Maintenance: The forgotten aspect to achieving low energy buildings?

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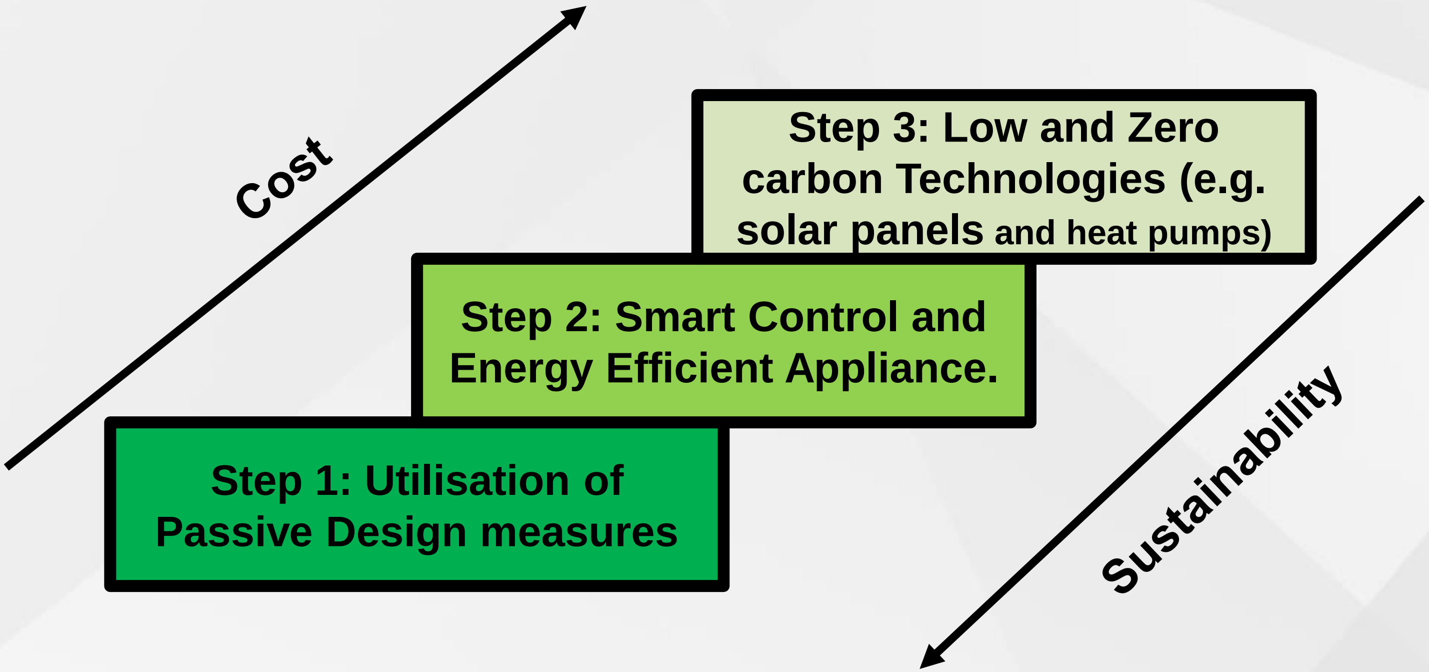
Key concept to consider

- **The building energy reduction hierarchy:**



Passive Design Measures

- Insulation (Reducing the building envelope's U-Value)
- Thermal mass to better regulate indoor temperature and reduce energy use.
- Solar Shading devices to reduce solar gain into the space and overheating
- Reduction of thermal bridging in the space.
- Airtightness to reduce infiltration in the space.
- Compactness of the space for heat retention.
- Optimum window to wall ratio.

What do regulations and standards say about passive design measures?

Table 4.1 Limiting U-values for new fabric elements and air permeability in new dwellings

Element type	Maximum U-value[1] W/(m²·K)
All roof types[2]	0.16
Wall[2]	0.26
Floor	0.18
Party wall	0.20
Swimming pool basin[3]	0.25
Window[4][5]	1.6
Rooflight[6][7]	2.2
Doors (including glazed doors)	1.6
Air permeability	8.0m³/(h·m²) @ 50Pa 1.57m³/(h·m²) @ 4Pa

Limiting heat losses and gains from building services

Hot water and heating pipework

4.24 In a new system, all of the following new pipework should be insulated.

a. Primary circulation pipes for heating circuits where they pass outside the heated living space, including where pipework passes into voids.

b. All primary circulation pipes for domestic hot water.

c. All pipes that are connected to hot water storage vessels, for at least 1m from the point at which they connect to the vessel.

d. All secondary circulation pipework.

4.25 In an existing system, when a boiler or hot water storage vessel is replaced, any accessible pipes in the dwelling should be insulated.

4.26 Heat losses from insulated pipework should not exceed those given in **BS 5422** for hot water services at 60°C, regardless of the actual design temperature. Meeting the standards in Table 4.4 is one way of demonstrating that heat losses will not exceed those given in **BS 5422**.

Thermal bridging

4.16 Thermal bridges occur when an area of a building has significantly higher heat transfer than the surrounding parts. Breaks in insulation, reduced insulation or more conductive materials can contribute to thermal bridge effects. The building fabric should be constructed so that thermal bridging, including at the party wall, is reasonably limited.

Thermal bridging in new dwellings

4.17 To limit thermal bridging in new dwellings, all of the following apply.

a. **Drawings** should be provided for junctions. The designer and installer should review drawings to check that junctions are buildable and to ensure construction sequencing is carefully considered for each detail. Complex details should be avoided wherever possible.

b. Before elements are concealed by subsequent work, an **on-site audit** should be undertaken to confirm that the designed details have been constructed. Photographs of the details should be taken in line with Appendix B.

c. **Product specification:** opportunities should be considered to use products that help to reduce thermal bridges. Options include both of the following.

i. Masonry construction: lightweight blockwork in the inner leaf of a cavity wall or both leaves of a party wall can help to reduce thermal transmittance, particularly at junctions, such as the ground floor to wall junction.

ii. Timber construction: the use of insulated plasterboard on the inside of the frame can help to reduce bridging at various junctions.

Low energy appliances and smart controls

- The use of 'A' rated appliances in terms of appliance energy efficiency ratings.
- From a lighting point of view using LED lighting over florescent or incandescent lighting
- Relying on motion sensors over on/off switches to close lights in the space
- The use of BEMS systems to better regulate performance of HVAC systems in the space
- The use of window control systems to better regulate and control the natural ventilation entering into the space.

Example of how to enhance the controls strategy

- **Basic Control:**

IF (CO_2 ≥ 1500 ppm) Open windows

- **Enhanced Control taking into account more parameters:**

IF (CO_2 ≥ 1000 ppm) AND (Indoor ºC < Seasonal setpoint ranges ºC) AND (Wind < Speed ms-1) Open Windows.

- **Enhanced Control taking into account more parameters and the context of the studied building.**

IF (CO_2 ≥ 1000 ppm) AND (Indoor ºC < Seasonal setpoint ranges ºC) AND (Wind < Speed ms^{-1}) AND (40% ≤ Indoor RH % < 60%) Open Windows

What do regulations and standards say about controls

Controls

System controls and zoning

5.14 For wet heating systems in new dwellings with a floor area of 150m² or greater, a minimum of two independently controlled heating circuits should be provided.

5.15 System controls should be wired so that when there is no demand for space heating or hot water the heating appliance and pump are switched off.

5.16 Domestic hot water circuits that are supplied from a hot water store should have both of the following.

a. Time control that is independent of space heating circuits.

b. Electronic temperature control.

5.17 Primary hot water circuits for domestic hot water or heating should have fully pumped circulation where this is compatible with the heat generator.

5.18 Wet heating systems should ensure a minimum flow of water to avoid short-cycling.

5.19 For space heating systems, temperature control should be installed for the heating appliance.

Active design measures to reduce energy reduction

- The transition into heat pumps (Both air source and ground source heat pumps) to provide space heating & cooling and how water.
- The use of mechanical ventilation heat recovery (MVHR) to retain heat – This touches into passivhaus standard.
- The use of high efficient boilers (Efficiencies above 90%) to provide heating and hot water.
- The use of solar and wind energy to provide electrical energy.

What do the building regulations say about active design measures?

Table 6.2 Minimum efficiencies for gas-fired heating systems in existing dwellings

System type	Minimum efficiency	Notes
Wet heating (e.g. radiators or underfloor heating)	92% (as defined in ErP[1])	Or, in exceptional circumstances in existing dwellings[2], SEDBUK 2009 efficiencies as follows: • 78% for natural gas • 80% for LPG Follow paragraph 6.2
Range cooker with integral central heating boiler	75% (as defined in SEDBUK 2009)	Follow paragraph 6.3
Warm air heating	**BS EN 17082**	If a gas-fired circulator is incorporated for domestic hot water, its full and part load efficiency should meet **BS EN 15502-2** Follow paragraph 6.4
Independent space heating appliance for primary and secondary space heating	63% gross 70% net	Gross efficiency using the following standards as appropriate: • **BS EN 1266** • **BS 7977-1** • **BS EN 613** • **BS EN 13278** Follow paragraph 6.5
Inset live fuel-effect combined fire/back boiler	45% for natural gas 46% for LPG	Gross efficiency using **BS 7977-2** Follow paragraph 6.6
All types except inset live fuel-effect combined fire/back boiler	63% for natural gas 64% for LPG	Gross efficiency using **BS 7977-2** as appropriate

NOTES:

1. Energy-Related Products Directive. For Standard Assessment Procedure modelling, SEDBUK values should be used.
2. Exceptional circumstances are defined in the ODPM's *Guide to the Condensing Boiler Installation Assessment Procedure for Dwellings*.

What about maintenance and system optimisation?

Maintenance and system failure

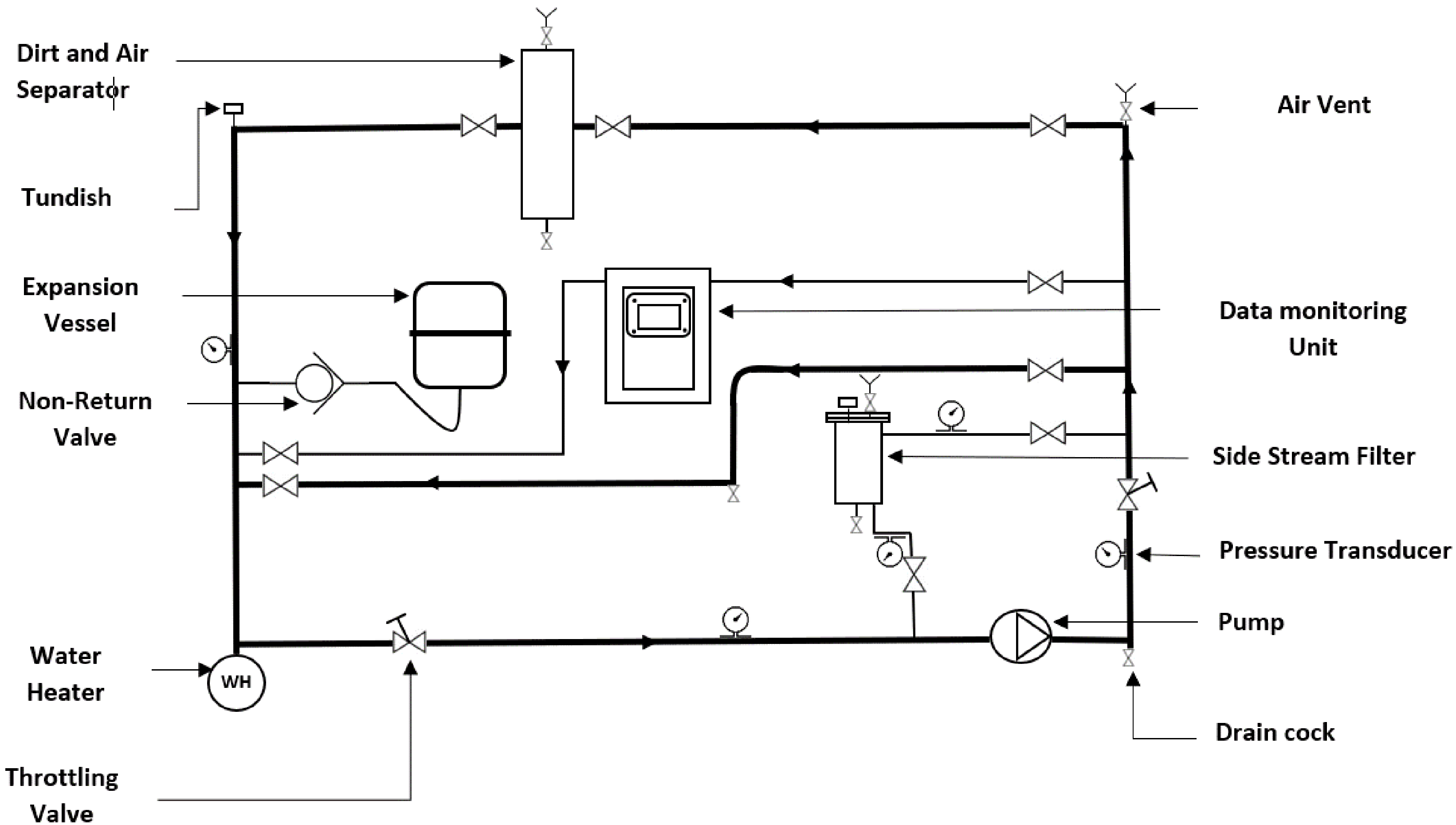
- System failure due to corrosion (In heating systems) can lead to economic losses of up to £1 million.
- Unmaintained hydronic systems can lead to significant energy losses due to reduced heat losses as a result of corrosion and poor fluid quality.
- Work by Opel et al (2018) showed that premature system failure and excessive energy use was an issue reported by 30% of those surveyed.
- A survey found that 25% of damages and failures to heating and cooling systems were caused by issues which can be avoided by maintenance.

How does that impact energy saving?

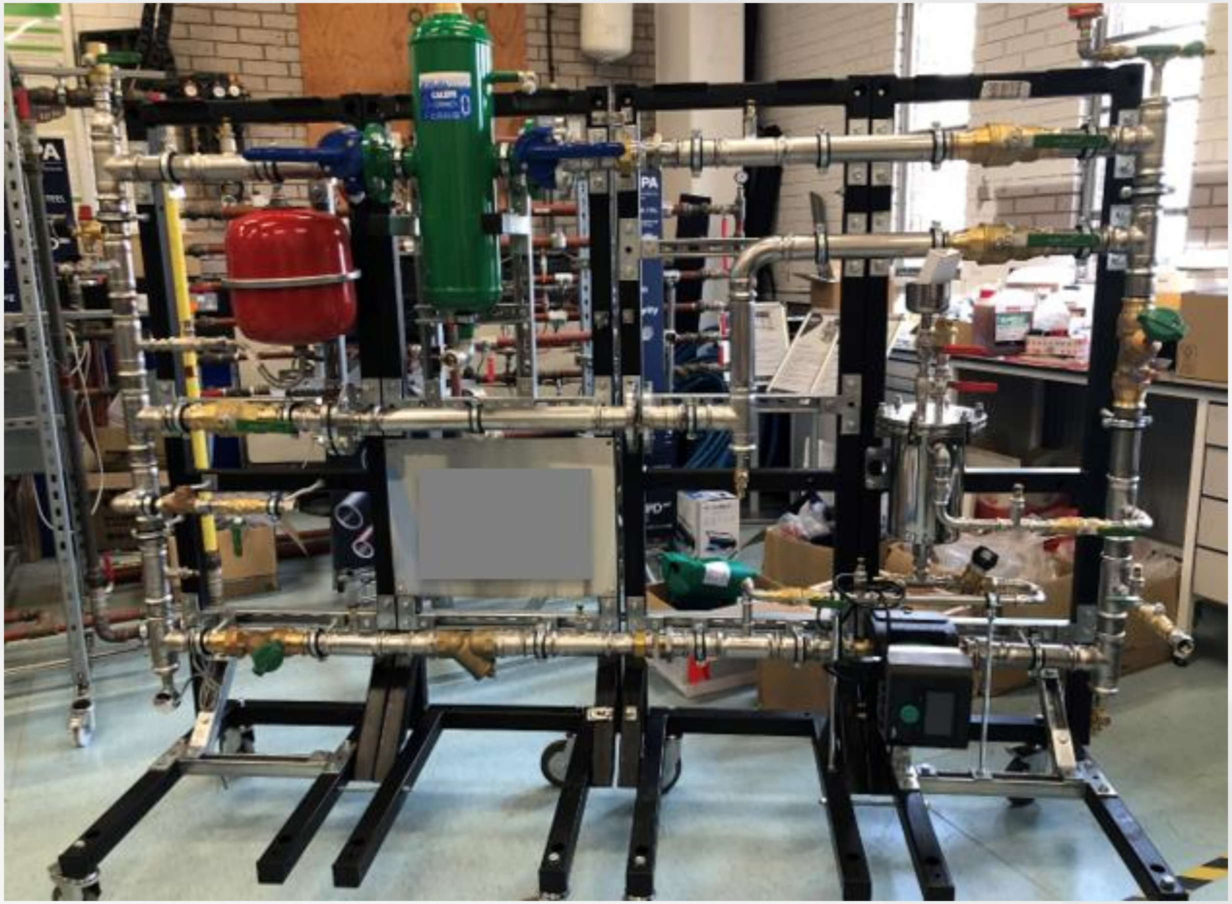
Design of the experiment

- An experiment was conducted replicating a heating and cooling system.
- The experiment was tested under different conditions (Clean – Dirty –Filtration)
- The aim was to establish to what extent can unclean systems impact the energy performance of heating systems.
- The experiment also explored to what extent can system efficiency be restored

Design of the Experiment



Visualisation of the experimental rig



Testing conditions

- All experiments were ran at a temperature range of 50 – 60C
- Corrosion was simulated for a system corroding for a period of 5 and 10 years.
- The system was tested under different pressures and flow rate values to replicate different systems operating conditions
    - Pressure tested were 0.5 BAR, 1 BAR & 1.5 BAR
    - Volume flow tested were 2 m3/h, 4m3/h & 6 m3/h.

Sequence of Testing

Step 4: Filter off

Step 3: Filter on

Step 2: Dirty System

Step 1: Clean System

Results 10-year system

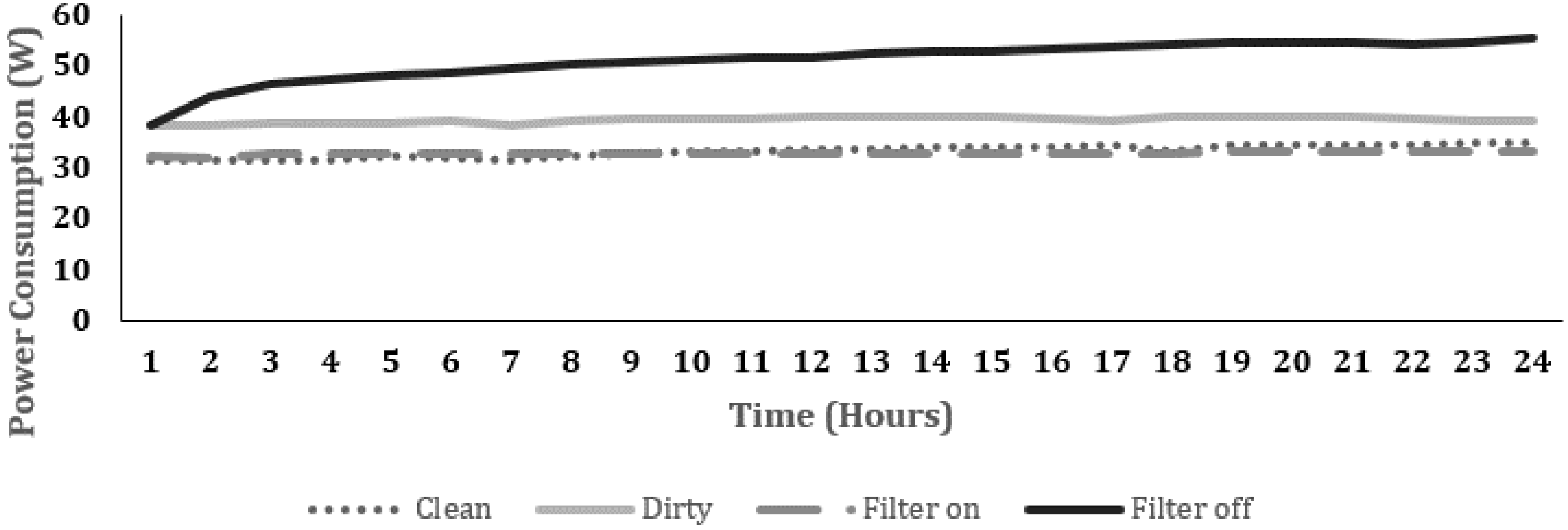


Figure 3.2 Pump power consumption under different conditions when operating at a flow rate of 4 m3/h and a pressure of 1 BAR

Results 10-year system

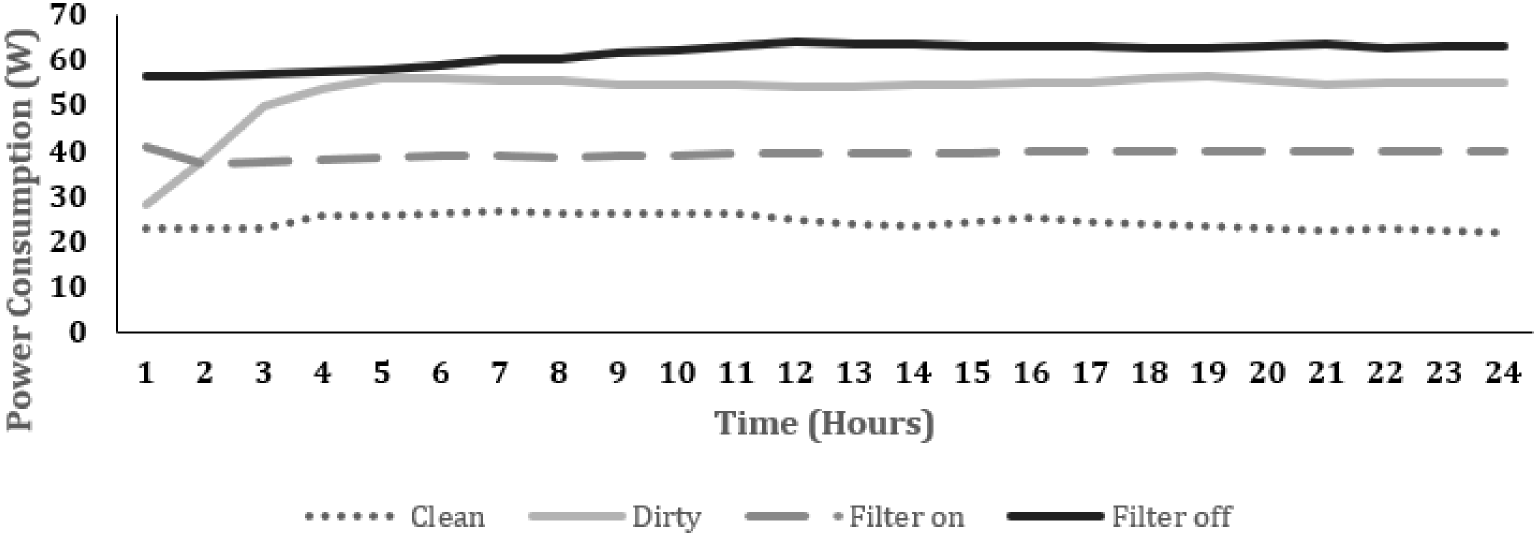


Figure 3.3 Pump power consumption under different conditions when operating at a flow rate of 4 m3/h and a pressure of 0.5 BAR

Results 10-year system

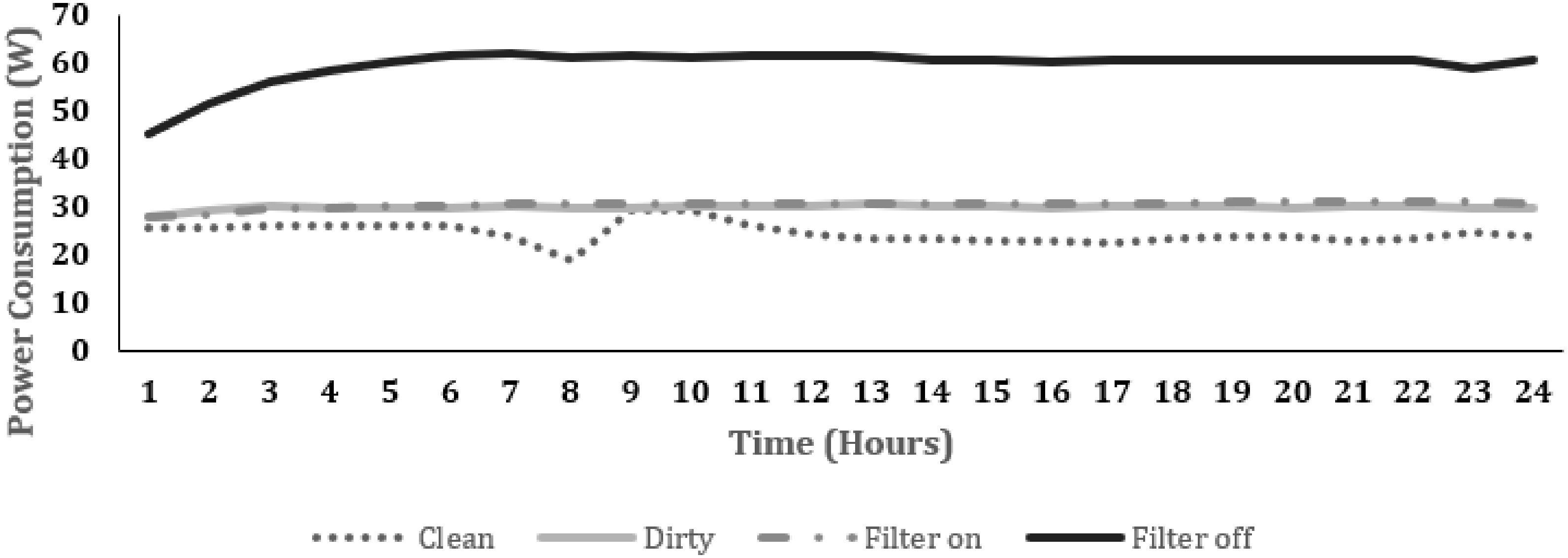
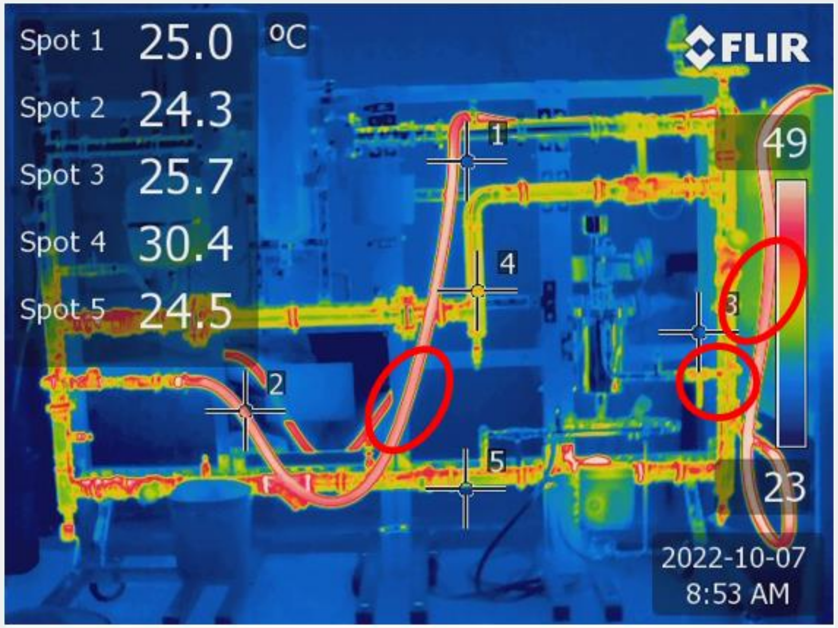
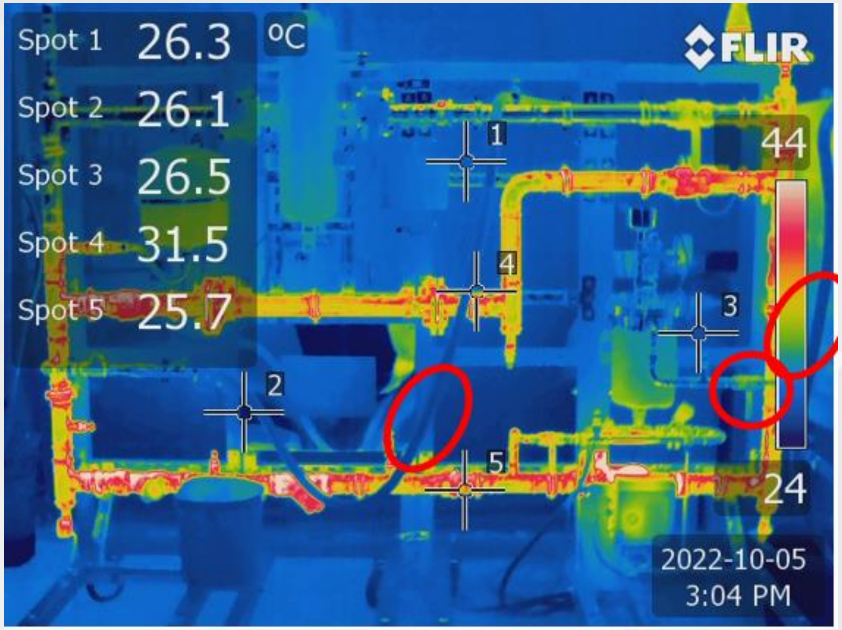


Figure 3.4 Pump power consumption under different conditions when operating at a flow rate of 4 m3/h and a pressure of 1.5 BAR

Results

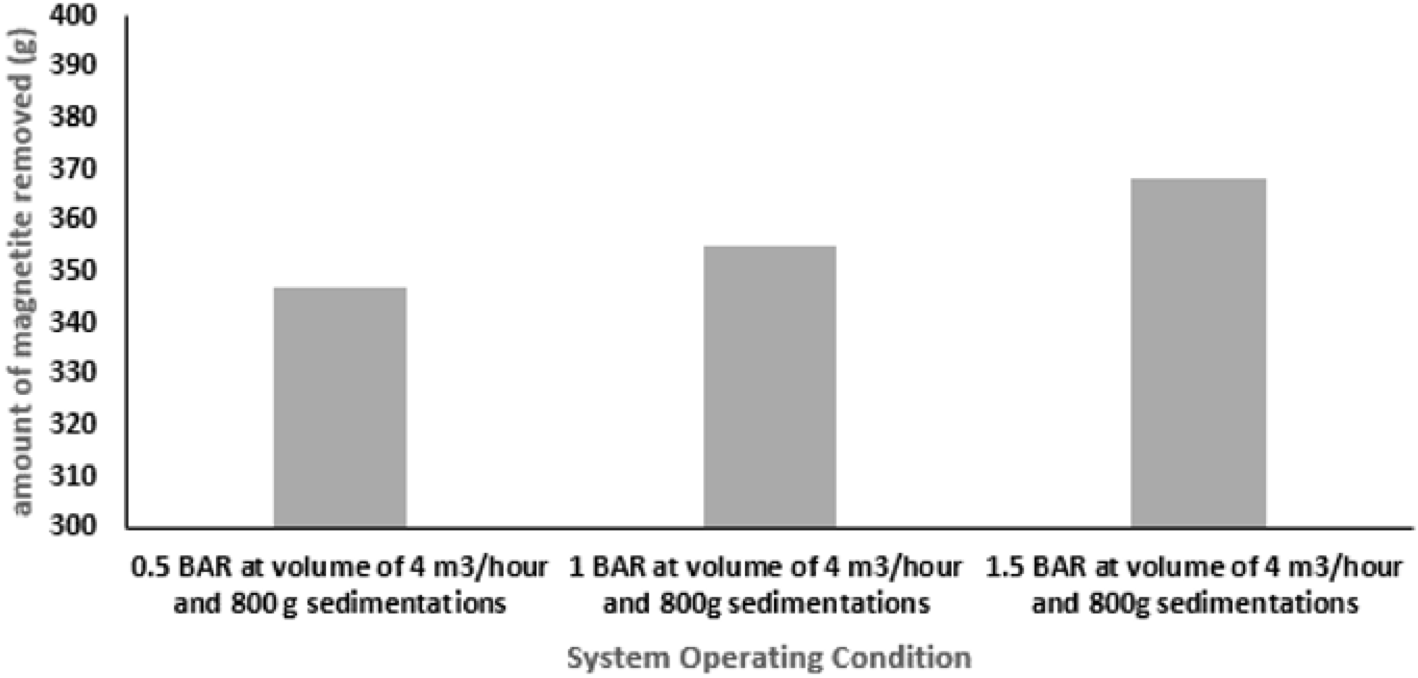


Clean System

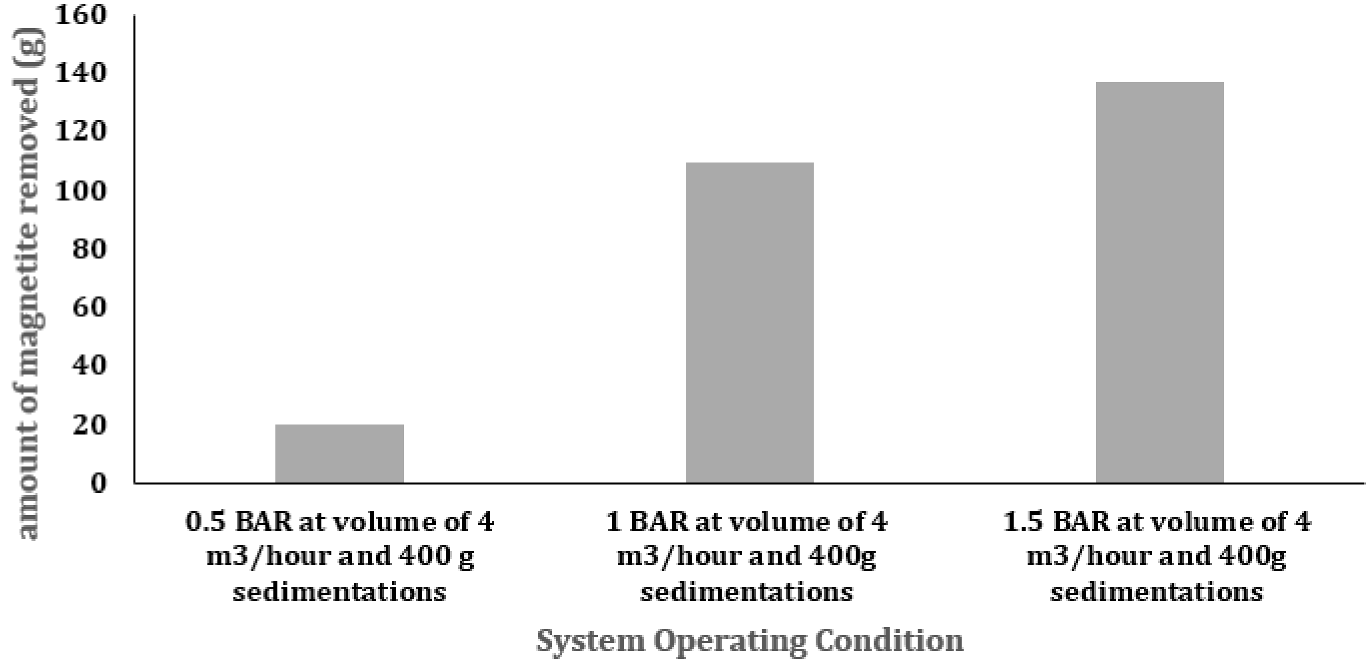


Dirty System

Results 10-year system



Results 5-year system



Summary

- Simple and regular maintenance could save and reduce significant amount of energy
- Maintenance and plant optimisation is important and essential for system longevity.
- System monitoring is essential for timely intervention and enhancing potential savings.

- Note: During the experiment process a total of three pumps and two heaters were damaged due to the poor water quality.

List of References

- *Munn, S., (2016)., Testing the water tackling corrosion in pipework – CIBSE journal, CIBSEJournal.com.*
- *Opel, O. et al., (2018)., 'Corrosion in Heating and Cooling water circuits – A field study'., in Energy Procedia. Elsevier Ltd., pp. 359-366. doi: 10.1016/j.egypro.2018.11.042.*

Any Questions?

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