XIV International Conference on Science, Arts and Culture
Geothermal Energy: Status and Future in the Adriatic Region
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# The GROUND-MED Project - Advanced GROUND source heat pump systems for heating and cooling in MEDiterranean climate

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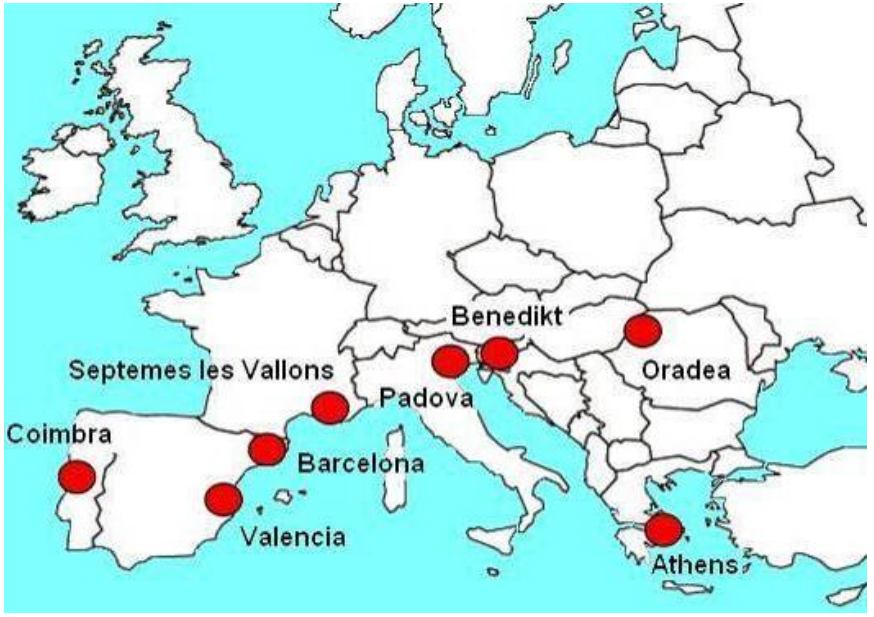
# Project summary

- Technology development, demonstration & monitoring of a new generation of ground source heat pump systems for heating & cooling, with the objective to maximize energy efficiency (measured annual SPF >5,0)
- 6-year project: 2009-2014
- Co-financed by FP7
- Budget ~7,25 x$10^6$ €
- EU support ~4,3 x$10^6$ €
- http://www.groundmed.eu/

- The technology is demonstrated at 8 buildings in South Europe:



# Project partners

**The project is implemented by a consortium of 24 partners coordinated by CRES**

- CRES (ΚΑΠΕ)
- CEA
- UOradea
- ISR-UCoimbra
- UPValencia
- UCDublin
- Upadova
- IPSetubal
- KTH
- CIAT
- HIREF
- OCHSNER WP
- EHPA
- EGEC
- CREΤh
- CETIAT
- GEJZIR
- GEOTEAM
- BESEL
- ECOSERVEIS
- EDRASIS
- Groenholland
- ENEREN
- FIZ

# Energy efficient technologies developed or tested (1)

## Heat pumps

- Tandem compressors: 4 prototypes
- Inverter compressor: 1 prototype
- Single on-off compressor: 3 prototypes
- External reversion of cooling/heating mode
- Heat rejection at the sanitary water loop

## Cold storage

- Phase change material at 8°C
- Ice-cubes with additives

# Energy efficient technologies developed or tested (2)

## Fan coil units (FCU)

- Low temperature heating: 35°C
- Light weight impeller
- Permanent magnet brushless motor

## Air handling unit (AHU)

- Utilizing condensing heat for dehumidification

## Indoor heating/cooling system

- Wall heating with wall embedded pipes

# Energy efficient technologies developed or tested (3)

## Water loop pumps

- Smart, variable speed, energy class A

## Borehole heat exchangers

- Oversized for enhanced performance
- Water without antifreeze as heat transfer fluid
- Grouting with fine gravel or coarse sand in the water table and bentonite above
- Free cooling provision directly from the earth

# Energy efficient technologies developed or tested (4)

## Operation control for improved efficiency

- Peak heating with max 40°C water supply to the FCU
- Peak cooling with min 15°C water supply to the FCU
- Temperature compensation depending on thermal load
- Synchronizing compressors with external pump and where feasible with internal pump(s) and air handling unit
- Frequency control of inverter driven compressor, pumps and fans based on experimentally derived functions

# Project objectives based on SPF

## Use of 4 COP, SPF values

$$COP = \frac{\text{Useful instant power}}{\text{Electrical power used}}$$

$$SPF = \frac{\text{Useful energy delivered in a given time period}}{\text{Electrical energy consumed in the same period}}$$

1. Electricity consumption at the compressors
2. + electricity consumption at the external pump
3. + electricity consumption at the internal pumps
4. + electricity consumption at the fans (FCU & AHU)

# Monitoring system

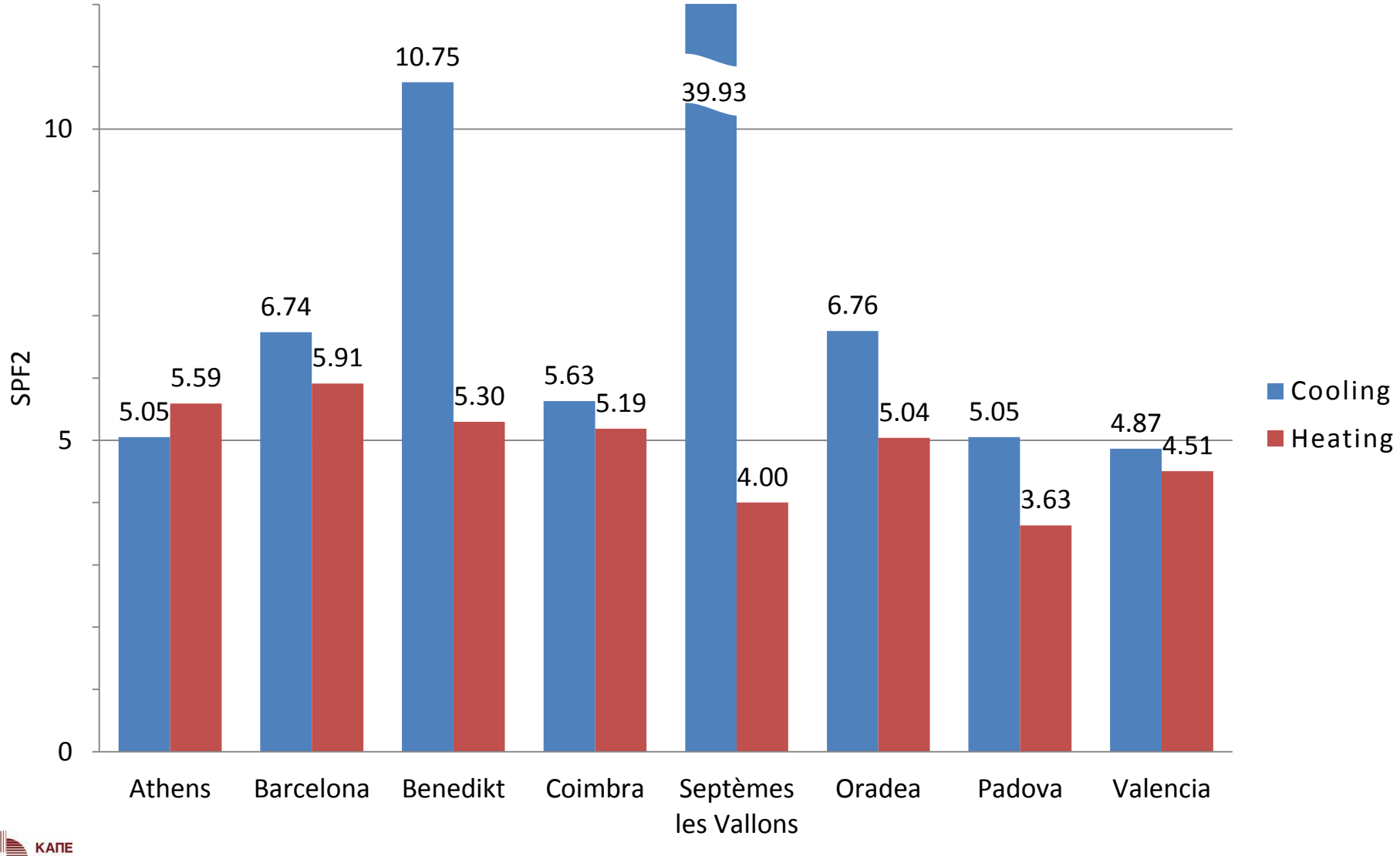
## Measuring equipment

- Thermal energy meters Brunata or Landis & Gyr
- Electrical energy analyzers Carlo Gavazzi

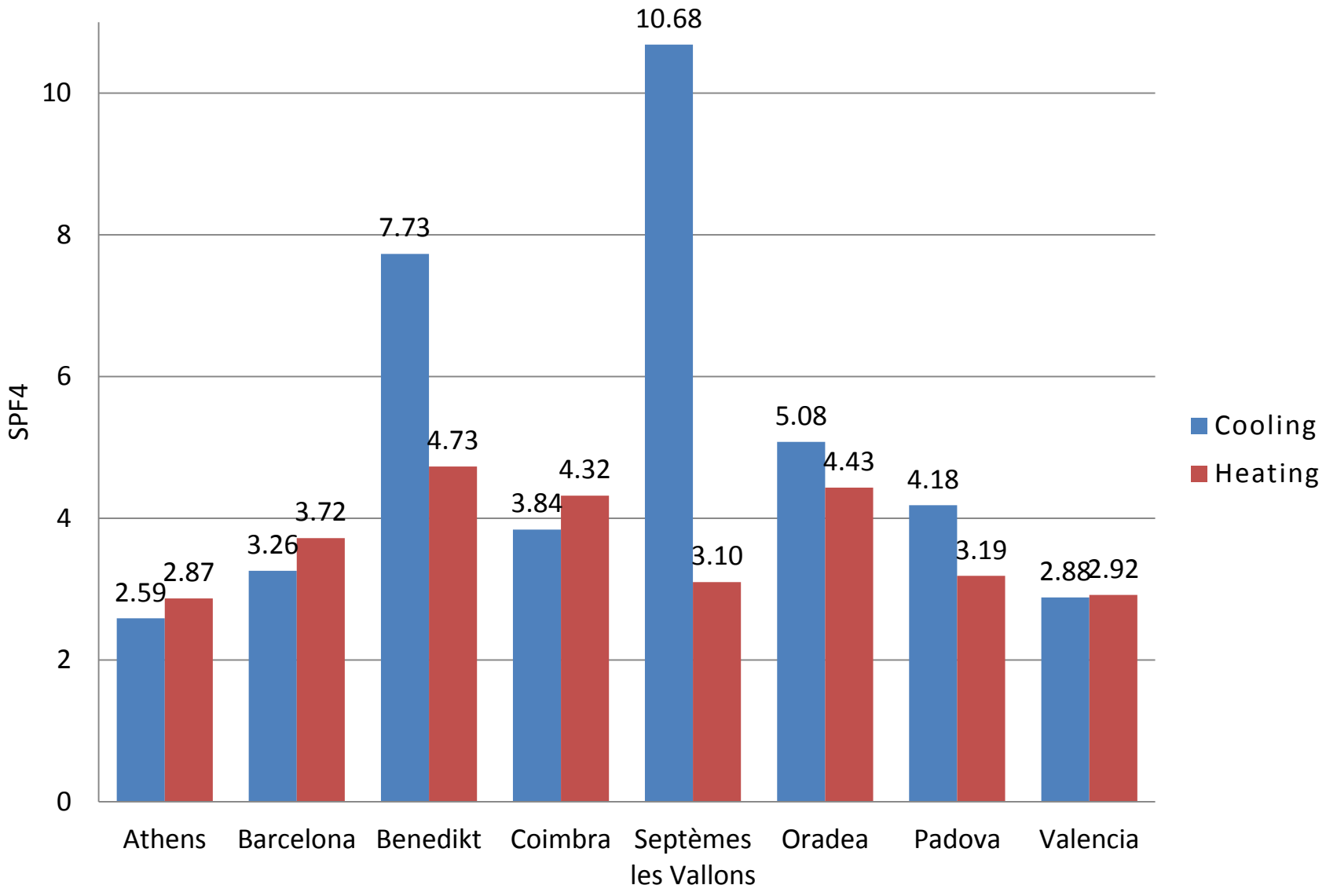
## Data logging

- Collecting data measurements in local PC
- Measurements taken every 15 sec, averaged every minute and stored in a local .txt file
- Data transmission to the central project server through ftp every 10 min
  - Hewlett Packard DL120 G7 Rack Data Server
- Available for download through the world wide web as .csv files
  - Detailed measurements in daily or user defined time frame files
  - Summary of daily average values for user defined periods

# SPF2


SPF2
10
5
0
5.05
5.59
6.74
5.91
10.75
5.30
5.63
5.19
39.93
4.00
6.76
5.04
5.05
3.63
4.87
4.51
Athens
Barcelona
Benedikt
Coimbra
Septèmes les Vallons
Oradea
Padova
Valencia
Cooling
Heating

# SPF4


SPF4
0
2
4
6
8
10
2.59
2.87
3.26
3.72
7.73
4.73
3.84
4.32
10.68
3.10
5.08
4.43
4.18
3.19
2.88
2.92
Athens
Barcelona
Benedikt
Coimbra
Septèmes les Vallons
Oradea
Padova
Valencia
Cooling
Heating

# CIAT local distribution centre, Septèmes les Vallons, Marseille

**Capacity:**

⇒25,0 kW heating

⇒22,5 kW cooling

**BHE:**

**6 x 100m,**

• Double-U

⇒11°C in winter

⇒17°C in summer

# Demonstrated technologies

## Heat pump

- CIAT prototype with tandem compressors

## Cold storage nodules

- CRISTOPIA prototype

## Air handling unit (AHU)

- CIAT prototype utilizing condensing heat

# Indoor heating/cooling system

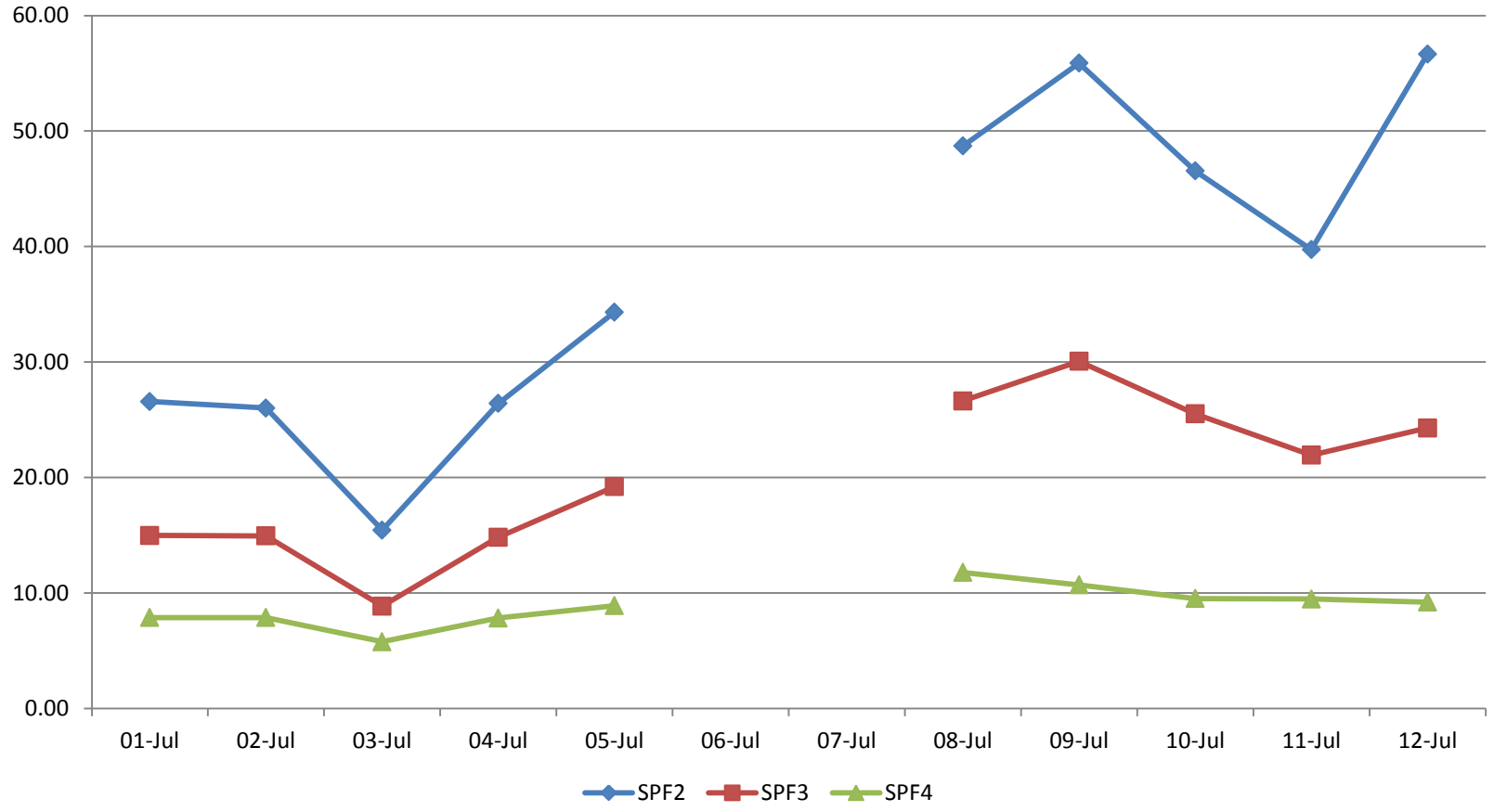
## Fan coil units

- CIAT prototypes
- Extremely low electrical consumption
- Exploiting coanda effect for low temperature heating

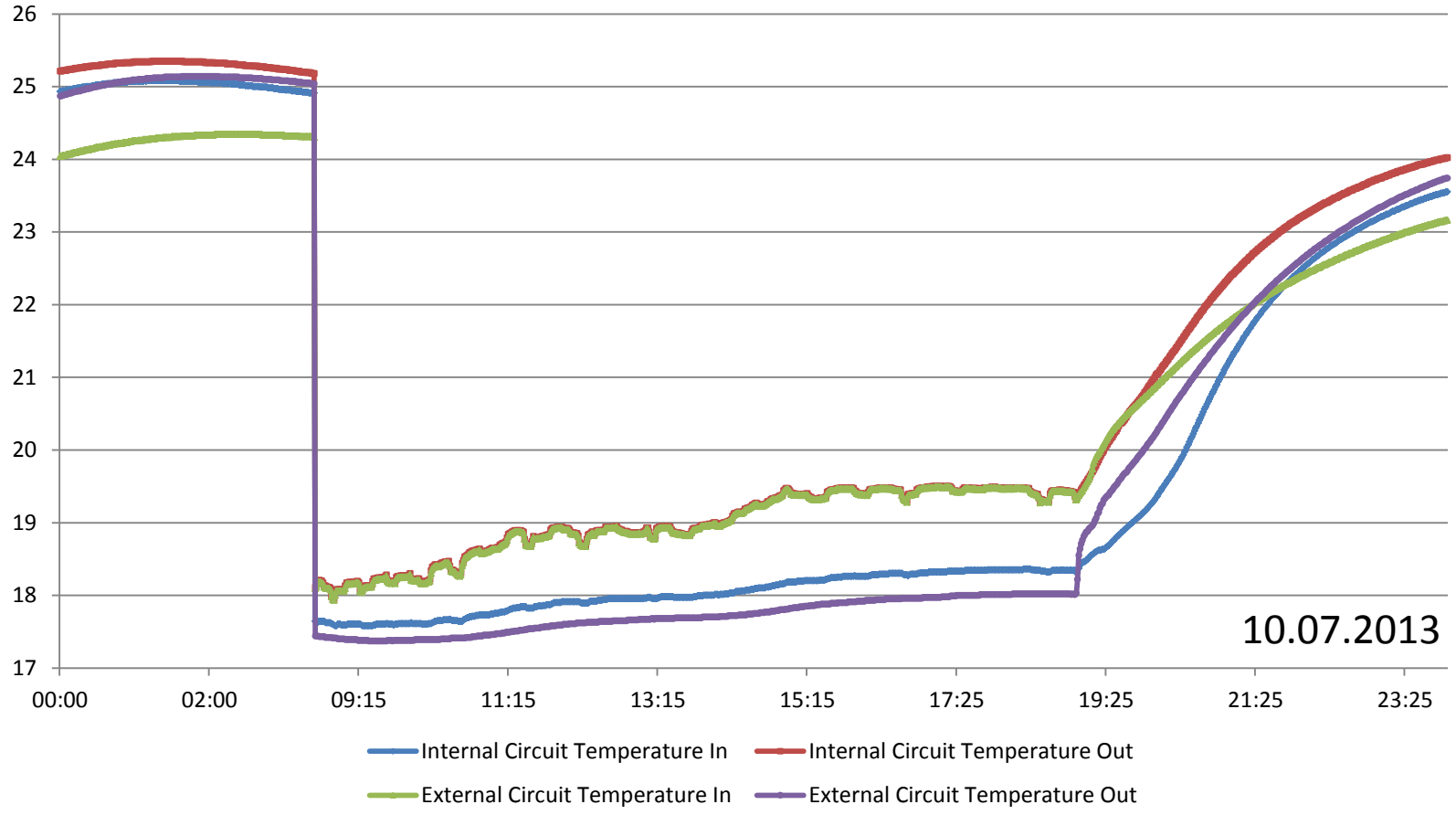
# *Cooling operation:*

# *Free cooling (directly from the BHE)*

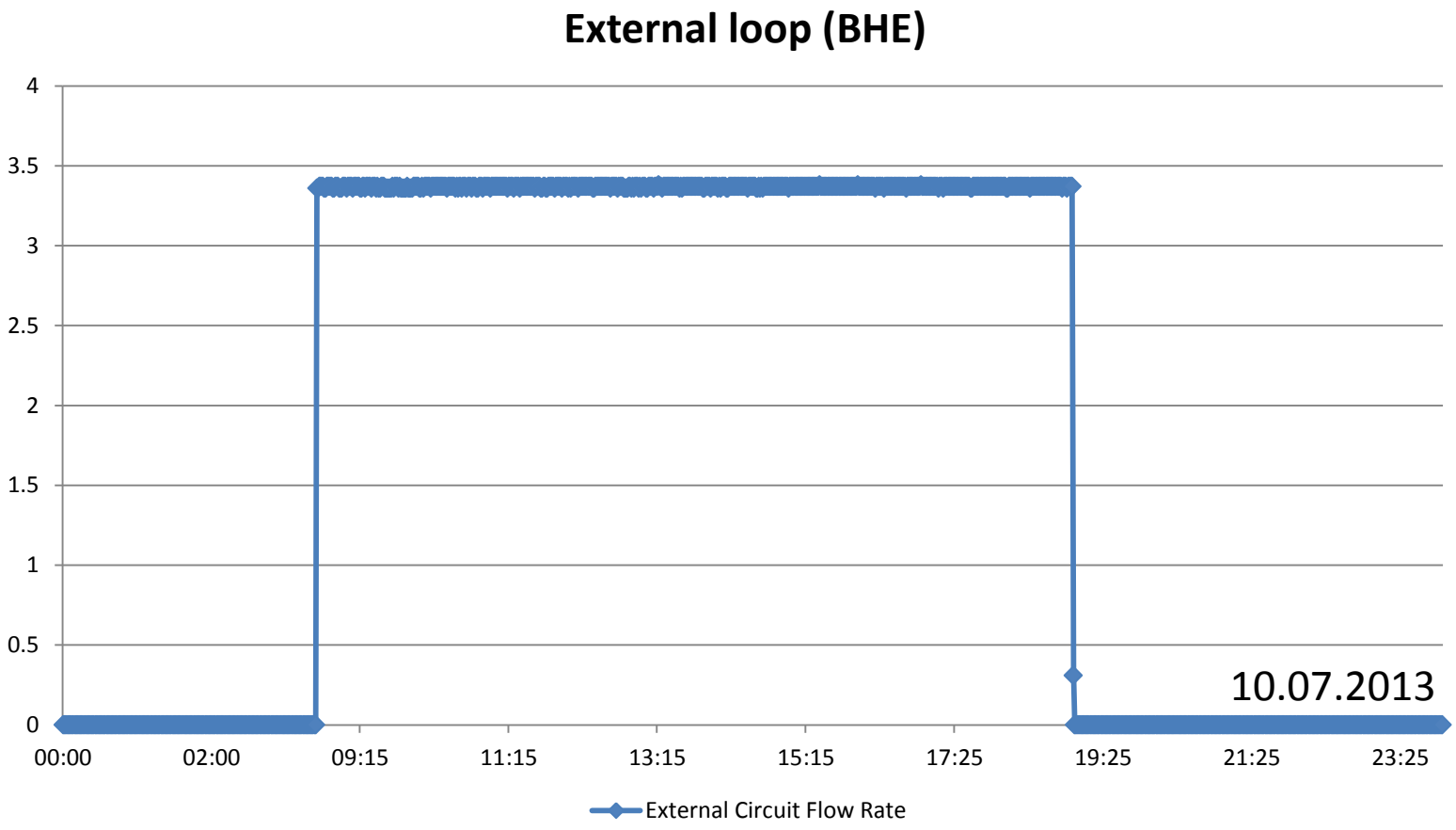
# Seasonal performance



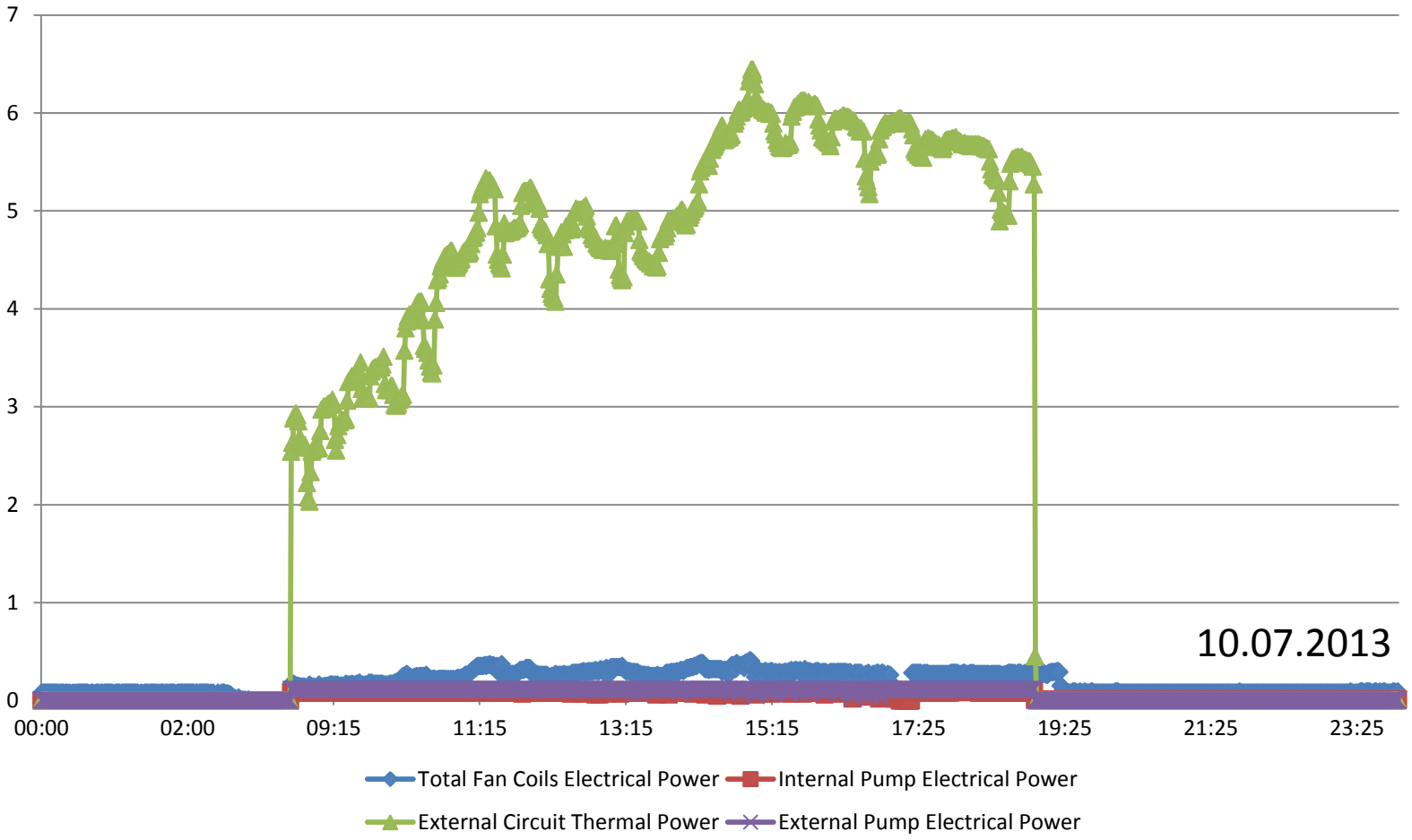
# Water temperature, °C



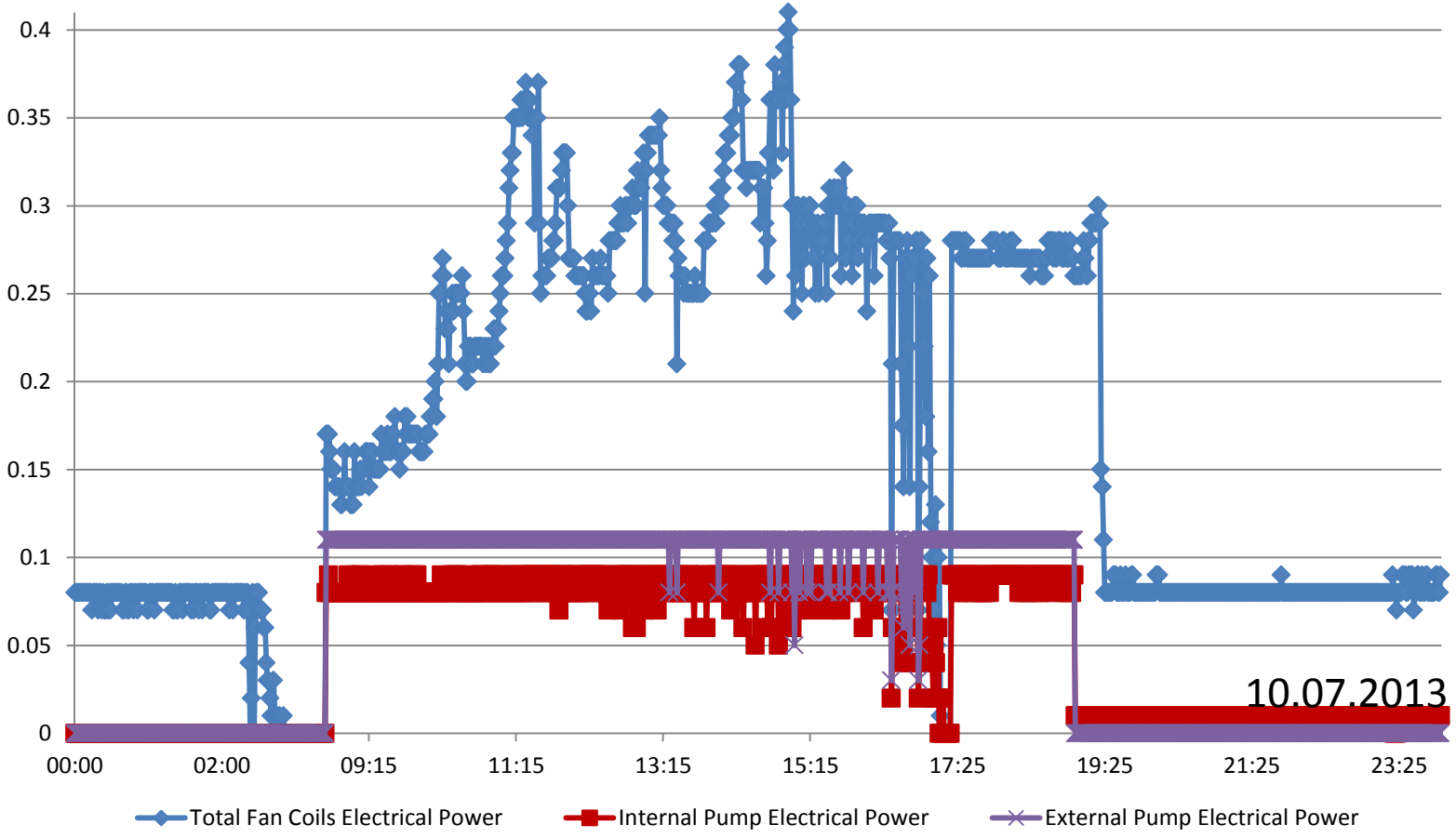
# Water flow rate, m³/h



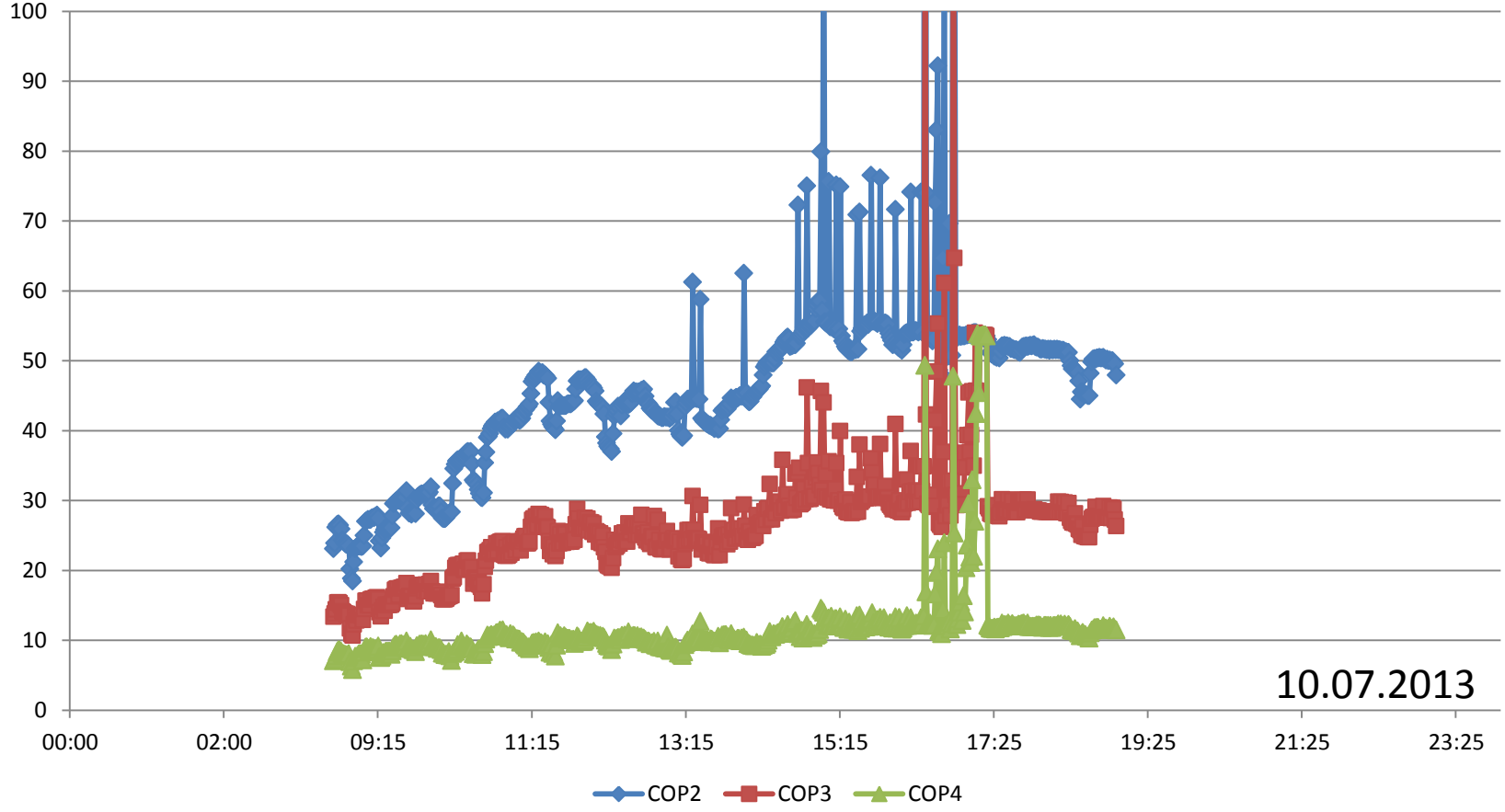
# Cooling capacity, kW



# Electricity consumption, kW



# COP transients



# HIREF factory, Tribano, Padova

**Capacity:**

⇒ 13 kW heating

⇒ 14 kW cooling

**BHE: 4 x 80m,**

- 2 x Double-U
- 2 x Single-U

⇒10°C in winter

⇒27°C in summer

# Demonstrated technologies

## Heat pump

- HIREF prototype with inverter compressor
- 4-way valve externally reversible

## Frequency control

- Compressor, pumps & fans speeds are optimized by micro-processor aiming at maximizing COP4

## Sanitary hot water

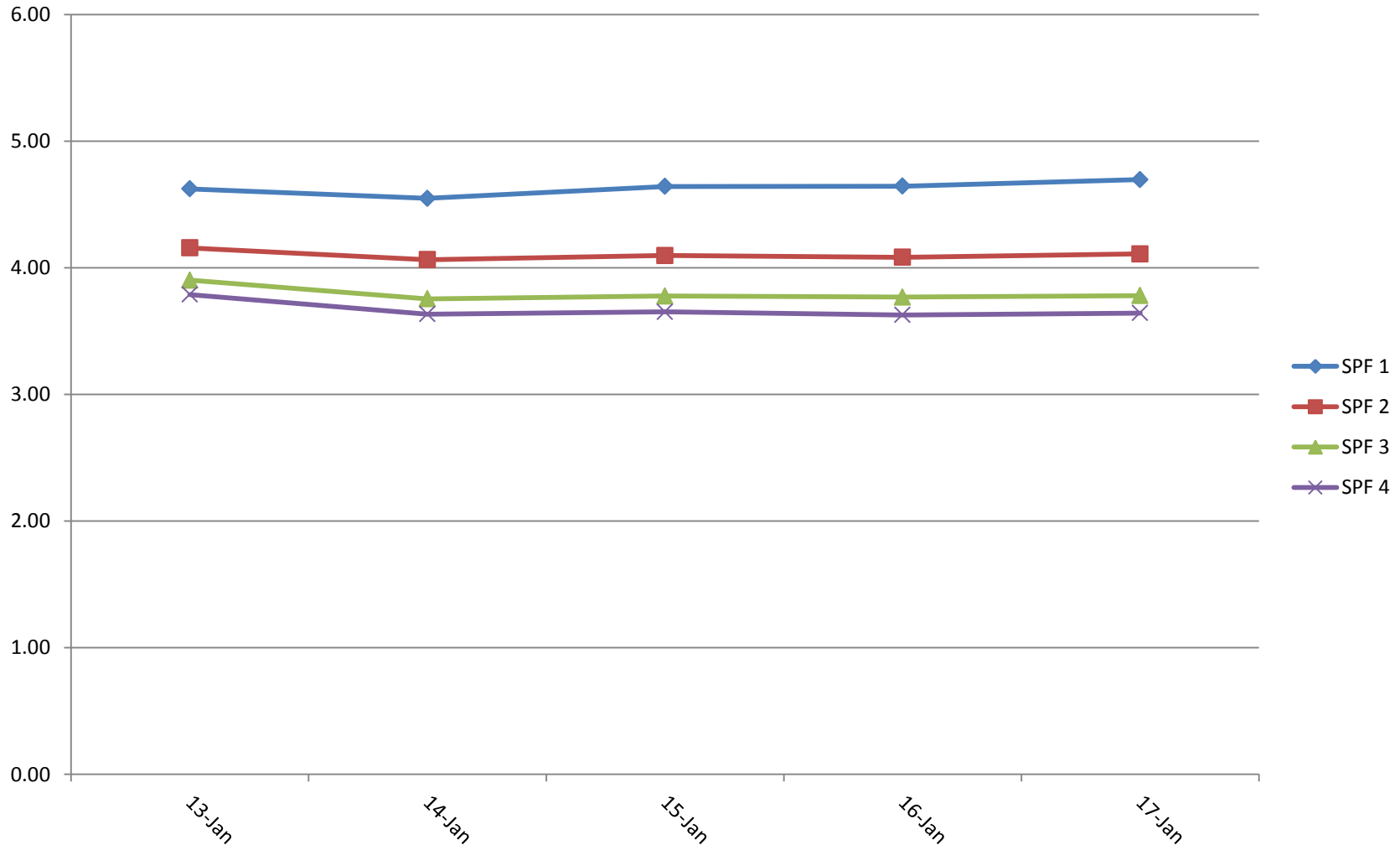
- Heated by rejected heat during cooling

# Heating/cooling by floor FCU

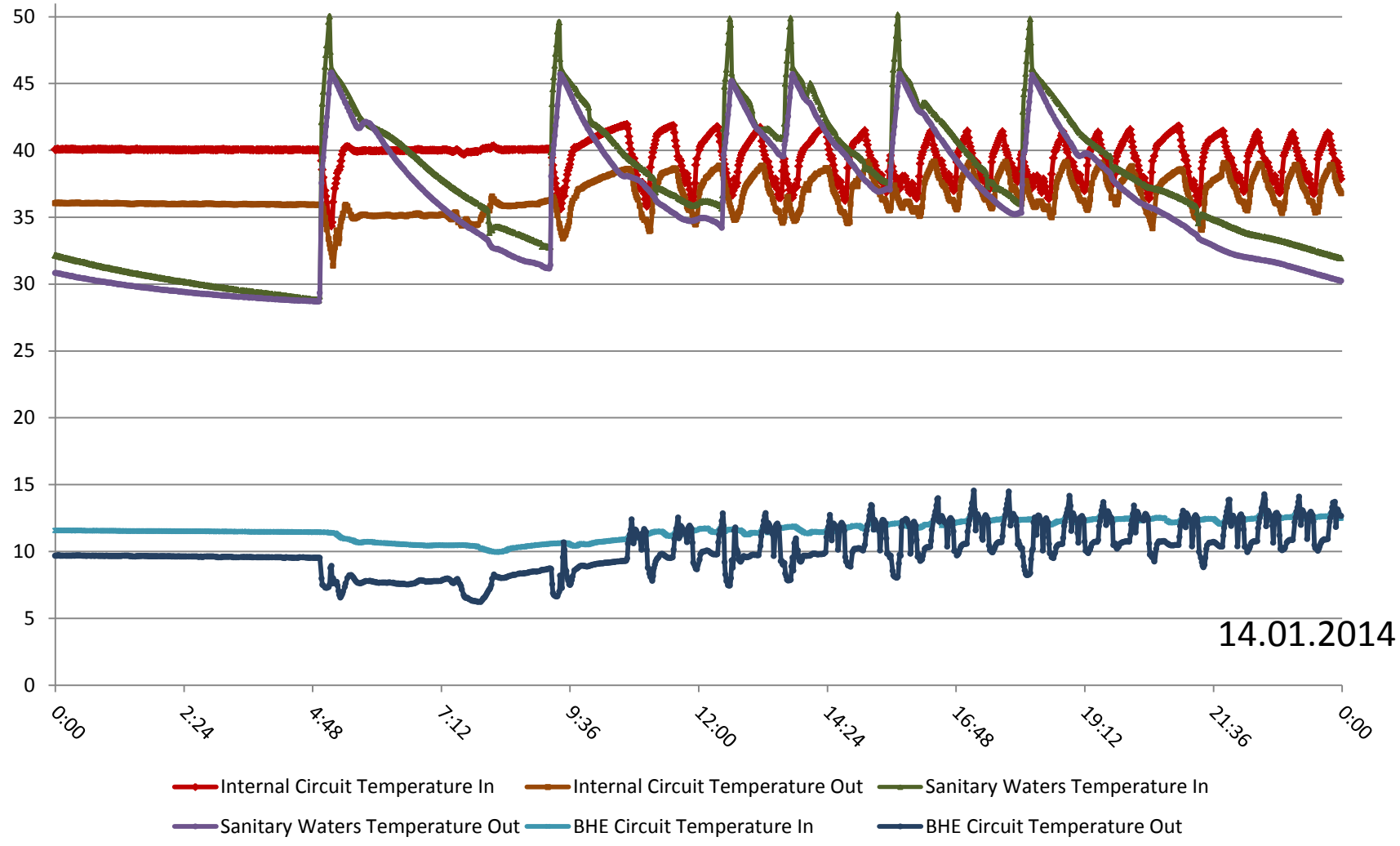
- HIREF prototype inverter driven

# *Heating operation*

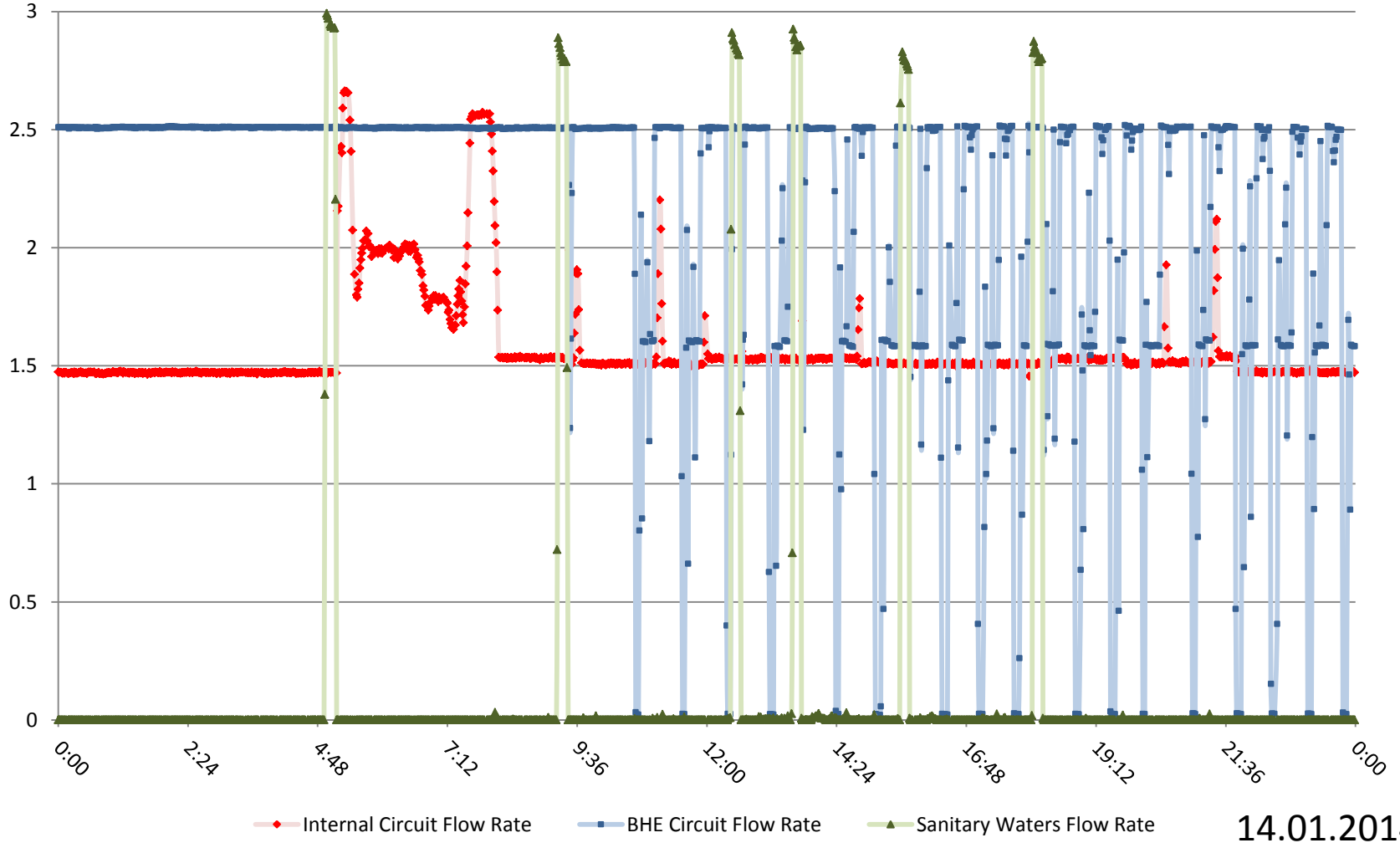
# Seasonal performance



# Water loops temperature, °C

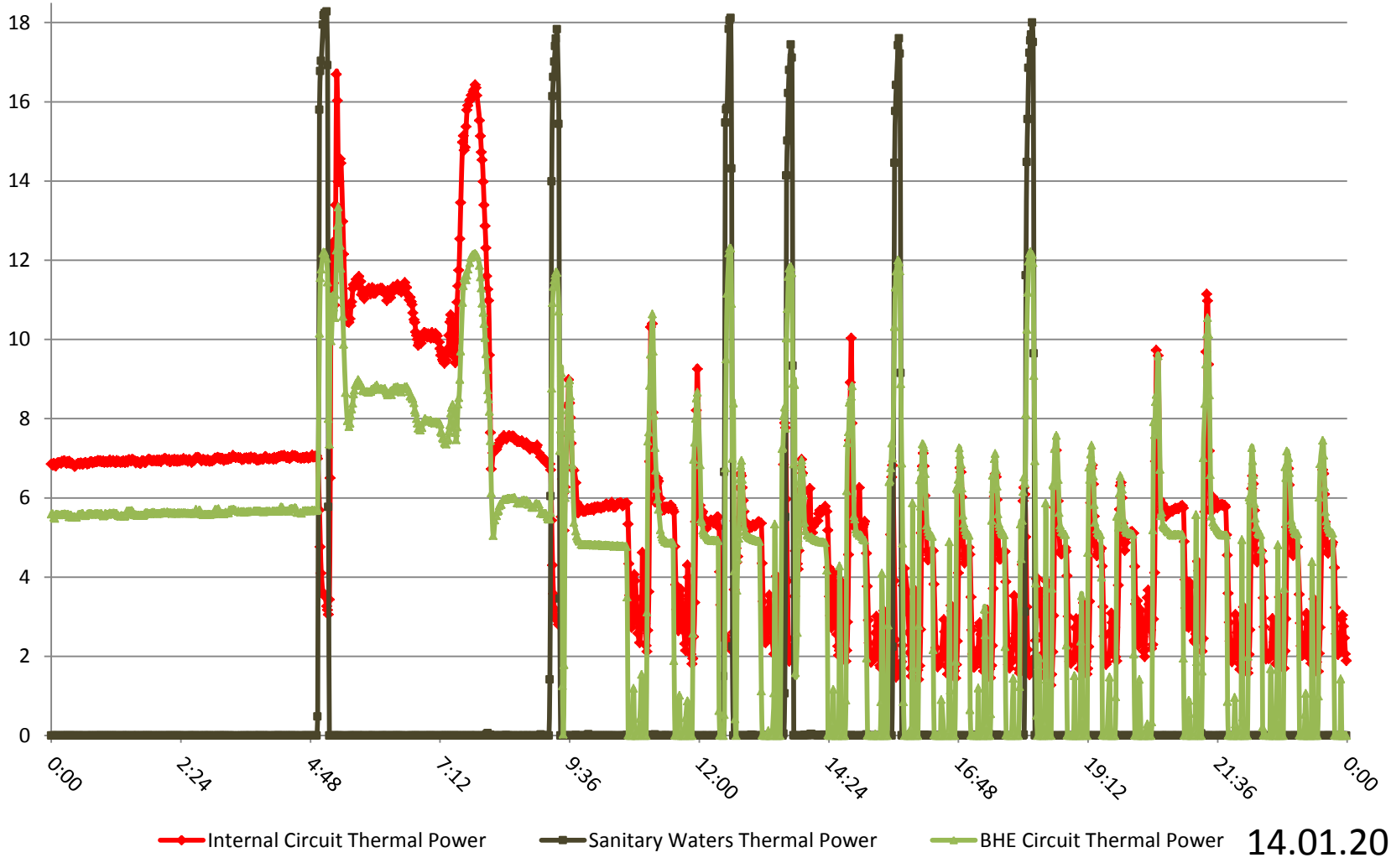


# Water loops flow rate, m³/h



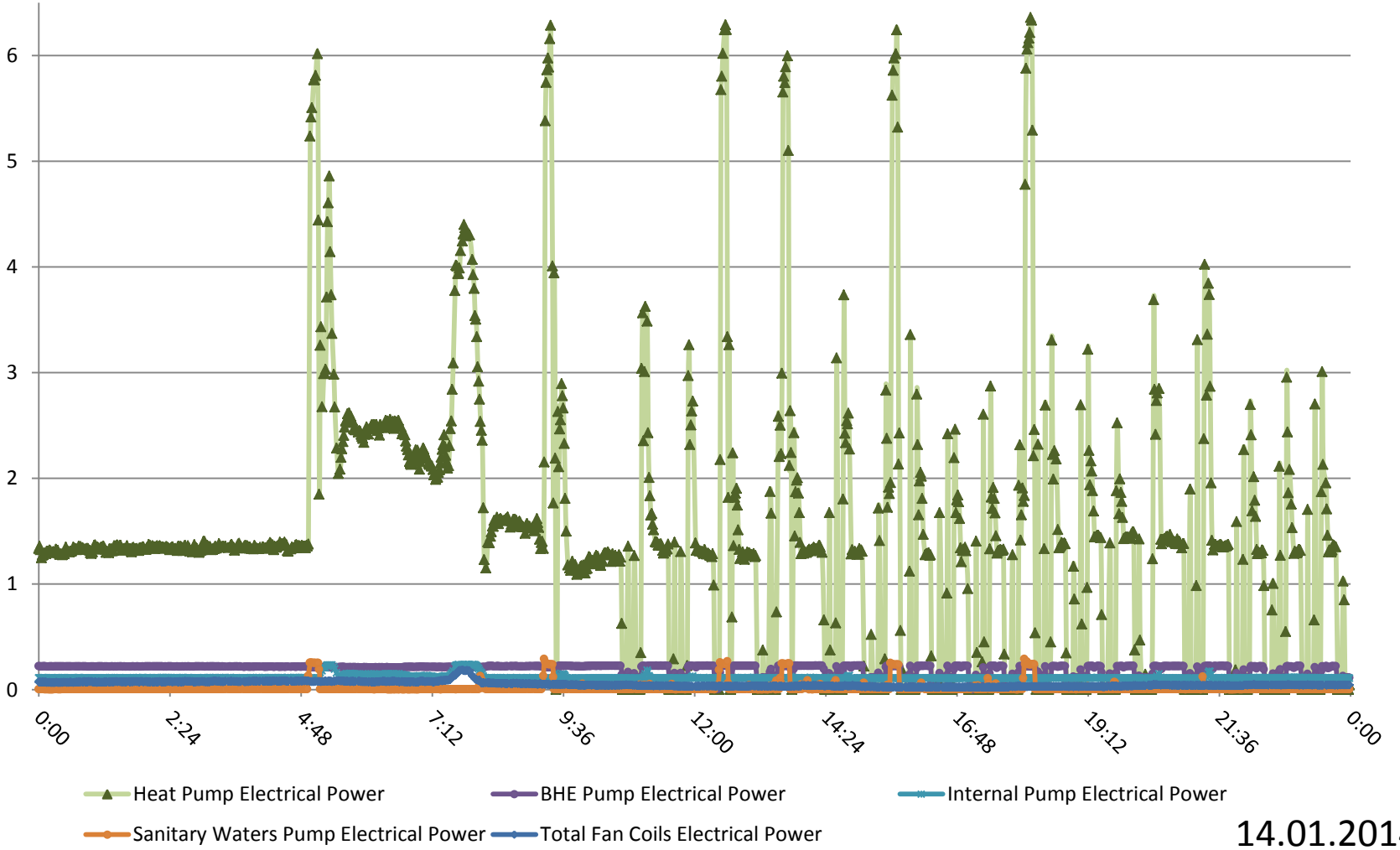

14.01.2014

# Thermal power, kW



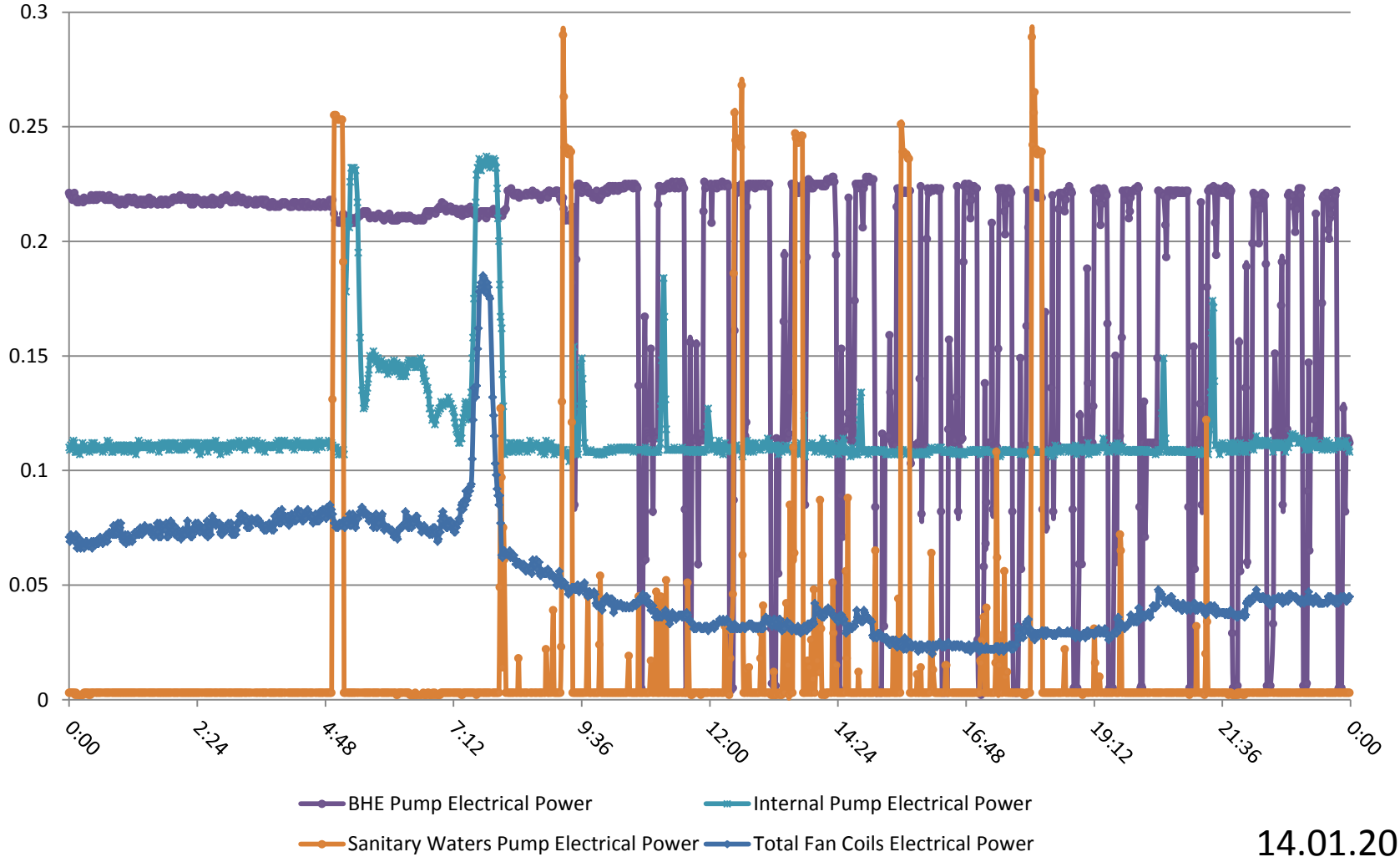

14.01.2014

# Electricity consumption, kW




14.01.2014

# Electricity consumption detail, kW




14.01.2014

# COP transients


14.01.2014

# Visual arts building, Oradea university campus

**Capacity:**

⇒ 38 kW heating

⇒ 31 kW cooling

**BHE: 10 x 130m,**

• Single-U type

⇒ 9°C in winter

⇒17°C in summer

КАПЕ
CRES

# Demonstrated technologies

## Heat pump

- OCHSNER prototype with electronic valve & external 3-way valves

## Heating-cooling system

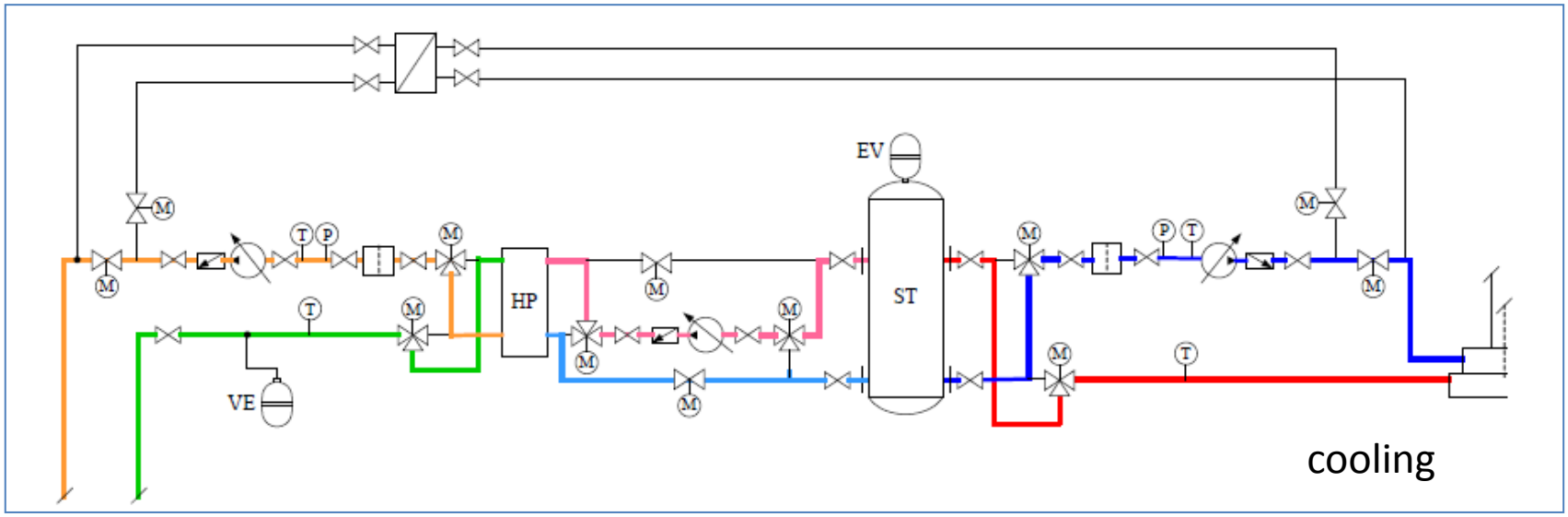
- Walls embedded piping

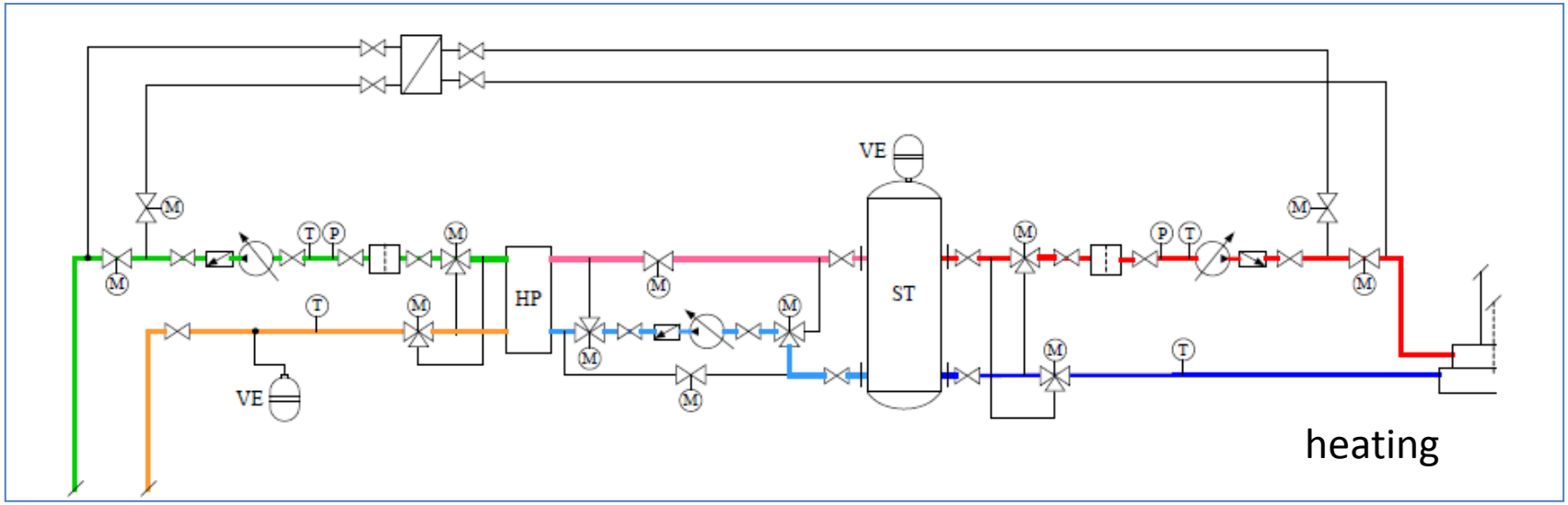
## Temperature compensation

- Heat pump controller controls water temperature set point proportionally to ambient temperature

# In-walls heating & cooling system

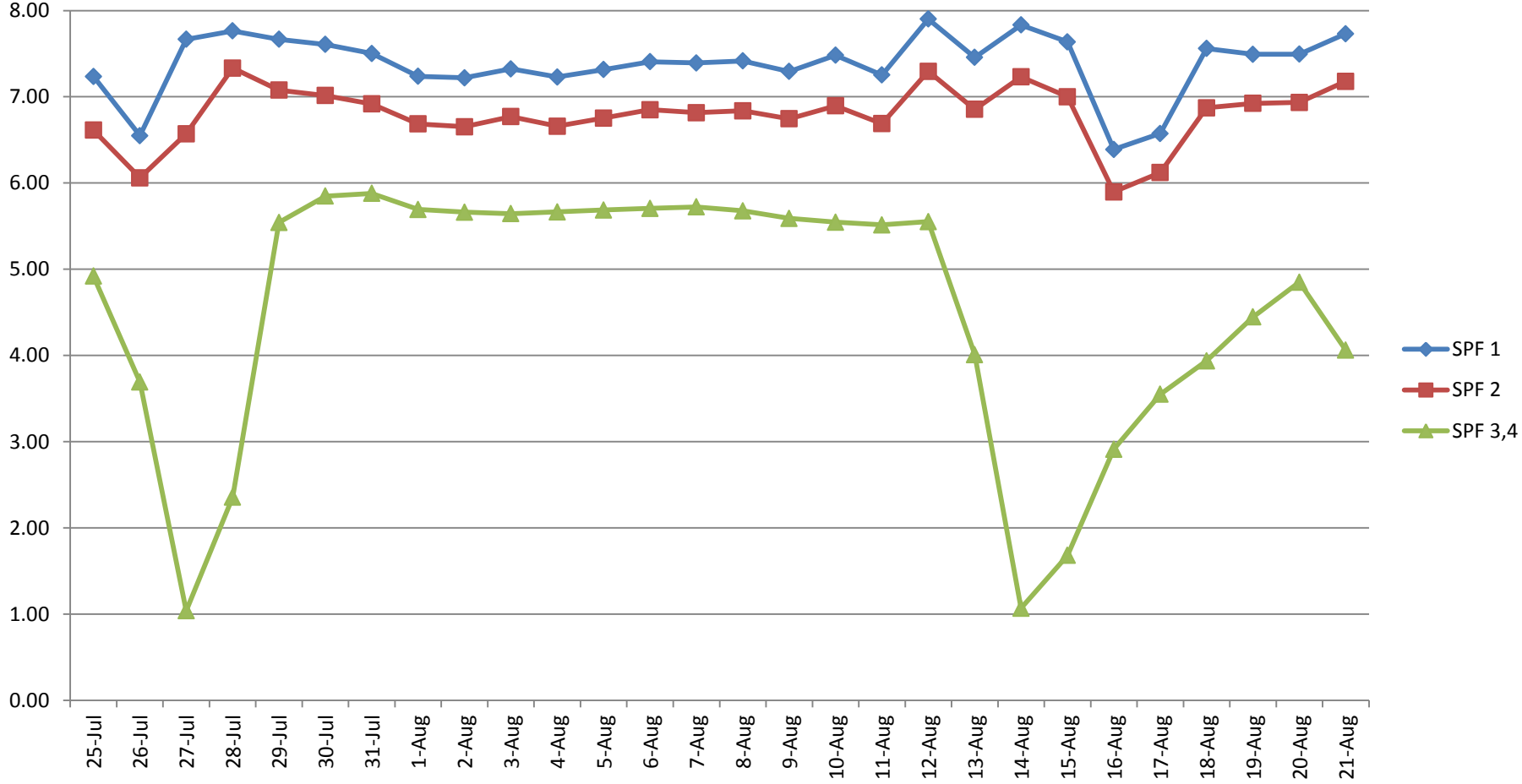
# Piping connection scheme



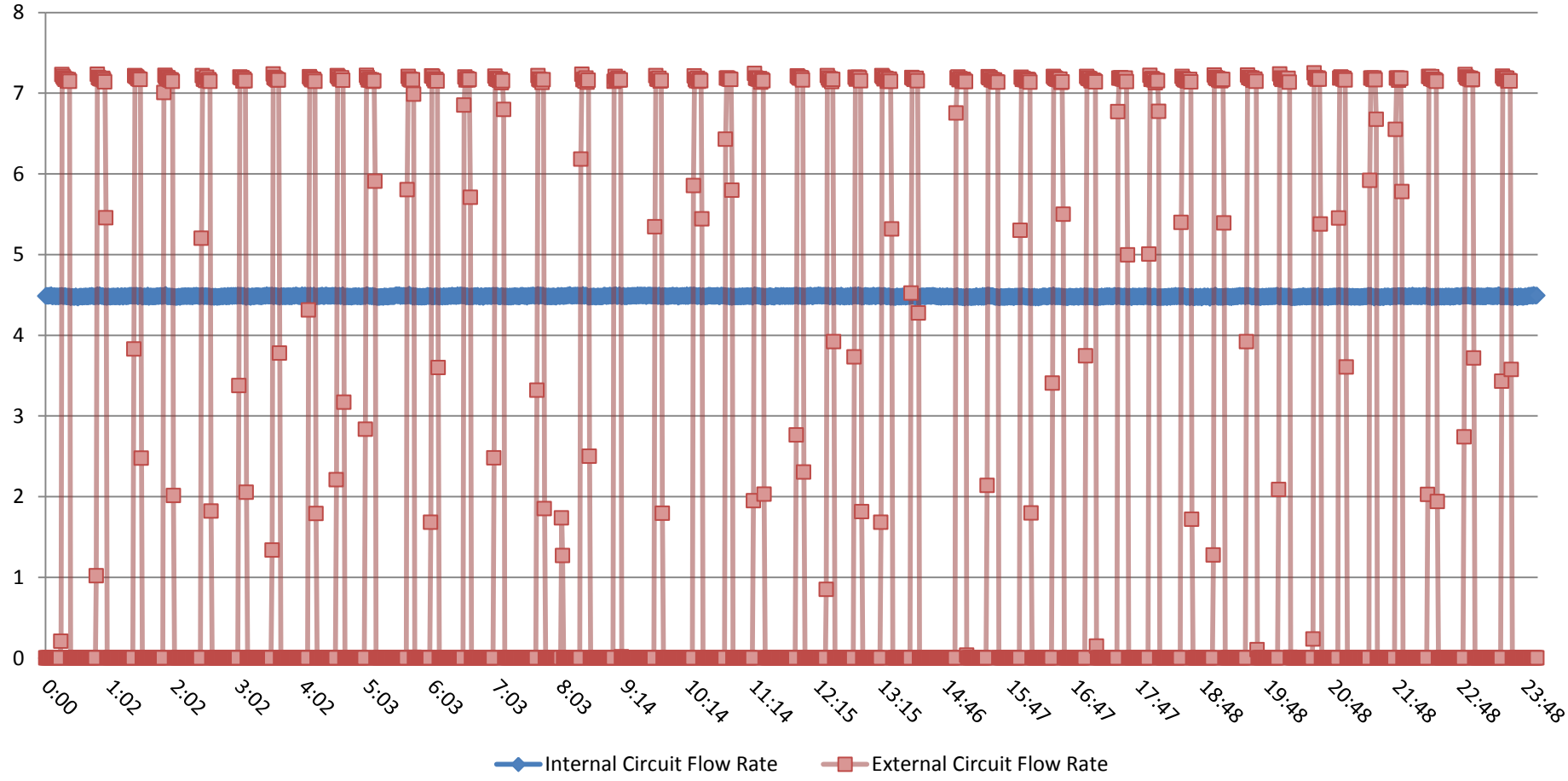



# *Cooling operation*

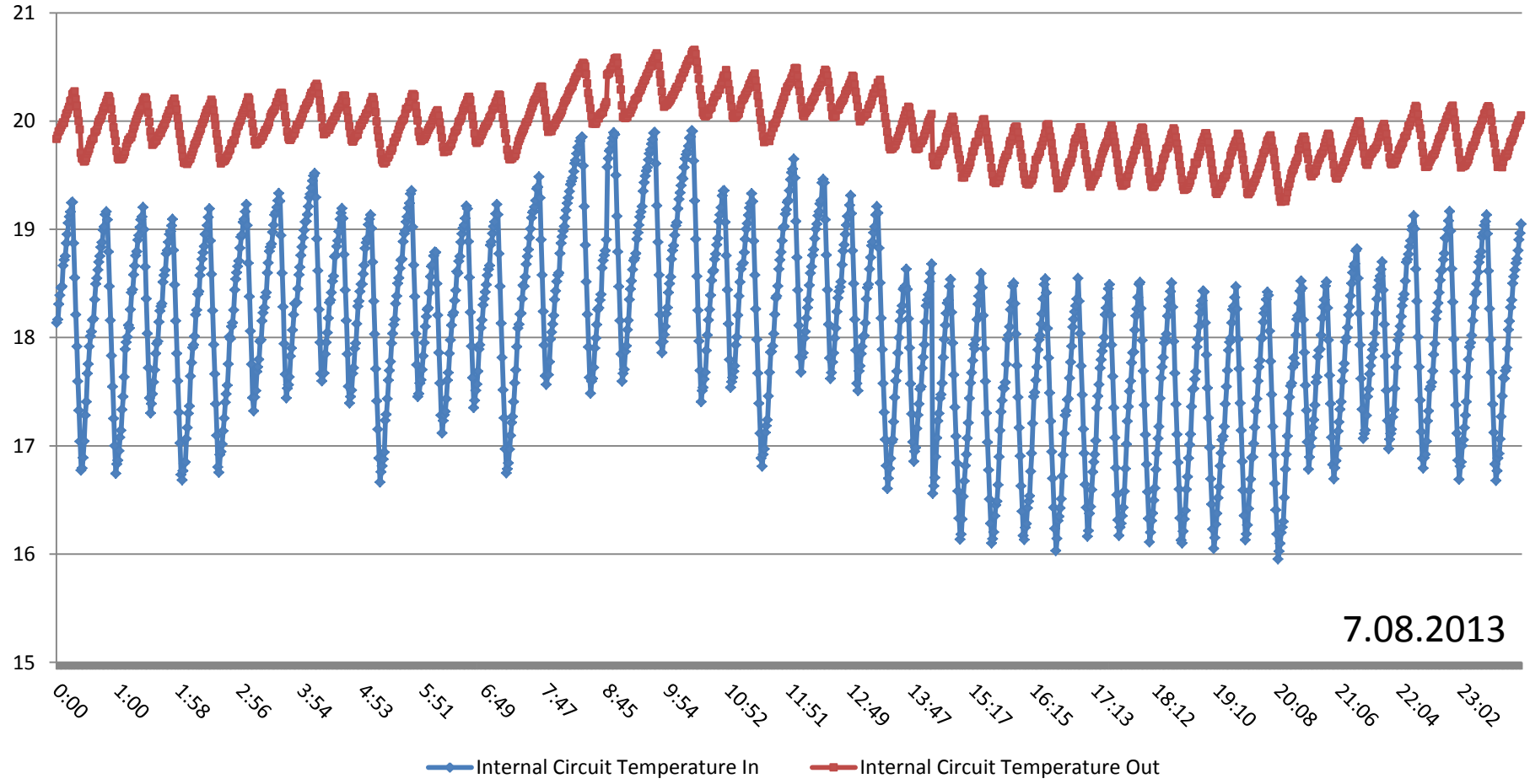
# Seasonal performance



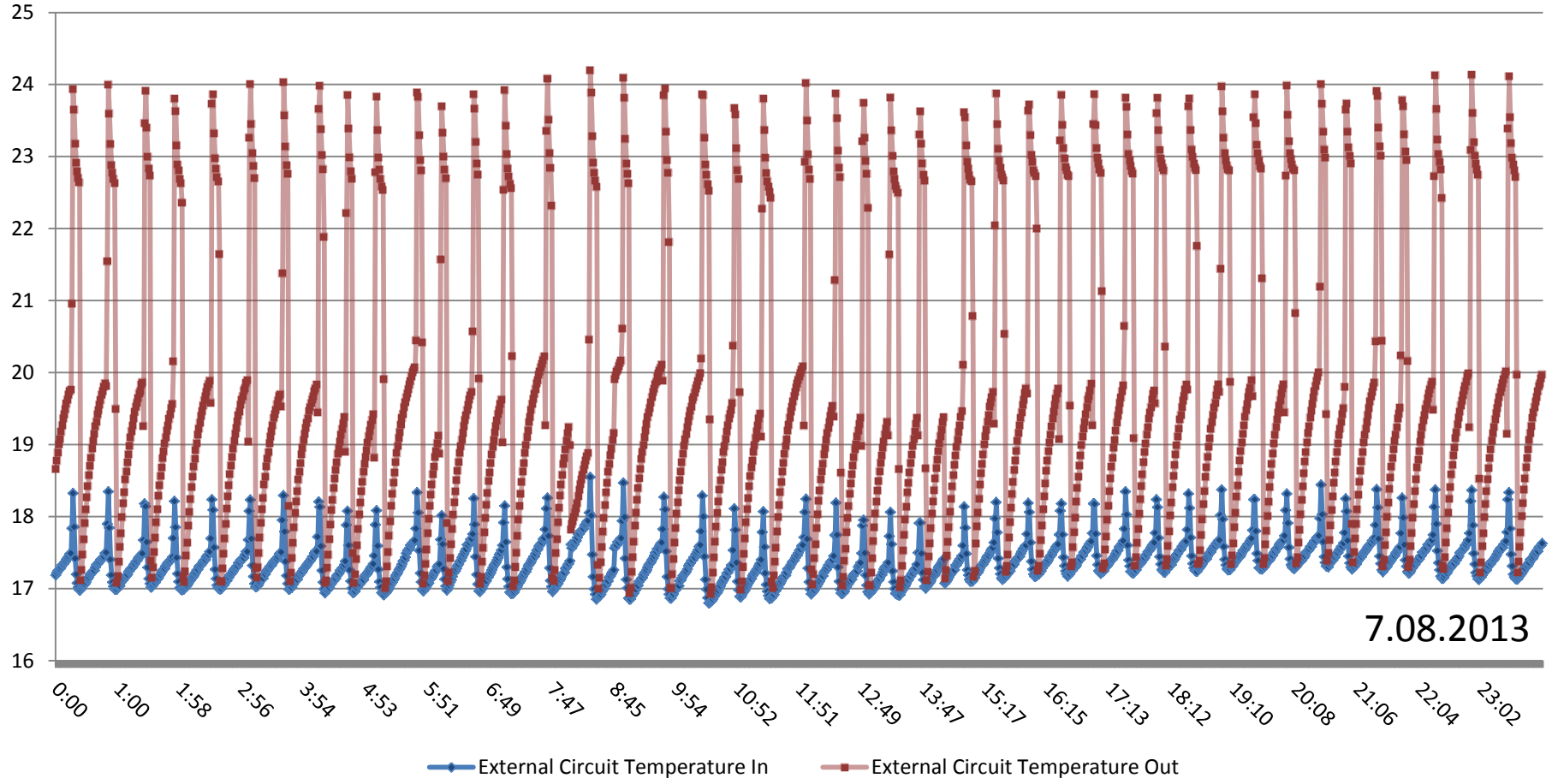
# Water loop flow rate, m³/h



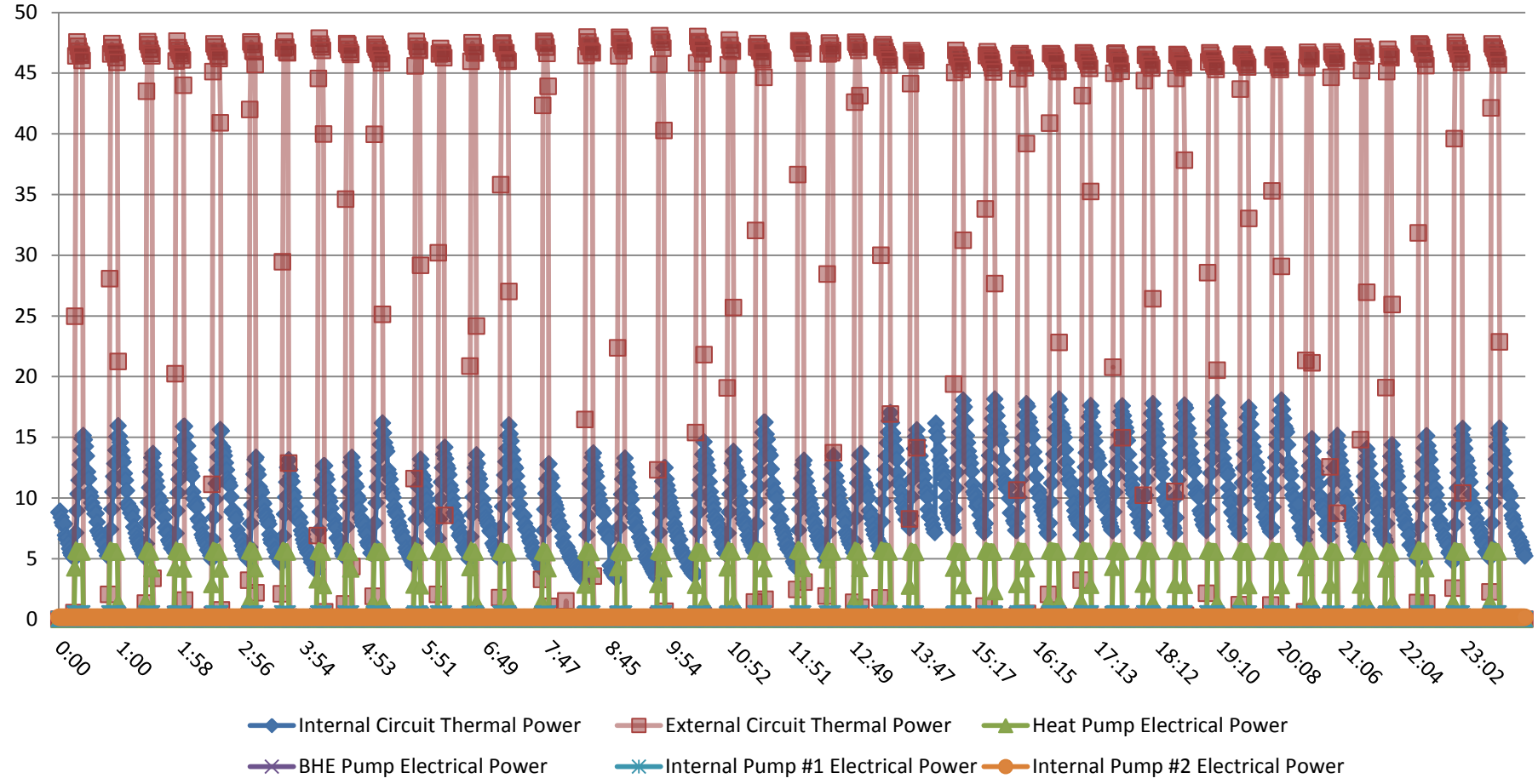
# Water temperature to/from the building, °C



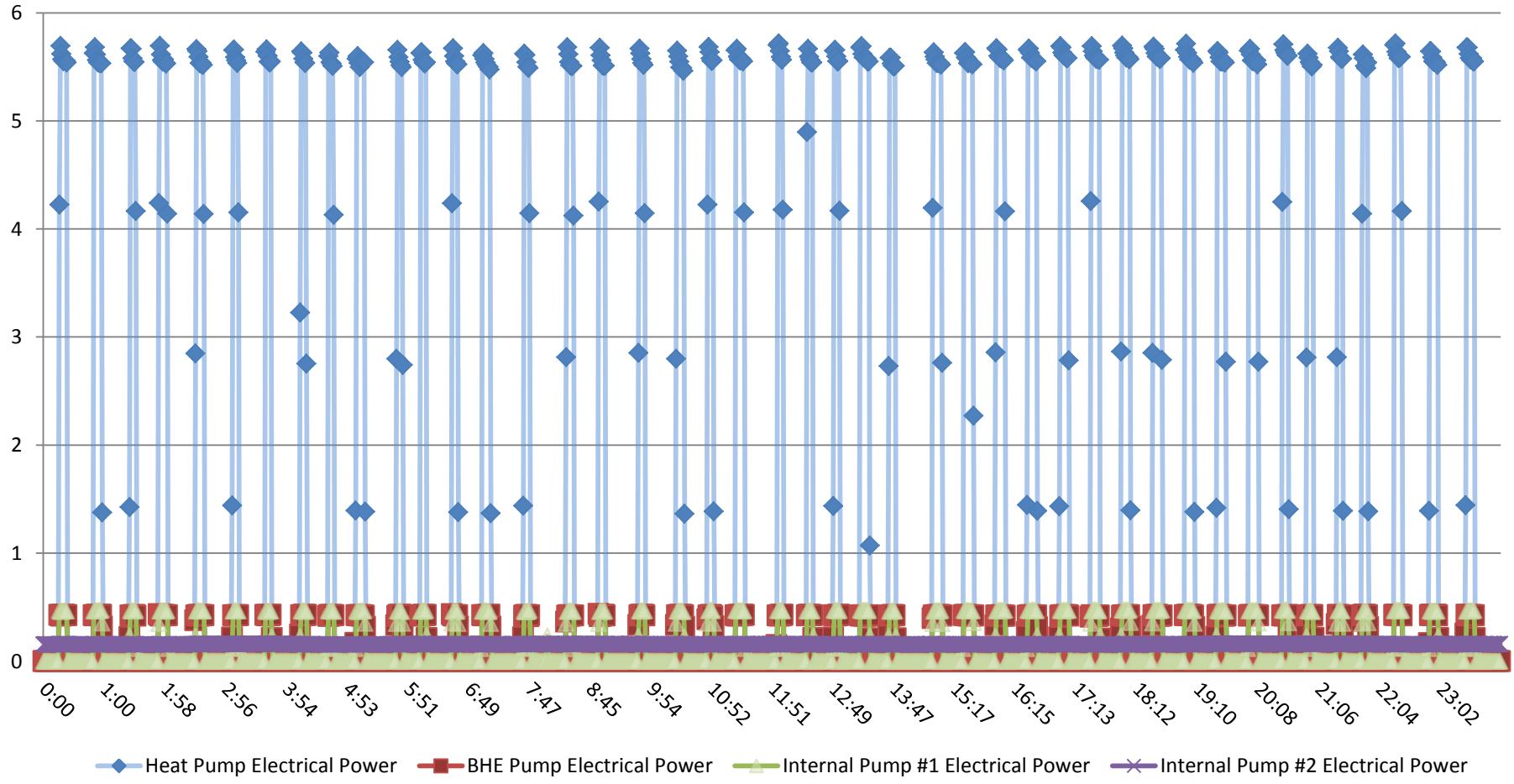
# Water temperature to/from the BHE, °C



# Cooling capacity, kW

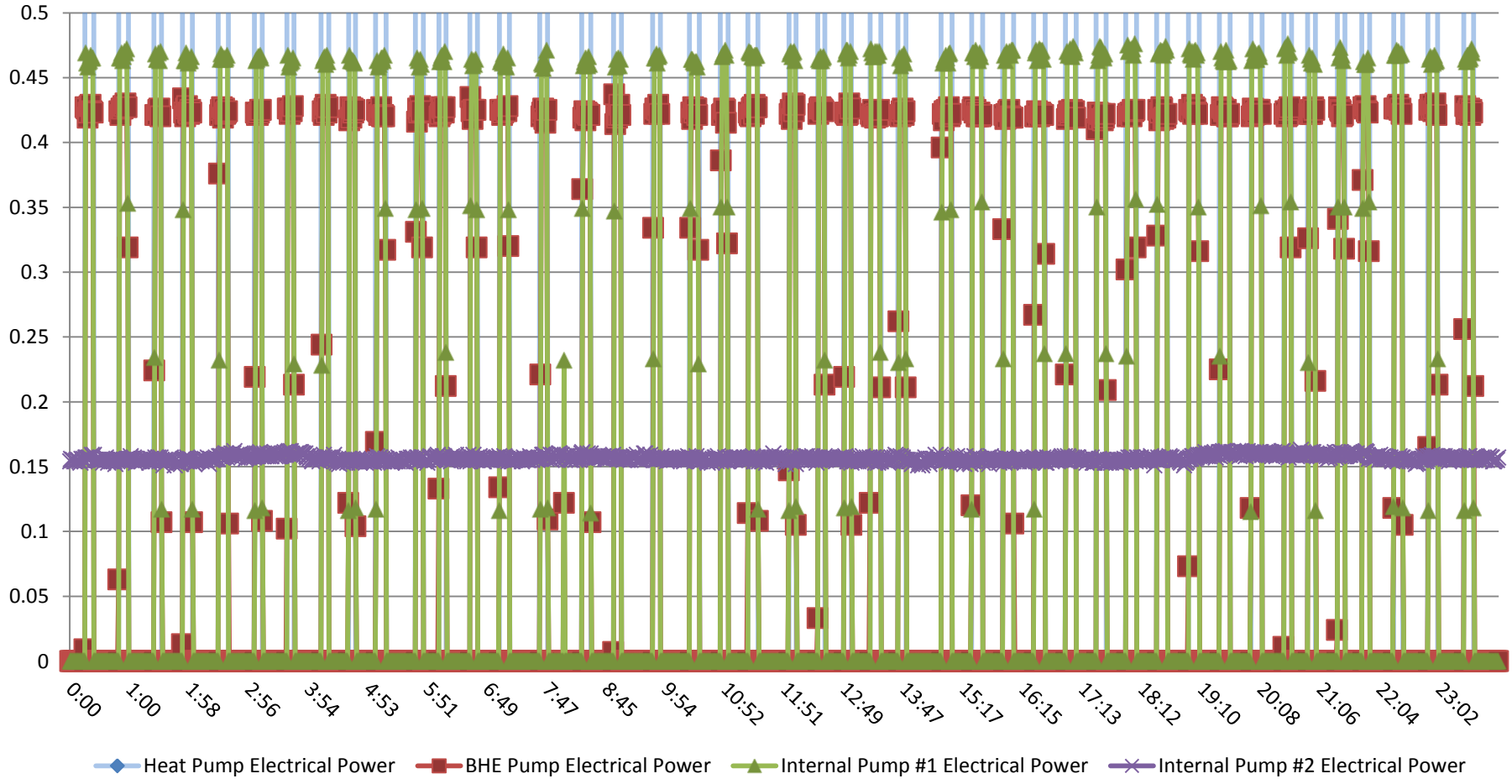


# Electricity consumption, kW



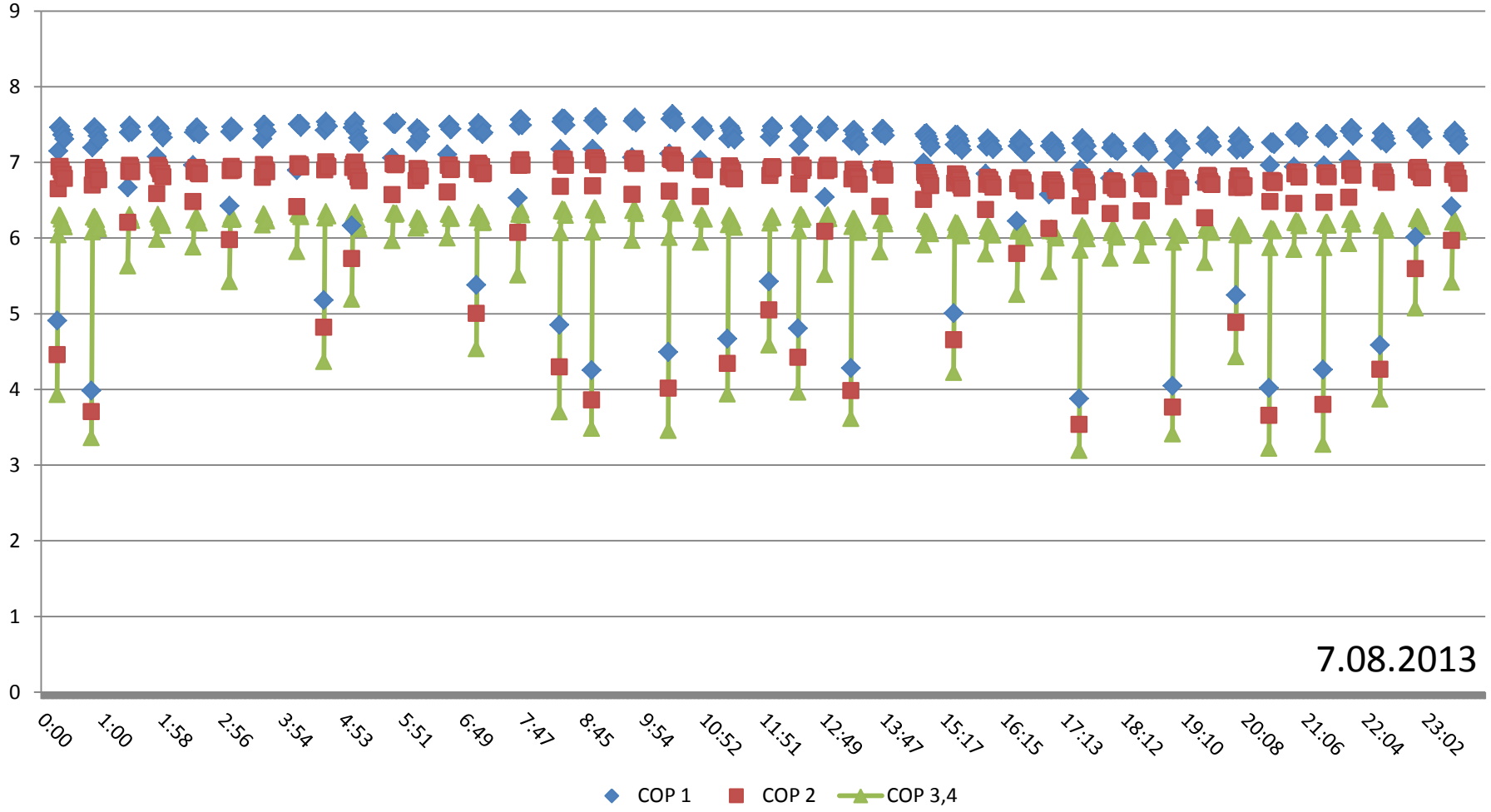

7.08.2013

# Electricity consumption detail, kW



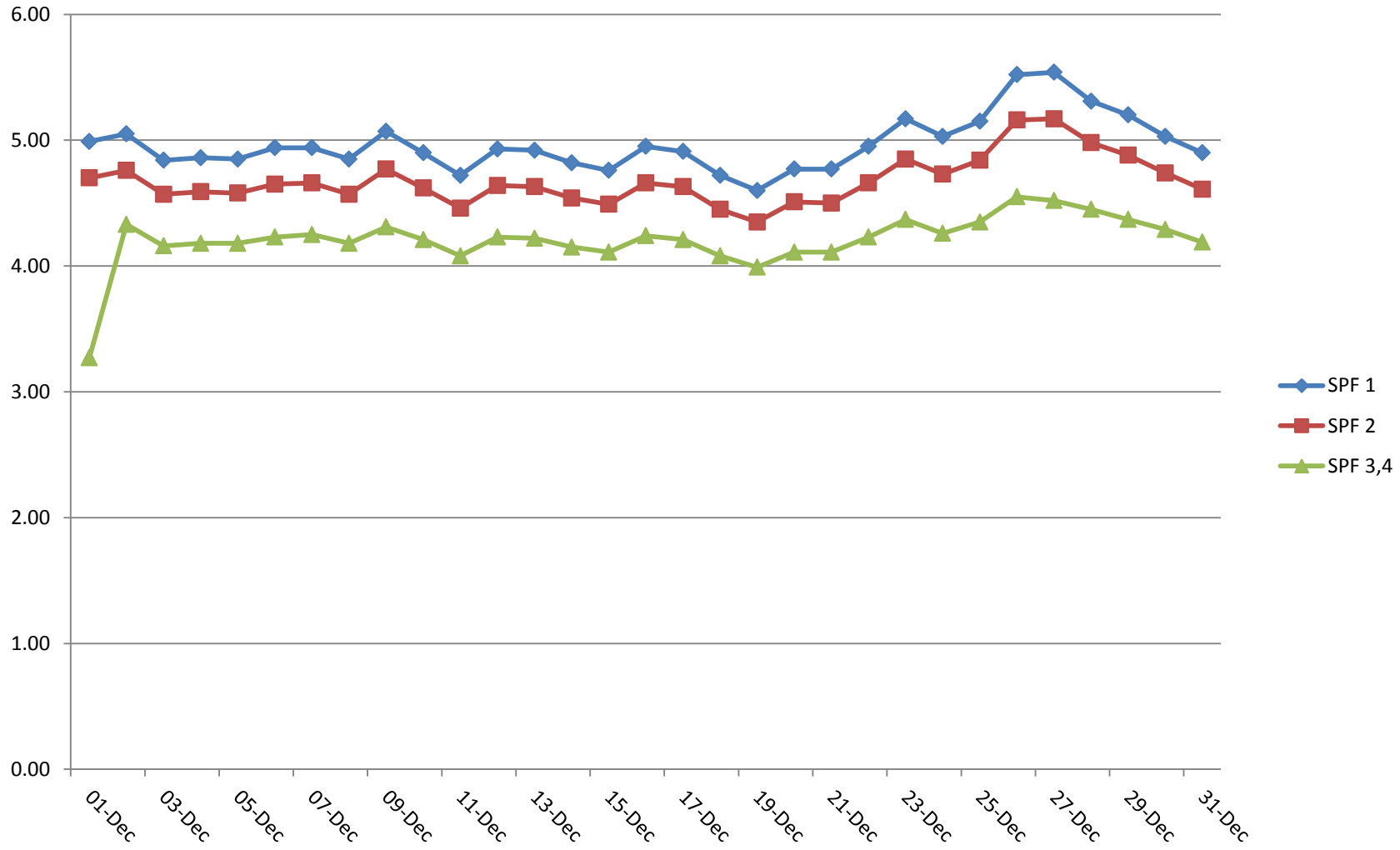

7.08.2013

# COP transients

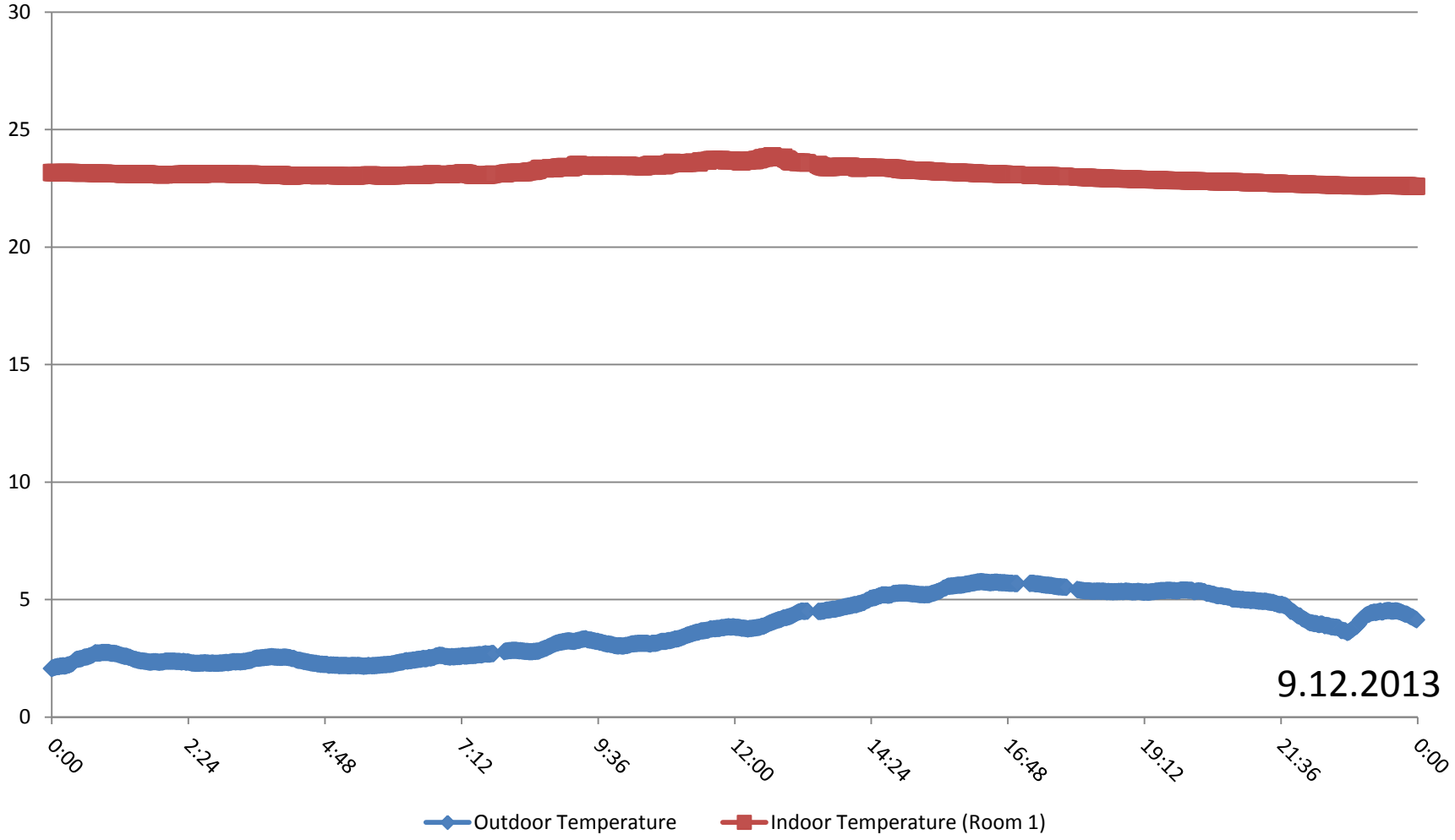


# *Heating operation*

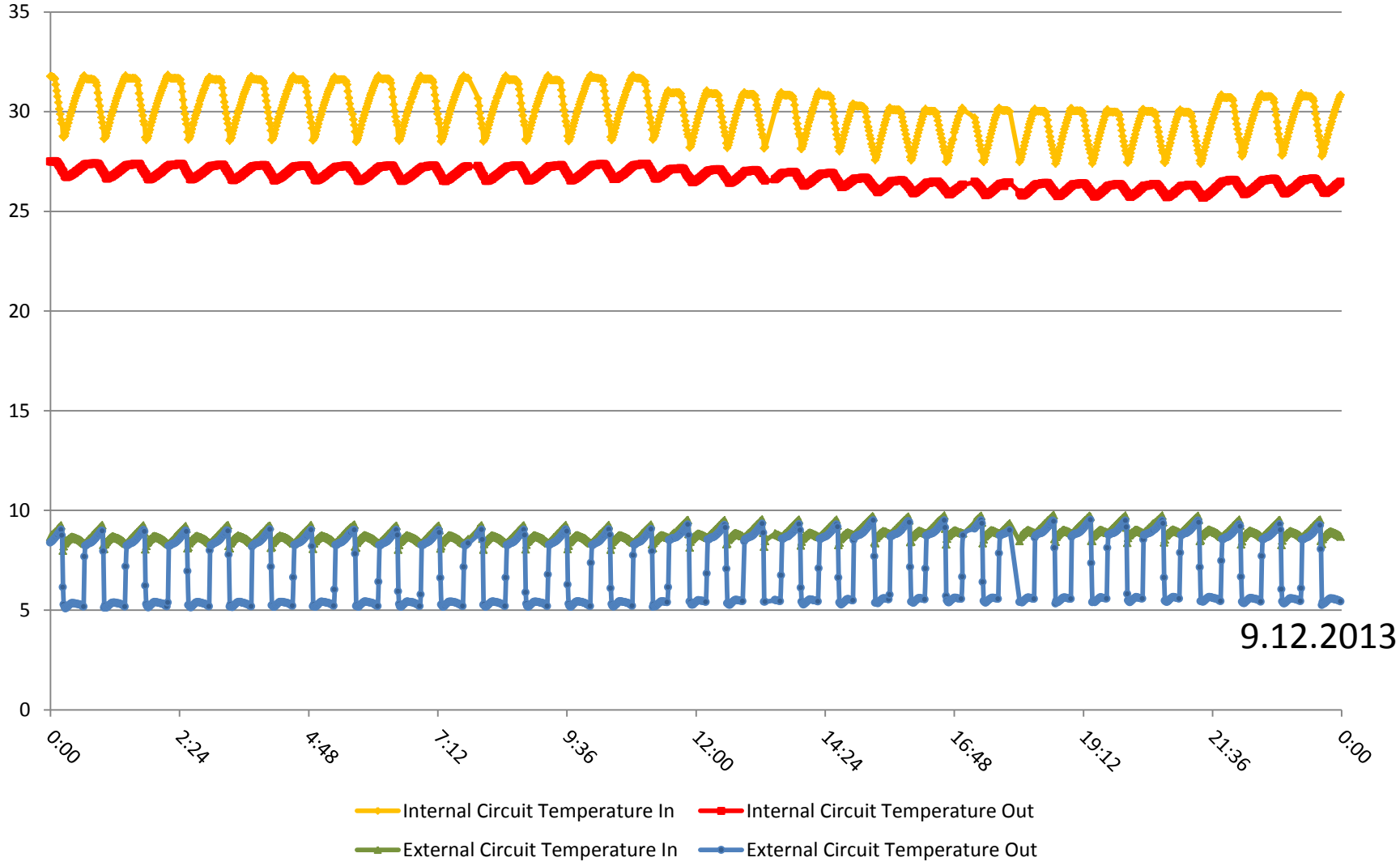
# Seasonal performance



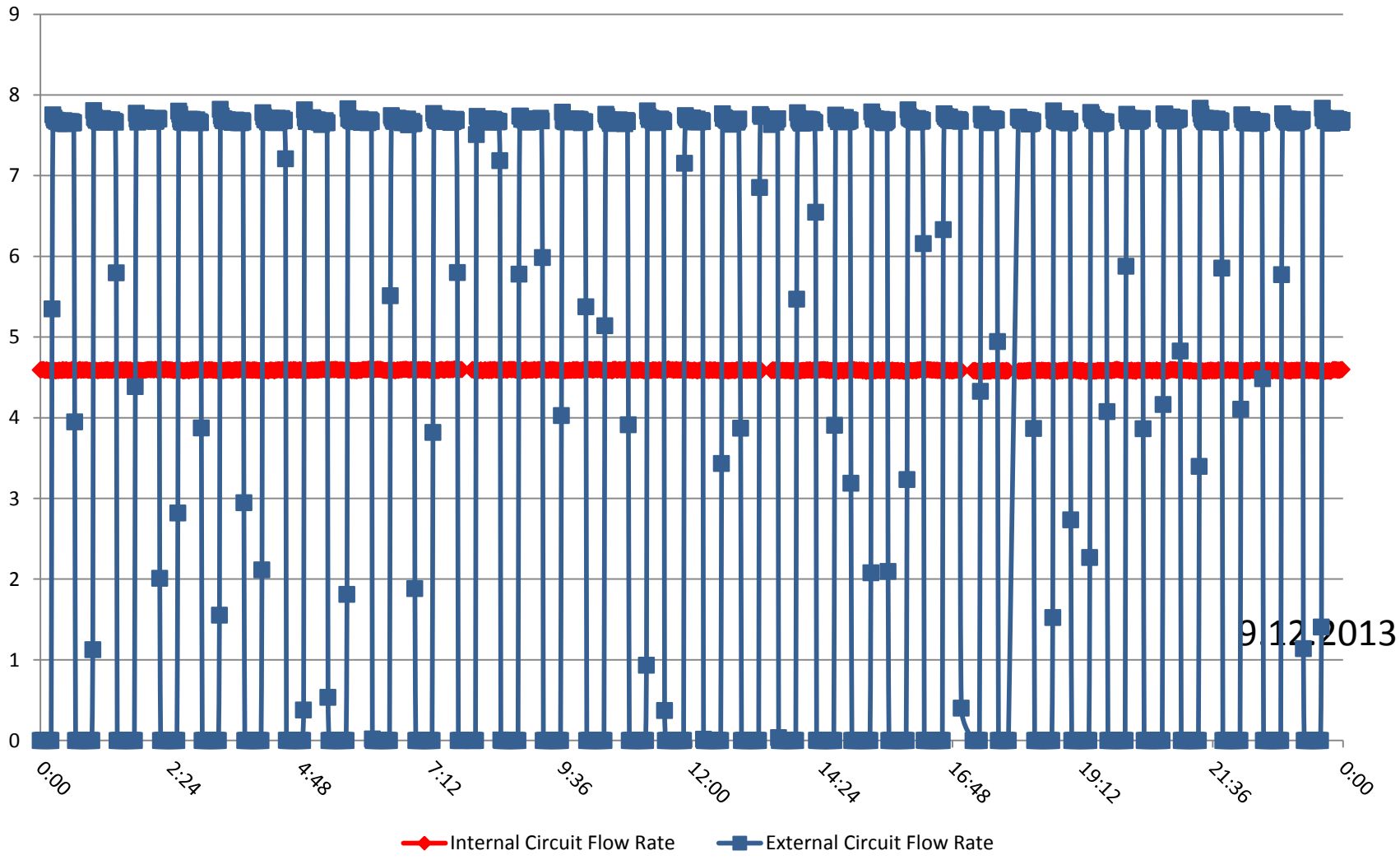
# Ambient & internal temperatures, °C



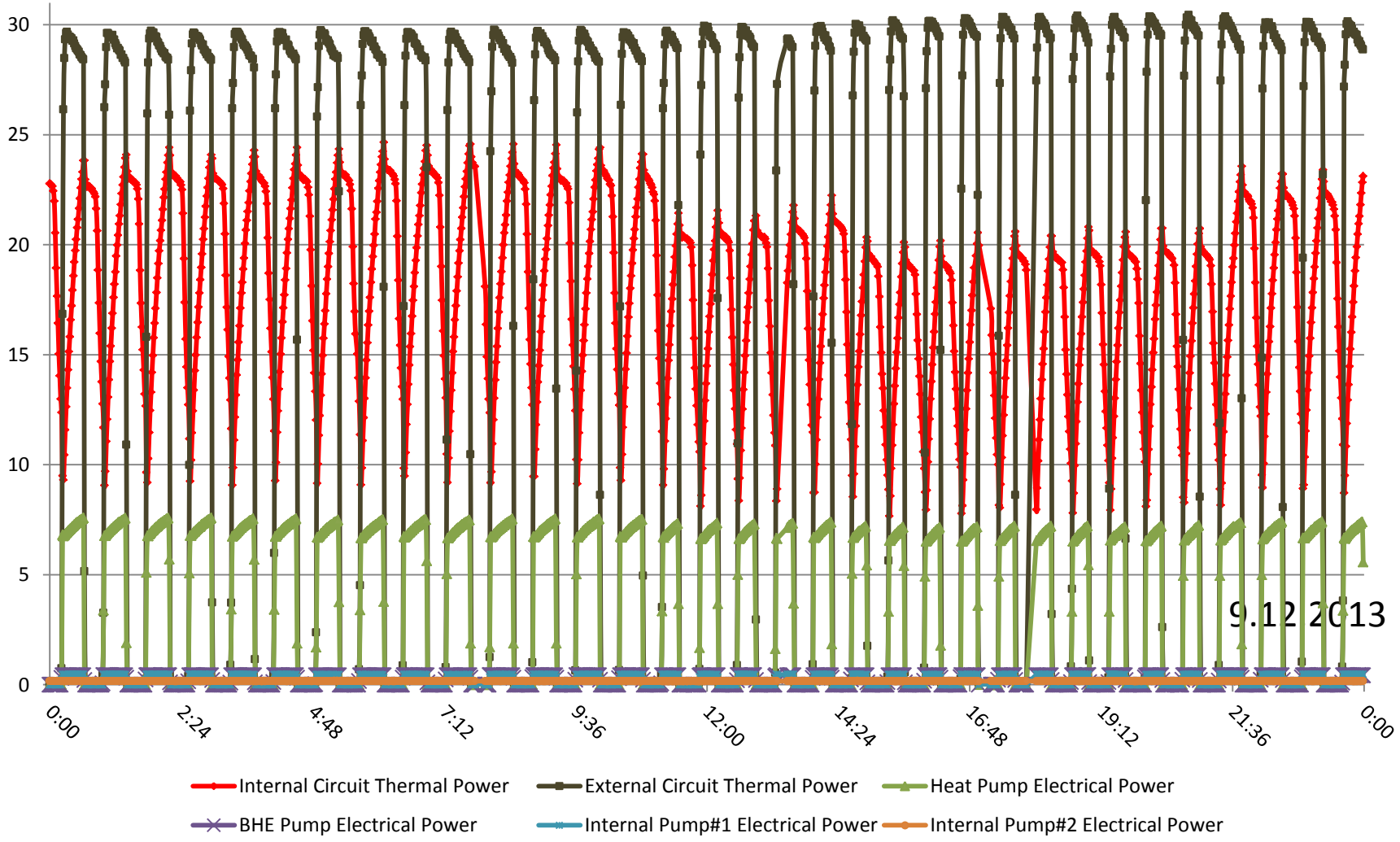
# Water loops temperature, °C



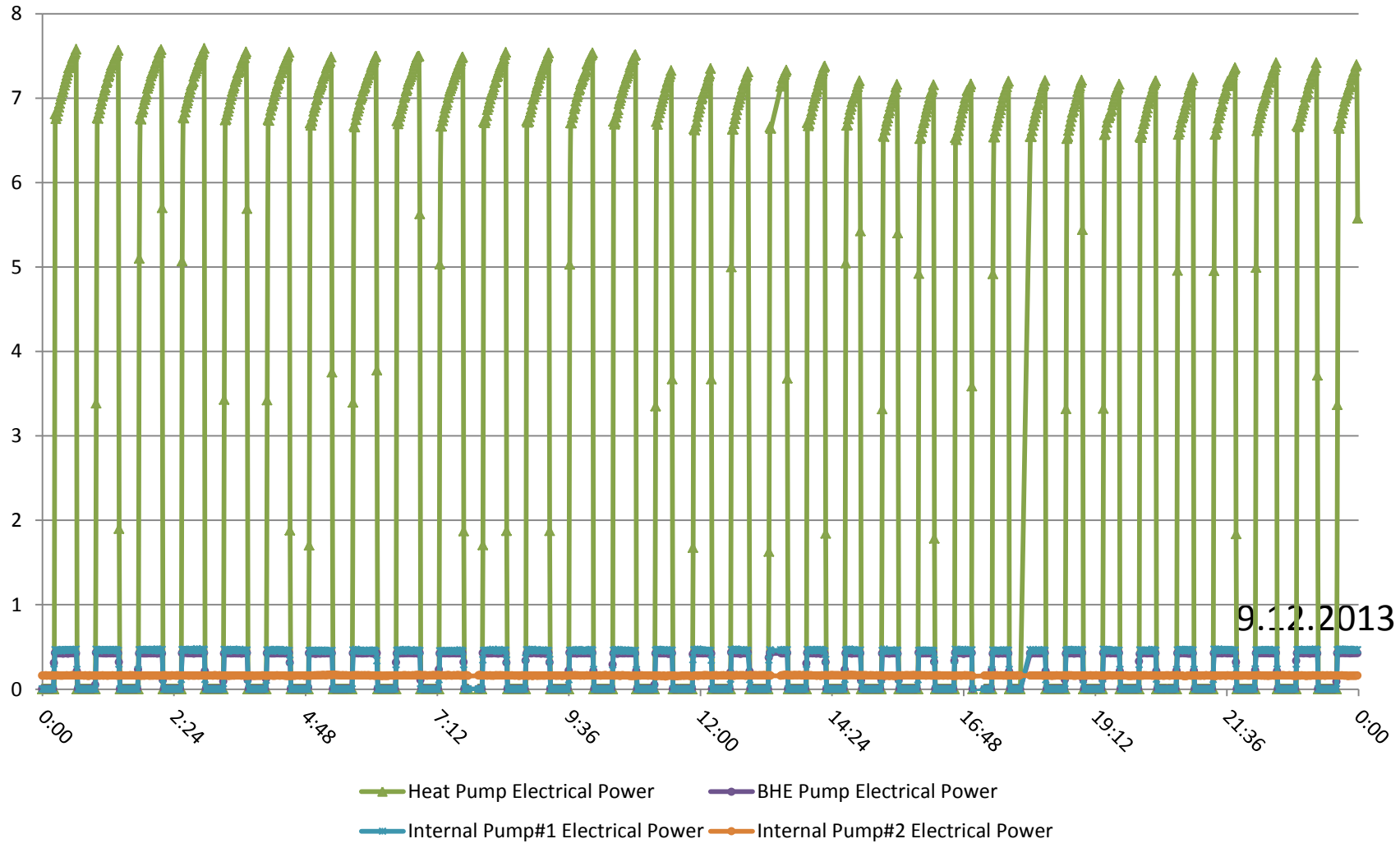
# Water loops flow rate, m³/h



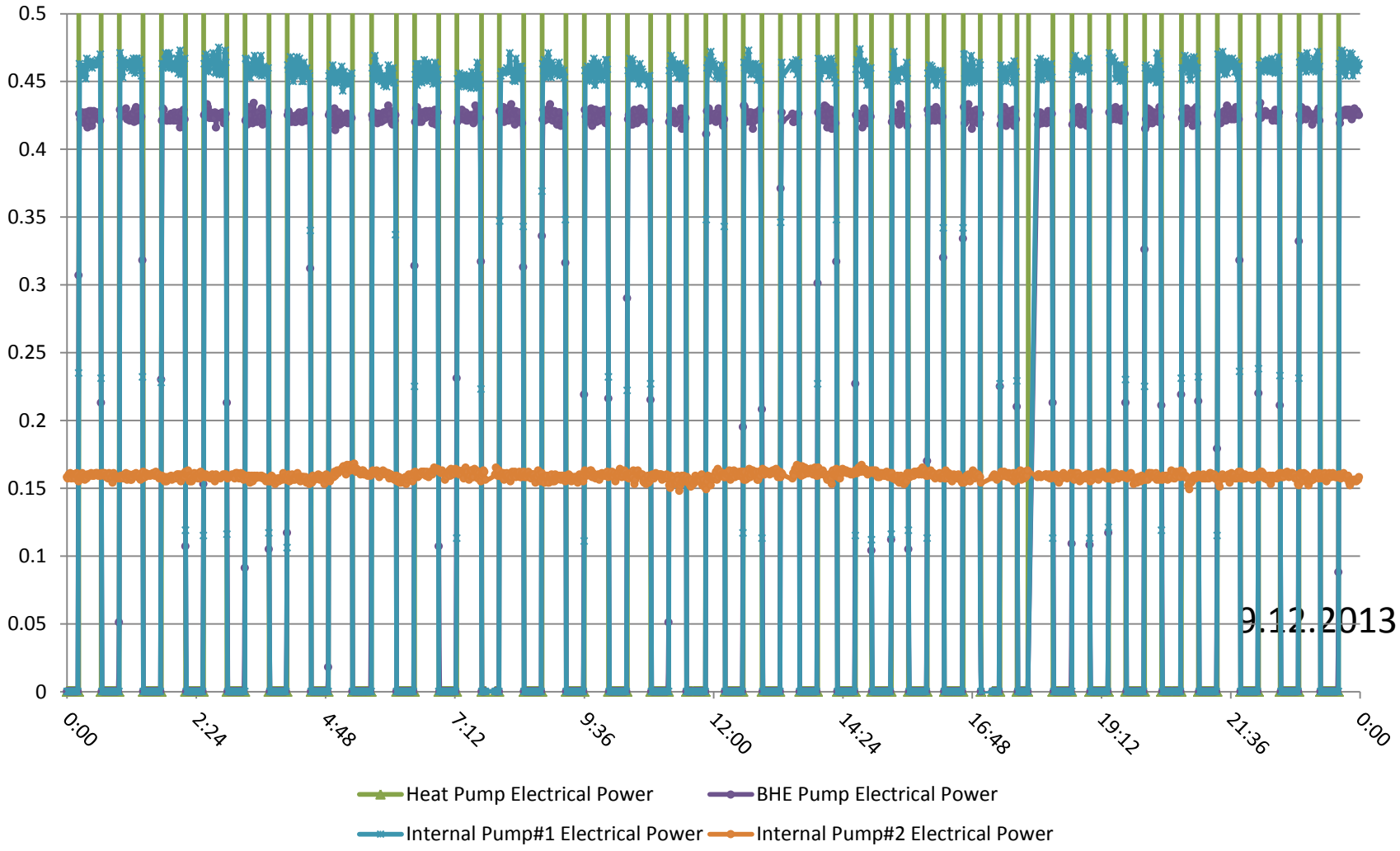
# Thermal power, kW



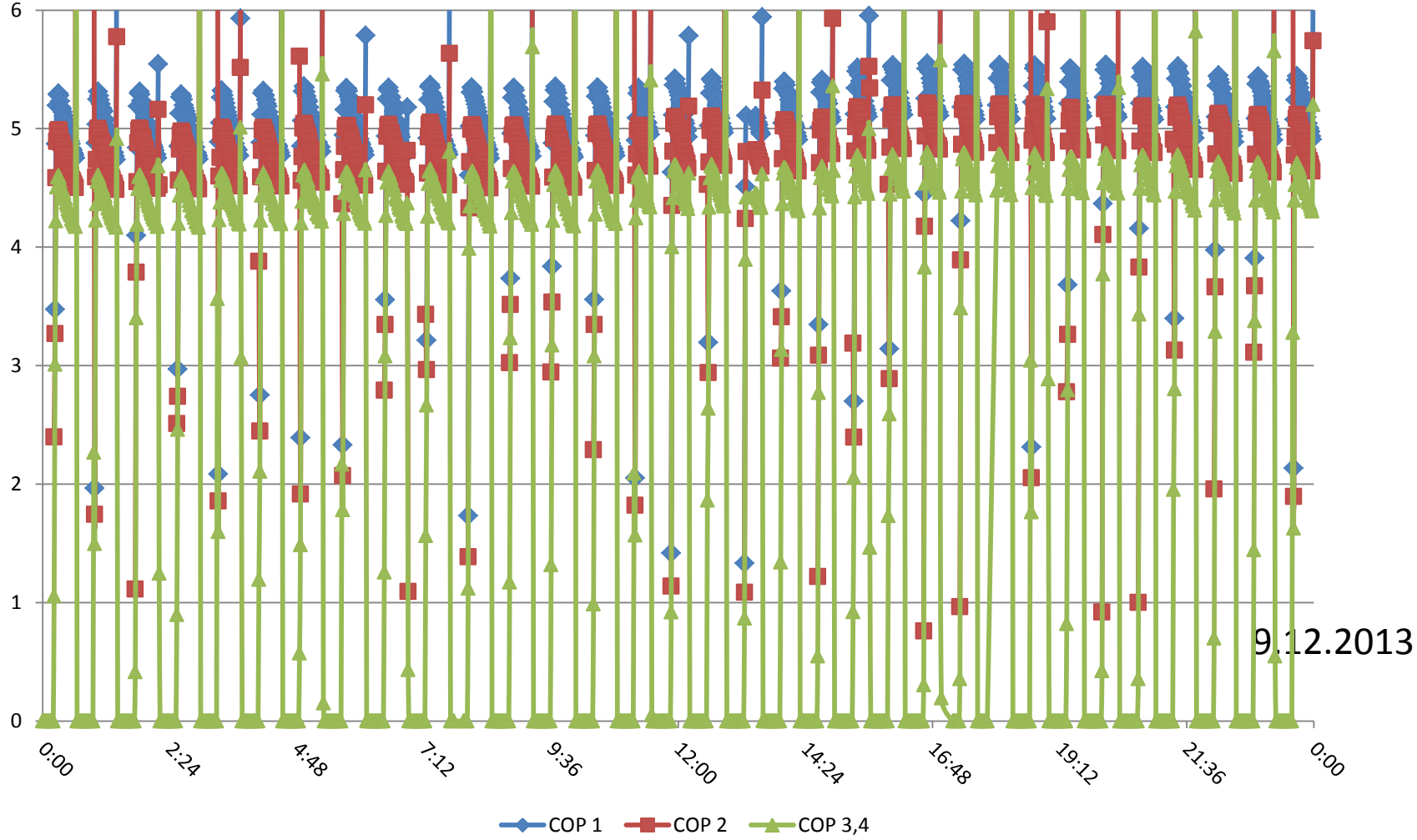
# Electricity consumption, kW



# Electricity consumption detail, kW



# COP transients



*Thank you for your attention*