

Testing of the 1st PTC system in Cyprus' Biggest Soft Drinks Factory

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Presentation Outline

- I. Introduction
 - I. Energy Situation
 - II. Solar Energy Potential
 - III. Energy for the industrial sector
- II. Main Body
 - I. System Installed
 - II. System's operating modes
 - III. CTES charging tests
 - IV. Energy Production tests
 - V. Collector's Reflectivity Drop due to Dirt
- III. Conclusions

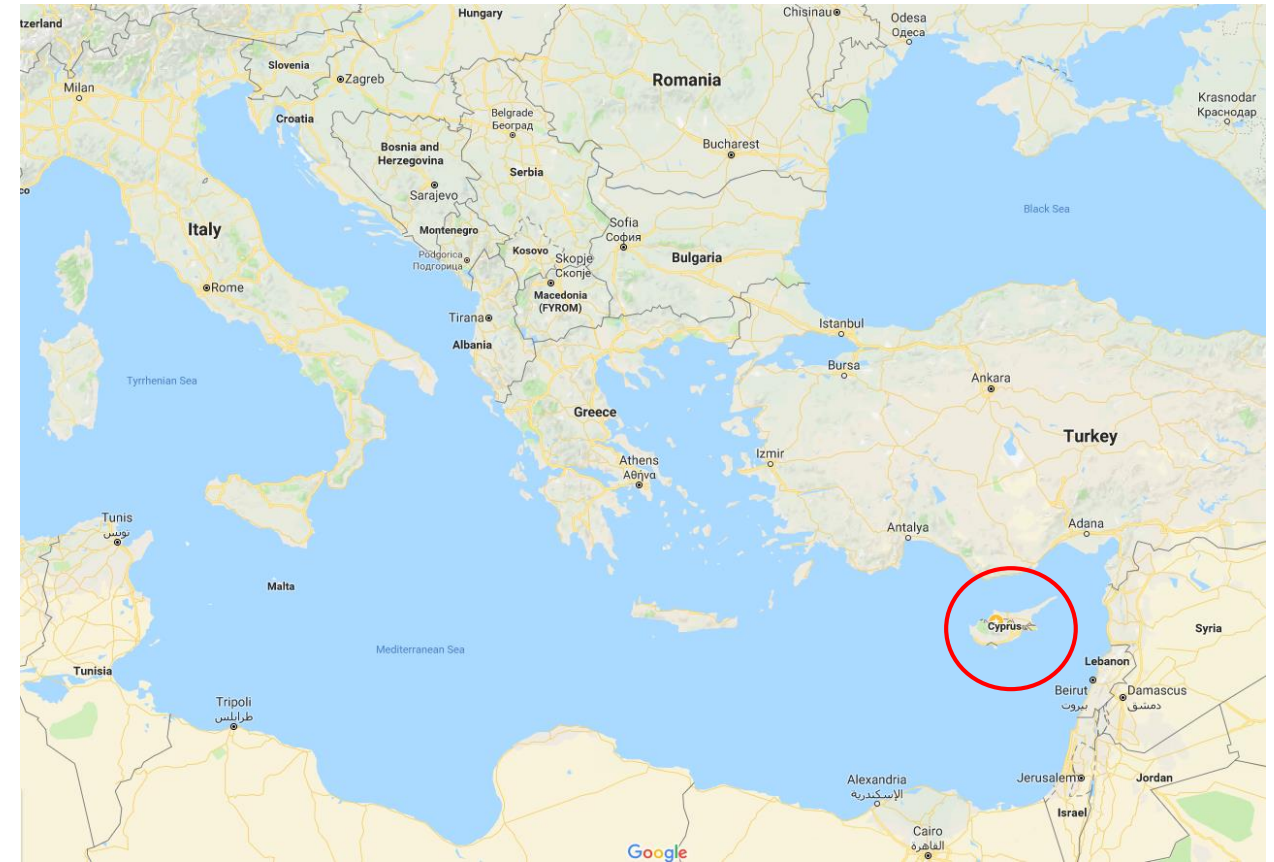
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Energy Situation

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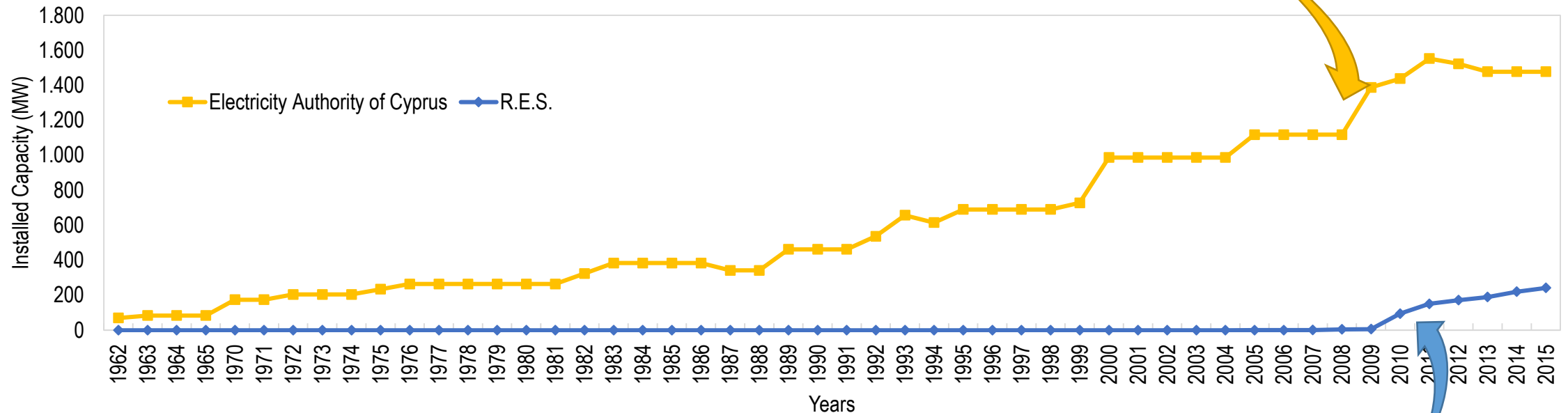
- Cyprus has a small and isolated energy system which is not connected with other energy networks
- There are no fossil fuel resources
- Very dependent on imported fuels (94%)
- Cyprus has 3 Power stations of Dekelia, Moni, and Vasilikos



Energy Situation

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- 94% of the country's energy needs are covered by oil
→ Need for better alternatives: RES

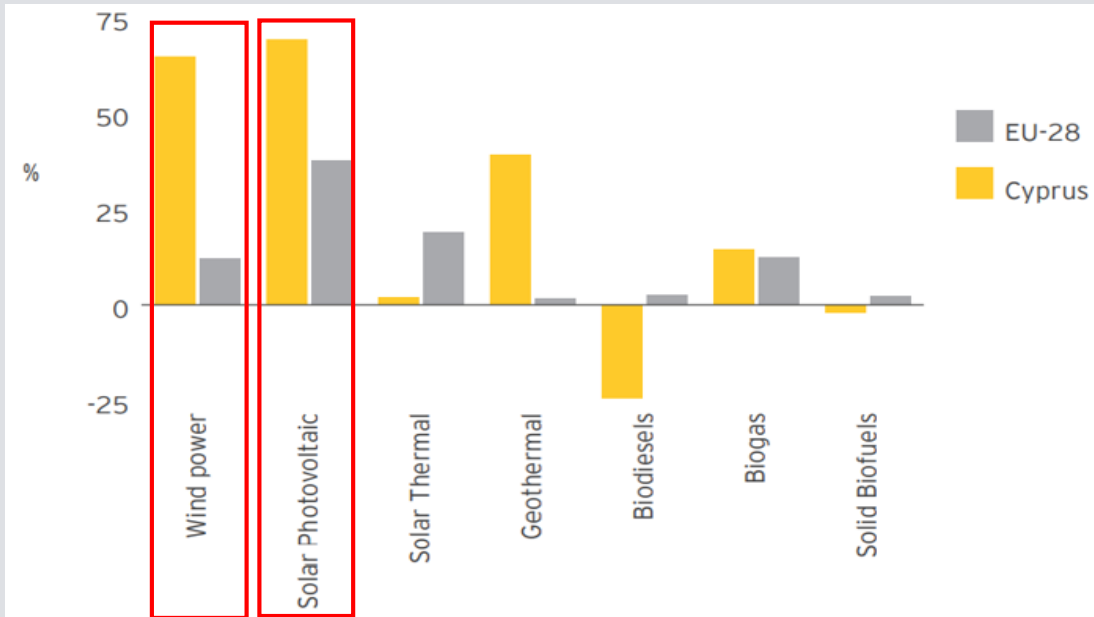


- The last years there is a shift to RES but there is a large space of improvement, education and motivation about energy from RES

Energy Production by RES

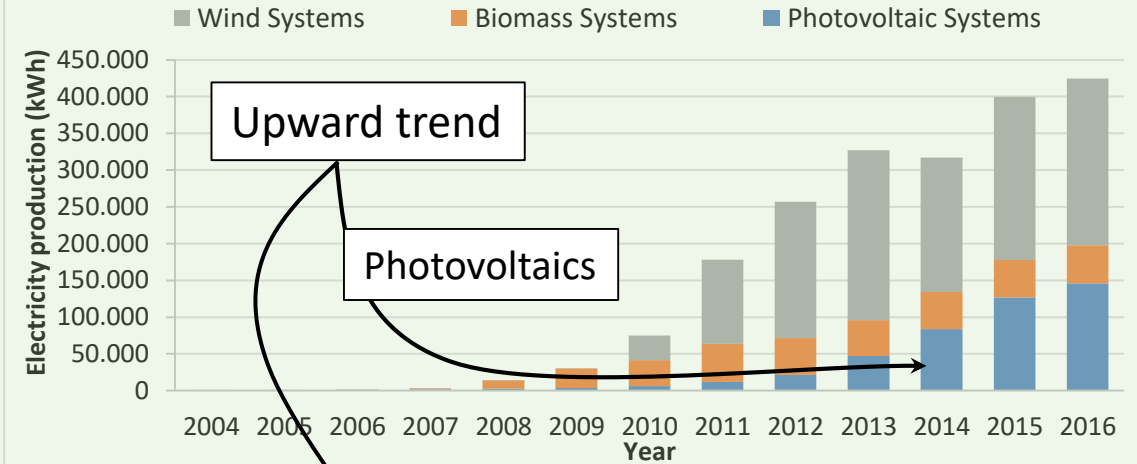
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RES production progress from 2010 to 2013



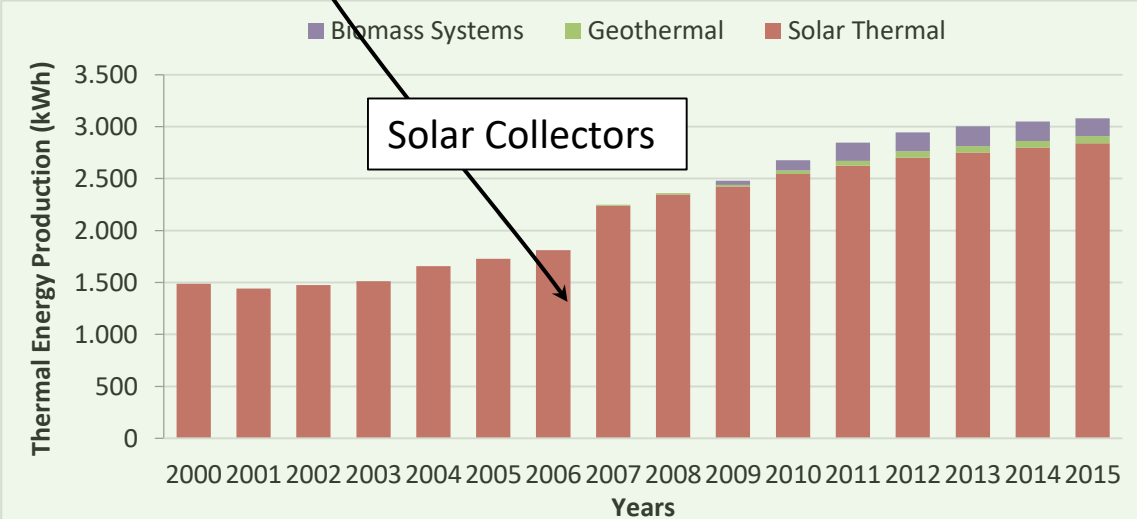
- PV energy: 70% ↑
- Wind energy: 65% ↑

R.E.S production



Upward trend

Photovoltaics

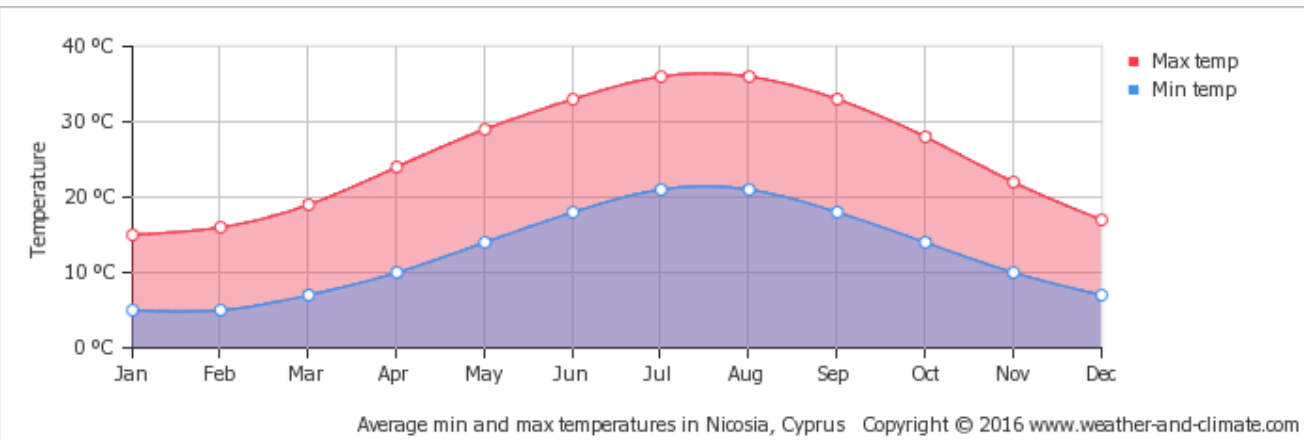


Solar Collectors

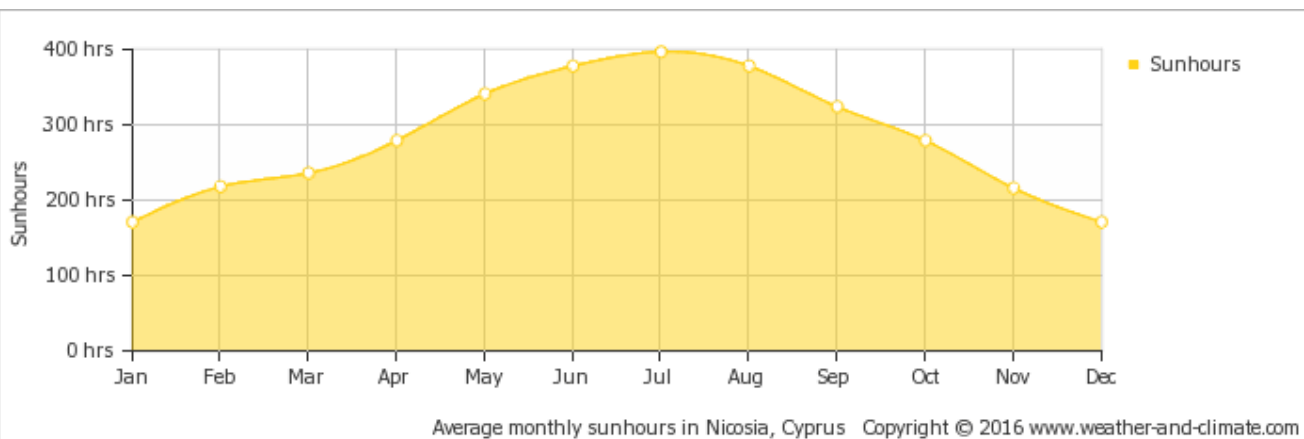
Solar Energy Potential

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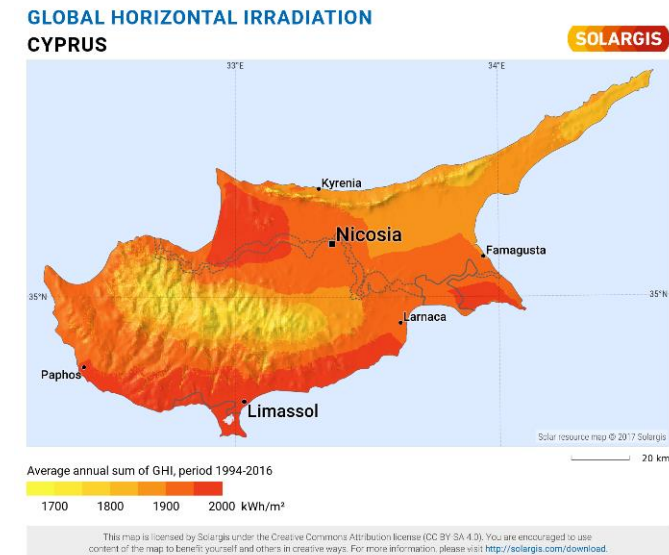
Monthly average temperature in Nicosia, Cyprus



Sunhours in 2016



Solar Energy Potential – Solar Radiation



- Daily average solar radiation of about 5.4 kWh/m² on a horizontal surface.
- The amount of global radiation falling on a horizontal surface with average weather conditions = 1727 kWh/m² per year.

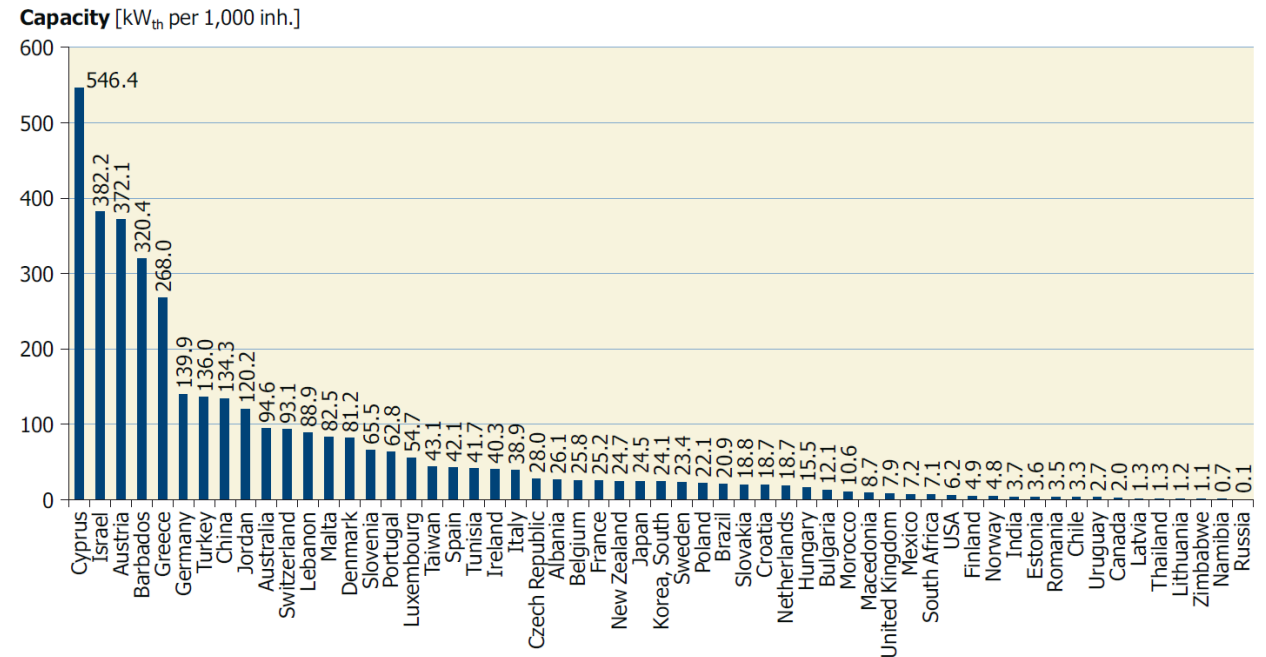
Solar Energy Potential

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- Solar thermal collectors for hot water are widely used
- Worldwide leader country for the use of solar water heating systems per capita
- The total capacity of glazed water collectors in 2012 was 546.4 kW_{th} per 1000 inhabitants



Coverage: 93% (domestic sector), 50% (tourist industry)

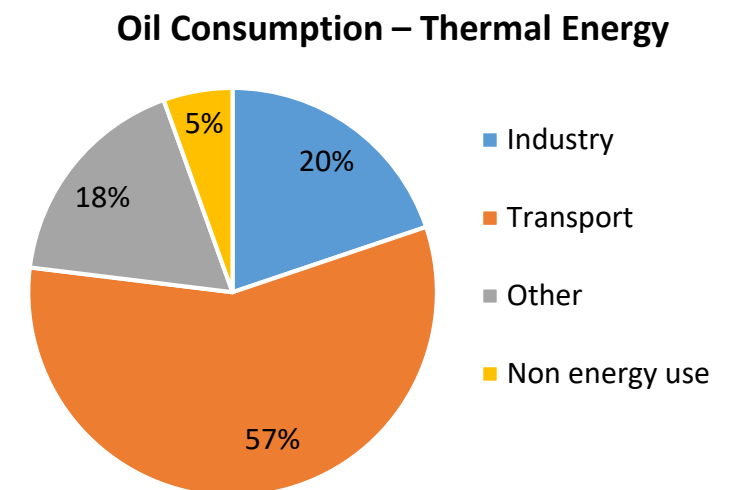
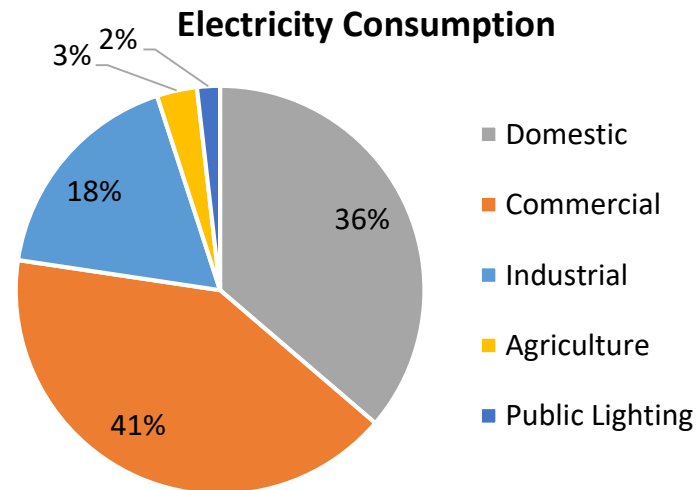
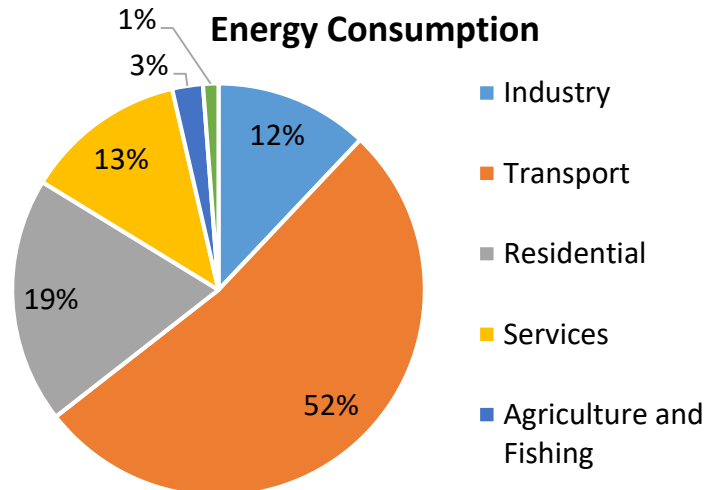


Energy for the Industrial Sector

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- Industrial Sector:
 - 4th biggest energy consumer
 - 3rd biggest electricity consumer
 - 2nd biggest thermal energy consumer (oil consumption)

Need to reduce oil consumption for thermal energy in the industrial sector



Energy for the Industrial Sector

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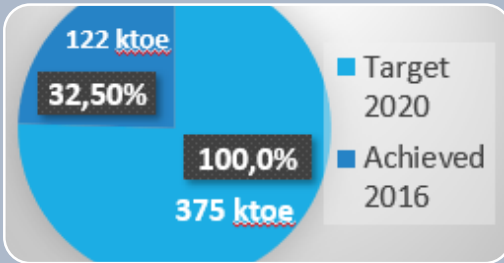
- The thermal load of the food industry and the non-metallic mineral products industry can be classified in relation to the required temperature range as follows:
 - Low temperature (<100°C)
 - Medium temperature (100°C – 300°C)
 - High temperature (>300°C)

Thermal demand of various factories from the food and beverage and non-metallic mineral products industries in Cyprus

Factory	Process	Temperature range (°C)	Hot water/ steam	Average load (tons/h)
Wine	Sterilization	90	Hot Water	1.5
Milk & Dairy products	Sterilization	120	Steam	2.2
	Drying			
Soft drinks	Pasteurization	95	Steam	3.5
	Cleaning / disinfecting process	150	Steam	
Meat	Cooking	90-100	Steam	1
Beer	Cleaning / disinfecting process/ hot water	80-90	Steam	5
Plastics	Separation	200-220	Steam	2
	Drying	180-200	Steam	
	Blending	120-140	Steam	
Bricks and blocks	Curing	60-140	Steam	4

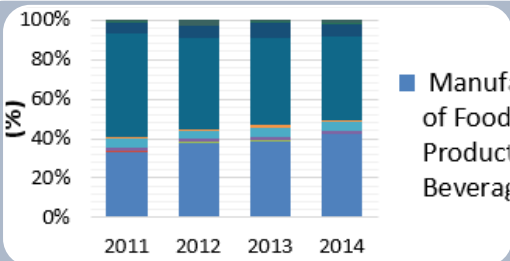
Energy for the Industrial Sector

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Need

- Cyprus needs to upgrade its primary energy consumption strategies to reach EU 2020 targets



Problem

- Food and beverage industry is the main consumer of fuels, 40% of the total consumption (20.2MEUR/yr)
- Need for steam/hot water at medium temperatures (up to 200°C)



Solution

- Parabolic trough collector with concrete thermal storage

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Selection of the Factory

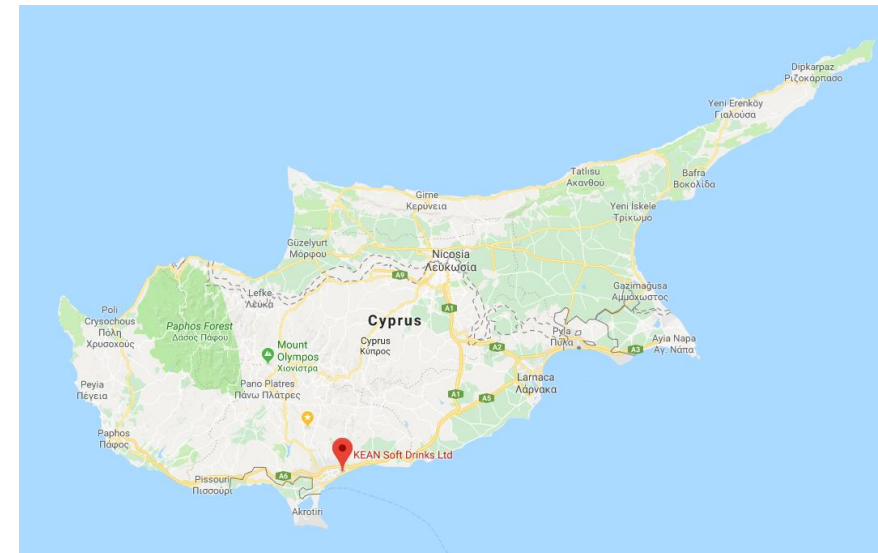
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- Criteria

- Need a system whose thermal production can satisfy the thermal need of the factory
- Space availability

- Selection: KEAN soft drinks factory

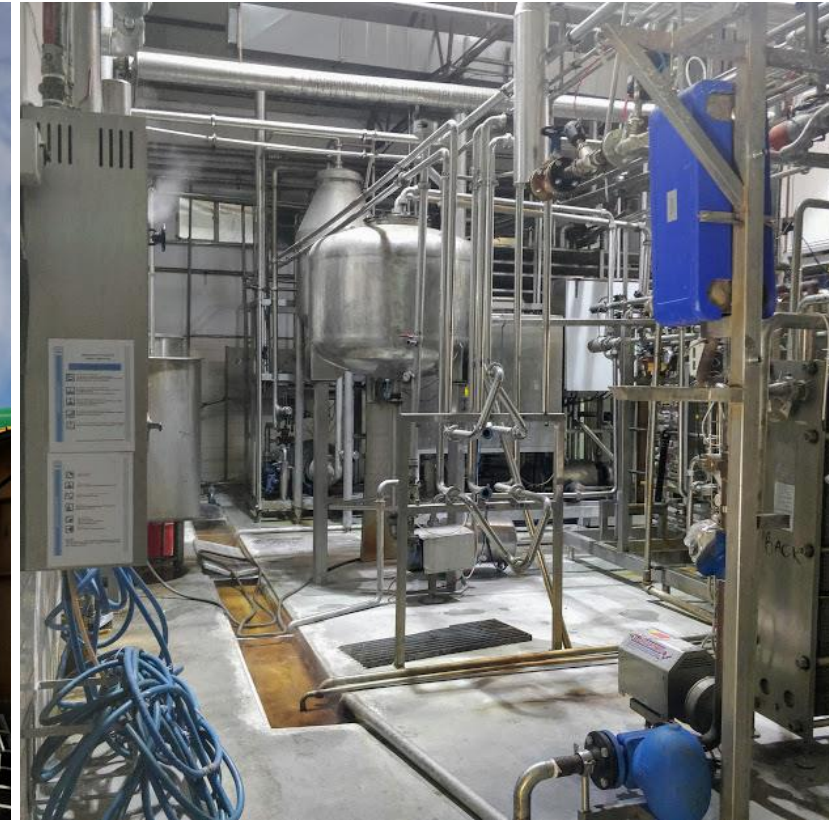
- The largest soft drinks industry in Cyprus
- Location: Limassol, Cyprus
- Thermal demand: $500 \text{ kW}_{\text{th}}$
- Thermal needs: Steam, 180°C
- Demand: 10 hours/day, 7 days/week



Selection of the Factory

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- KEAN soft drinks factory
 - Process that need thermal energy – Steam
 - Cleaning / disinfecting of the machines and tools
 - Pasteurization



System Installed in KEAN

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PTCs CF100

8 collectors in 2 parallel series

Aperture area: 288 m² (12 m x 3 m x 8 col.)

Tube absorption ≥ 95 %

Mirror reflectivity ≥ 94 %

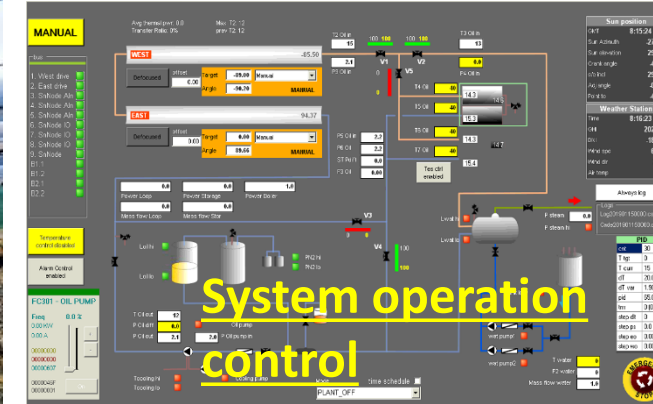


Weather Station

- Wind speed & direction
- Radiation
- Rain gauge
- Temperature & RH



Steam boiler



System Installed in KEAN

ESCC2019- CUT

CONCRETE THERMAL ENERGY STORAGE

Total mass 28157 Kg

Length 5 m
Width 0.548 m,
Height 0.670
(4 modules in 2 containers)

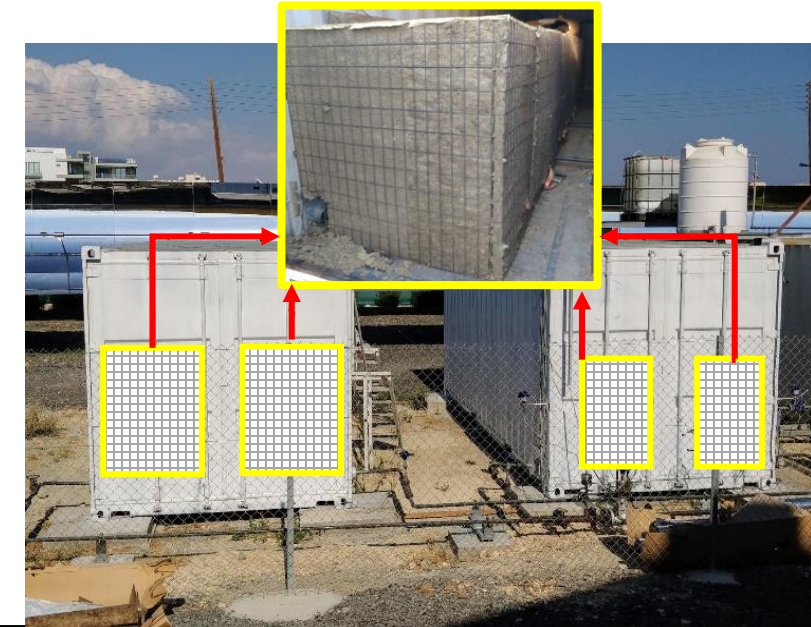
Heat transfer coefficient 16168.59
kJ/h K

HELIOSOL[®] XA

Boiling point: 375 °C

High heat resistance, Non-corrosive, No
hazard classification, clear, odorless, colorless

Recommended use temperature: -40 °C – 425 °C



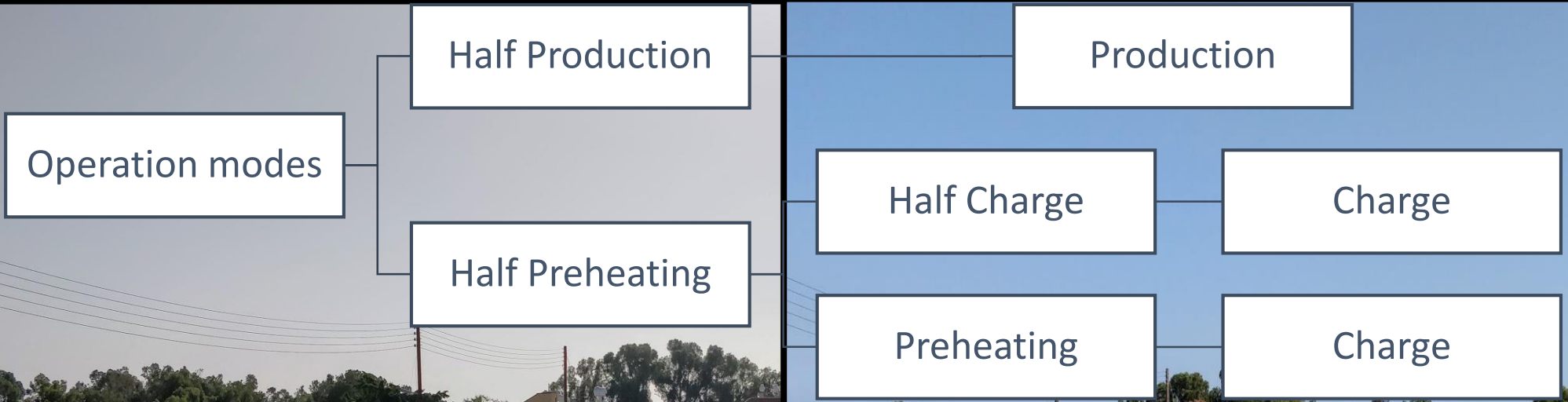
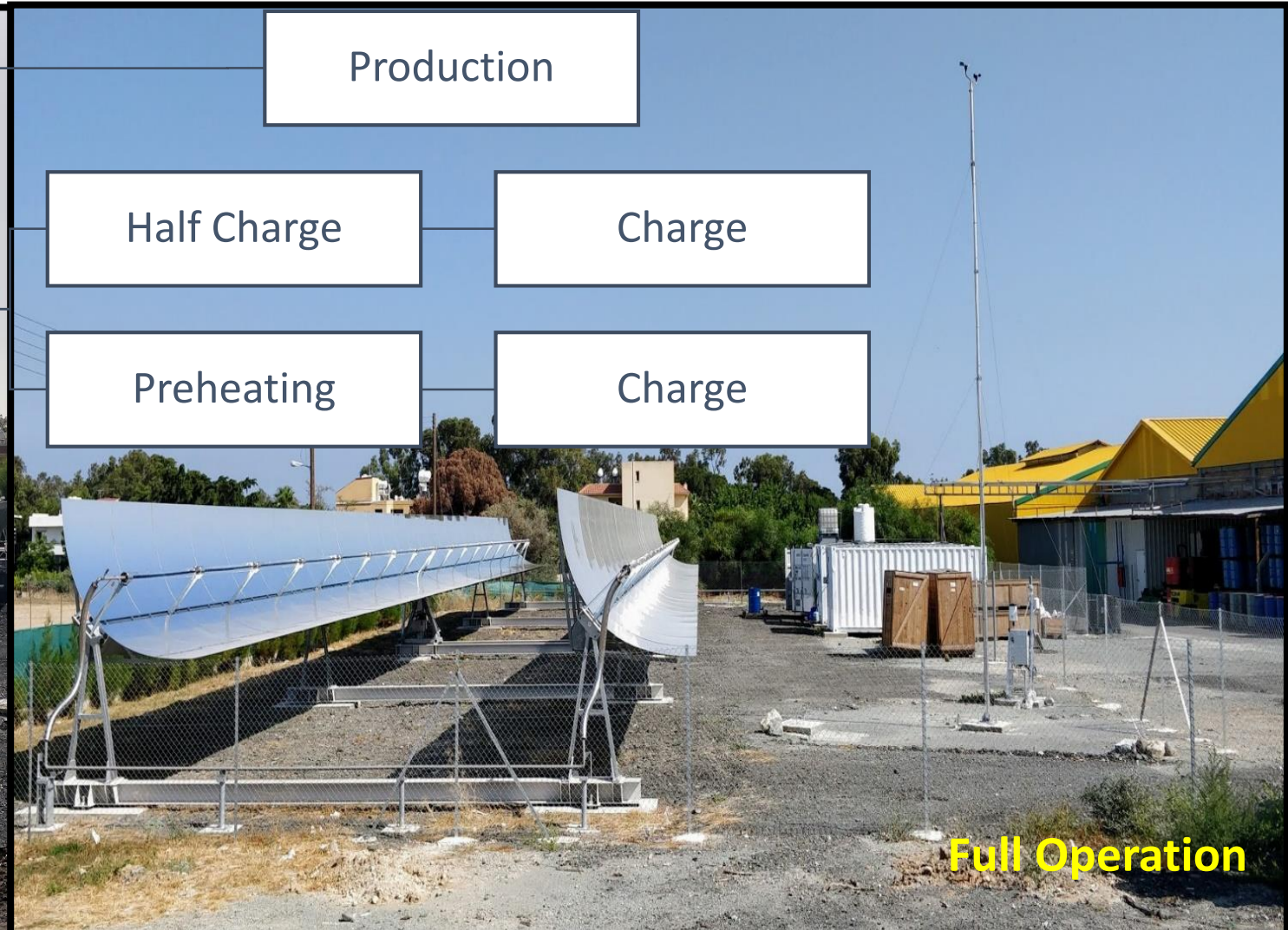
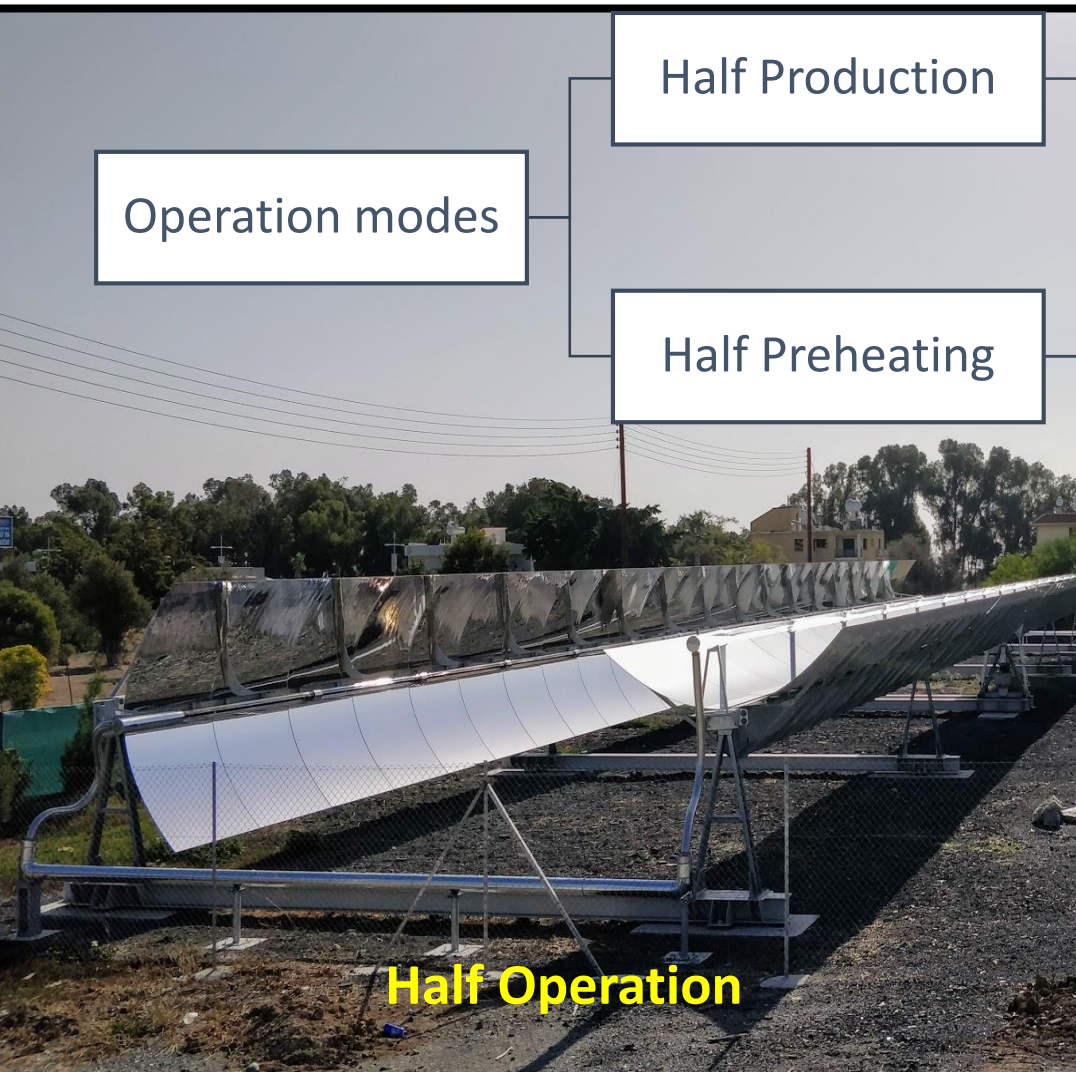
System Installed in KEAN

ESCC2019- CUT



System's Operating Modes

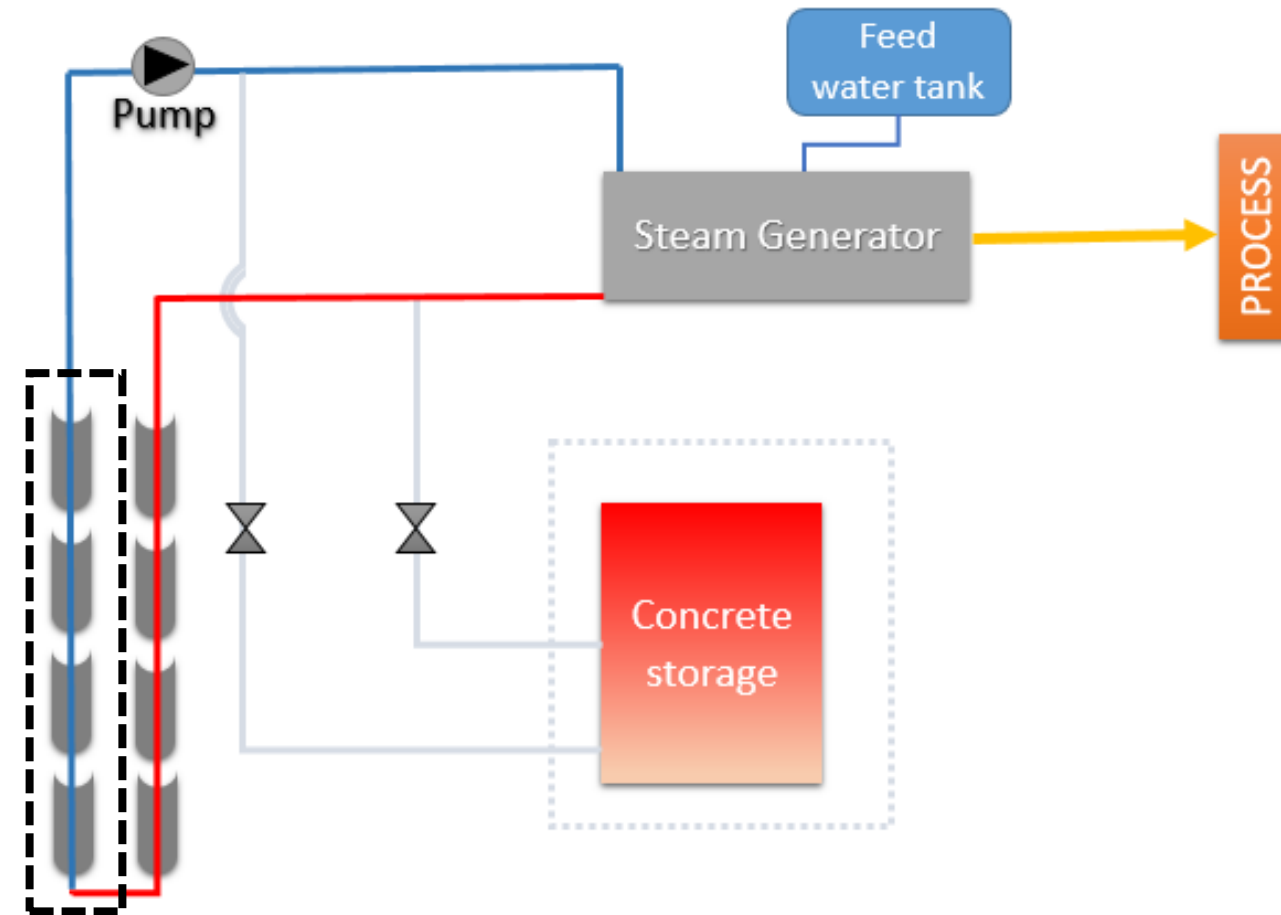
ESCC2019- CUT



System's Operating Modes

ESCC2019- CUT

- Mode: Half Production
 - West trough is on tracking
 - East trough is at stow
 - The HTF is circulated through the PTC and to the steam Generator
 - When Steam Generator Pressure is above 9 bar is feeding steam to the process

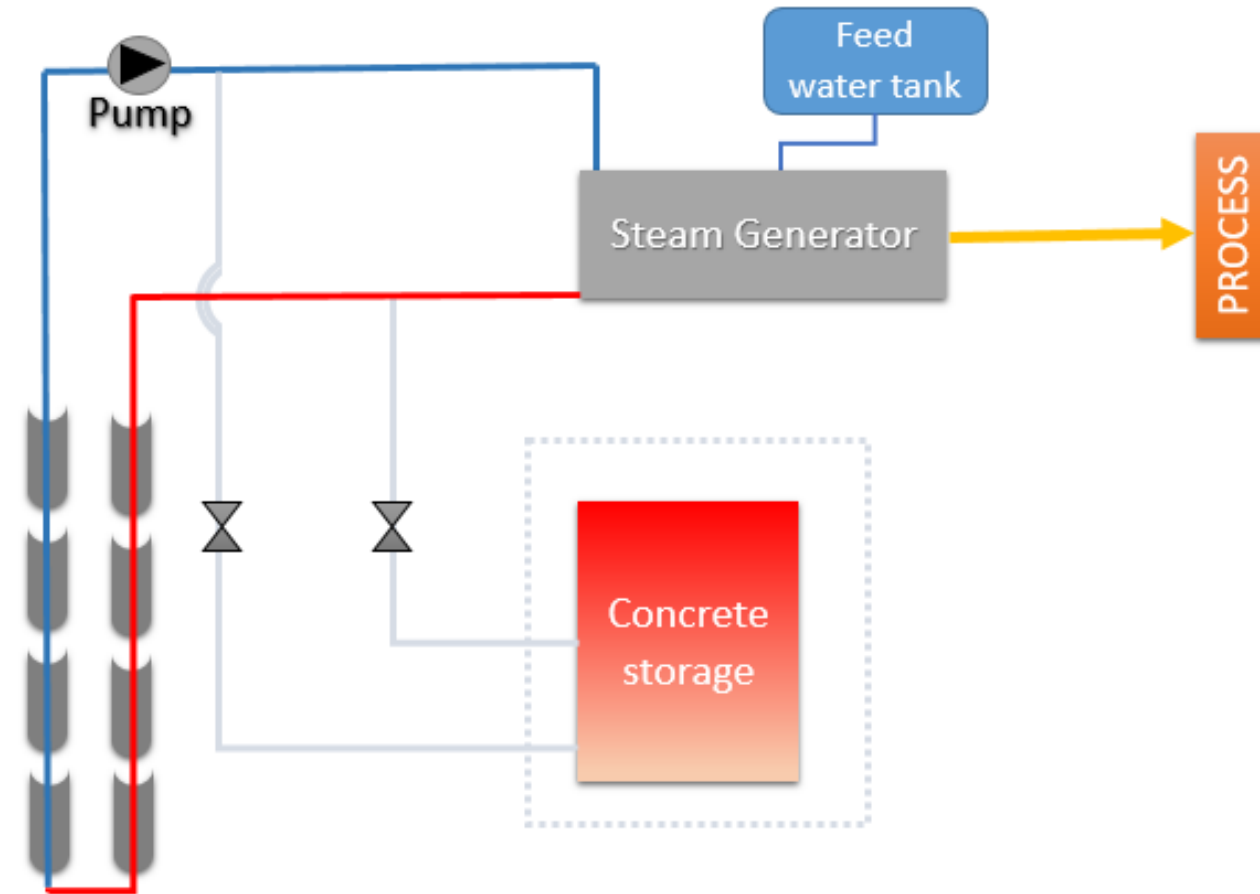


System's Operating Modes

ESCC2019- CUT

- Mode: Production

- West trough is on tracking
- East trough is at stow
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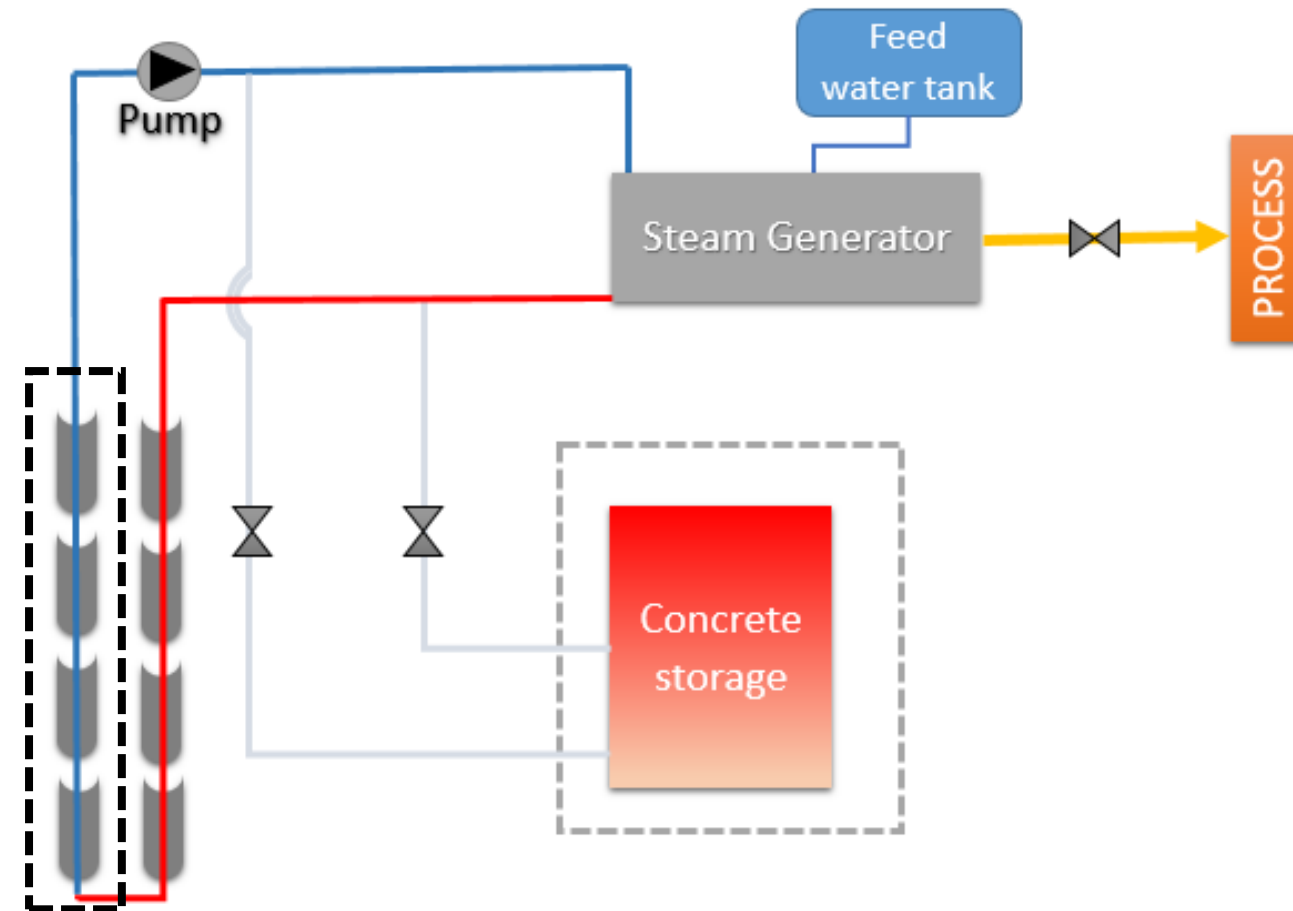


System's Operating Modes

ESCC2019- CUT

- Mode: Half Preheating

- Mode before charging mode
- West trough is on tracking
- East trough is at stow
- The HTF is circulated through the PTC and to the Steam Generator
- Preheating mode is enabled until HTF temperature being above the average concrete temperature

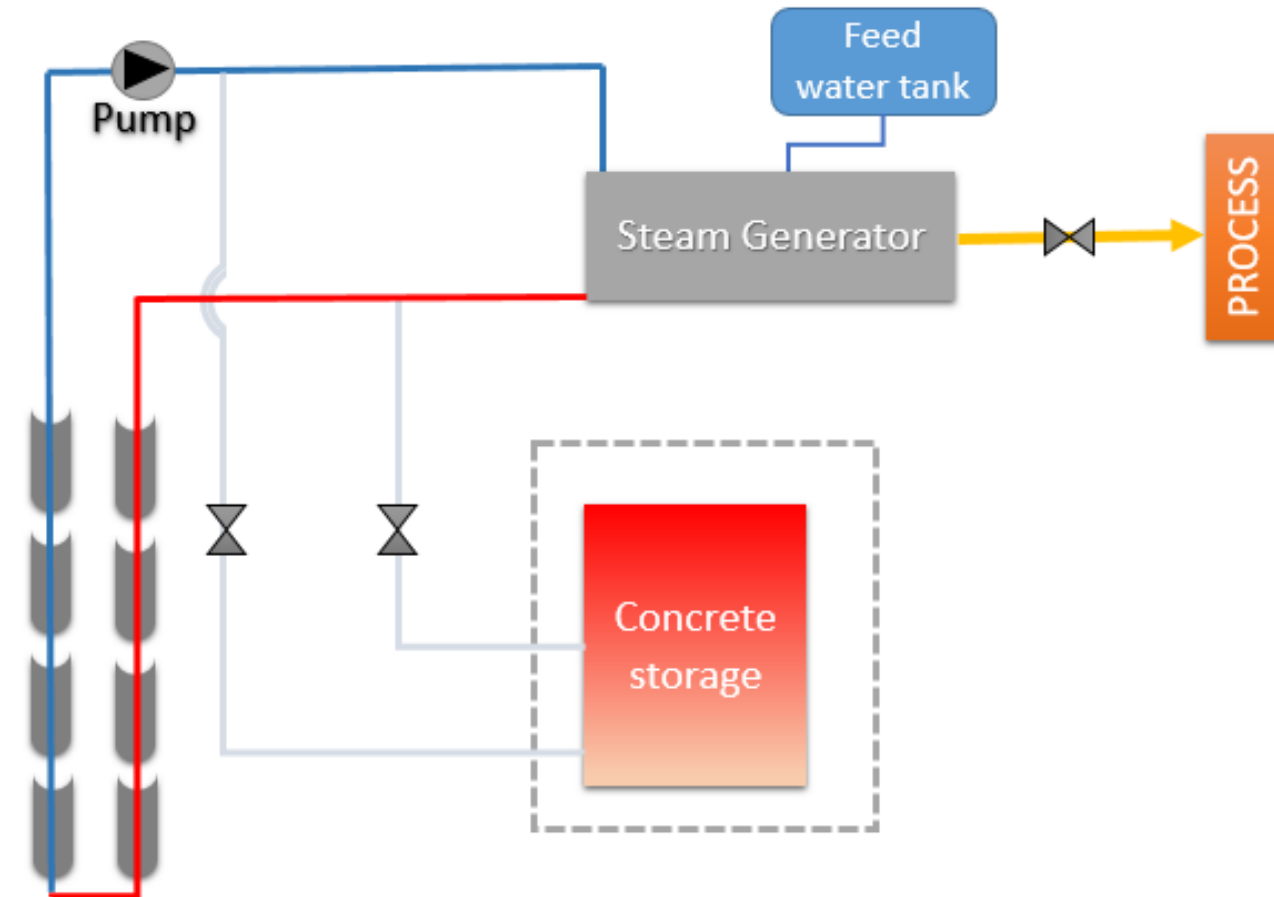


System's Operating Modes

ESCC2019- CUT

- Mode: Preheating

- Mode before charging mode
- Both troughs are on tracking
- The HTF is circulated through the PTC and to the Steam Generator
- Preheating mode is enabled until HTF temperature being above the average concrete temperature

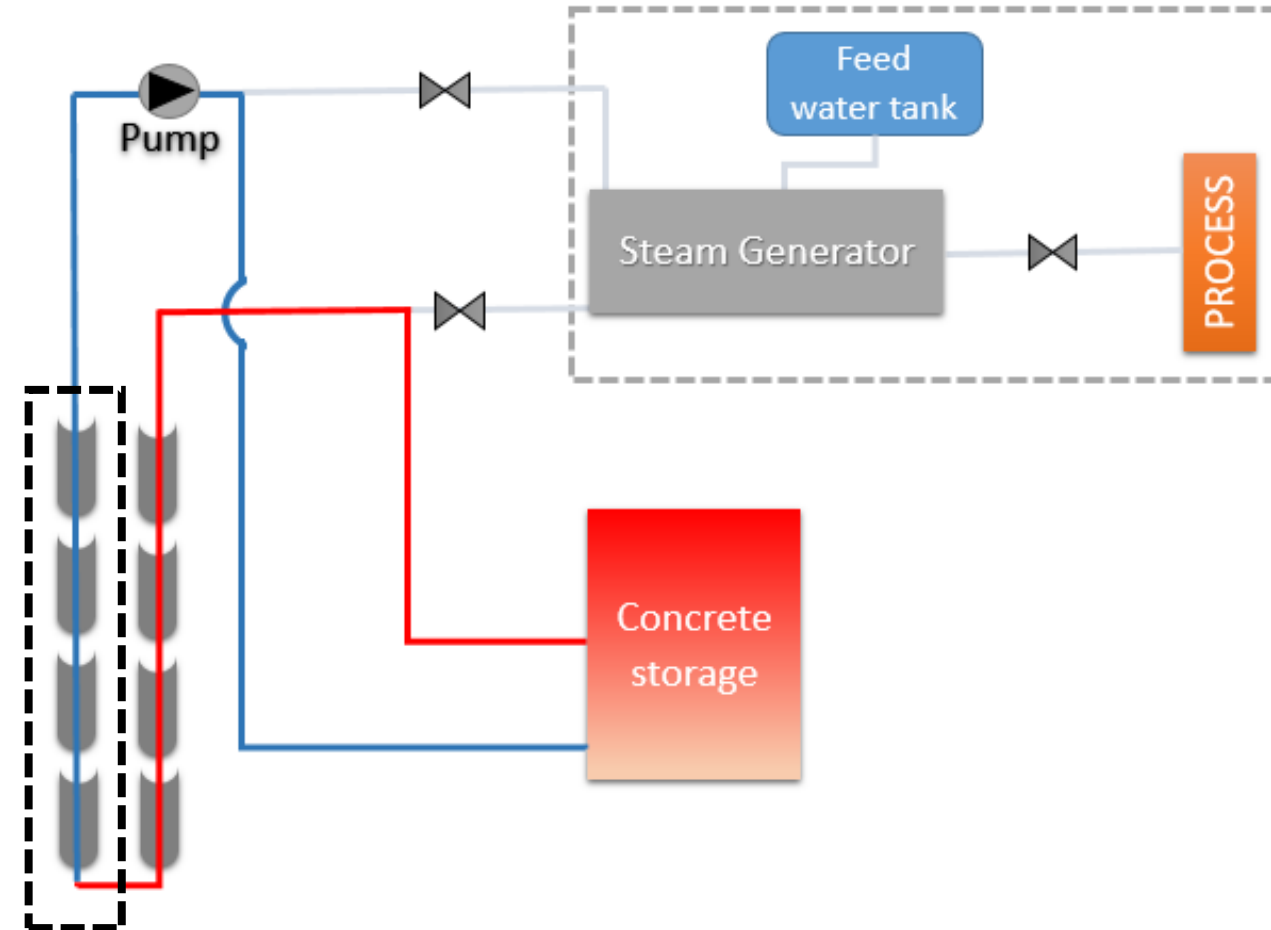


System's Operating Modes

ESCC2019- CUT

- Mode: Half Charge

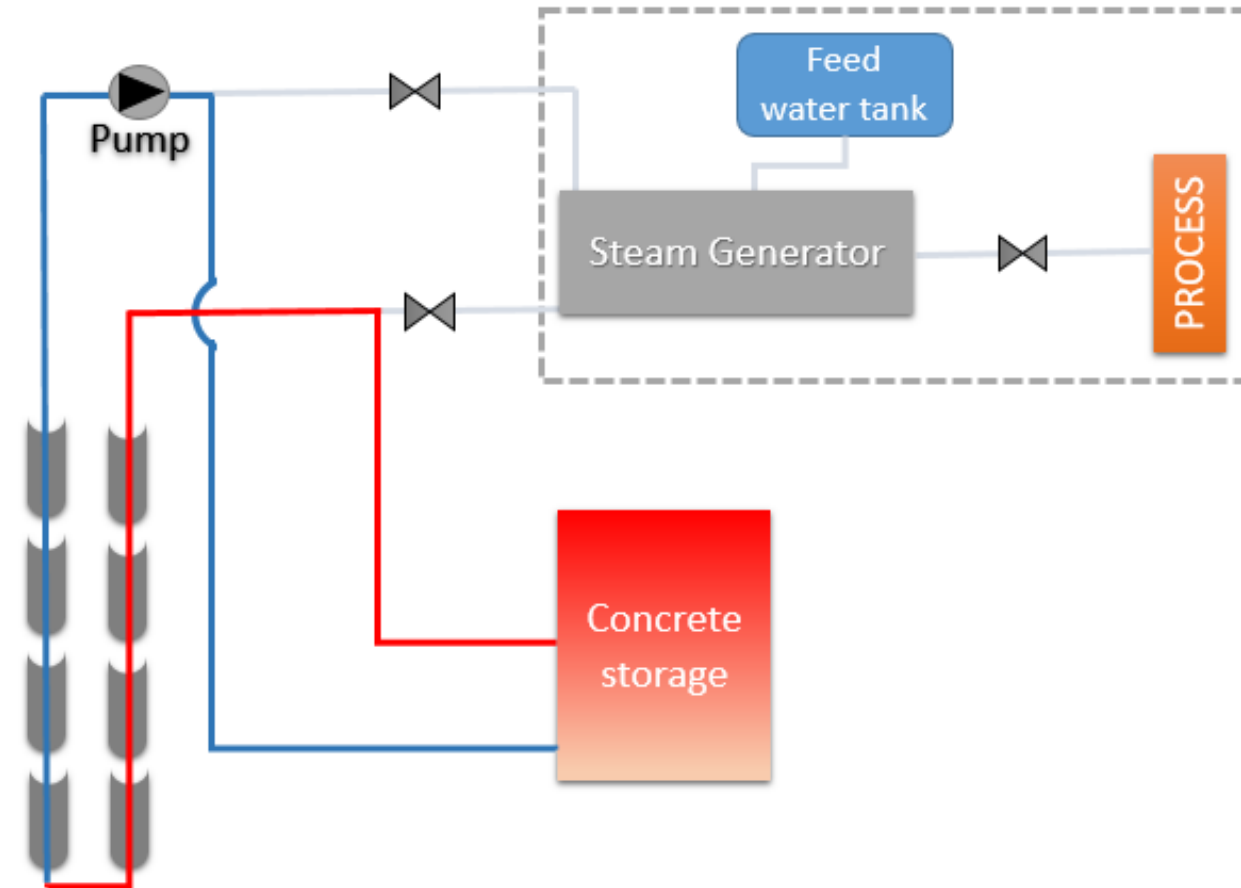
- West trough is on tracking
- East trough is at stow
- The HTF is circulated through the PTC and to the CTES



System's Operating Modes

ESCC2019- CUT

- Mode: Charge
 - West trough is on tracking
 - East trough is at stow
 - The HTF is circulated through the PTC and to the CTES



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CTES Charging Tests

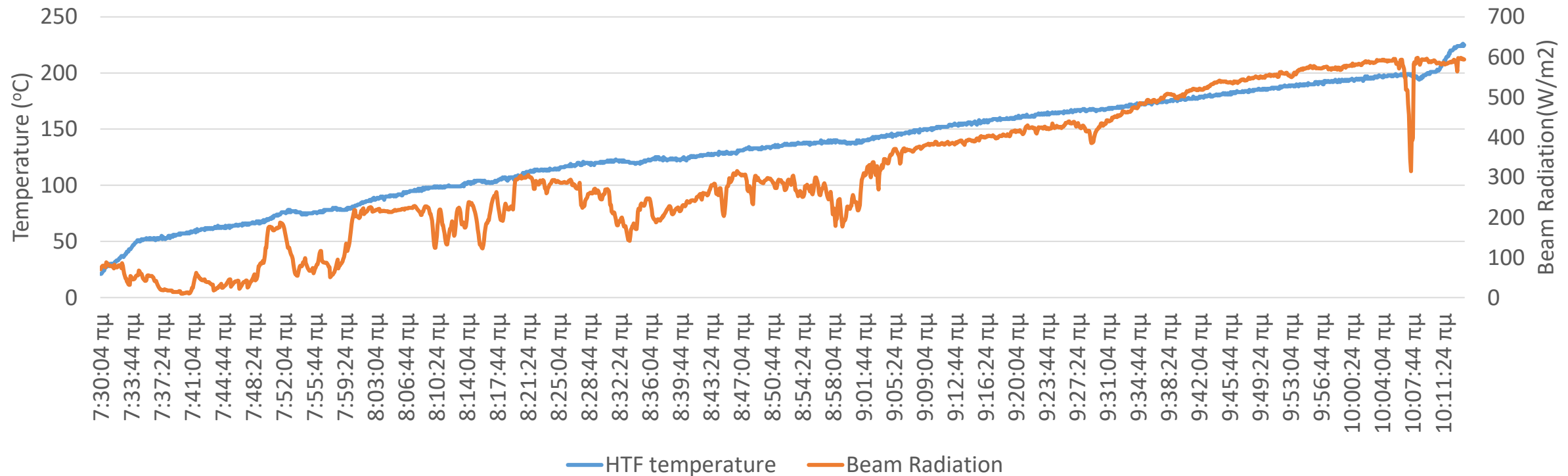
ESCC2019- CUT

- Test: 24/4/2019

- Mode:



Average DNI: 315W/m²
HTF temperature incensement: 21 °C-225 °C
Duration of operation: ≈ 3 hours



CTES Charging Tests

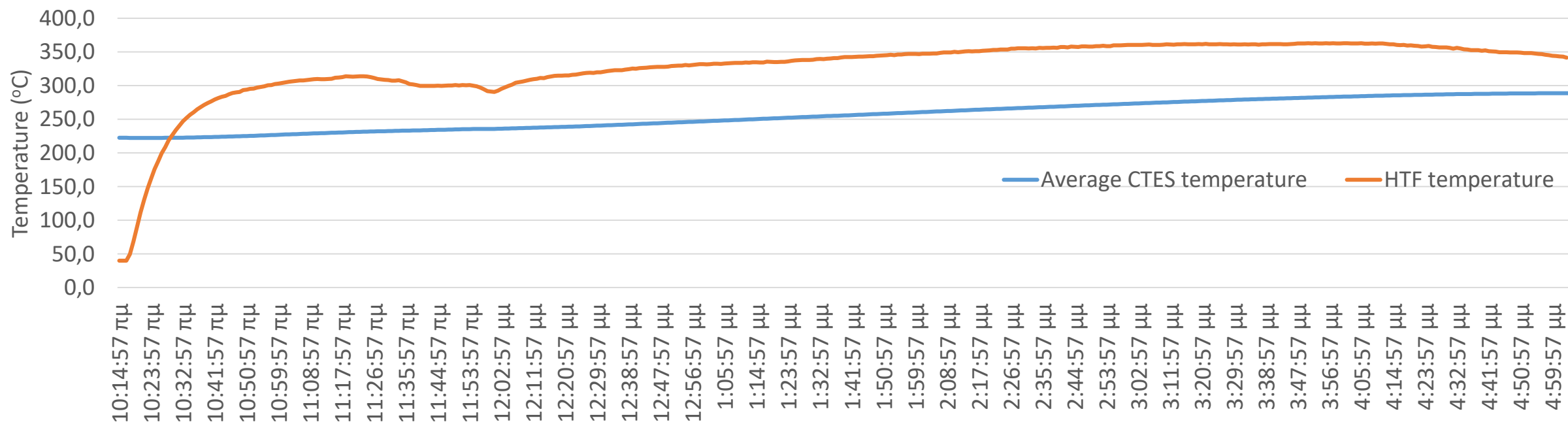
ESCC2019- CUT

- Test: 24/4/2019

- Mode:



Average DNI: 600 W/m²
Storage temperature : 222.5 °C – 288.6 °C
HTF charging temperature: 315°C-363°C
Duration of operation: ≈ 6 hours

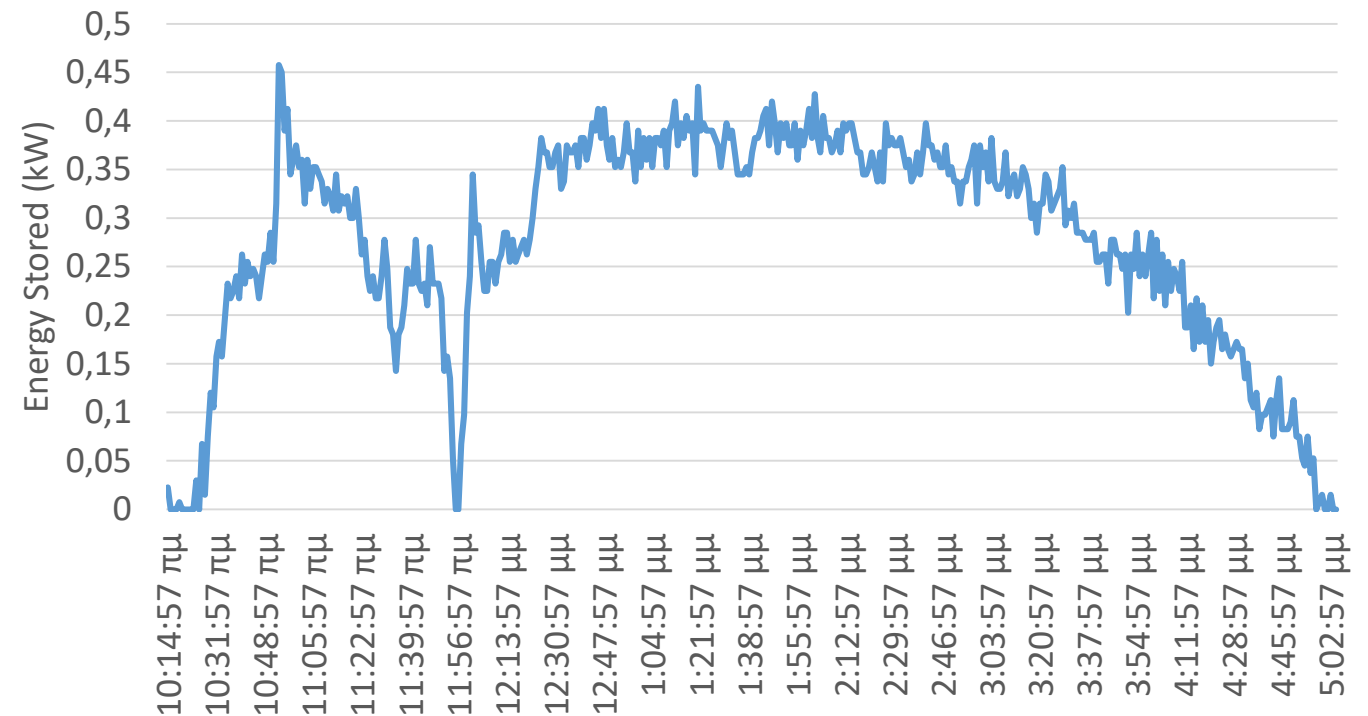


CTES Charging Tests

ESCC2019- CUT

- Test: 24/4/2019
- Maximum DNI: 712 W/m²
- Average DNI during all process: 315 W/m²
- CTES maximum temperature : 288.6 °C

Total energy stored: 115 kW_{th} in 6 hours of operation



CTES Charging Tests

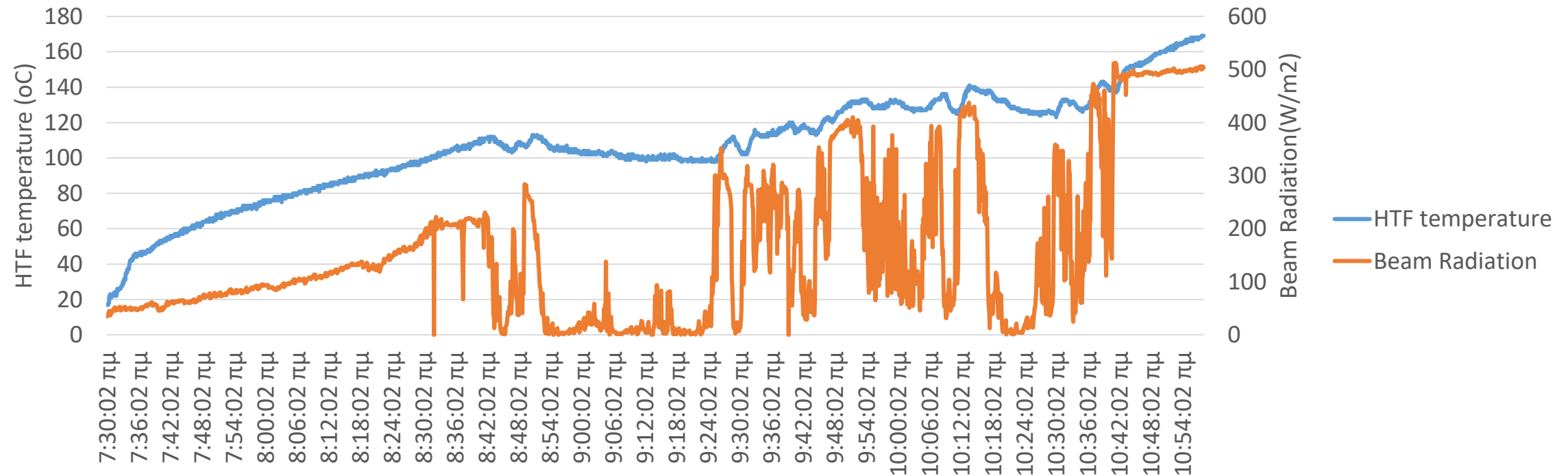
ESCC2019- CUT

- Test: 25/4/2019

- Mode:



Average DNI: 160W/m²
HTF temperature incensement: 17 °C - 169 °C
Duration of operation: ≈ 3.5 hours



CTES Charging Tests

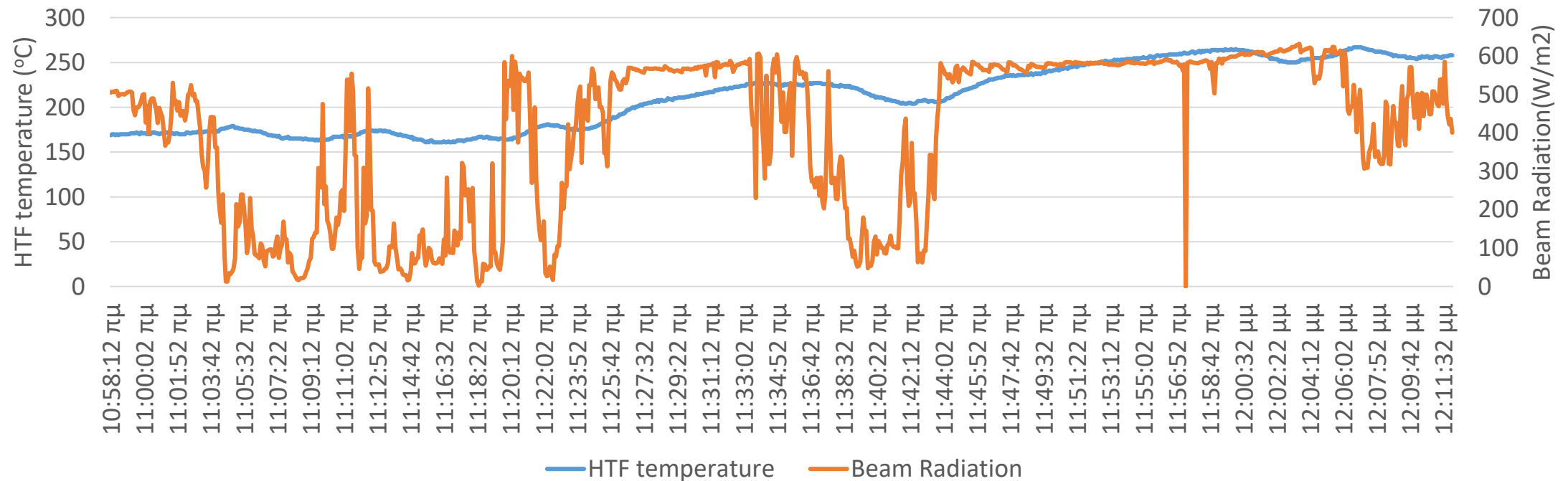
ESCC2019- CUT

- Test: 25/4/2019

- Mode:



Average DNI: 405W/m²
HTF temperature incensement: 169 °C - 258°C
Duration of operation: ≈ 1 hour



CTES Charging Tests

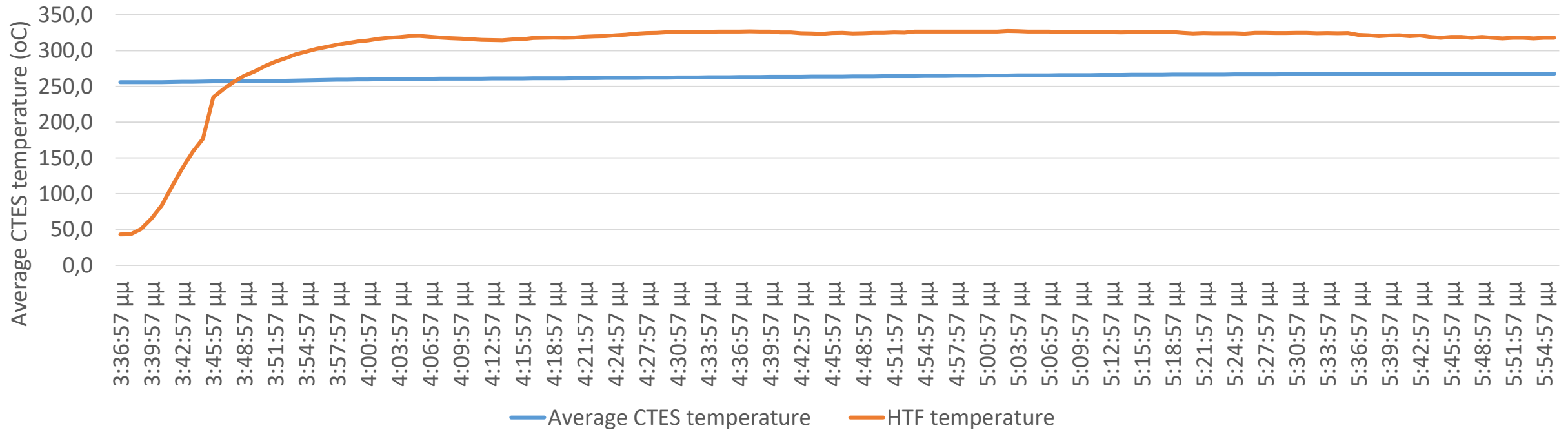
ESCC2019- CUT

- Test: **25/4/2019**

- Mode:



Average DNI: 315 W/m²
Storage temperature : 255 °C – 267.6 °C
HTF charging temperature: 305°C-327.5°C
Duration of operation: ≈ 2.5 hours

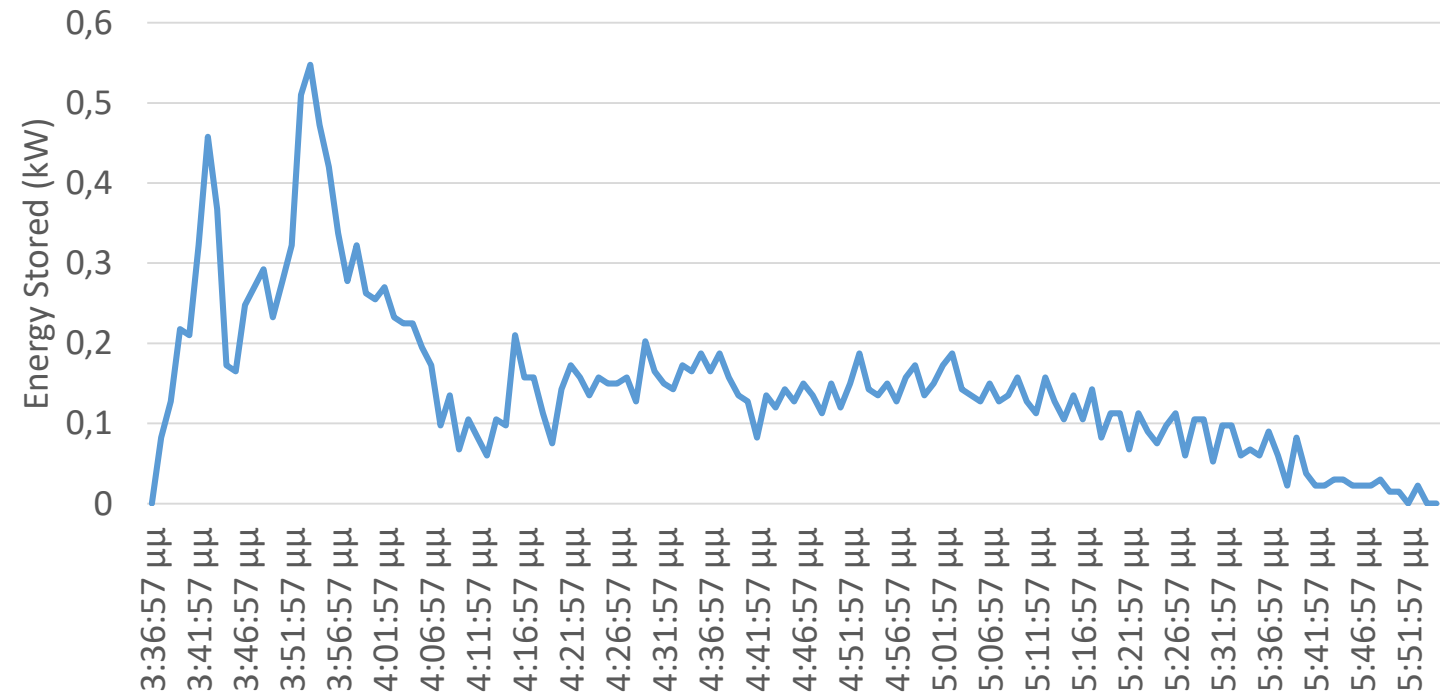


CTES Charging Tests

ESCC2019- CUT

- Test: 25/4/2019
- Maximum DNI: 570 W/m²
- Average DNI: 240 W/m²
- CTES maximum temperature : 267.6 °C

Total energy stored: 20.5 kW_{th} in 2.5 hours of operation



CTES Charging Tests

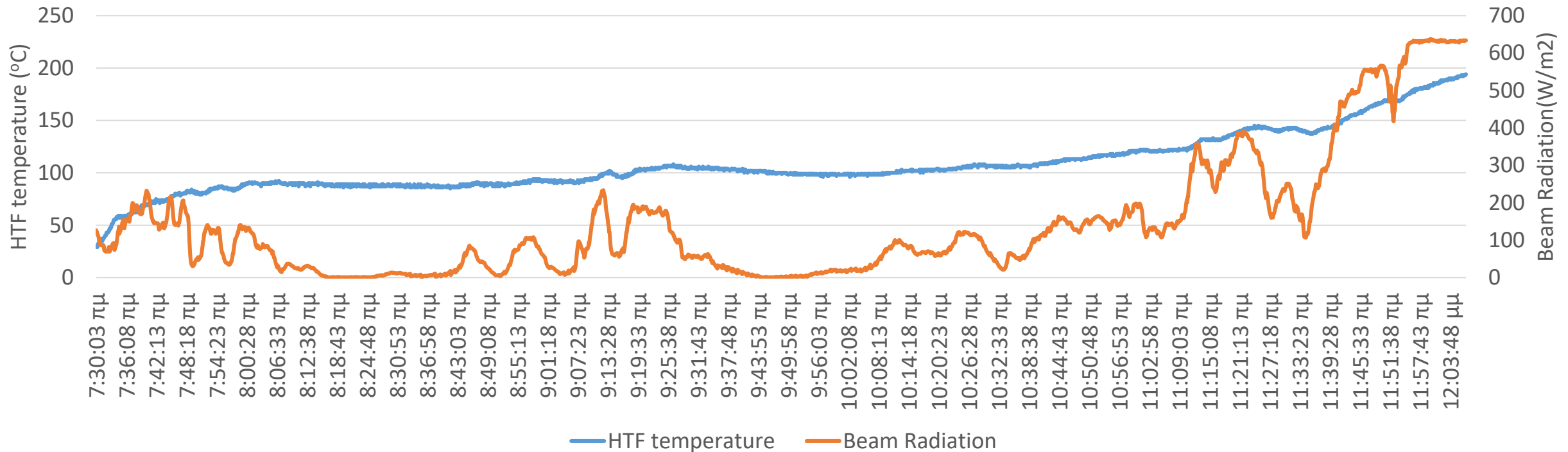
ESCC2019- CUT

- Test: 26/4/2019

- Mode:



Average DNI: 145 W/m²
HTF temperature incensement: 29 °C - 194°C
Duration of operation: ≈ 4.5 hour



CTES Charging Tests

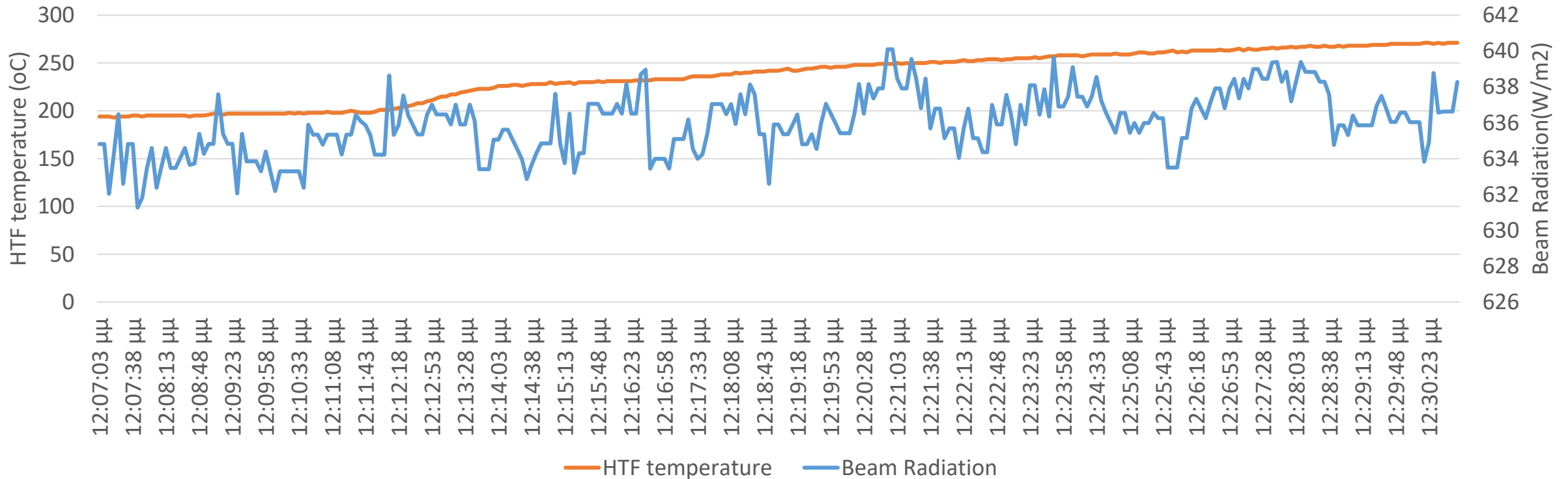
ESCC2019- CUT

- Test: 26/4/2019

- Mode:



Average DNI: 636 W/m²
HTF temperature incensement: 194 °C - 271°C
Duration of operation: ≈ 0.5 hour



CTES Charging Tests

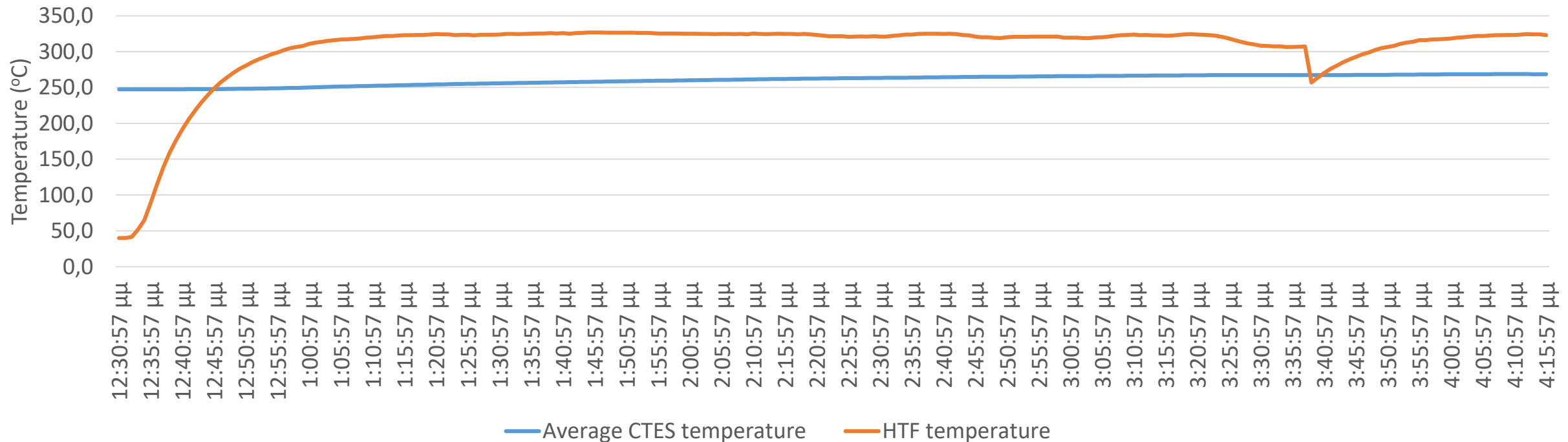
ESCC2019- CUT

• Test: 26/4/2019

• Mode:



Average DNI: 461 W/m²
Storage temperature : 247.4 °C – 268.4 °C
HTF charging temperature: 300 °C-326.75 °C
Duration of operation: ≈ 4 hours

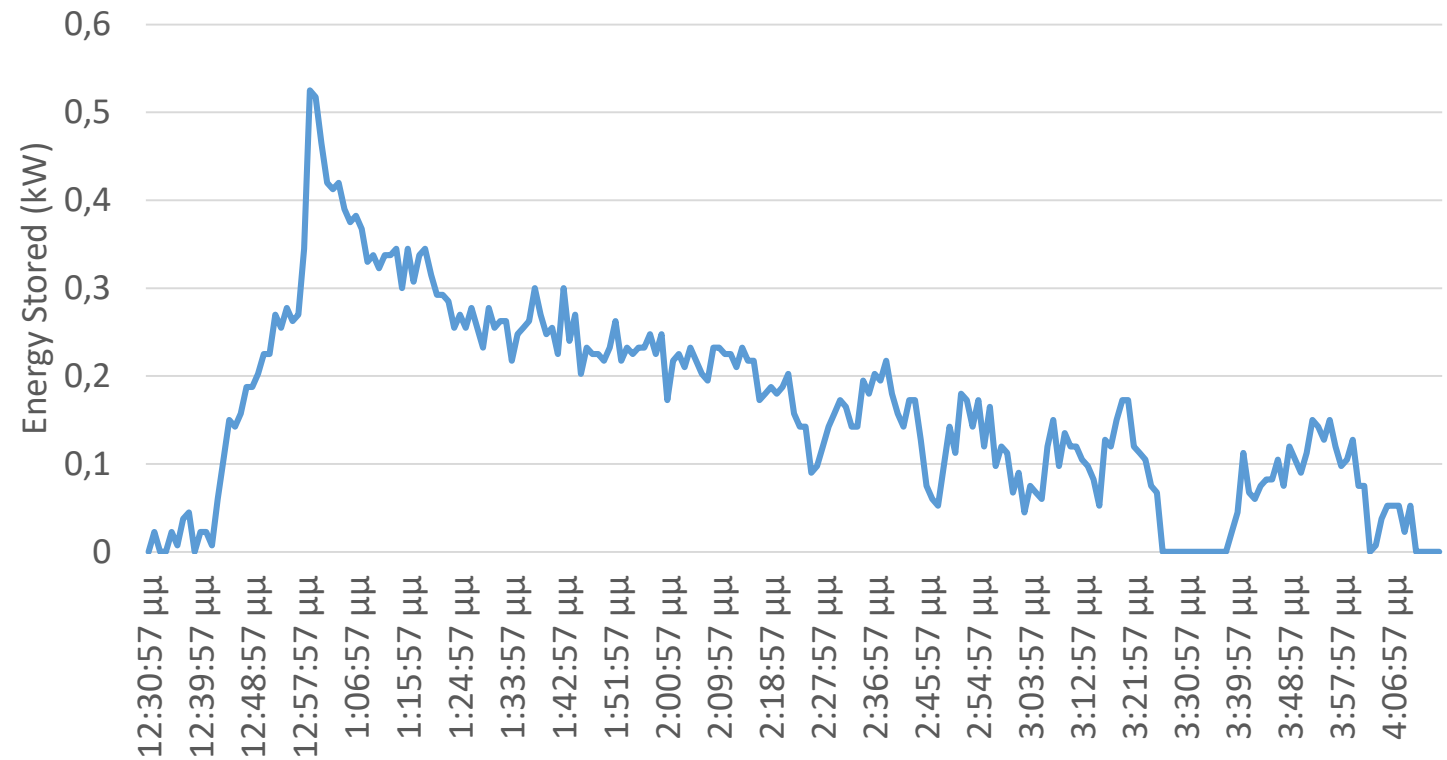


CTES Charging Tests

ESCC2019- CUT

- Test: 26/4/2019
- Maximum DNI: 640 W/m²
- Average DNI: W/m²
- CTES maximum temperature : 268.4 °C

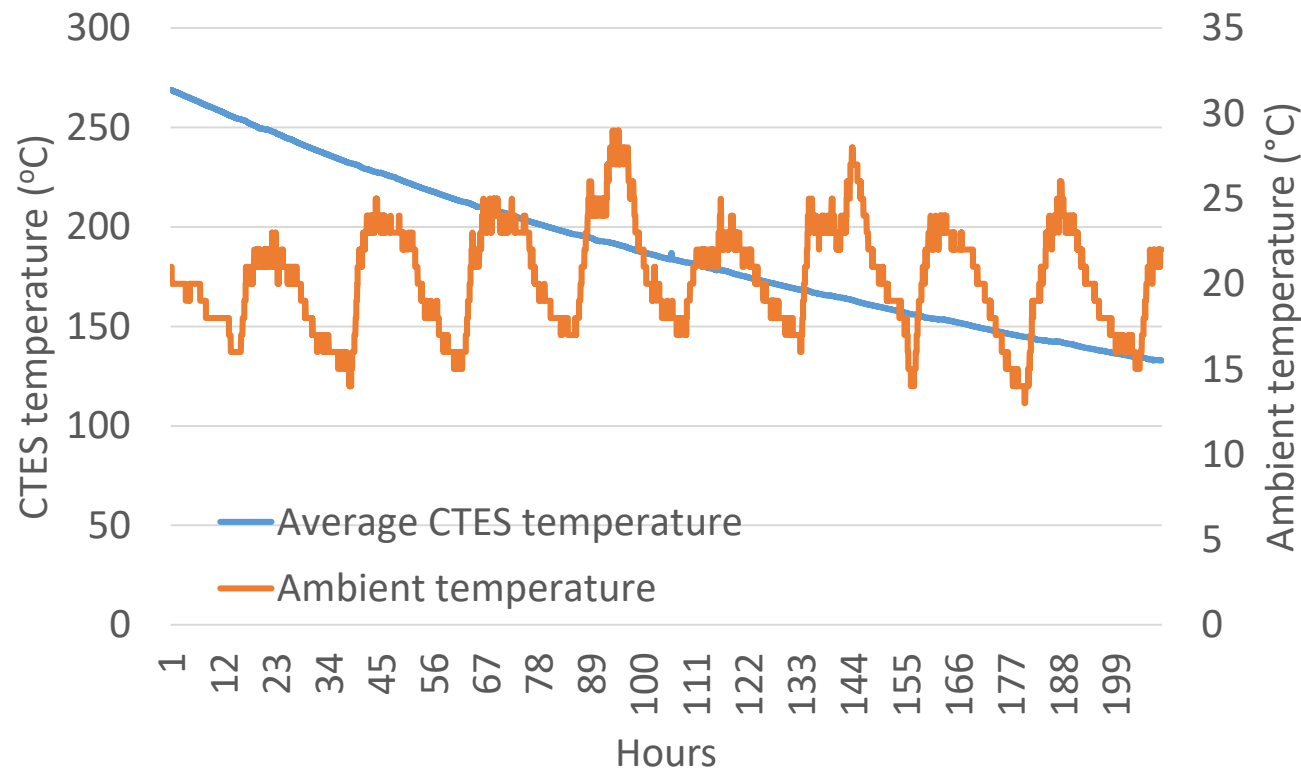
Total energy stored: 37 kW_{th} in 4.5 hours of operation



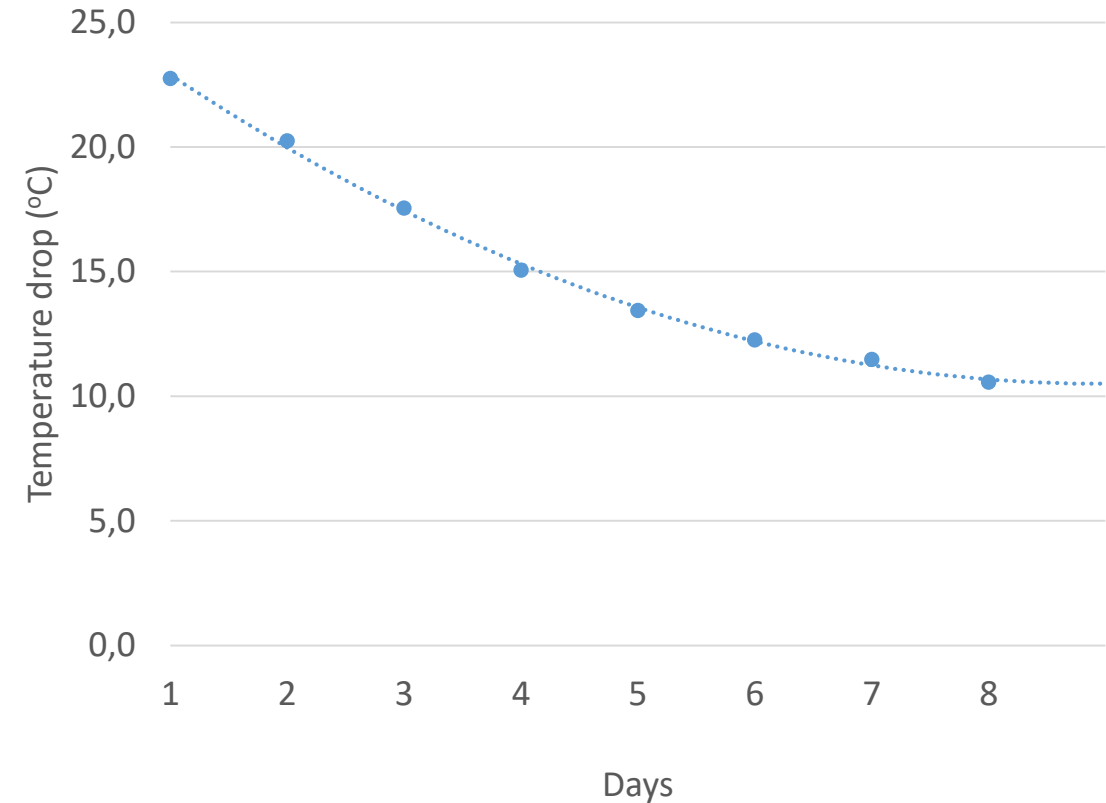
CTES Temperature Drop – Discharging'

ESCC2019- CUT

CTES left 209 hours with no HTD distribution:
Temperature Drop from 268 °C – 132°C



Slight temperature drop
First and 2nd day → less than 23°C
From 3rd to 9th day → less than 17°C per day



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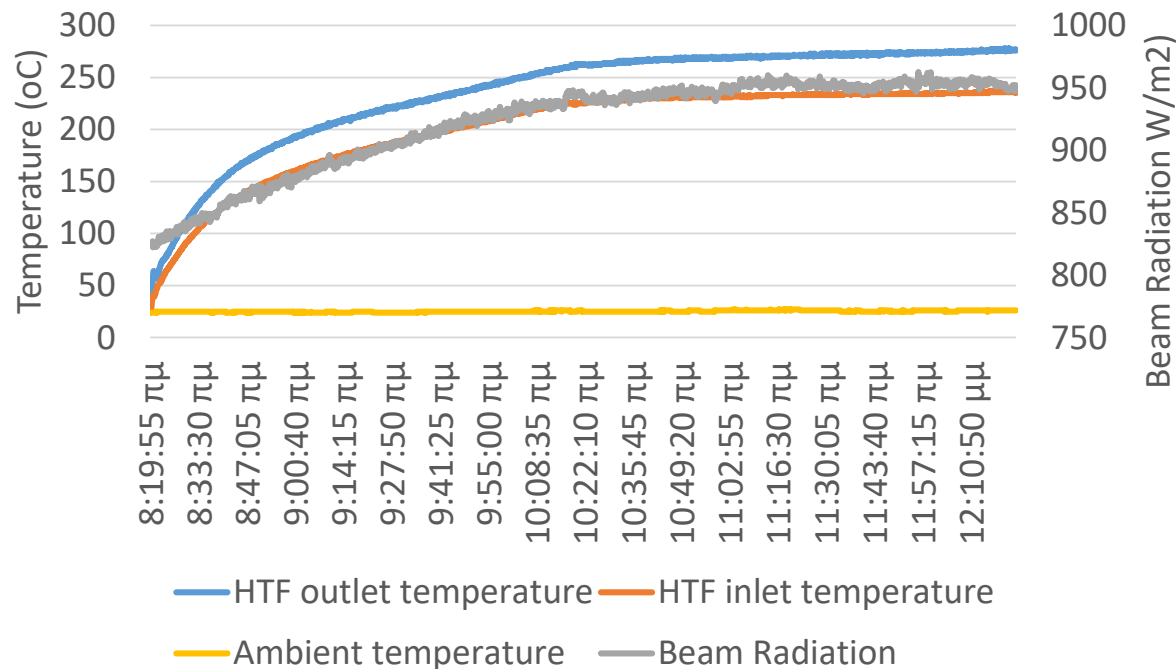
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Energy Production Tests

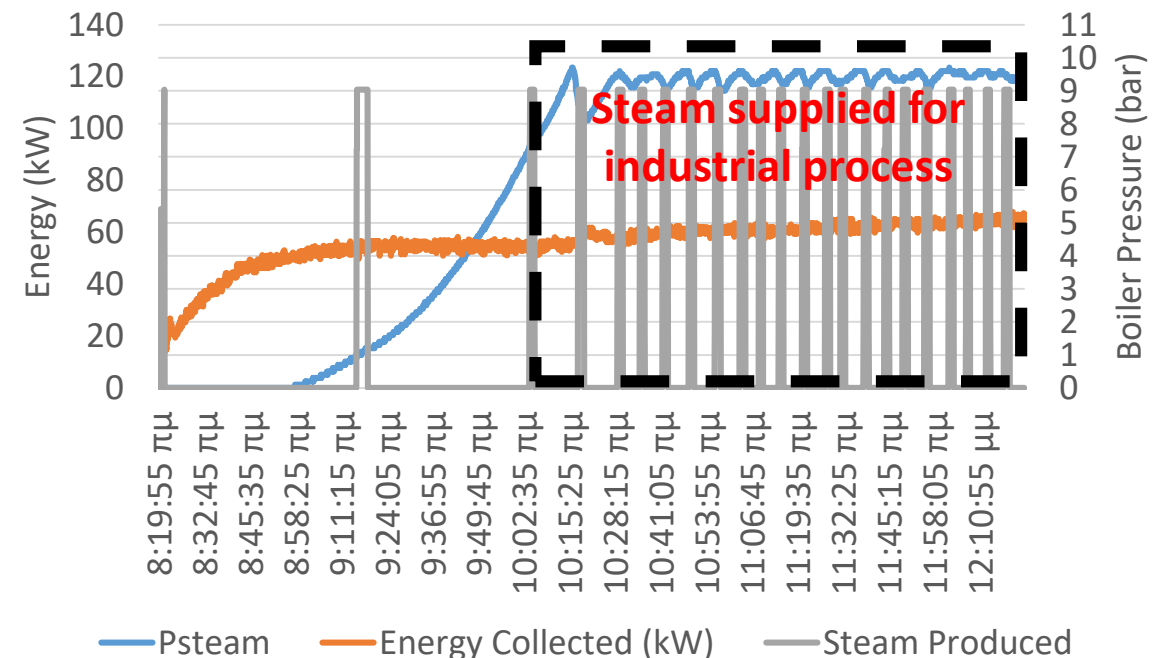
ESCC2019- CUT

- Test: 16/5/2019

- Mode:



Average DNI: 922 W/m
 Duration of operation: 4 hours
Total energy produced produced and supplied during half production mode: 3.9 MW_{th}
Energy collected to Energy supplied: 42.39 %



Energy Production Tests

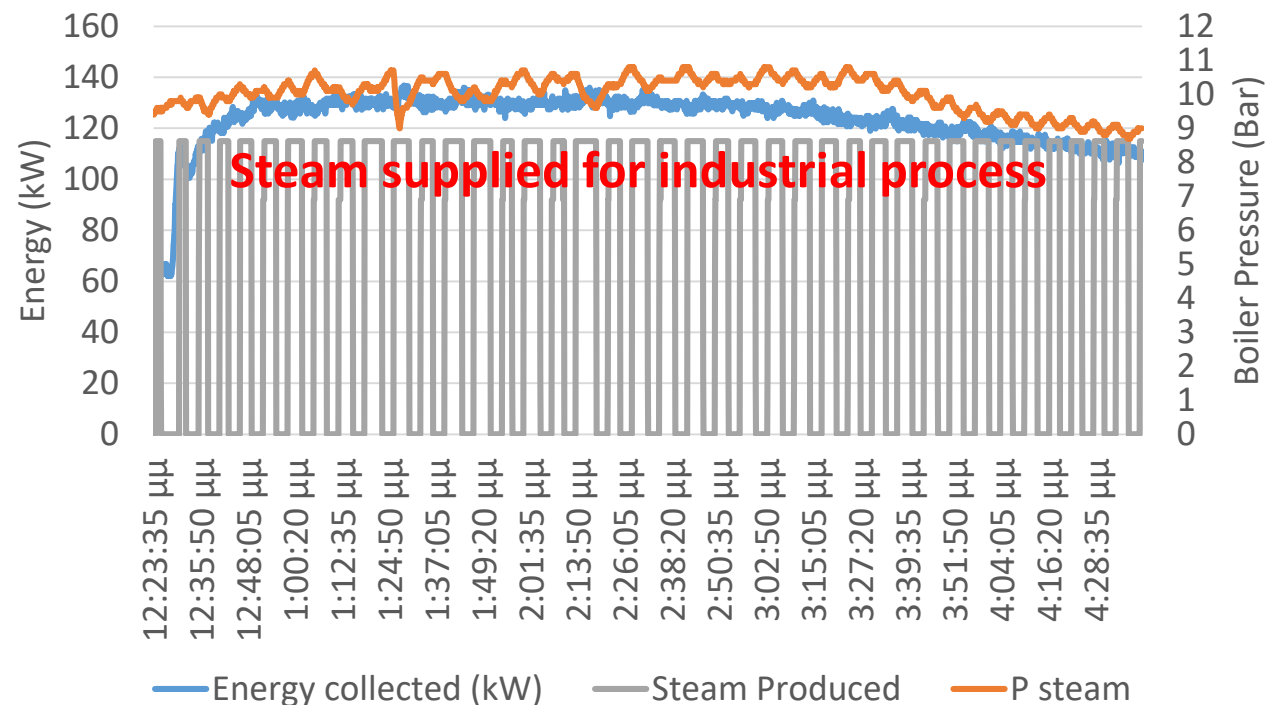
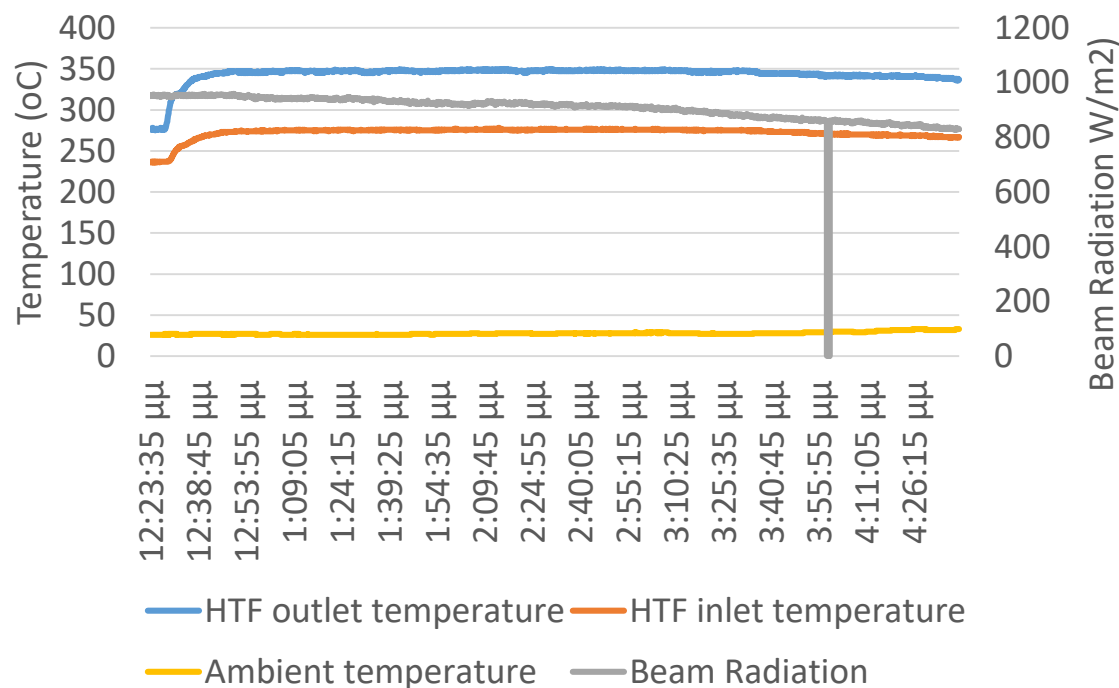
ESCC2019- CUT

- Test: 16/5/2019

- Mode:



Average DNI: 922 W/m²
 Duration of operation: 4 hours
Total energy produced and supplied during production mode: 187.2 MW_{th}
Energy collected to Energy supplied: 49.15%



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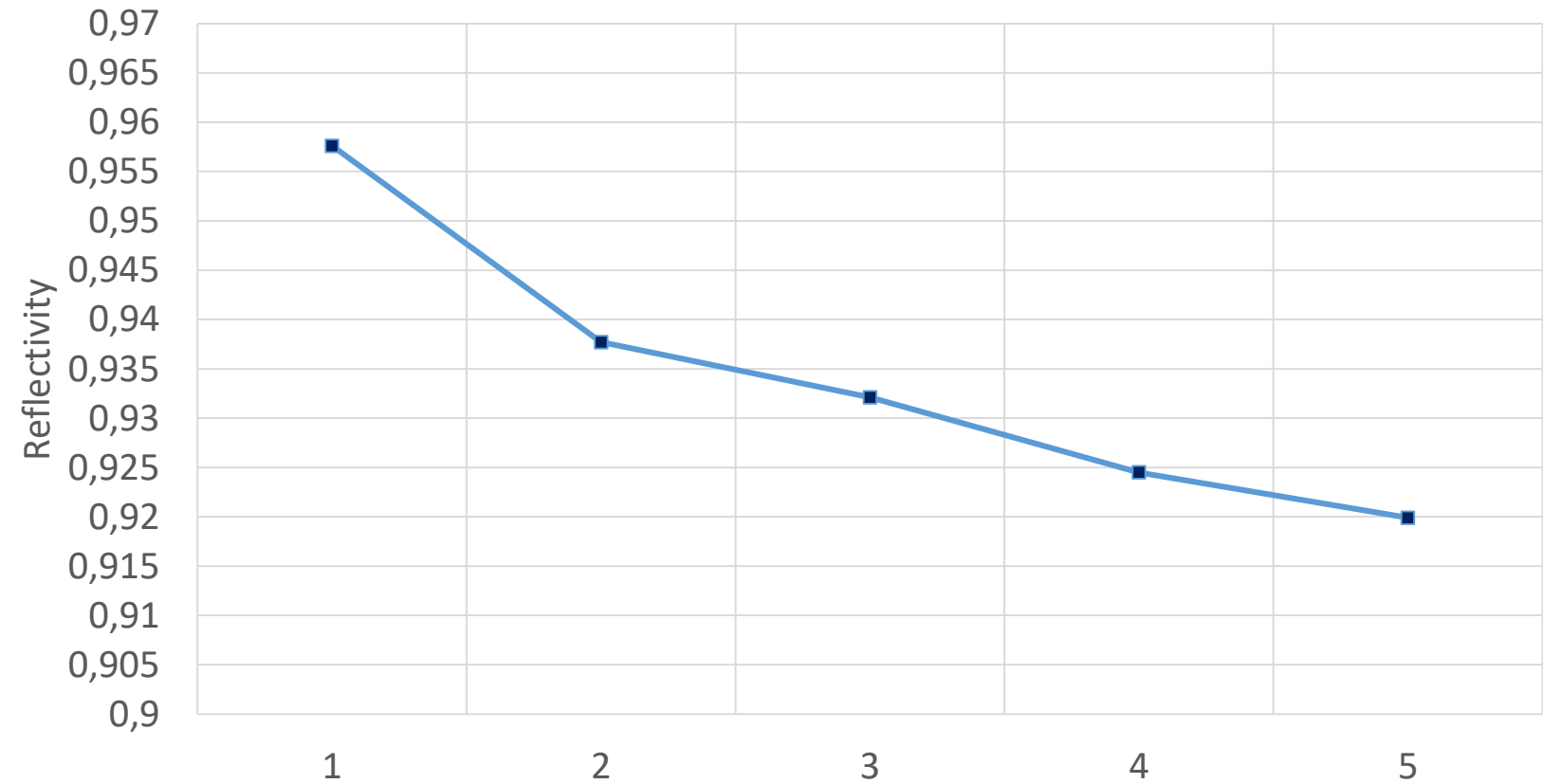
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Dirt Coefficient

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From 95.7% to 92%

- 3.7% drop



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Summary

ESCC2019- CUT

- The main fuel consumers in Cyprus are the transport (57 %) and industrial (20 %) sector.
- For industrial sector, manufacturing category is the most intensive (60 % of the whole fuel consumption).
- Food and beverage category is the main consumer of fuels consumption 40% of the total consumption (20.2MEUR/yr).
- The CTES storage with an average DNI of 712 W/m²K can store 20 kW_{th} per hour.
- The CTES left undisturbed and the temperature is dropped from 138 °C (268 °C to 132°C) after 209 hours.
- The U_{loss} varies from 15-20 W/m²K for a temperature drop of 10°C.
- The PTC system can produce and supply steam for industrial process of 42.5 MW_{th} per hour (with east and west mirrors tracking the sun, and average DNI: 854 W/m²K).
- The HTF needs 4 hours with West trough only tracking, to reach 276°C (average DNI: 922 W/m²K).
- The maximum energy collected to energy supplied was 49.25% (average DNI: 884 W/m²K and 5.5 operation hours) .

Acknowledgements

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engineered technologies



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Technology

Thank you for your attention..

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