

# Monitoring results from the SUNSTORE 4 smart district heating plant in Marstal, Denmark

Thomas Schmidt

Steinbeis  
Research Institute  
for Solar and  
Sustainable  
Thermal  
Energy Systems  
[www.solites.de](http://www.solites.de)

Meitnerstr. 8  
70563 Stuttgart, Germany  
[www.solites.de](http://www.solites.de)

The logo for solites, featuring the word "solites" in a lowercase, white, sans-serif font. The "o" is stylized with a small loop.

# Outline

- Introduction
- System level results
- Component level results
  - Solar collectors
  - Biomass boiler and ORC plant
  - Heat pump
  - Seasonal thermal energy storage
- Conclusions

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# Summary of main system components

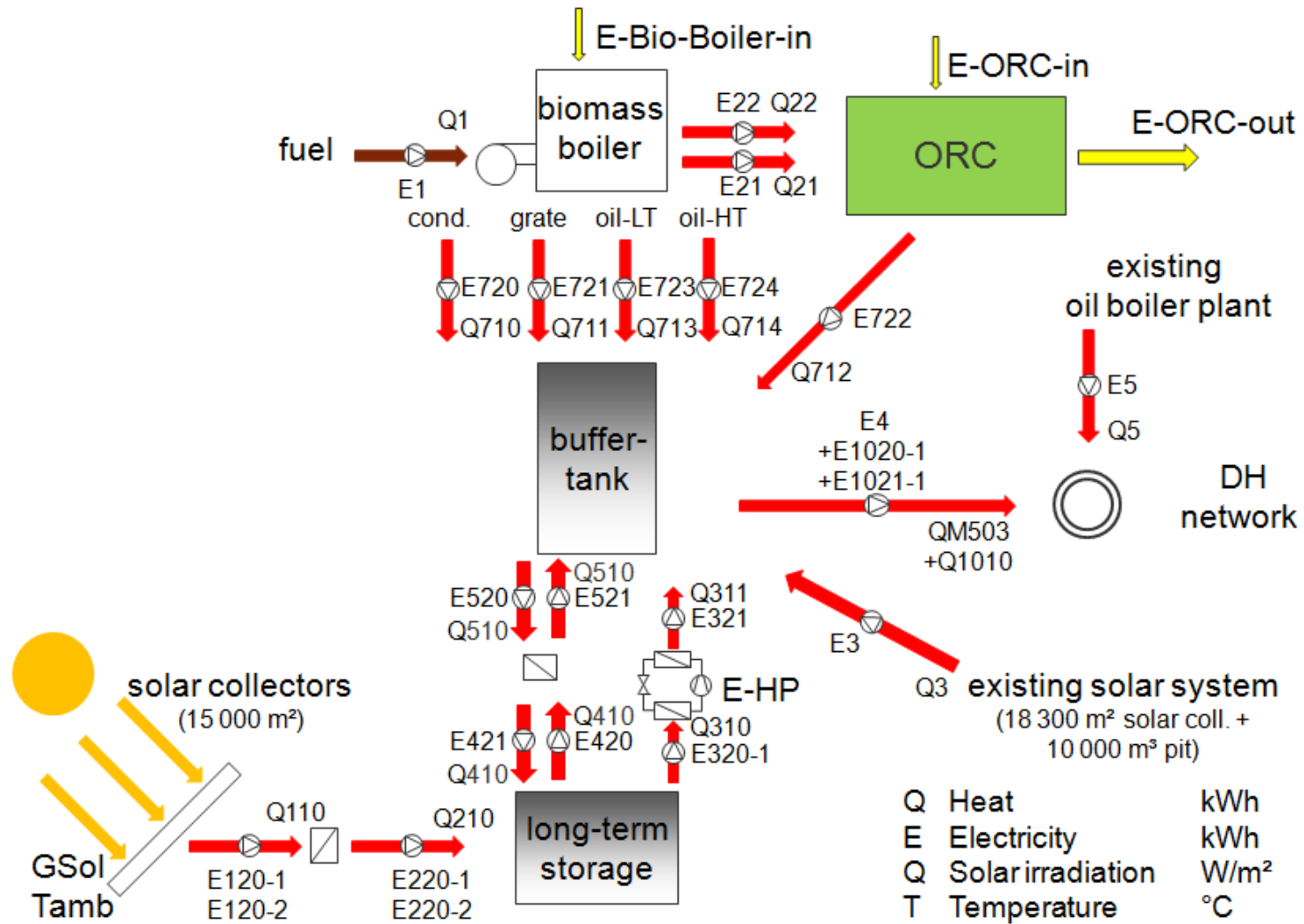
## SUNSTORE 1 + 2:

- 18 300 m<sup>2</sup> solar collectors
- 2 100 m<sup>3</sup> buffer storage
- 10 000 m<sup>3</sup> pit thermal energy storage (S2 PTES)
- 400 kW<sub>th</sub> heat pump
- 18.3 MW<sub>th</sub> bio-oil boilers

## SUNSTORE 4:

- 15 000 m<sup>2</sup> solar collectors
- 75 000 m<sup>3</sup> pit thermal energy storage (S4 PTES)
- 4 MW<sub>th</sub> biomass boiler
- 750 kW<sub>el</sub> ORC unit (Organic Rankine Cycle)
- 1.5 MW<sub>th</sub> CO<sub>2</sub> heat pump

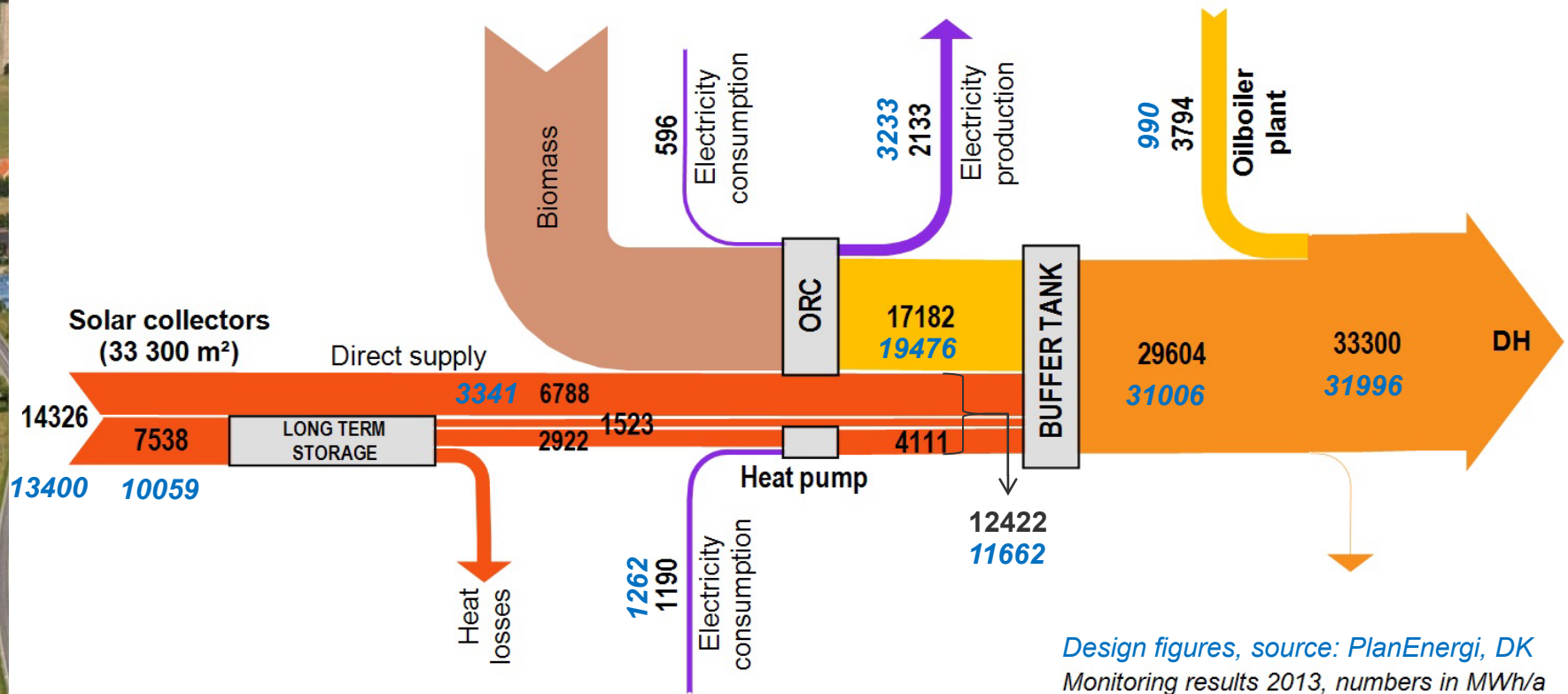
# Monitoring concept





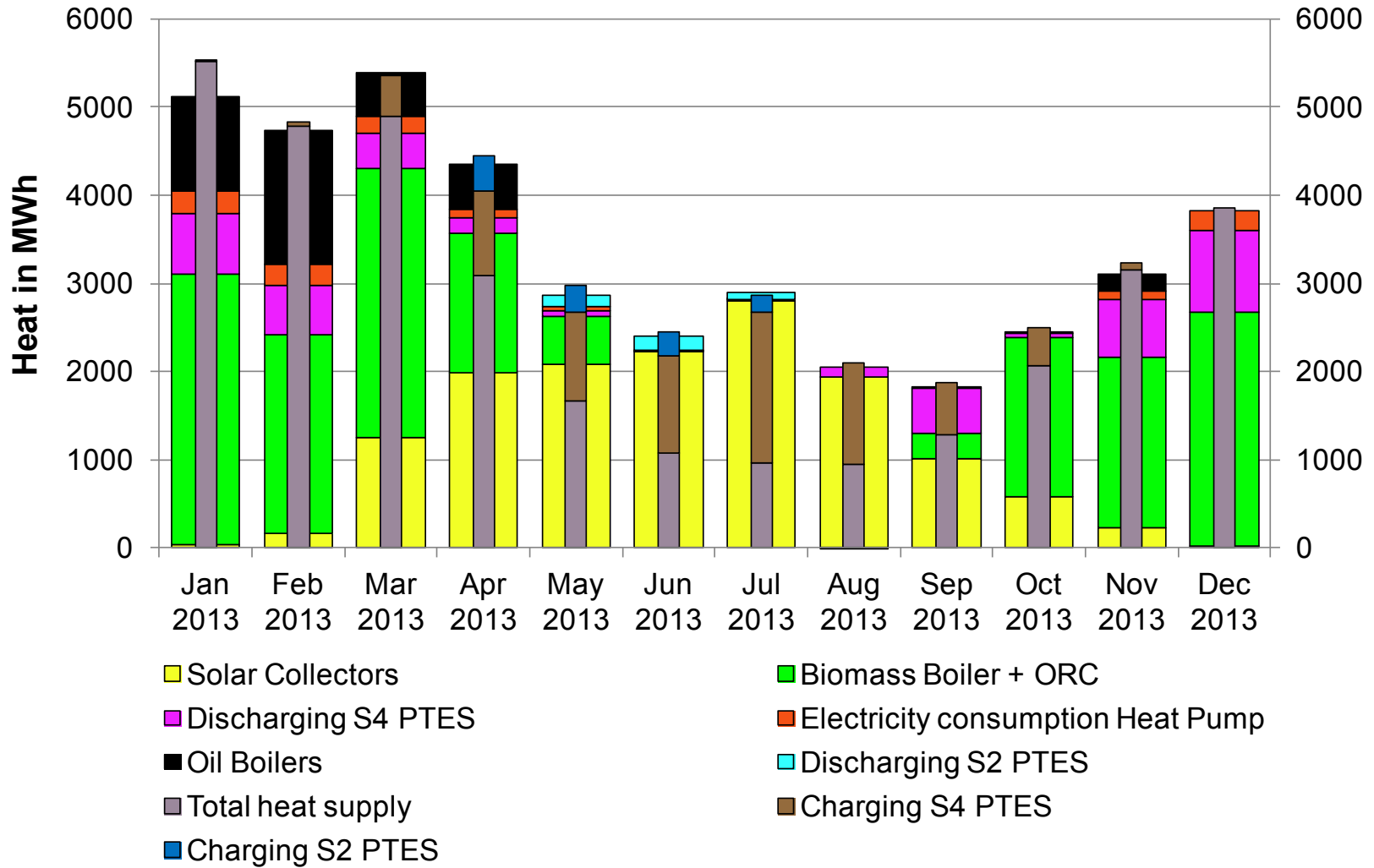
# Energy flow diagram | Year 2013

Solar fraction: 34 %  
 Biomass fraction: 52 %  
 RES fraction: 100 %

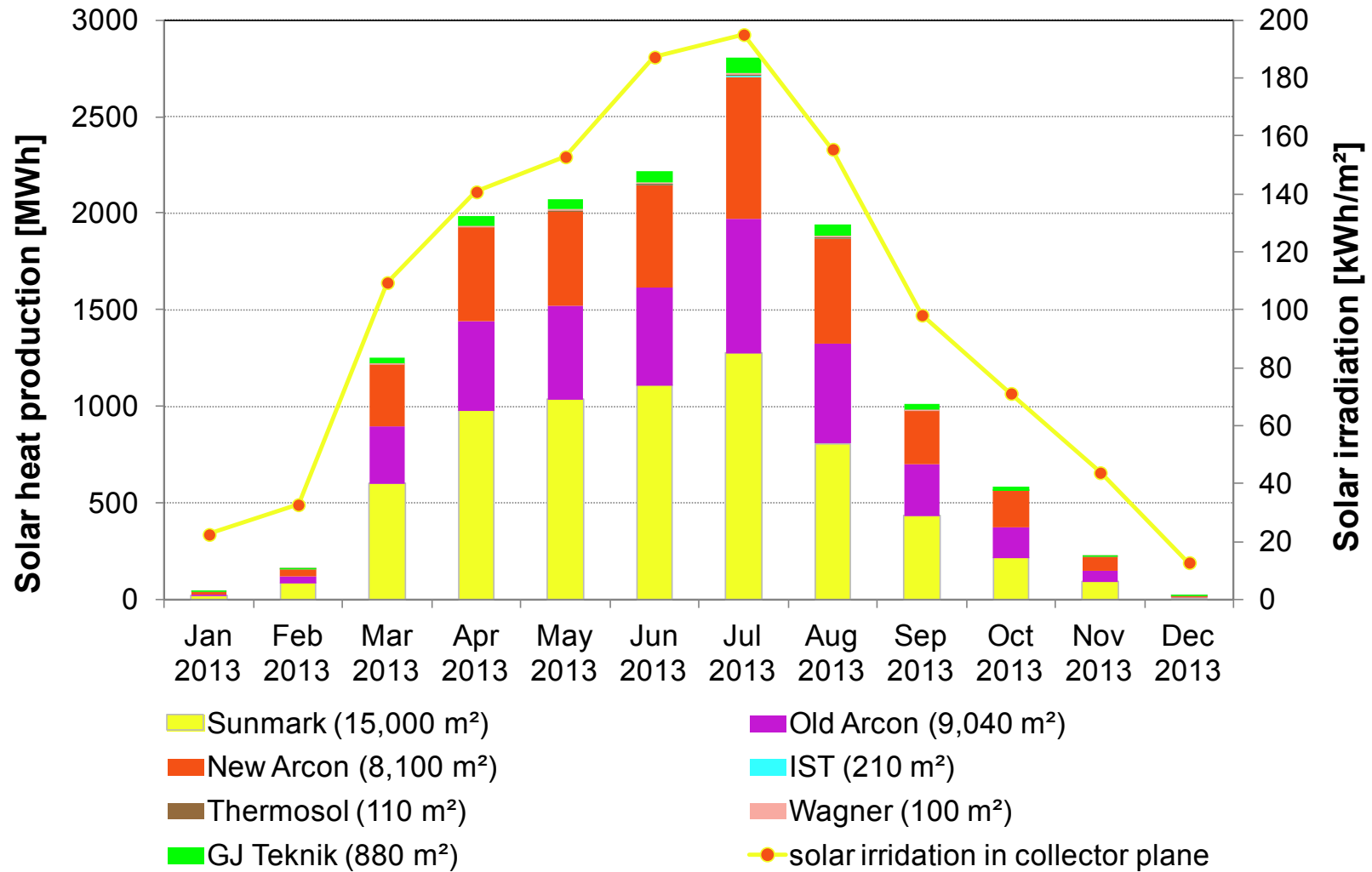


Design figures, source: PlanEnergi, DK  
 Monitoring results 2013, numbers in MWh/a

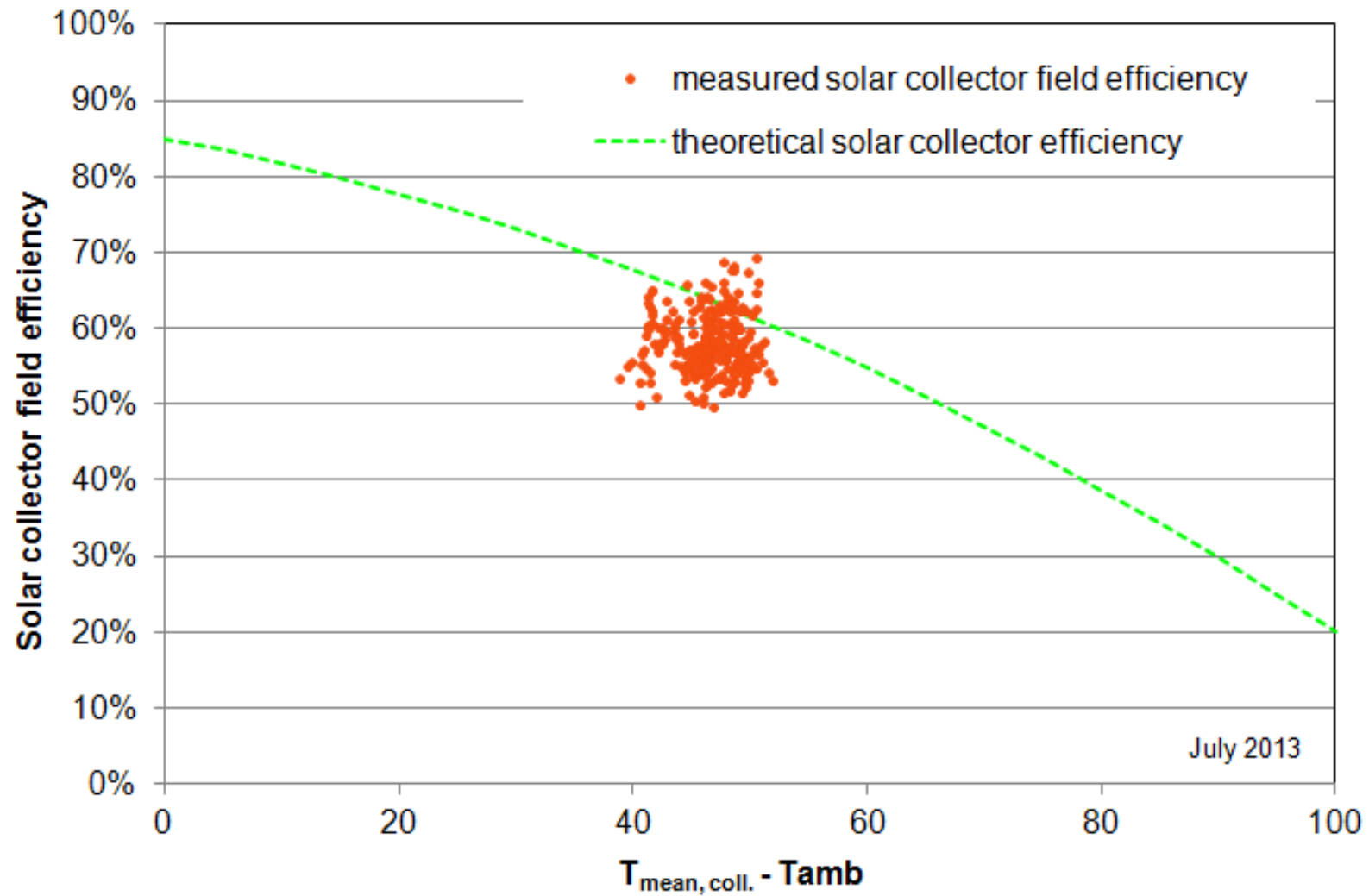
# System heat balance



## Solar collector fields | heat production

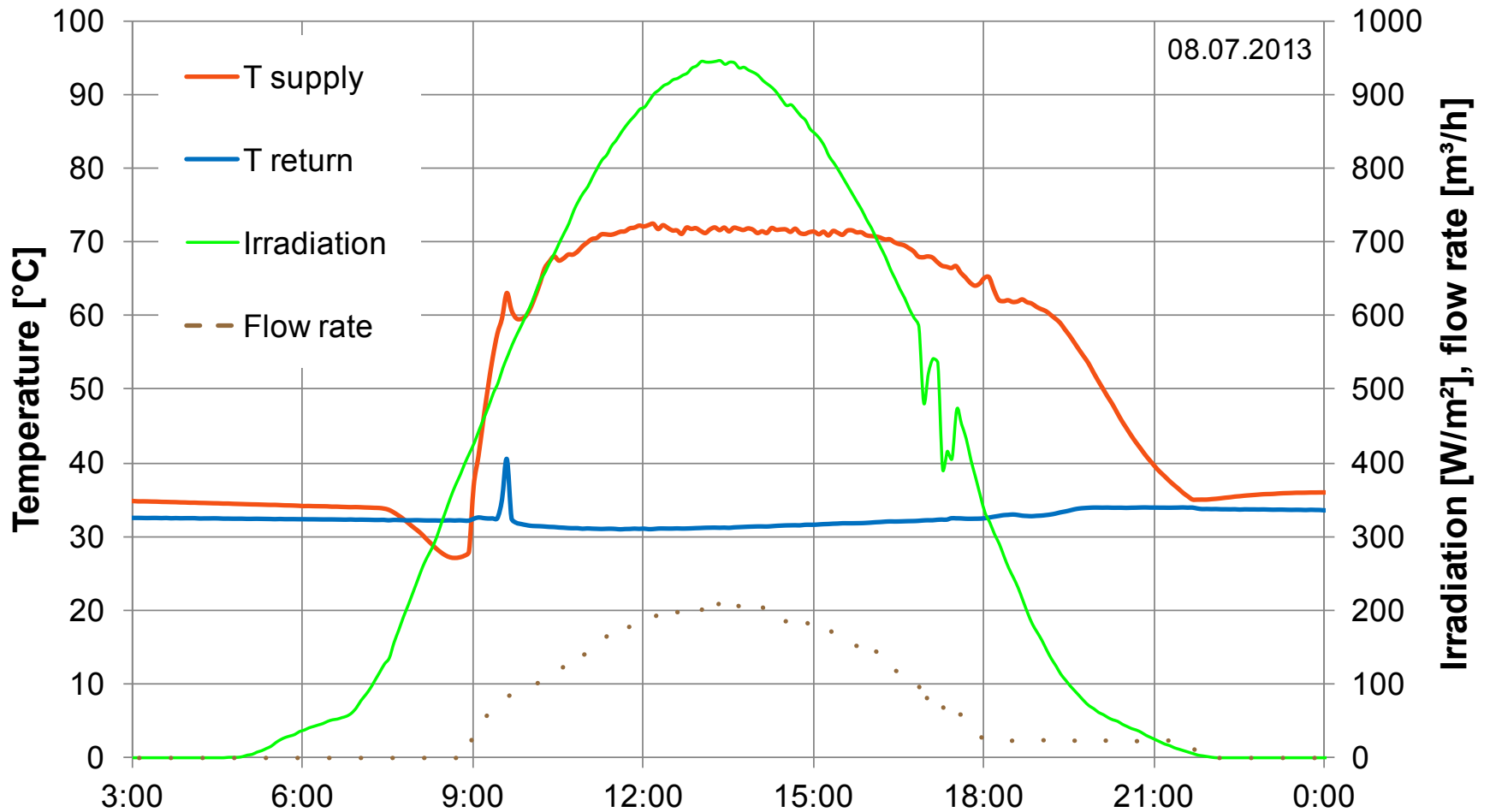


## Sunmark solar collector field | efficiency

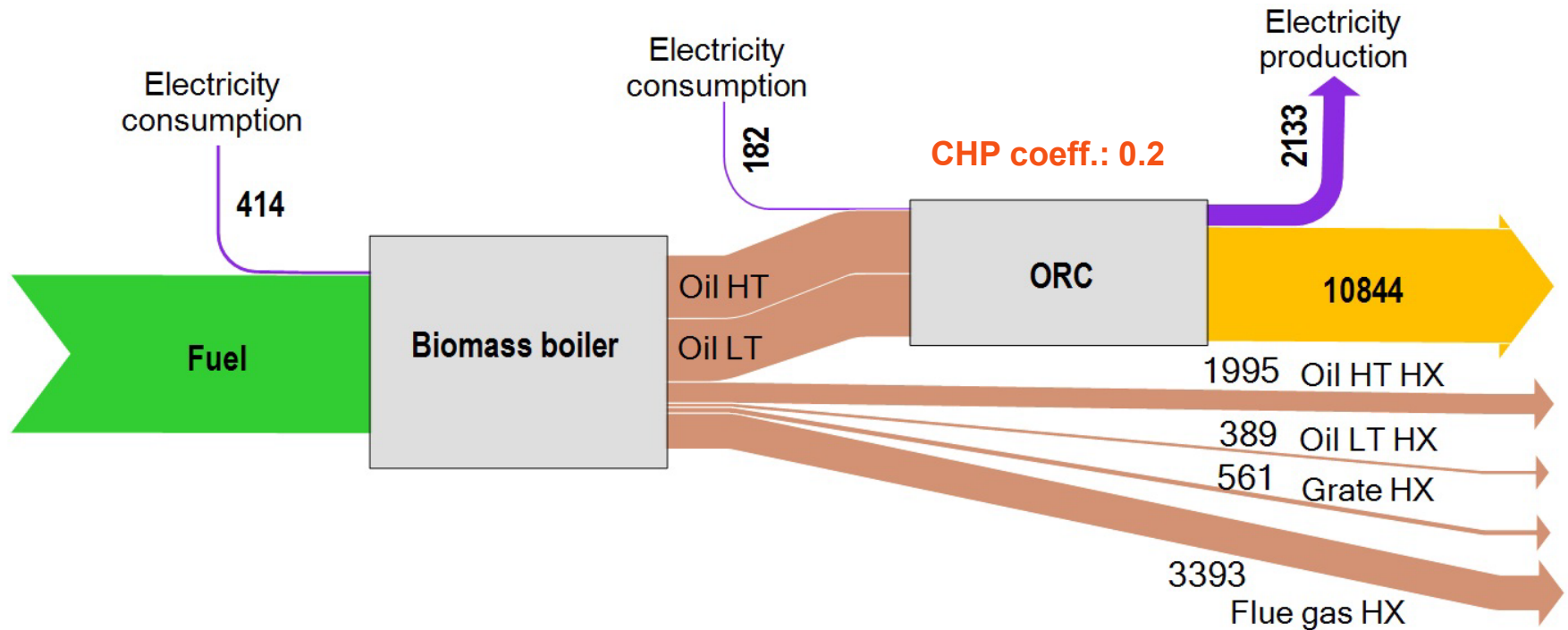




## Sunmark solar collector field | operation



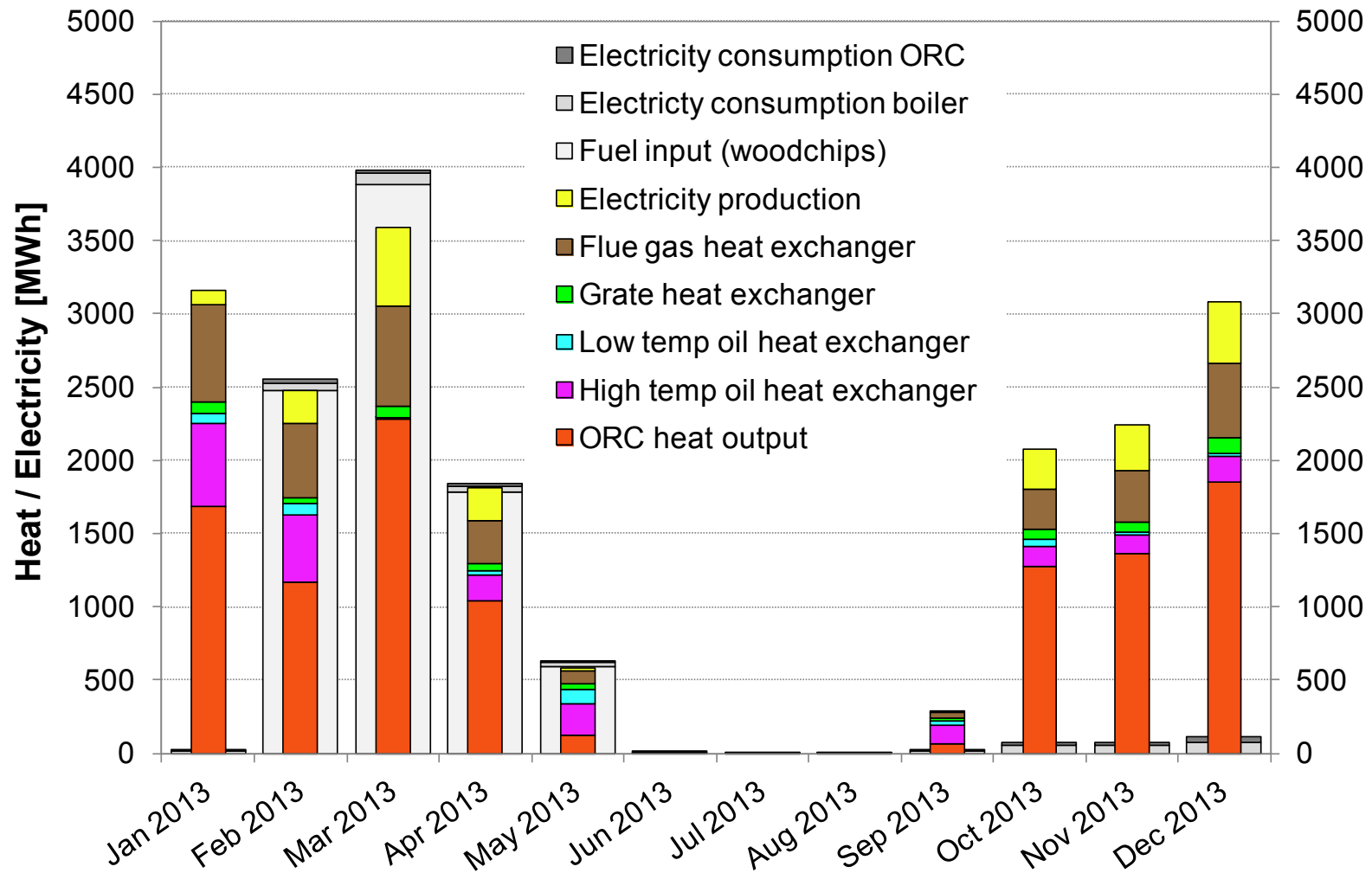
## Biomass boiler and ORC | energy flow



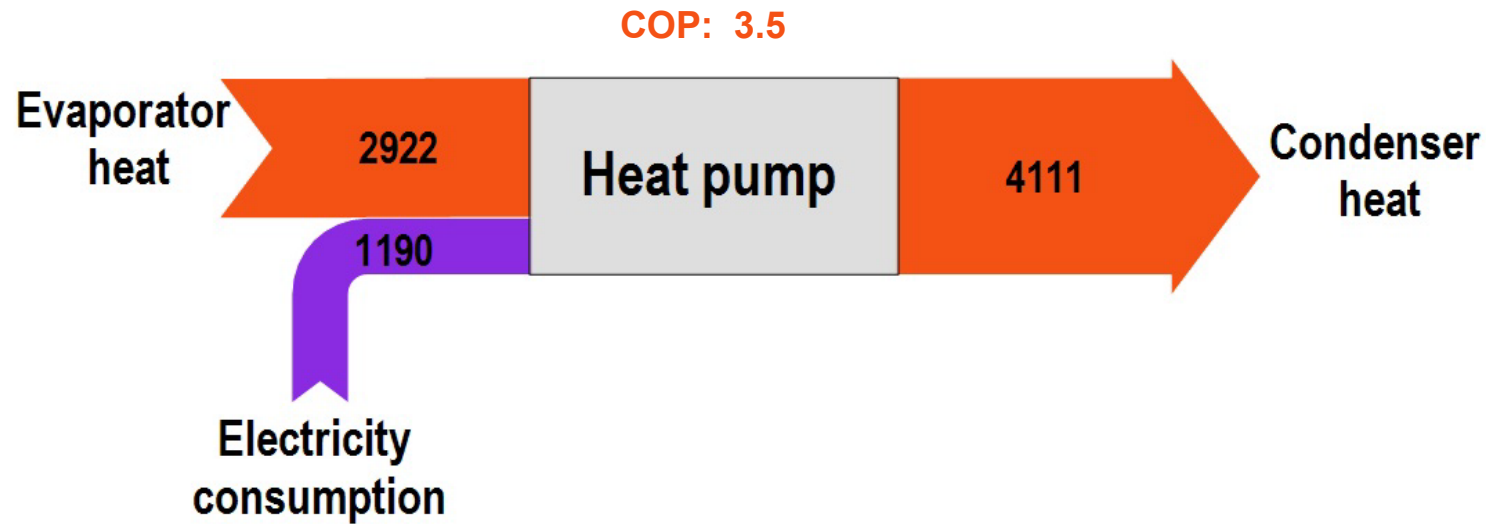
LT: low temperature; HT: high temperature, HX: heat exchanger

Monitoring results 2013, numbers in MWh/a

## Biomass boiler & ORC | energy balance

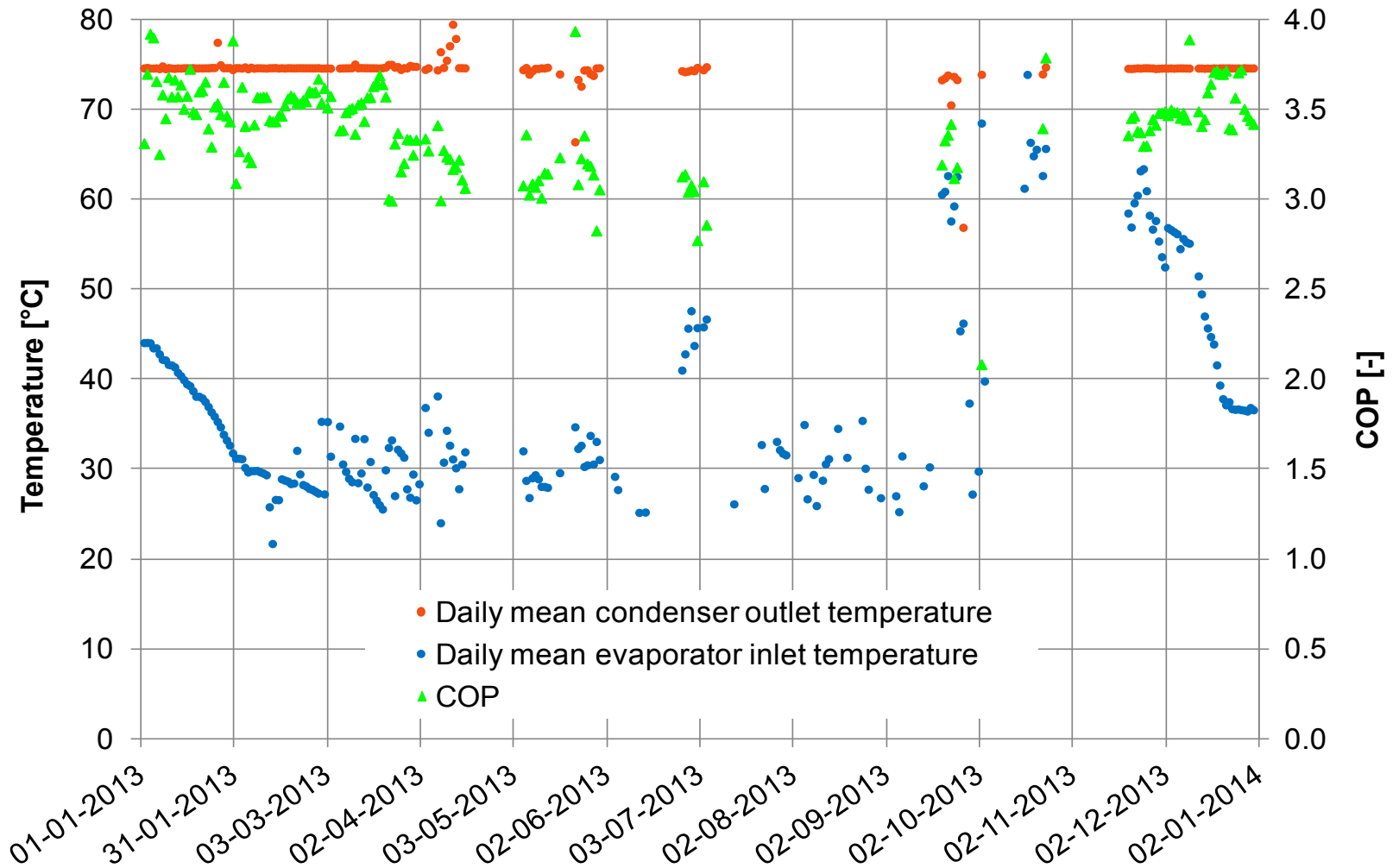


## Heat Pump | energy flow



*Monitoring results 2013, numbers in MWh/a*

## Heat pump operation | daily mean values





## Sunstore 4 pit | energy flow

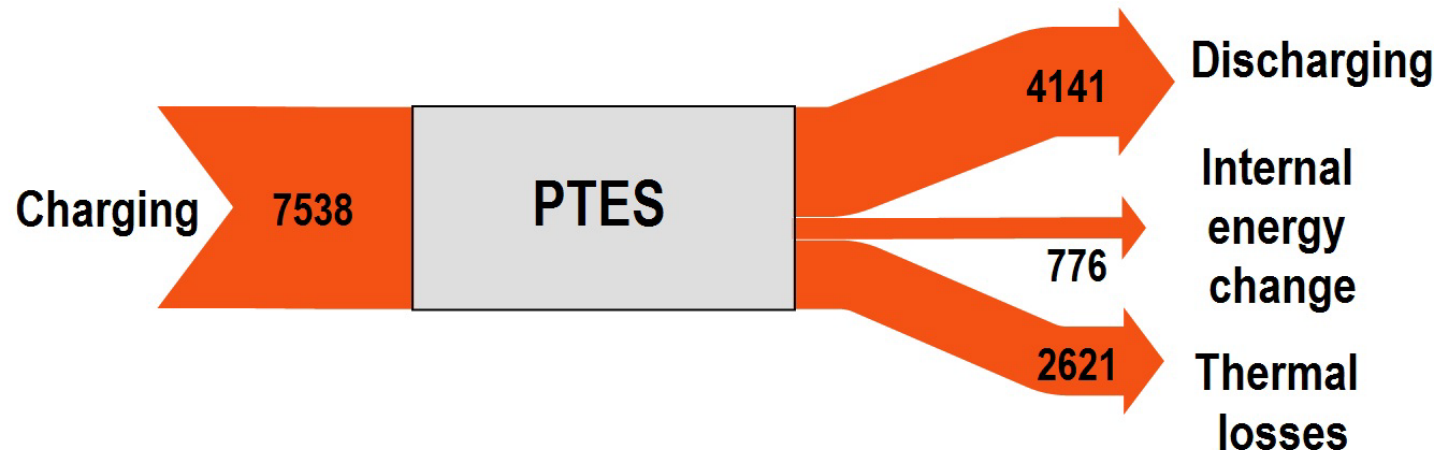
Storage efficiency: 65 %

T-max: 77.0 °C

No. of storage cycles: 0.8

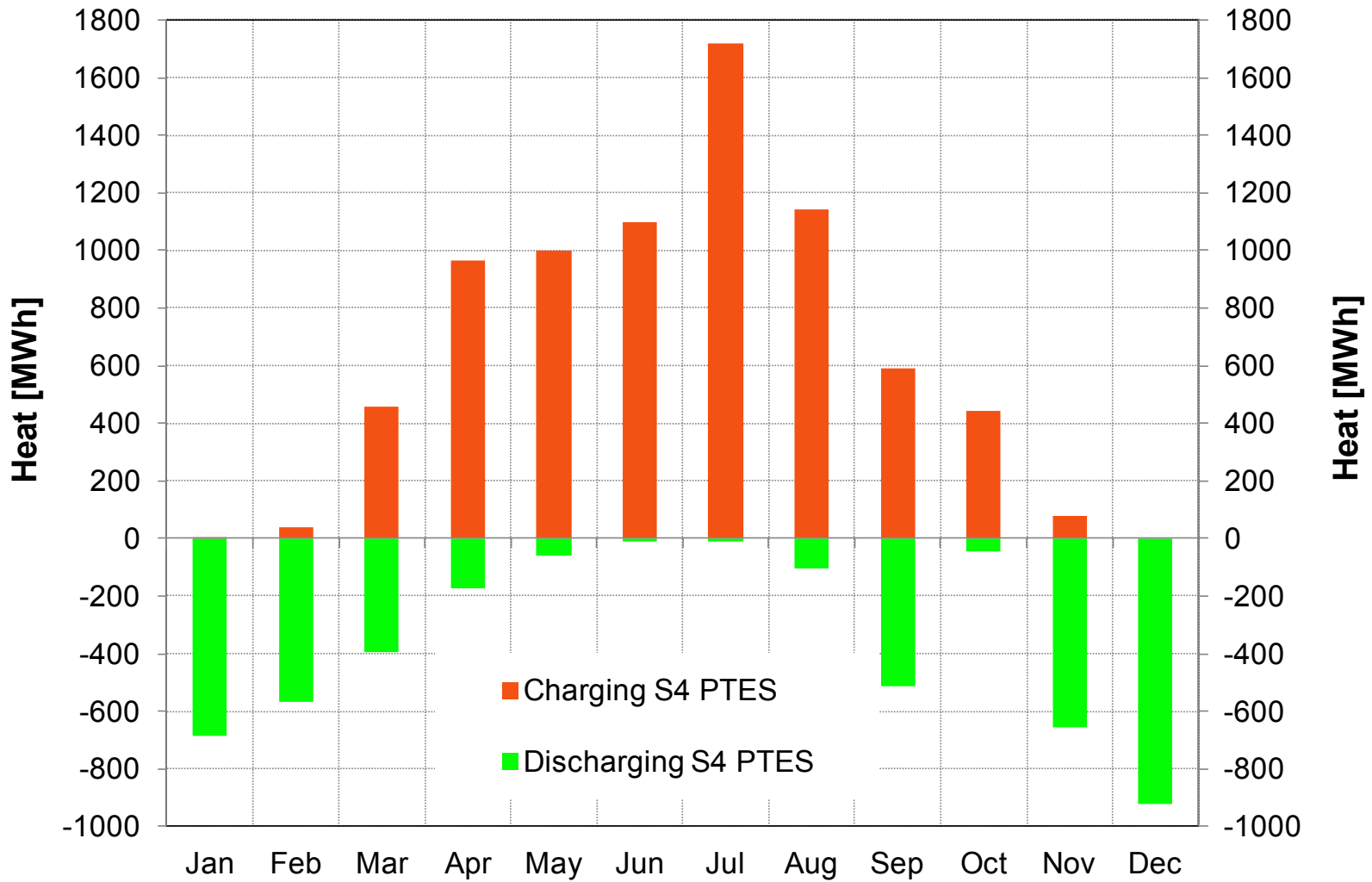
T-min: 12.9 °C

Heat capacity (64 K): 5 500 MWh

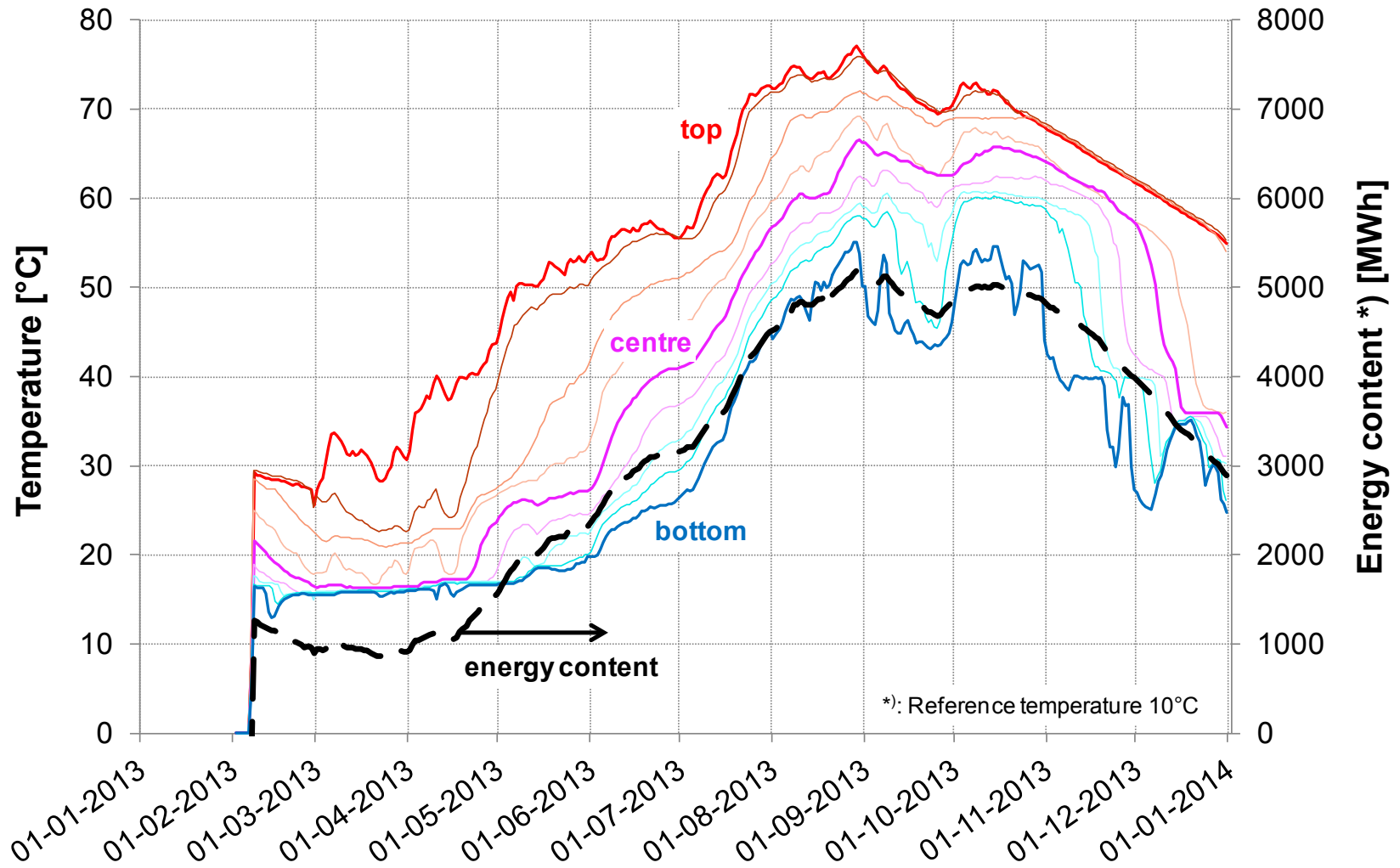


*Monitoring results 2013, numbers in MWh/a*

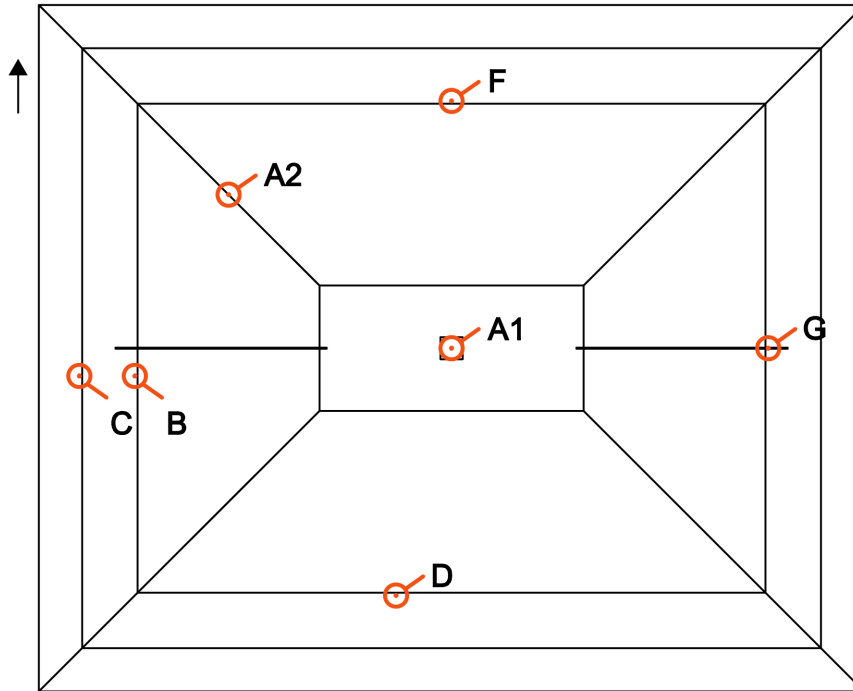
## Sunstore 4 pit | energy balance



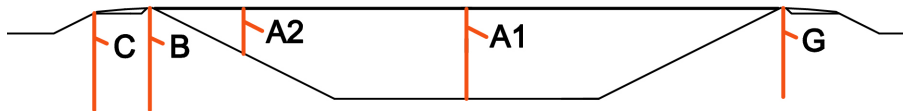
## Sunstore 4 pit storage | temperature development



## Sunstore 4 pit storage | ground temperature sensors

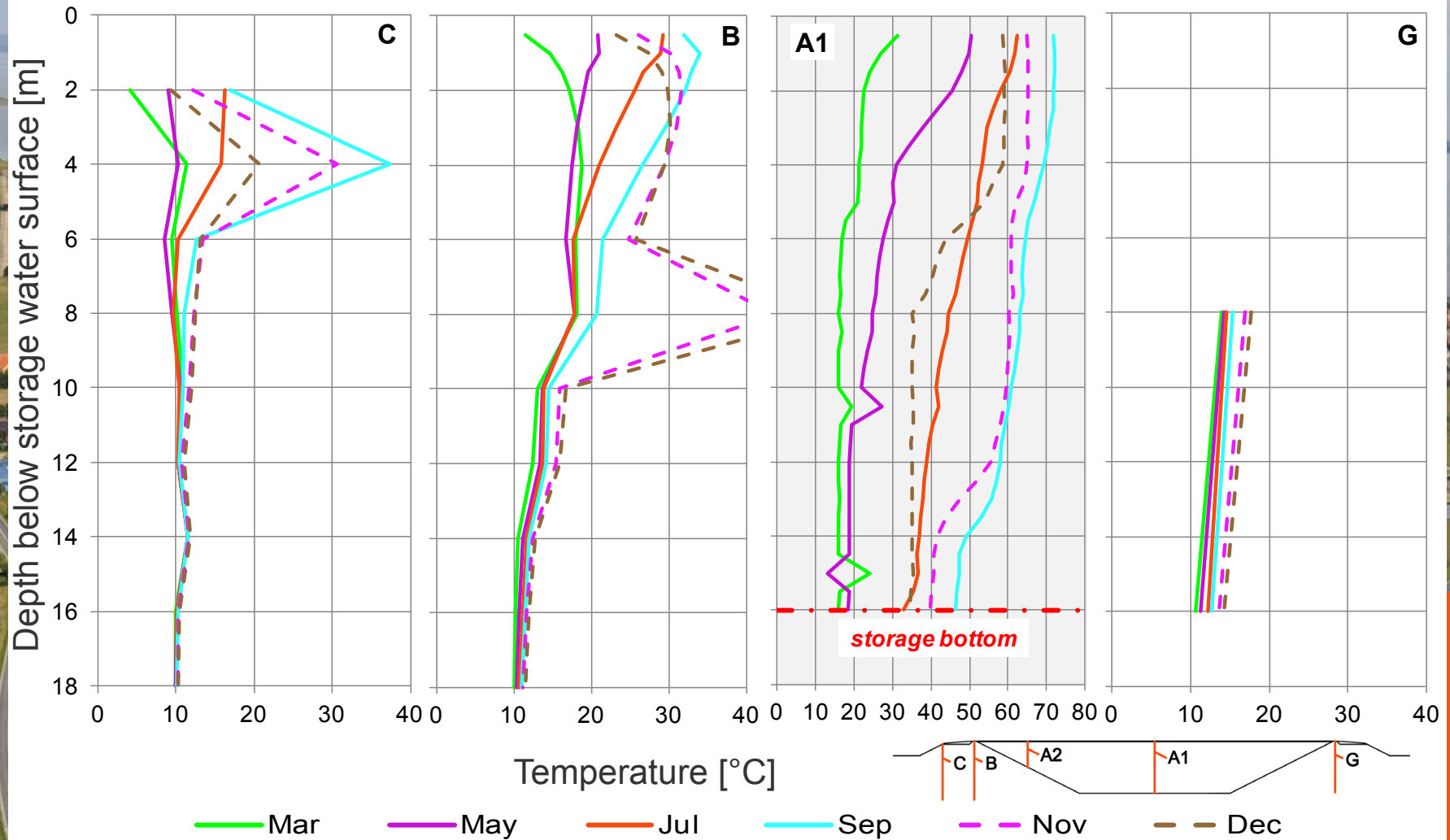


top view



vertical section

## Sunstore 4 pit storage | ground temperatures 2013





## Conclusions

- Monitoring results for 2013 show good agreement with design data
- Solar fraction: 34%
- Renewable energy share: 100%
- Efficient operation of main SUNSTORE 4 components confirmed
- Further reduction of backup boiler contribution expected

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Thank you for your attention...

More information:

[www.sunstore4.eu](http://www.sunstore4.eu)

[www.solar-district-heating.eu](http://www.solar-district-heating.eu)

[www.solites.com](http://www.solites.com)



Photo: Marstal Fjernvarme