MELOMED GATESVILLE SOLAR WATER HEATING

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Background

Hospitals have a very large demand for hot water and water heating is therefore a major expense. Most hospitals world-wide (and in South Africa) use heat pumps to save energy when supplying their hot water requirements.

It is also possible to supplement the heat pumps by retrofitting solar hot water systems, to save even more cost.

The goal of switching to a hybrid solar hot water system is to reduce the cost of energy so that the project shows a healthy ROI on the capital outlay. Even with heat pumps, Melomed Gatesville used approx. 350,000 kWh per month (11,600kWh per day), at a 2017 cost of R432,000 per month. Any savings of energy therefore make a very significant impact on the bottom line.

After designing a small solar water heating system, Solarex applied for a grant from Soltrain/AEE INTEC, a program of the Austrian Development Agency. This grant makes the economics of the project very attractive, with the only condition being that the plant may be used as a demonstration unit.

Melomed accepted the updated proposal in December 2016, and the AEEE INTEC grant was awarded in March 2017. After final design, equipment was specified and ordered, and construction started in May 2017.

Plant specification and design

Each system follows the schematic below.

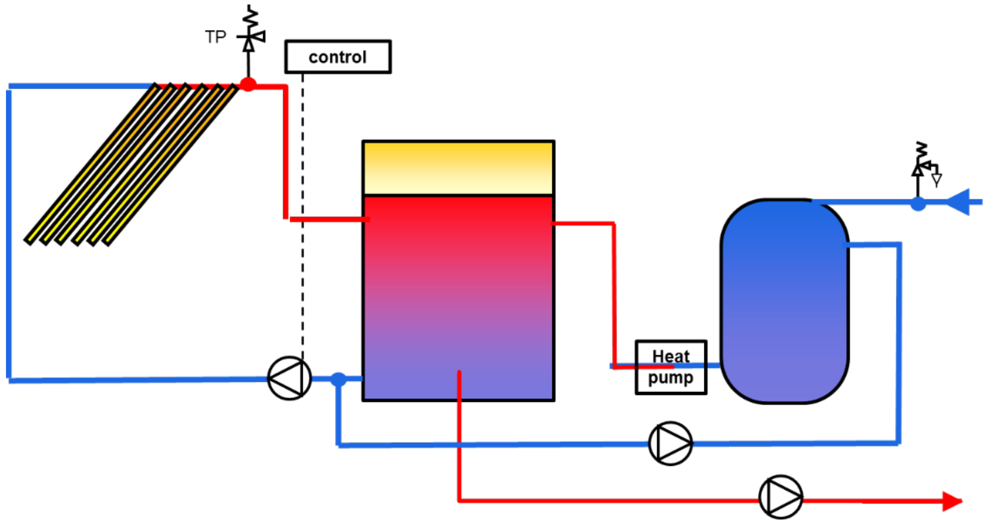


Figure 1: Hot water system schematic

The Melomed Solar plant is divided into 2 sections. One feeds the older A&B Blocks, with the second feeding the new C Block hot water system.

Each system has an energy generation capacity of 31kW, giving a total size of 62kW.

The systems each consist of 2 banks of 10 evacuated tube solar collectors (Jianxing Diyi New Energy Co, model DIYI-C01-24).

Total aperture area per panel is 2,506m^2, so the total aperture is 100,24m^2.

The solar system design provides for 28% of the estimated heat required for water heating, so there is opportunity for expansion.

One of the requirements of the hospital is that there should be no penetration of the roof's waterproofing layer. This was achieved by bolting the framework to 25kg concrete ballast blocks, resting on rubber pads. During the severe storm in June, the structures were well tested, and little movement was found.

Installation

The 2 plants were installed during the months of May/June 2017, with completion on 21 June 2017.

Few problems were experienced during construction, apart from a weather delay in early June, when a severe winter storm hit Cape Town. High winds and rain made it impossible to work on scaffolding or roof areas.

On completion, the equipment and installation was assessed by Rudi Moschik, an expert engineer from AEE Intec, who operate the Austrian Soltrain programme on behalf of the Austrian Development Agency.

The quality inspection took place on 3 July, and the plants were signed off by Soltrain on 6 July 2017.

As part of the installation, all existing hot water piping lagging was refurbished and re-labelled. Pigeon droppings and feathers are a major issue, so the areas were also cleaned.

Commissioning

After leak checking, the plants were operated in test mode for a period of 10 days. During this time, there were problems with the existing old Tekniheat heat pumps tripping.

During a site visit it was found that the heat pumps were experiencing over-pressure on the outlet side. This is caused by the inability to dissipate excess heat when the water feed temperature is high (in turn, caused by the additional energy supplied by the solar collectors).

NOTE: Modern heat pumps have significantly improved and can provide for most heating requirements up to 58ºC (older heat pumps could not receive water much above 38ºC due to the high head pressures). With the new refrigerant gases, available, as well as very efficient heat exchangers and electronic expansion valves, heat pumps can now operate at a much higher temperature as well as operate at a far lower ΔT.

See the Appendix for the as-built schematic diagrams of each system.

After making the necessary modifications the new installations were inspected, and the following observations were made:

Block C (ground floor tank installation)

1. Both heat pumps were operational with no HP trips
2. The Solar system delivered water between 63 and 58 °C
3. Feed tank outlet temperature was 55 °C

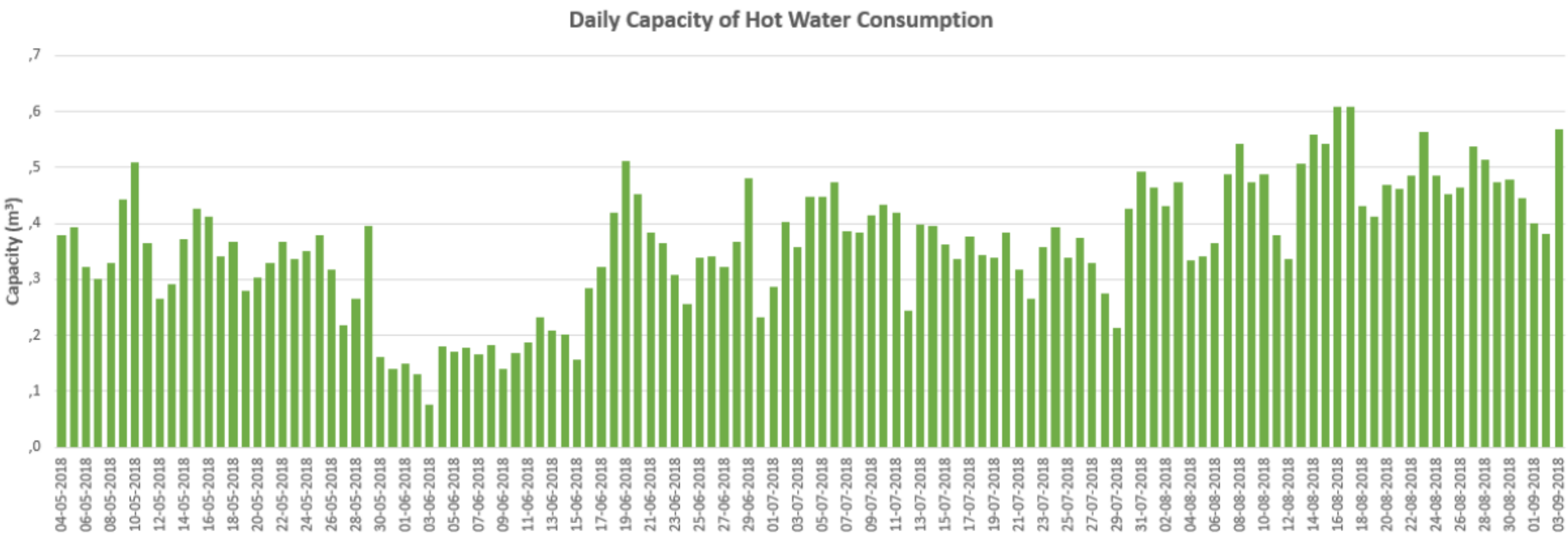
Block A (top of building installation)

1. Changed the suction point for the solar to the cold tank
2. We now pull water from the cold tank, heat the water to 60 °C with solar and send it to the hot tank
3. The result is that the heat pumps seldom run as the solar now moves most of the water from one tank to the other
4. Both heat pumps were operational with no HP trips
5. Solar system delivered water between 64 and 58 °C
6. Feed tank outlet temperature was 50 °C

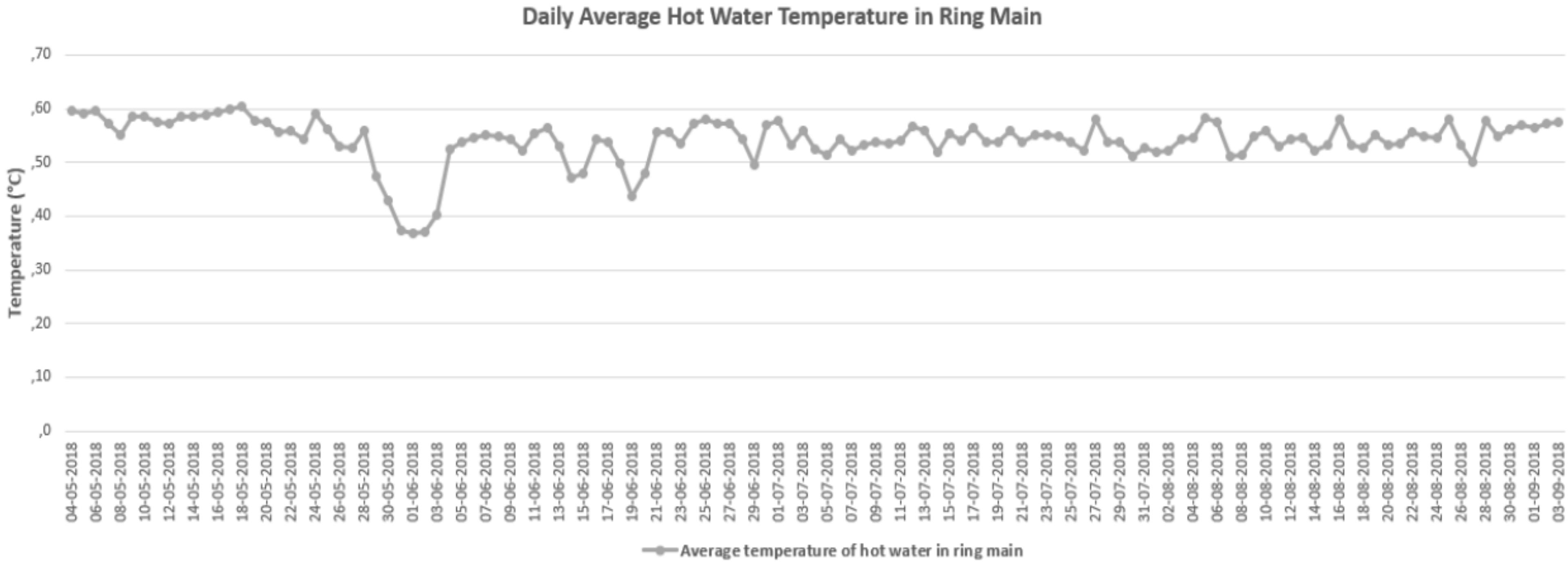
The heat pumps have no run-dry protection, so it is recommended that a low-level switch be fitted to the cold-water feed tank.

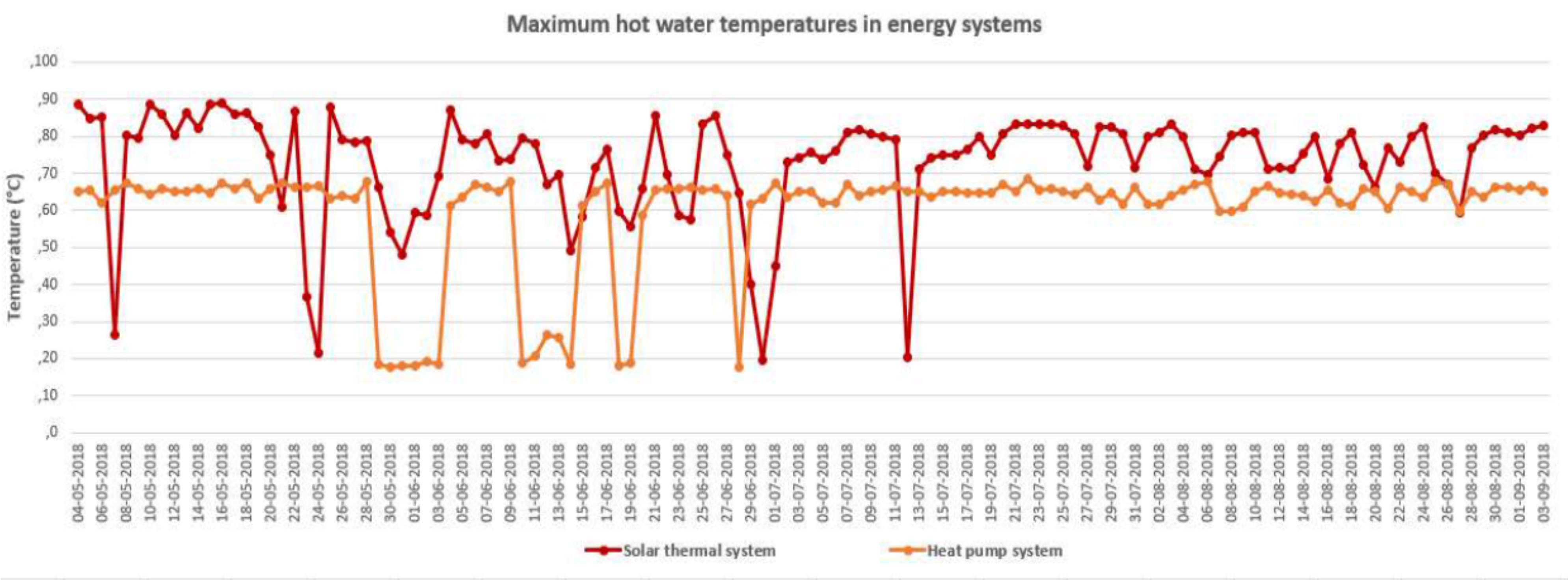
Monitoring

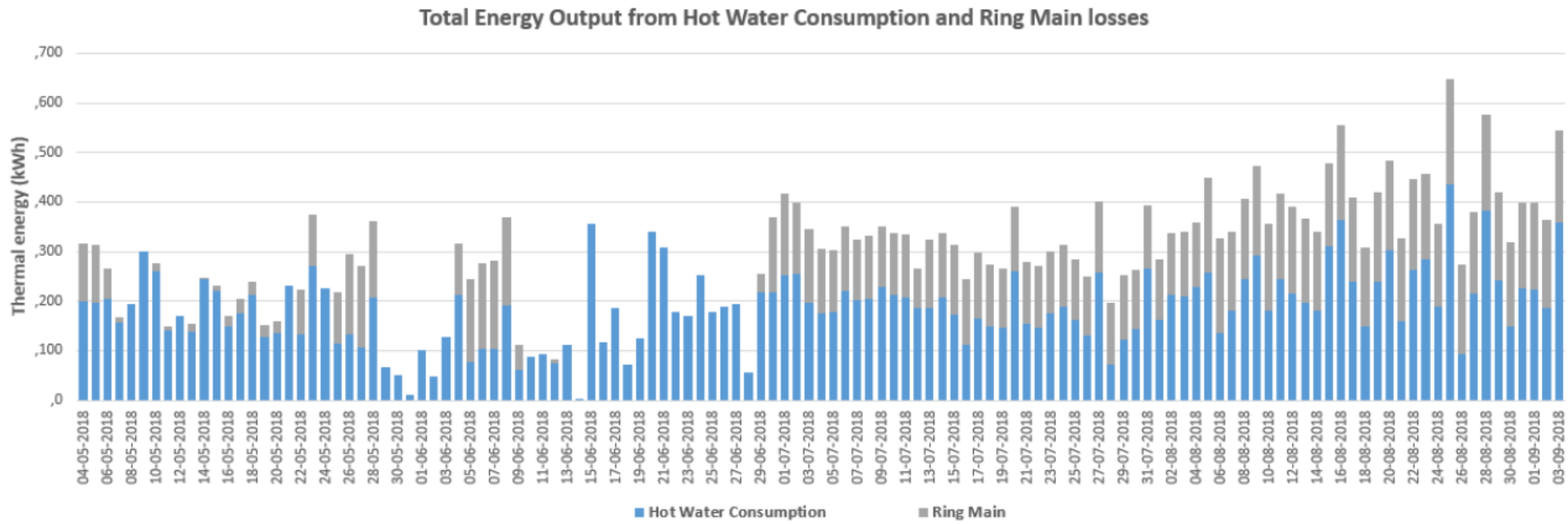
The thermal performance of one of the hot water plants was monitored by the Centre for Renewable Studies (CRSES) at Stellenbosch University for a period of 12 months to allow for a full analysis of the energy generated, and to indicate where further improvements might be made to optimise the energy efficiency of the entire hot water system.



Daily Capacity of Hot Water Consumption
Capacity (m³)
,0
,1
,2
,3
,4
,5
,6
,7


Daily Average Hot Water Temperature in Ring Main
Temperature (°C)
,70
,60
,50
,40
,30
,20
,10
,0
04-05-2018
06-05-2018
08-05-2018
10-05-2018
12-05-2018
14-05-2018
16-05-2018
18-05-2018
20-05-2018
22-05-2018
24-05-2018
26-05-2018
28-05-2018
30-05-2018
01-06-2018
03-06-2018
05-06-2018
07-06-2018
09-06-2018
11-06-2018
13-06-2018
15-06-2018
17-06-2018
19-06-2018
21-06-2018
23-06-2018
25-06-2018
27-06-2018
29-06-2018
01-07-2018
03-07-2018
05-07-2018
07-07-2018
09-07-2018
11-07-2018
13-07-2018
15-07-2018
17-07-2018
19-07-2018
21-07-2018
23-07-2018
25-07-2018
27-07-2018
29-07-2018
31-07-2018
02-08-2018
04-08-2018
06-08-2018
08-08-2018
10-08-2018
12-08-2018
14-08-2018
16-08-2018
18-08-2018
20-08-2018
22-08-2018
24-08-2018
26-08-2018
28-08-2018
30-08-2018
01-09-2018
03-09-2018
Average temperature of hot water in ring main


Maximum hot water temperatures in energy systems
Temperature (°C)
,100
,90
,80
,70
,60
,50
,40
,30
,20
,10
,0
04-05-2018
03-09-2018
Solar thermal system
Heat pump system


Total Energy Output from Hot Water Consumption and Ring Main losses
Thermal energy (kWh)
,700
,600
,500
,400
,300
,200
,100
,0
04-05-2018
06-05-2018
08-05-2018
10-05-2018
12-05-2018
14-05-2018
16-05-2018
18-05-2018
20-05-2018
22-05-2018
24-05-2018
26-05-2018
28-05-2018
30-05-2018
01-06-2018
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29-06-2018
01-07-2018
03-07-2018
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20-08-2018
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28-08-2018
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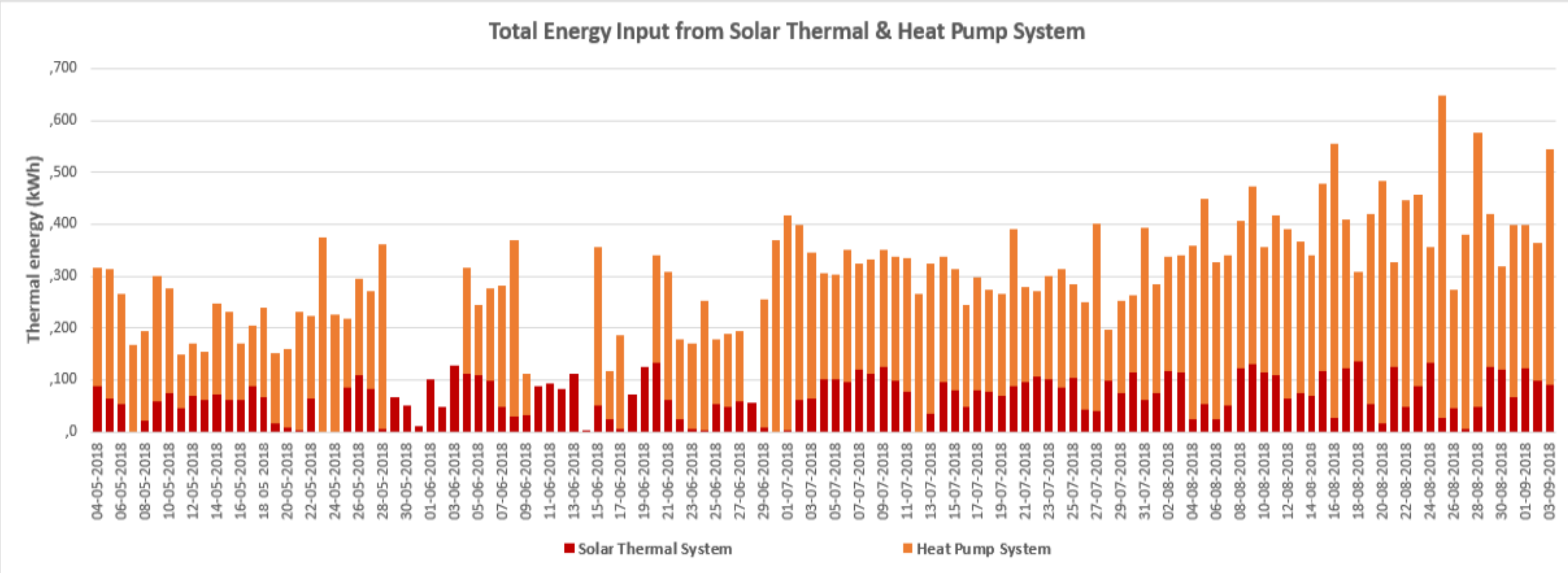
01-09-2018
03-09-2018
Hot Water Consumption
Ring Main



Winter months – solar contribution low

Summer – about 50%/50%

CONCLUSIONS

Key performance results from 1 May 2018 to 30 April 2019	
Solar thermal heat input	34 538 kWh_{th}
Heat pump heat input	72 597 kWh_{th}
Ring main	45 013 kWh_{th}
Heat consumption	52 210 kWh_{th}
Volume of hot water usage	1 419 168 Litres
Losses	9 912 kWh_{th}
Solar fraction	32%

- Hot water consumption is lower than assumed (actual 3,662lpd vs assumed 15,000lpd for the section monitored) – this is due to the water restrictions during the drought period
- In winter months (May-August), solar thermal is producing 24% of the water heating load
- Summer solar fraction increases to >50%
- Annual average approximately 50/50 across both systems. Ideally, the solar fraction should be increased to 80%.
    - This expansion would be done when the older heat pumps are replaced.
- Saving from Solar heat was initially R65,000 per annum (3 to 3½ year payback)
    - 2017 tariff was R0,69/kWh
    - 2021 tariff average R1,40/kWh
    - Current savings R130,000 per annum
- Maximum temperatures from the solar system are about 60 to 80ºC
- Heat pump regulated at 60 to 65ºC
- Ring main losses are 99kWh per day

Figure 2: Process control diagram Block C (North side)

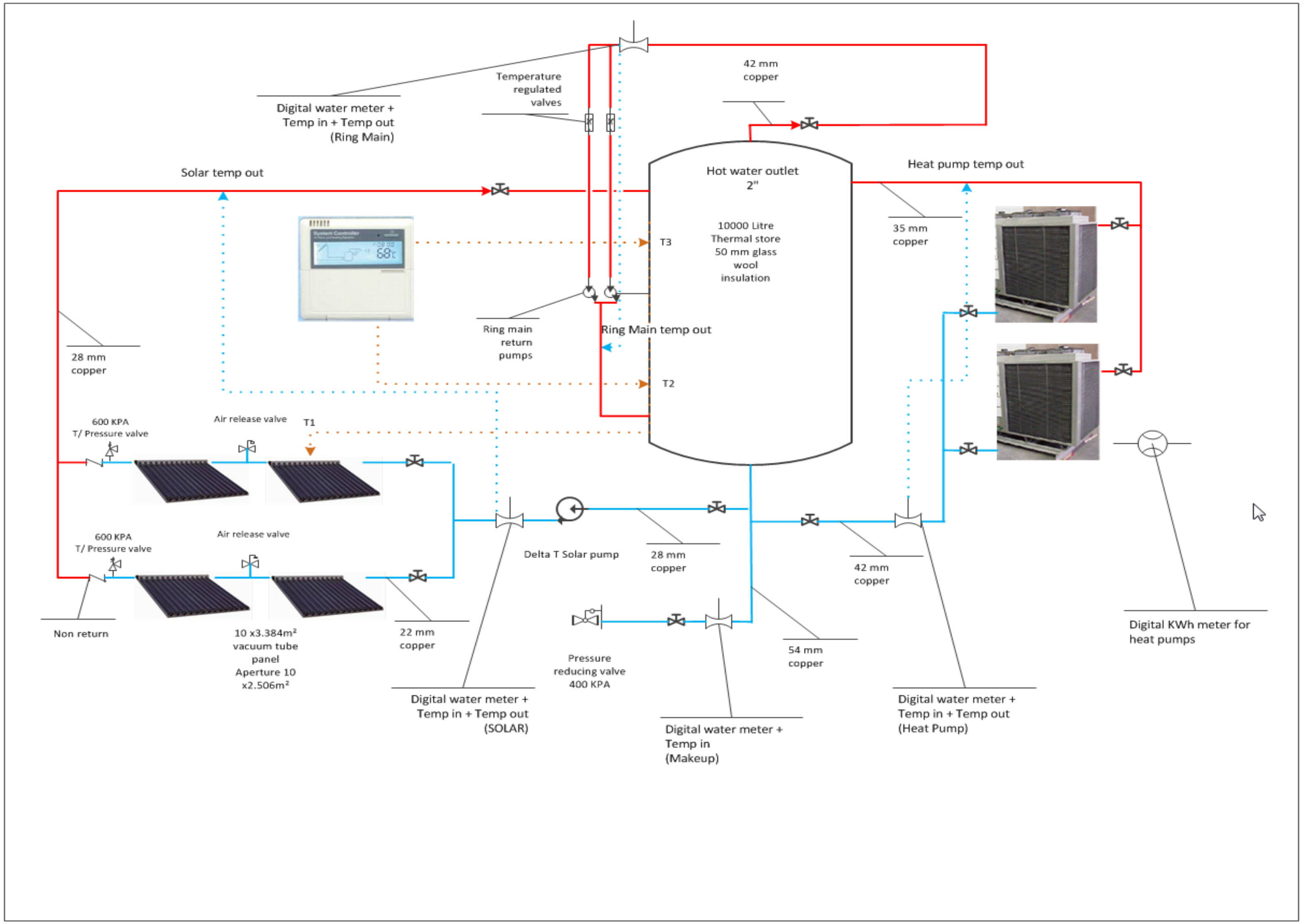
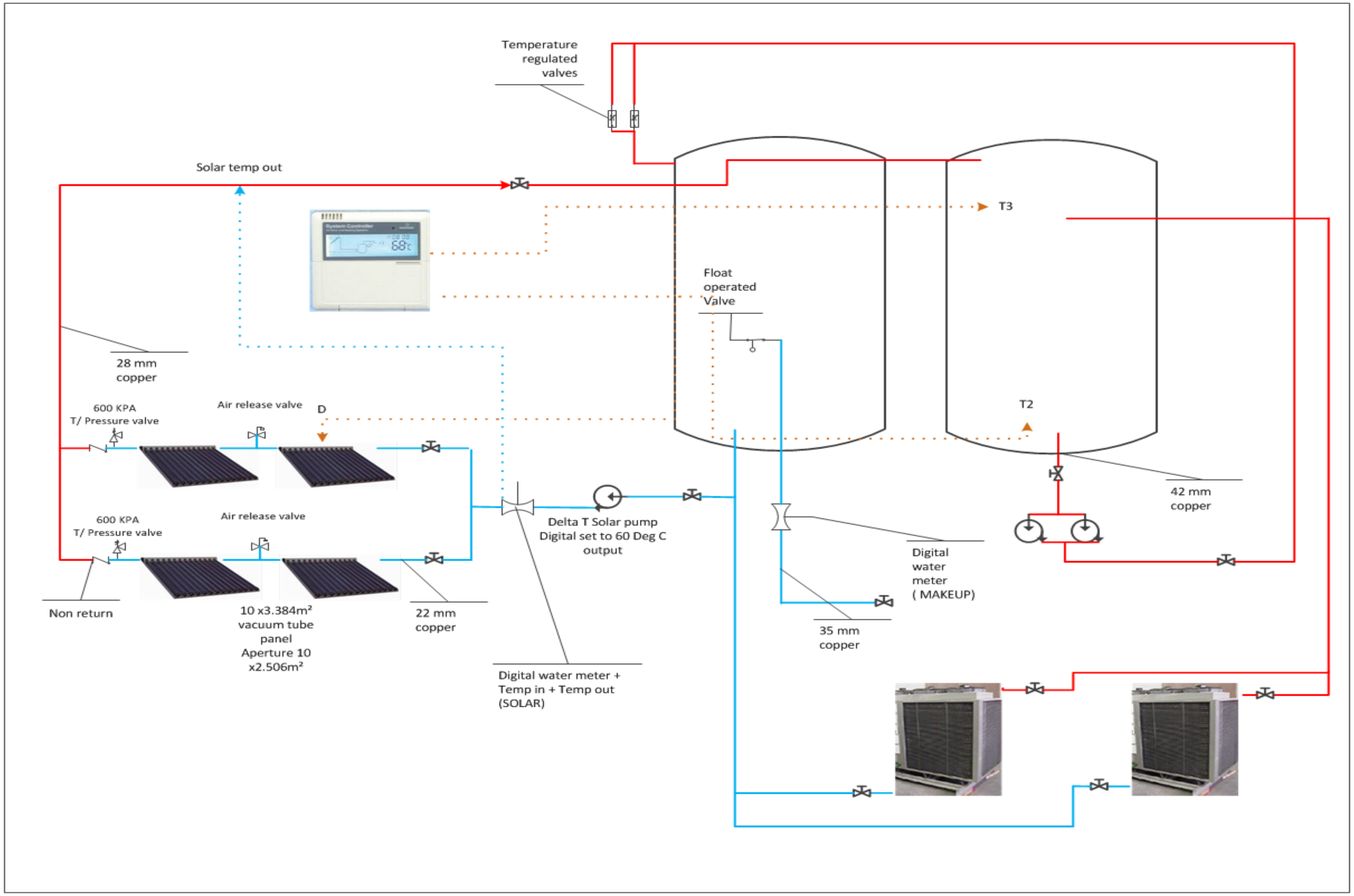


Figure 3: Process flow diagram Block A/B (South side)



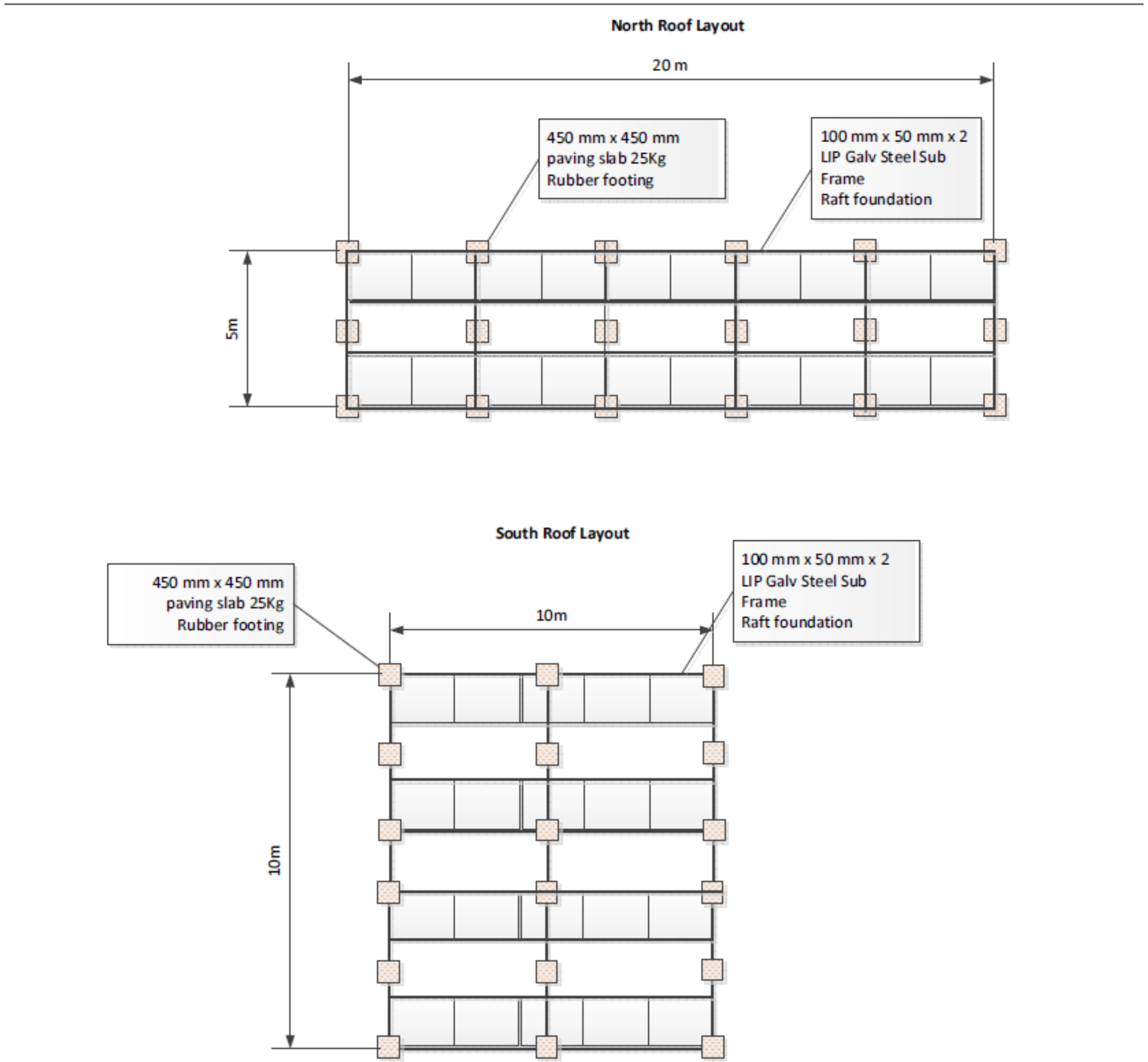


Figure 4: Foundation layout