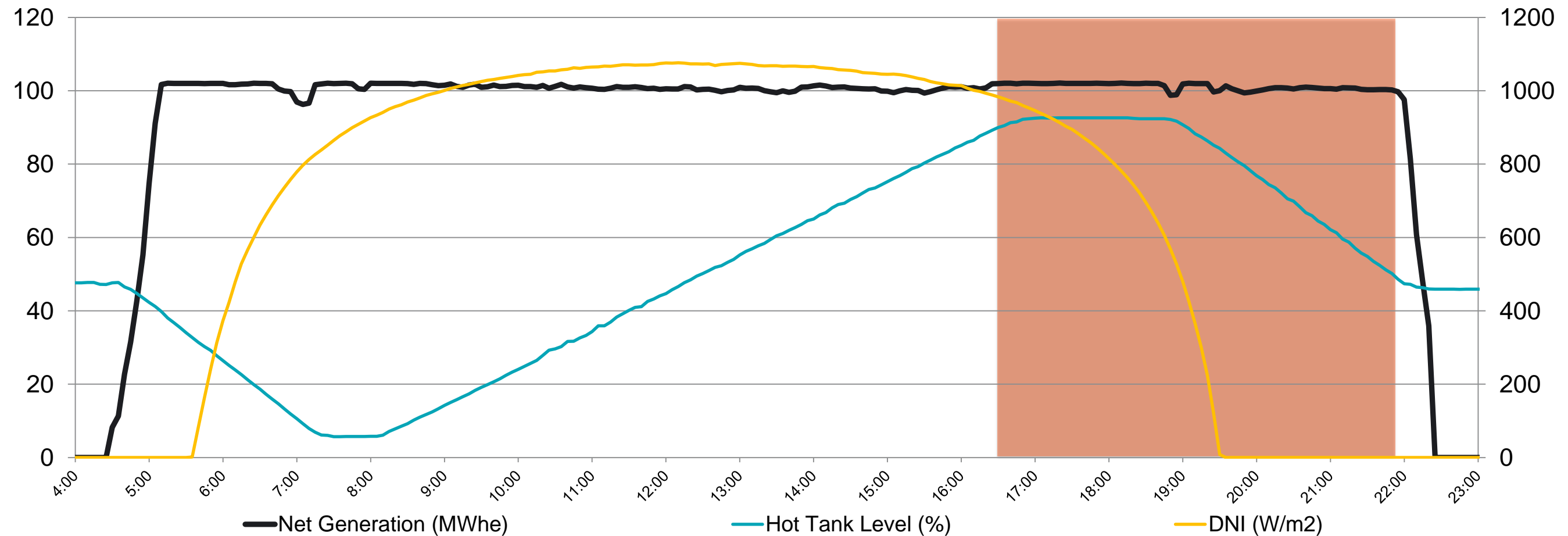


## Summer Clear Day

- Solar resource is enough and stable. Whole day generation.
- Start up: TES system. The day before, Hot Tank was not fully discharged before 22:00 h, therefore the Plant is able to carry out the start-up before sunrise.
- Operation: Maximum load + Solar Generation + Charge Mode.
- Peak hours: Maximum load.



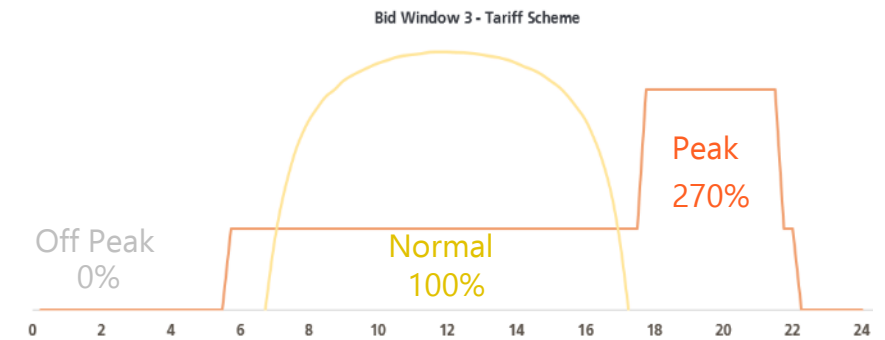
10.12.2018



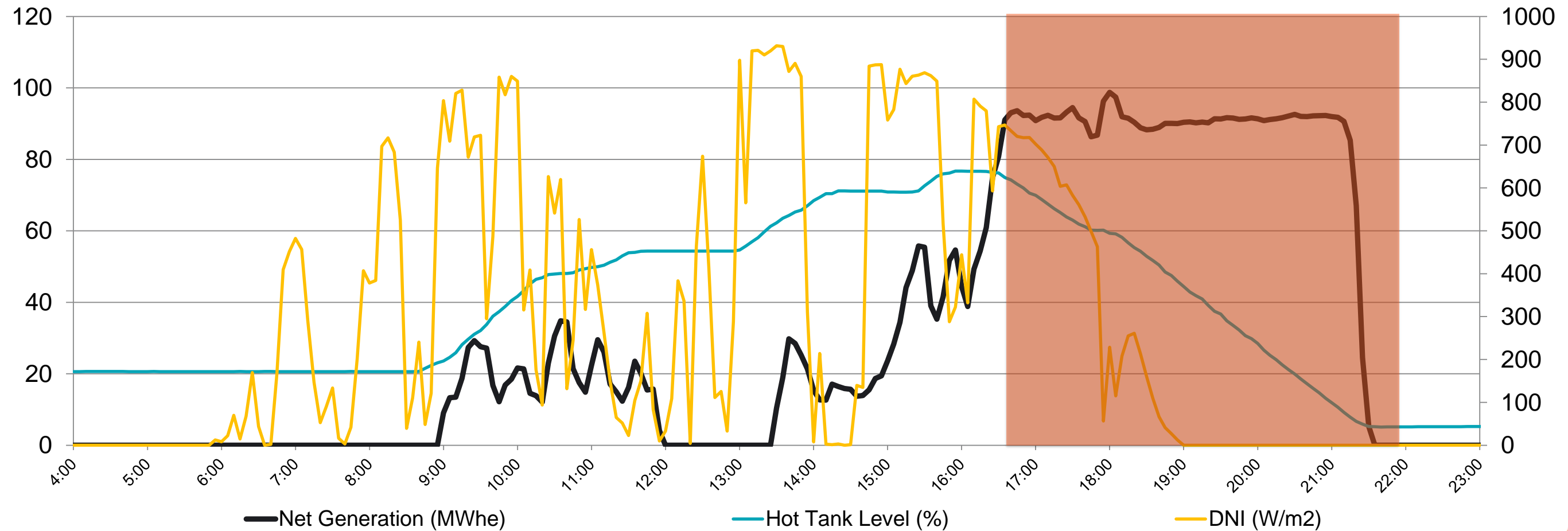


## Summer Transient Day – The more complex Operation Strategy

- Solar resource might be enough but not stable. Generation prioritized at peak hours but duly managing the excess of energy stored from day before to cover peak time.
- Start up: Solar/TES System (depending on forecasting).
- Operation: Warm up + Charging mode as priority + % load with Excess of Energy
- Peak hours: Maximum Energy. Partial load to maximize energy stored at TES system

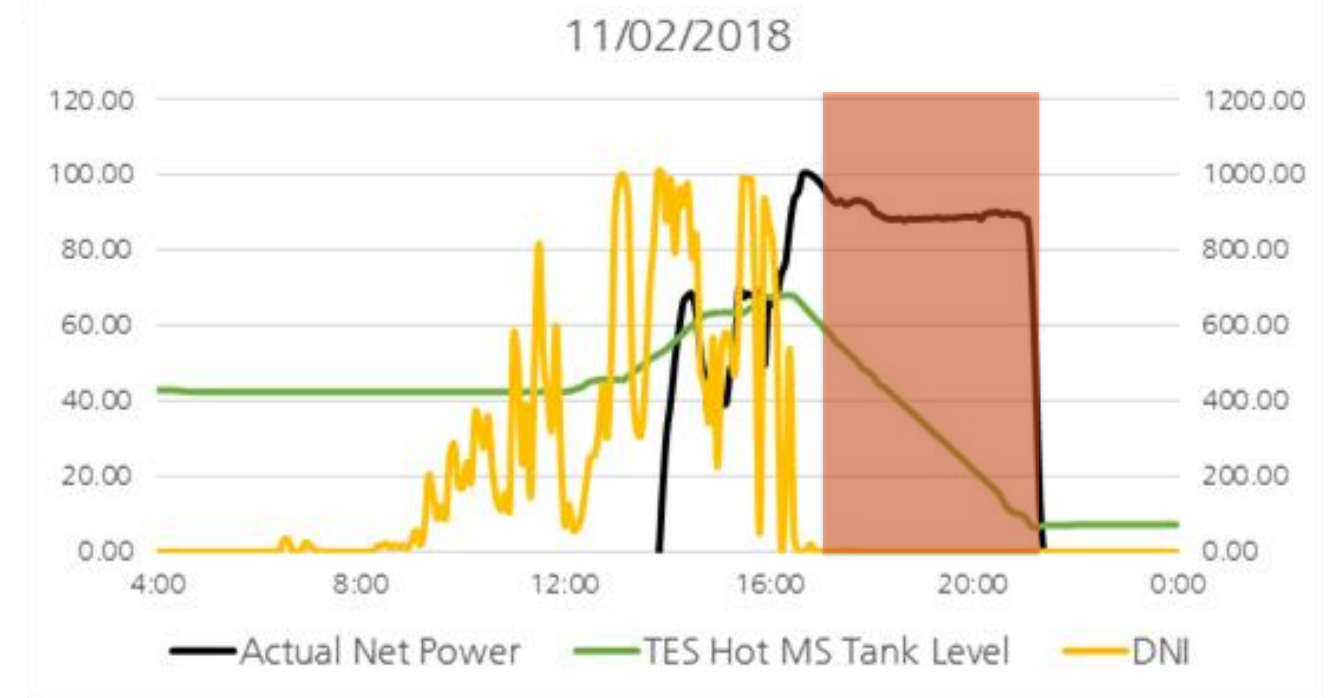
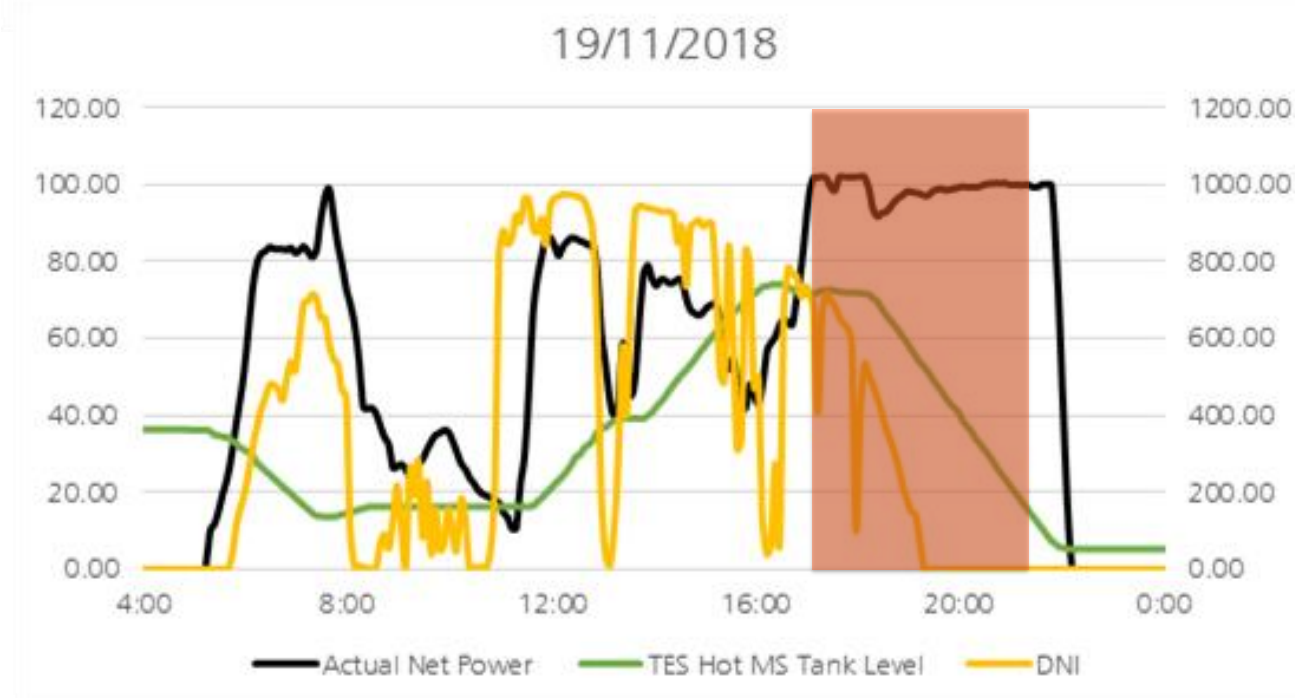
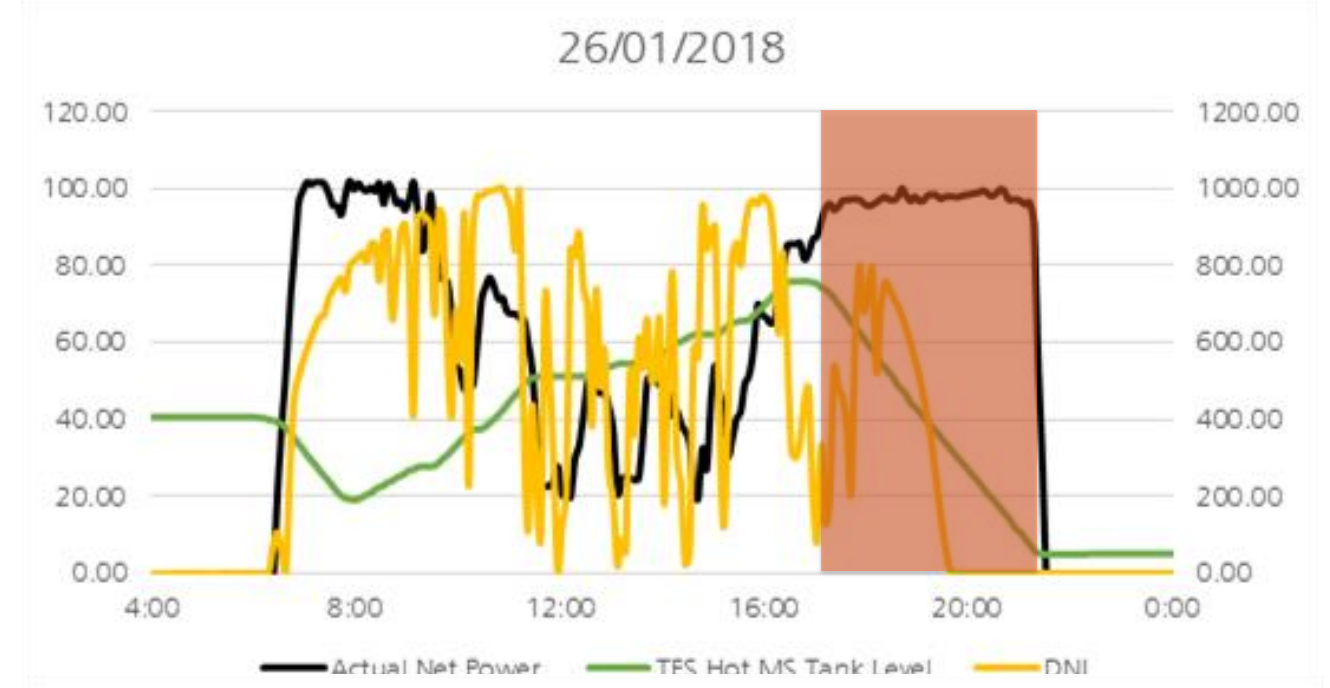
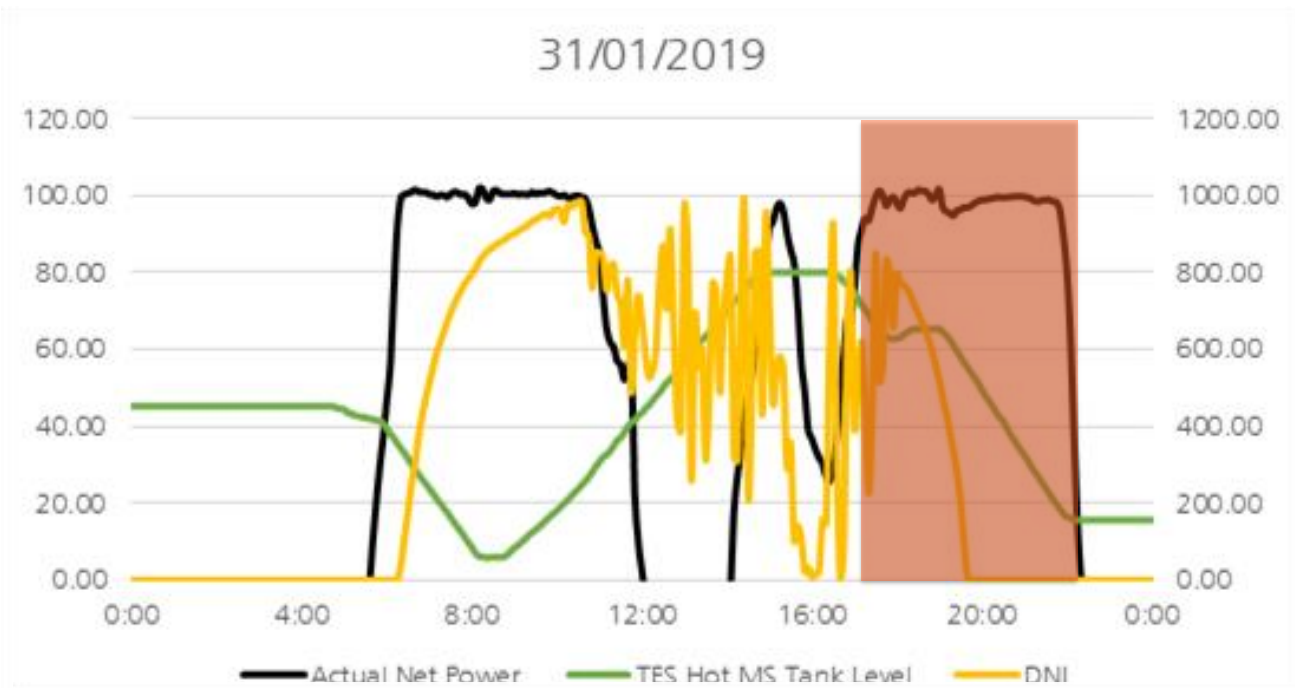


29.10.2018





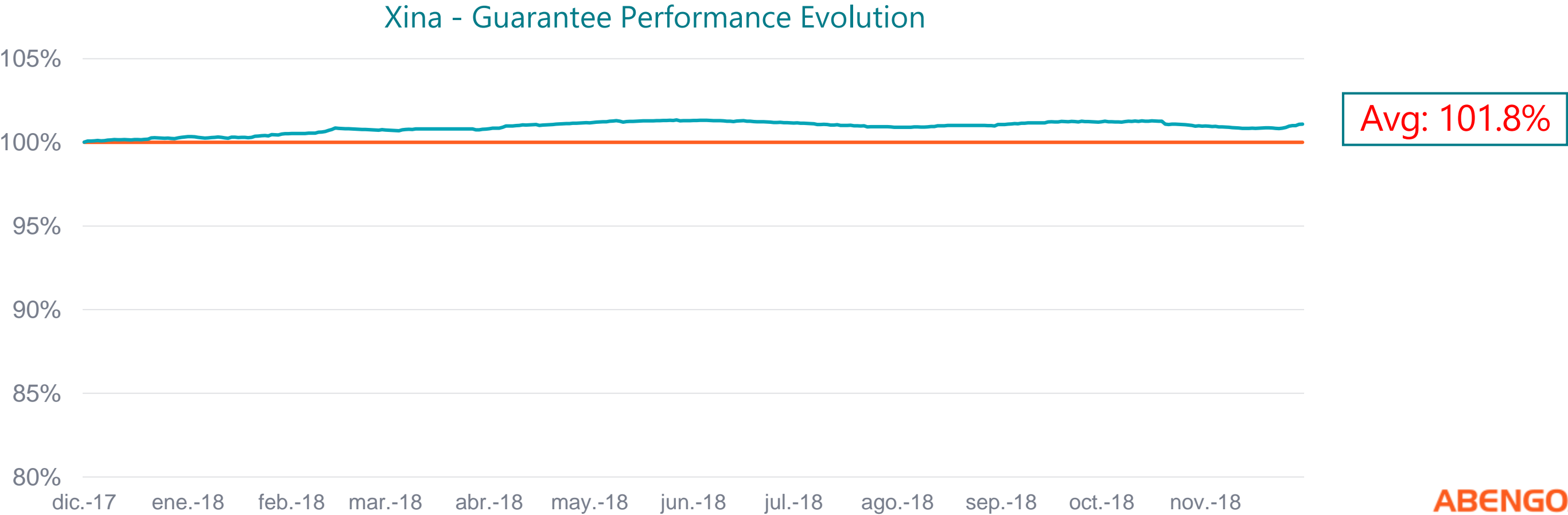
## Summer Transient Day – The more complex Operation Strategy





## Production Guaranteed Period

- Within the first 24 months of Operation the Contractor may select 12 consecutive Months to evaluate the Total Energy Generation and the Total Auxiliary Consumption.
- On the 30<sup>th</sup> November 2018, Xina Solar One achieved this very important milestone after **12 months operating above 100% of the expected generation** and below 100% of the expected auxiliary consumption
- On the 31<sup>st</sup> July 2019 it is expected to obtain the Final Completion Certificate, once the Liability Period of 2 years will expire.





# ABENGOA



Innovative technology solutions for **sustainability**

A photograph of a solar tower power plant. The image shows several large, curved heliostats (mirrors) mounted on metal structures, reflecting the sky. The scene is set in a desert environment under a clear blue sky. The text "Thank you" is overlaid in the center of the image.

Thank you