Coach Lane Campus
Decarbonisation of Blocks F, G, H and Sports Hall
Mechanical and Electrical Services
Stage 3: Developed Design

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Revisions

Version	Amendment	Date
01	Stage 3 Issue	03.11.23
02	Client Comments and Hysopt Information added	22.11.23

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1.0 Introduction

The following section of the Report considers the proposed Mechanical and Electrical Services design proposals for decarbonisation of the heating and domestic hot water systems within Northumbria University, Coach Lane East Campus, Coach Lane, Newcastle upon Tyne, NE7 7XA.

The Report will identify proposals for the installation of air source heat pumps (ASHPs) as the primary heat source for low temperature hot water (LTHW) heating to replace the current gas fired boilers and gas fired water heaters.

As installed information and half hourly energy consumption for gas and electrical power has been provided by the University to allow an analysis of the existing supplies to be undertaken as part of the analysis.

A digital twin provider, Hysopt have taken the information from this Report and have developed operating parameters of the existing and proposed systems to confirm how the proposed systems will perform with the new heat pumps installed as part of the system. The Hyspot information is provided within Appendix B of the Report.

2.0 Existing Site

The existing site comprises of a main teaching block which is split into 3 defined areas, Blocks F, G and H and Sports Hall together with surrounding sports fields and facilities for outdoor sports activity.

Blocks F, G and H are each serviced independently for heating and hot water from dedicated roof mounted plant rooms. The Sports Hall is a standalone building serviced independently from the remainder of the site.

Fig 1 shows the existing site plan and location of each building located on the site.

The works will be confined to these areas of the site internally with any external servicing provided below ground to service entry locations as described in this Report.

Fig 1: Site Plan

3.0 Existing Services

Mechanical Services

Blocks F, G and H and the Sports Hall are each serviced independently for heating and hot water from plant rooms as indicated in Fig 2.

Each plantroom is similar in nature with gas fired boiler plant providing the heat source for LTHW heating and the domestic hot water gas fired water heaters generating the hot water supply.

Fig 2: Plant Space Locations

Within Block F plantroom 3No. Broag Remeha 350-6 gas boilers are currently installed rated at 90kW output are located within a mezzanine plantroom within block F. There is also a supplementary Broag Remeha 350 gas fired boiler rated at 174kW fitted which is located within the third floor plant area below the mezzanine plantroom. The boilers are shown in Figs 3&4 below.

Fig 3: Block F Original Boiler Plant – Mezzanine Plantroom

Fig 4: Block F Supplementary Boiler Plant – Third Floor Plantroom

The supplementary boiler has been installed after the building was completed and is connected into the primary flow and return header of the existing boiler plant located within the mezzanine plant room.

The boilers are installed with a common horizontal primary flow and return header in a pumped reversed return configuration from which two pumped secondary circuits emanate.

The circuits consist of a constant temperature (CT) circuit and variable temperature (VT) circuit from the primary headers.

The CT circuit serves the existing air handling units and heating coils within the block. The output of the air handling unit and heating coils is controlled through 3 port control valves.

The VT circuit serves a system of radiators throughout the block. The overall system is controlled through direct weather compensation and optimiser circuit. The radiator heat output is controlled through thermostatic radiator valves.

Hot water is generated through an independent Andrews 40/61 gas fired water rated at 19kW located within the ground Floor plantroom.

Within Block G the plantroom houses 2No Broag Remeha 350-5 gas boilers are currently installed rated at 90kW output. There is also a supplementary Broag Remeha 350 gas fired boiler rated at 174kW fitted in each plantroom adjacent to the original gas fired boilers. The boilers are shown in Fig 5 below.

Fig 5: Block G Boiler Plant

The supplementary boiler has been installed after the building was completed and is connected into the primary flow and return of the existing boiler plant.

The boilers are installed with primary flow and return headers in a pumped reversed return configuration from which two pumped secondary circuits serving a CT circuit and VT circuit from the primary headers.

The CT circuit serves the existing toilet air handling unit coil within the block. The output of the air handling unit and heating coils is through 3 port control valves.

The VT circuit serves a system of radiators throughout the block. The overall system is controlled through direct weather compensation and optimiser circuit. The radiator heat output is controlled through thermostatic radiator valves

Hot water is generated through an independent Andrews 84/87 gas fired water rated at 26.0kW.

Within Block H plantroom 2No Broag Remeha 350-5 gas boilers are currently installed rated at 90kW output. There is also a supplementary Broag Remeha 350 gas fired boiler rated at 174kW fitted in each plantroom adjacent to the original gas fired boilers. The boilers are shown in Fig 6 below.

Fig 6: Block H Boiler Plant

The supplementary boiler has been installed after the building was completed and is connected into the primary flow and return of the existing boiler plant.

The boilers are installed with primary flow and return headers in a pumped reversed return configuration from which two pumped secondary circuits serving a CT circuit and VT circuit from the primary headers.

The CT circuit serves the existing toilet air handling unit coil within the block. The output of the air handling unit and heating coils is through 3 port control valves.

The VT circuit serves a system of radiators throughout the block. The overall system is controlled through direct weather compensation and optimiser circuit. The radiator heat output is controlled through thermostatic radiator valves.

Hot water is generated through a Hamworthy Dorchester direct gas fired water heater rated at 19.1kW which was fitted in 2017 as a replacement to the original Andrews water heater.

Within the Sports Hall first Floor plantroom 3No Broag Remeha 350-5 gas boilers are currently installed rated at 90kW output. The boilers are installed with primary flow and return headers in a pumped reversed return configuration from which two pumped secondary circuits serving a constant temperature (CT) circuit and 2No variable temperature (VT) circuit from the primary headers.

The CT circuit serves the existing air handling units and heating coils within the block. One of the VT circuits serve a system of radiators throughout the block, with the other circuit serving the Sports Hall radiant panels.

Hot water is generated through 4No Andrews gas fired water located within two first floor plant spaces. Two of the heaters are located within the boiler plantroom with a further two fitted in a supplementary plant space on First Floor of the building:

The heaters and models are as follows:

- Andrews 81/264 Auto rated at 80kW (Supplementary plant space)
- Andrews Hiflo Evo HF65/380 rated at 79kW (Supplementary plant space)
- 2No Andrews gas fired water rated at 79.0kW (Main Plantroom)

Each heating system is pressurised through independent pressurisation units and expansion vessels.

Conventional flues discharge exhaust gases from each plant room to atmosphere from both boilers and water heaters.

Each plantroom houses an independent automatic control panel interfaced to provide a fully automated Trend BMS system serving the site.

Each building is provided with a Trend Building Management System (BMS) with Trend 945 supervisors located within the Northumbria University main BMS hub through modem links.

The system is controlled through a series of Trend IQ controllers across site connected via the modem to the central control location.

Electrical Services

The Coach Lane East Campus is served by a 1MVA Northern Powergrid (NPG) Network Sub-Station located in the main car park near block H. NPG HV cable infrastructure is routed from the public highway in Coach Lane via the entrance road to the sub-station position.

The site is served at LV with the supply terminated in a cubicle type switchboard accommodated in a client LV switchroom attached to the sub-station.

Fig 7: Existing Sitewide Electrical Distribution

From this position underground sub-main cables have been run out to serve blocks F, G and H independently, 2No. supplies having been run out to each block to serve 400A and 200A rising busbar installations located within dedicated risers.

A further sub-main cable has been installed to the Sports Hall terminated into a dedicated main panel board.

All services within each block being served from the above supply arrangements.

4.0 Proposed Services

The following section of the Report identifies the Mechanical and Electrical Services proposals for the building.

The mechanical and electrical proposals for the building will consist of the following elements:

- LTHW Heating
- Domestic Hot and Cold-Water Services
- Automatic controls & wiring
- Incoming Electrical Supply
- LV Distribution & Metering
- Containment & Wiring Systems
- External Lighting
- Fire Alarm System
- Lightning protection system
- Earthing & Bonding system

Concept descriptions of these services are identified in the following sections of the Report.

5.0 Statutory Obligations

The following Statutory Bodies have been identified and this Report will identify if any issues are apparent with satisfying these obligations of the Bodies.

(a) The CIBSE Codes and Guides.

(b) Water Supply Bylaws.

(c) British Gas Regulations.

(d) The BESA Codes and Guides.

(e) BS 7671 Regulations for Electrical Installations.

(f) Regulations under the Electricity Acts.

(g) The Health & Safety at Work, etc Act.

(h) Construction Design & Management Regulations (CDM)

(i) The Electricity at Work Regulations.

(j) The National Inspection Council for Electrical Installation Contracting (NICEIC).

(k) Local planning Authority

(l) The Building Regulations.

(m) All other relevant British Standard Specifications and Codes of Practice, whether mentioned in this Specification, or not.

(n) Northumbria University Engineering Services and Policy Documents

6.0 Statutory Services

6.1 Mains Water

There will be no requirement to modify the existing incoming mains water installation due to the proposed works.

6.2 Natural Gas Supply

The existing gas service will be retained although supplies to the existing gas fired boilers and water heaters which are being decommissioned will be suitably valved off and capped at each plant space.

It should be noted that reduced capacity to the site may affect standing charges from the gas supplier, so the University should arrange for a review of their charging strategy upon completion of the works.

6.3 Electrical Supply

It is envisaged that the existing Northern Powergrid (NPG) supply arrangement to the site has inherent capacity to accommodate the proposed Air Source Heat Pump installations. As a result, it is anticipated that no major infrastructure upgrades will be needed to serve the site.

Half hourly meter readings indicate the recorded max. demand for the site to be 341 kVA. Existing protection settings are set at 800A on the incomer to the main switchboard which would appear to indicate the current maximum supply capacity available to be in the region of 500kVA. With the increased load from the ASHP's this figure will be exceeded, and an application will therefore be required for an increase in supply capacity. Protection settings will subsequently need to be adjusted accordingly and meter tails confirmed as being sufficiently sized for the increased supply.

6.4 Telecommunications/Data

There will be no requirement to modify the existing incoming telecoms/data installation due to the proposed works.

7.0 Mechanical Services

7.1 Scope of Works

The mechanical services installation will comprise the following elements:

- Provision of new primary LTHW heating services
- Modifications to LTHW heating installations
- Modifications to domestic hot and cold water installations
- Modifications to the automatic controls and wiring installations

Ambient Conditions

All plant, equipment and systems will be capable of withstanding the following ambient conditions:

a) External plant and equipment:

Air temperature -20°C to +40°C, 90% RH

b) Internal plant and equipment:

Air temperature -5°C to +40°C, 90% RH

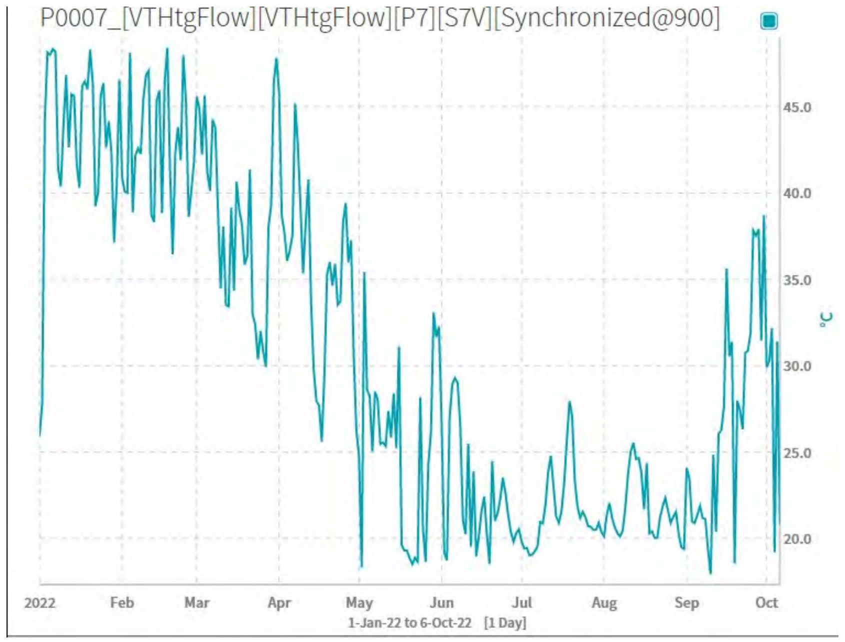
These figures are not design values for the sizing of HVAC plant.

Current Operating Parameters

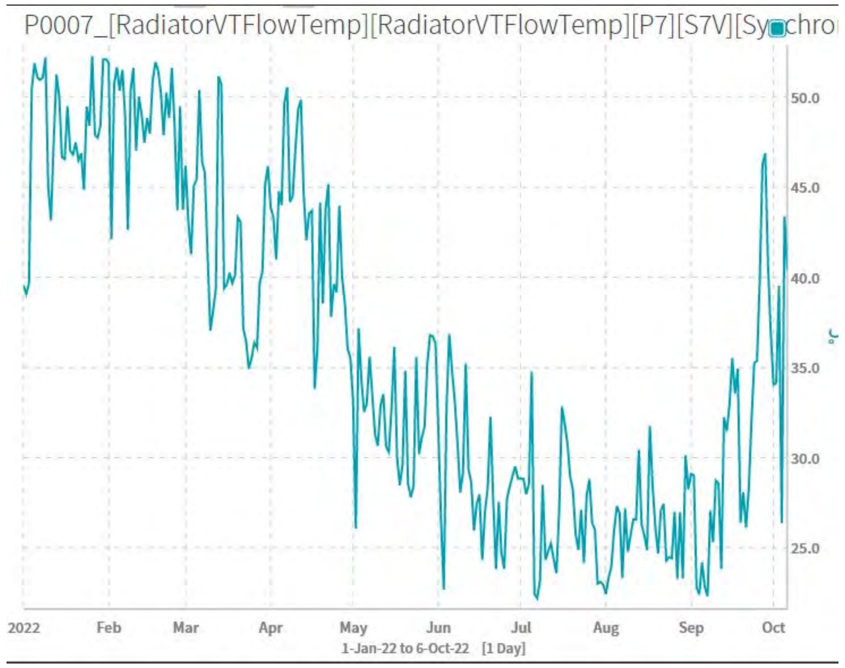
Data has been extracted from the sitewide BMS to obtain current operating flow temperatures of the existing variable temperature (VT) heating circuits.

This is graphically represented below for the period 01 January 2022 to 06 October 2022:

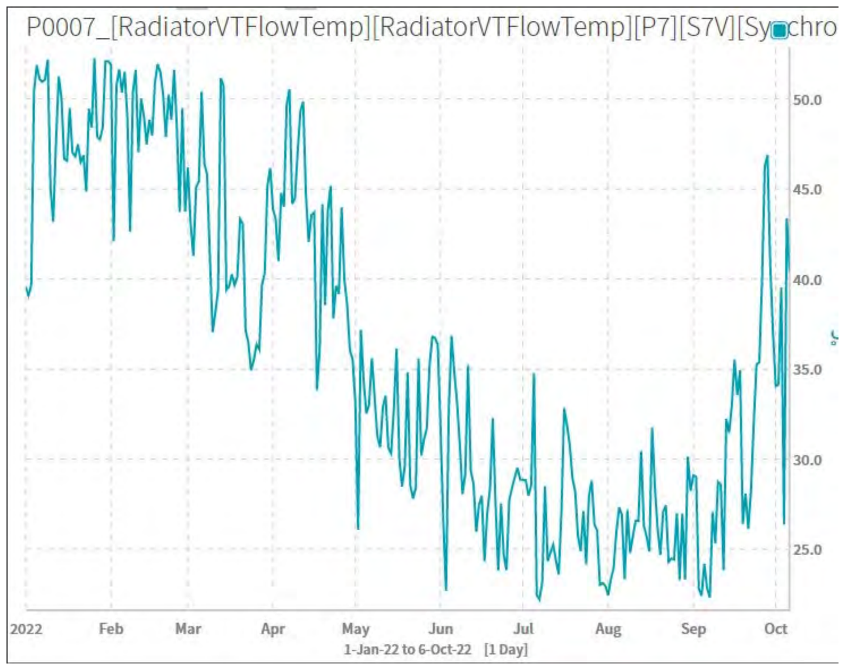
Block G



Block H



Sports Hall



No data was available for Block F although based on the graphs it would appear that each of the VT systems recorded operate at a maximum flow temperature of 55°C throughout the winter period when the VT heating circuits would be operational, dropping lower through May to October when the VT circuits are expected to be off.

It can be anticipated that the flow temperatures with Block F will follow a similar pattern.

The current LTHW heating system is designed to operate at a 10°C flow and return temperature differential.

Confirmation of the flow temperature of 70°C has been confirmed by the University for the CT circuits serving air handling plant and heating coils. This has been analysed in conjunction with the above graphs to determine the output of the coils if reduced flow temperatures are proposed to serve the air handling plant and heating coils to each building to negate the need to replace the coils.

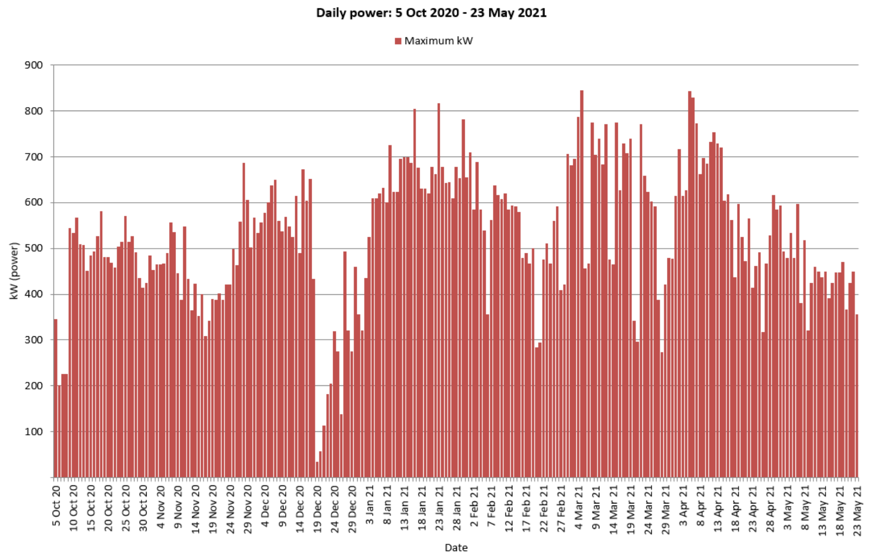
Consumption Data

From the half hourly consumption data, the following graphical displays have been generated to indicate the hourly peak gas and electrical power consumption for the site at Coach Lane East which houses both buildings.

This data is for the full site, so a further set of data solely for the Sports Hall has been obtained and through subtraction the data has been split between the buildings.

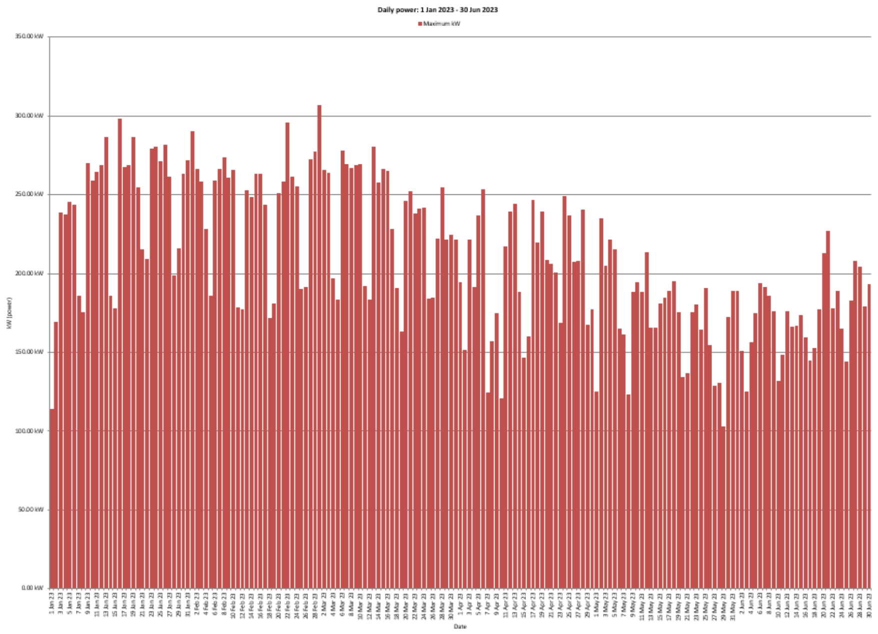
Further analysis has been undertaken in conjunction with Hysopt to confirm the ASHP sizes for each building.

Peak Gas Consumption



The data shows peak hourly gas consumption for the site of 845kW on 05 March 2021 between the hours of 05.00 and 06.00.

Peak Electrical Consumption



The data shows a maximum electrical power consumption for the site of 307kW (341kVA based upon 0.9PF) on 01 March 2023 between the hours of 11.00 and 12.00.

This information will be used to assist in selection of the output for the proposed ASHPs.

Annual Gas Consumption

Some of the annual gas consumption figures based on the half hourly data were corrupted but an uncorrupted sample has been recorded for a period of 01 January 2021 to 31 December 2021 where the annual gas consumption was recorded as 1,622,048kWh/annum.

Annual Electrical Power Consumption

Some of the annual electrical consumption figures based on the half hourly data were corrupted, but an uncorrupted sample has been recorded for a period of 01 January 2021 to 31 December 2021 where the annual electrical consumption was recorded as 1,124,471kWh/annum.

Gas Consumption – Binned Data

Table 1 – Binned Gas Consumption Data (Coach Lane Campus East Total)

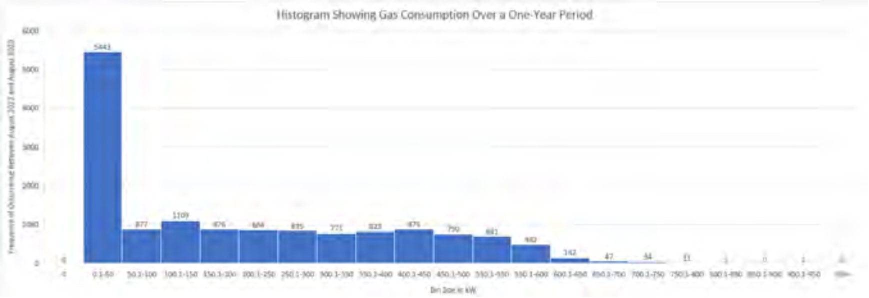
Bin	***Frequency***	***Sum %***
0	0	0
0.1-50	5443	37.19
50.1-100	877	43.18
100.1-150	1109	50.76
150.1-200	876	56.74
200.1-250	864	62.65
250.1-300	835	68.35
300.1-350	771	73.62
350.1-400	823	79.24
400.1-450	875	85.22
450.1-500	750	90.35
550.1-550	691	95.07
550.1-600	482	98.36
600.1-650	142	99.33
650.1-700	47	99.65
700.1-750	34	99.88
750.1-800	11	99.96
800.1-850	5	99.99
850.1-900	0	99.99
900.1-950	1	100
950+	0	100
Total	14636	

Table 1 shows the half hourly data for the site binned to indicate the frequency that specific peak consumption has been achieved on an hourly basis between August 2022 -August 2023.

Table 2 – Binned Gas Consumption Data (Sports Hall Only)

Bin	***Frequency***	***Sum %***
0	670	0
0.1-10	3296	40.03
10.1-20	434	45.30
20.1-30	2287	73.08
30.1-40	48	73.66
40.1-50	32	74.05
50.1-60	52	74.68
60.1-70	58	75.38
70.1-80	106	76.67
80.1-90	105	77.95
90.1-100	135	79.58
100.1-110	249	82.61
110.1-120	300	86.25
120.1-130	269	89.52
130.1-140	273	92.83
140.1-150	213	95.42
150.1-160	119	96.87
160.1-170	71	97.73
170.1-180	49	98.32
180.1-190	31	98.70
190.1-200	23	98.98
200.1-210	16	99.17
210.1-220	11	99.31
220.1-230	13	99.47
230.1-240	13	99.62
240.1-250	8	99.72
250.1-260	6	99.79
260.1-270	4	99.84
270.1-280	2	99.87
280.1-290	3	99.90
290.1-300	1	99.91
300.1-310	0	99.91
310.1-320	1	99.93
320.1-330	2	99.95
330.1-340	3	99.99
340.1-350	1	100.00
Total		8234

From this data the size of the proposed ASHPs can be assessed and assists in optimum sizing for the ASHPs. This is shown graphically below.



From the data it shows that the frequency of hourly consumption of up to 600kW for the site occurs for 98.36% of the time.

The overall connected gas load for site for heating and hot water is 1348kW which indicates the level of overcapacity currently installed on the site.

From the data it is anticipated that the hot water demand will be expected to increase the heat pump size due to generating the hot water service through a storage system rather than direct gas fired, and this has been taken account of when assessing the ASHP output sizes.

By subtraction the consumption identified in Tables 1 &2 has provided the following proposed outputs for the heat pumps

Main Block	400kW
Sports Building	200kW

These outputs will be used within the Hysopt analysis to assess the system performance and revised operational outputs.

7.2 Mechanical Services Strategy

Design Criteria

The Mechanical Services installation will be designed utilising the following design criteria:

External Design Conditions

Winter: Weather data for Newcastle based on CIBSE Guide A, Environmental Design 2017 Edition.

Winter	-5.0°C wb/-5.0°C db (Fully Saturated)
Summer	30.0 °C wb/22.0°C db

Internal Design Conditions

The existing external design conditions for the building will be used to confirm the building internal temperature performance.

Noise Levels.

Noise levels generated by the building services to the external environment will be in accordance with the requirements of the local building control/environmental health officer.

Internally noise from building services plant and equipment will be in accordance with CIBSE Guide A Environmental Design 2017 Edition.

The mechanical services strategy are indicated on the following drawings within Appendix A of this Report:

- 10131-LIN-Z1-XX-DR-M-500001 – Block F Existing LTHW Heating Schematic
- 10131-LIN-Z1-XX-DR-M-500002 – Block F Proposed LTHW Heating Schematic
- 10131-LIN-Z1-03-DR-M-500001 – Level 03 Block F Plantroom Layout
- 10131-LIN-ZZ-03-DR-M-500001 – Block F&G LTHW Heating Primary Services Distribution Routes
- 10131-LIN-Z2-XX-DR-M-500001 – Block G Existing LTHW Heating Schematic
- 10131-LIN-Z2-XX-DR-M-500002 – Block G Proposed LTHW Heating Schematic
- 10131-LIN-Z2-03-DR-M-500001 – Level 03 Block G Plantroom Layout
- 10131-LIN-Z3-XX-DR-M-500001 – Block H Existing LTHW Heating Schematic
- 10131-LIN-Z3-XX-DR-M-500002 – Block H Proposed LTHW Heating Schematic
- 10131-LIN-Z3-03-DR-M-500002 – Level 03 Block H Plantroom Layout
- 10131-LIN-Z3-03-DR-M-500002 – Block H LTHW Heating Primary Services Distribution Routes
- 10131-LIN-Z4-XX-DR-M-500001 – Sports Hall Existing LTHW Heating Schematic
- 10131-LIN-Z4-03-DR-M-500001 – Sports Hall Plantroom Layout
- 10131-LIN-Z4-03-DR-M-500002 – Sports Hall Plantroom Layout
- 10131-LIN-Z4-ZZ-DR-M-500001 – Sports Hall LTHW Heating Primary Services Distribution Routes

The mechanical services systems strategy is described below.

Plantrooms and Distribution

New external plant space will be provided to accommodate the proposed air source heat pumps to Blocks F, G and H as indicated in Fig 8 below.

Fig 8: ASHP Location – Blocks F, G, H

In Blocks F, G and H the area proposed to house the ASHPs is within a location currently used for bin storage adjacent to Block H as indicated in Fig 9 below.

Fig 9: ASHP Location – External Compound

The primary LTHW heating flow and return pipework will be distributed below ground from the ASHP location enter the building within an

existing vacant service riser that distributes through the building to the roof.
The proposed entry point is to the right of the Block H entrance doors at the gable end of the building as indicated in Fig 10.

Fig 10: Block H Primary Pipework Proposed Entry Location

The pipework will rise within the riser to roof level from where the distribution will enter Block H plantroom and be distributed horizontally before entering the roof void service corridor which links the 3 blocks.

At each plant area the pipework will enter the plantroom for connection to the new services proposed within each space as indicated on the Fig 11 below.

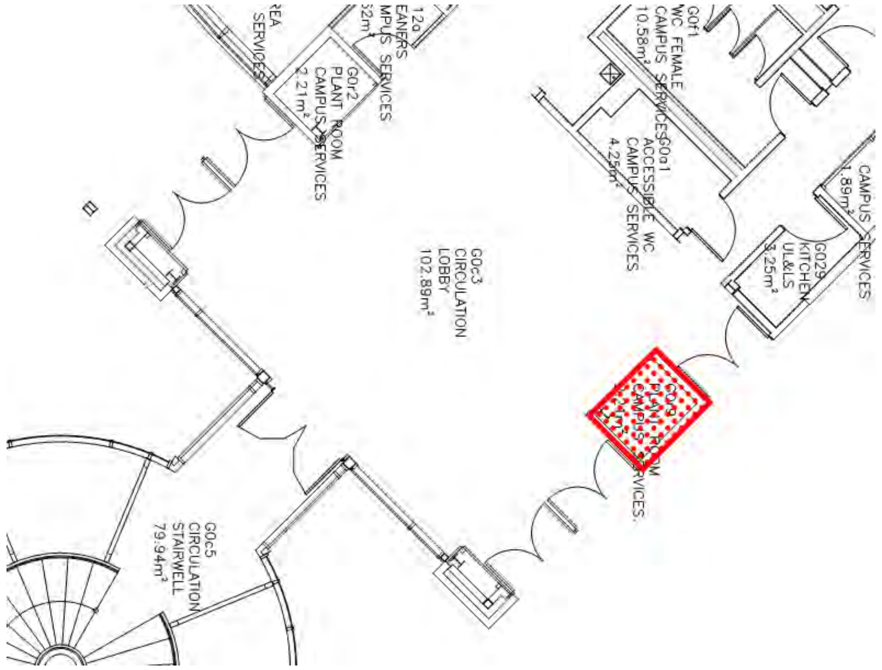


Fig 11: Primary LTHW Heating Distribution Riser

The space currently designated for the Sports Hall to house the ASHPs is within an external compound to the rear of the building as indicated in Fig 12.

Fig 12: ASHP Location – Sports Hall

The proposed location for the ASHPs will be within the existing storage compounds as indicated in Fig 13. Noting that the compound will need to be reconfigured to form the plant area.

Fig 13: ASHP Location – Sports Hall External Compound

The primary pipework for the ASHPs will distribute below ground and rise externally on the building facade to enter the building at high level within the Sports Hall.

Within the Sports Hall the pipework will be distributed at high level and branch to serve the storage vessels in both plantrooms as indicated on the drawings within Appendix A.

Incoming Mains Water Supply

The existing mains water supplies to each plant space will be modified where required to suit new revised plantroom layouts.

Natural Gas Supply

The existing natural gas services to each plant item will be valved and capped off within each plant space following the removal of ant gas fired equipment.

LTHW Heating

The proposal is to remove the original 90kW rated gas fired boilers in Blocks F, G and H together with all gas fired water heaters.

This will allow the ASHPs to operate as the heat source and utilise the 3No 174kW rated gas fired boilers located within the plantrooms in Block F, G and H to be retained as the backup and top up heat source in a bivalent arrangement.

The heat pumps will be located externally as described above and will supply the primary circuit of LTHW heating to each building.

The heat pump configuration would consist of two heat pumps to serve Block F, G and H each rated at 200kW (400kW total) sized to accommodate circa 96% of the overall LTHW heating load of the building.

The heat pumps will connect to a system of primary circulation pipework that will provide the main distribution of LTHW heating supplied to each of the plant rooms. The pipework route is currently established as indicated on the drawings within Appendix A.

The current heat pump selection proposed for Block F, G and H is from the **Clade Aspen SN 200kW** range of propane based heat pumps.

The heat pumps will also provide the primary heating source to generate domestic hot water to the buildings following the removal of the gas fired water heaters.

New thermal stores with a capacity of 2000 litres will be provided within Block H plantroom to act as the central store for the new distribution system.

Currently a horizontal primary reversed return header system serves the existing gas fired boiler plant. This circuit will be reconfigured to allow the connection of the new primary circuit from the thermal store in each plant space to serve Blocks F, G and H in lieu of the removed boilers.

These works will require modifications to the existing the primary header systems and domestic water services within each plant space. The works will involve break ins to the existing header systems and reconfiguration of the headers to accommodate connections from the primary heat pump circuit and the retained gas boiler.

From the reconfigured header system the existing LTHW heating circuits within each of the three plant areas consisting of a VT pumped circuit serving systems of radiators and CT circuit which supplies to air handling plant and heating coils, consistent across all plant areas will be retained.

An additional pumped CT circuit will be provided within each plantroom to serve a new hot water storage calorifier that will operate as the hot water generator following removal of the gas fired water heaters.

It has been confirmed from readings obtained from the Building Management System (BMS) that the current VT circuits operate at a maximum flow temperature of approximately 55°C. Confirmation of flow temperatures within the primary circuits and CT circuits have been provided by the University as 70°C.

In order to maximise the efficiency of the ASHPs, discussions with Clade Technical Department have confirmed the operating temperatures within the primary circuit of LTHW heating system to be 65°C flow 50°C return. This would increase the current 10°C flow and return temperature differential across the current system to 15°C which would mean retention of the secondary circuit pumping arrangements, pipework and a review of flow rates within the systems.

The heat pump configuration for the Sports Hall would consists of two heat pumps each rated at 100kw (200kW total) from where a primary circuit of LTHW heating will be generated and supplied to each of the plant rooms.

The current heat pump selection proposed for the Sports Hall is from the **Clade Aspen 100kW** range of propane based air source heat pumps.

The heat pumps will also provide the primary heating source to generate domestic hot water to the buildings following the removal the gas fired water heaters.

At the plant area the pipework will enter the plantroom for connection to the new thermal stores as indicated on the drawings within Appendix A.

Currently a horizontal primary reversed return header system serves the existing gas fired boiler plant. This circuit will be reconfigured to allow the installation of thermal storage vessels in the plant space to serve the Sports Hall in lieu of the removed boilers.

These works will require modifications to the existing the primary header systems and domestic water services within each plant space. The works will involve break ins to the existing header systems and reconfiguration of the headers to accommodate connections from the primary heat pump circuit and the retained gas boiler.

From the reconfigured header system the existing LTHW heating circuits within the plant area consisting of 2No VT pumped circuits serving systems of radiators and the Sports Hall radiant panels and CT circuit which supplies to air handling plant and heating coils will be retained.

An additional pumped CT circuit will be provided within each plantroom to serve a new hot water storage calorifier that will operate as the hot water generator following removal of the gas fired water heaters.

It has been confirmed from readings obtained from the Building Management System (BMS) that the current VT circuits operate at a maximum flow temperature of approximately 55°C. Confirmation of flow temperatures within the primary circuits and CT circuits have been provided by the University as 70°C.

In order to maximise the efficiency of the ASHPs, discussions with Clade Technical Department have confirmed the operating temperatures within the primary circuit of LTHW heating system to be 65°C flow 50°C return. This would increase the current 10°C flow and return temperature differential across the current system to 15°C which would mean retention of the secondary circuit pumping arrangements, pipework and a review of flow rates within the systems.

Following analysis has been undertaken of the air handling units and field heating coils to assess the impact of the reduced flow temperature on the output of the coils.

At this stage based on the information on the heating coils within the Operating and Maintenance manuals, the design output of each coil is based on a 10°C flow and return temperature differential, with a minimum additional 10% allowance on the water flow rates to each coil.

This inherent capacity will assist in allowing the LTHW heating system to operate at a lower flow temperature without compromise on the air handling unit and other heating coils. However, in peak conditions it may be necessary to increase the flow temperature to maintain the performance of the coils.

This would be achieved, by elevating the LTHW heating flow temperature to 70°C using the retained gas boiler to top up the system flow temperature from 65°C flow to 70°C when required.

At 65°C flow temperature the hot water storage temperature within the proposed calorifiers would be maintained to safe operating conditions. However, the proposal would be to provide direct electric immersion heaters to each calorifier to maintain a minimum 60°C storage condition and a facility for pasteurisation.

It was recommended by Clade for the primary return to the heat pumps to be 50°C. This will be able to achieved based on the high proportion of VT load. This load is currently being generated at 55°C flow, so it is anticipated that lower return temperatures will be generated to meet the requirements of Clade.

Domestic Hot and Cold Water

Following removal of the gas fired water heaters the proposed solution for the production of domestic hot water to both buildings would be to provide local unvented storage calorifiers to meet the hot water demand within each plant space.

The calorifiers would be connected to a new secondary system of LTHW heating and be connected to the existing secondary hot water flow and return and cold-water service local within each plant space.

The calorifiers will be fitted with local electric immersion heaters to provide top up, back up and pasteurisation for the hot water systems.

The calorifiers within Block FGH will each be sized at 250 litres to meet the hot water demand for generally toilet facilities.

Within the Sports Hall a larger demand is anticipated due to the quantity of showers within changing areas. Based on the current arrangement of 47No showers across the various changing rooms a storage capacity of the calorifier(s) of 2000 litres is proposed to meet the demand.

Automatic Controls

The existing Building Management System (BMS) will be reconfigured to remove the gas fired plant and include the proposed ASHPs.

This will include removal of the 3 port valve arrangements at each air handling unit and heating coil and replacing the valves with 2 port Pressure Independent Control Valves (PICV) to implement variable flow across the low loss headers to all plantrooms.

PICVs would be installed at each connection to the low loss headers to ensure variable flow across the headers at constant secondary flow temperature.

The digital twin modelling provided by Hysopt has shown that this application in creating variable flow, the ASHPs are utilised for longer periods and in conjunction with the proposed thermal stores limit the start/stops of the heat pumps.

The system will be redesigned to operate using the existing functions for:

Energy efficient control of plant and systems including optimum start/stop and enthalpy control of recirculation air systems.

Remote manual and automatic stop/start of plant and systems.

Duty cycling and sharing of duplicate plant and equipment.

Accurate control of space conditions.

Status monitoring of plant and equipment.

Monitoring of system and plant failure and alarm conditions.

a) Adjustable sequenced start of plant and restart in the event of power failure.

b) Frost protection of the building

c) Safety interlocking of plant and equipment.

d) Metering of the water and electrical systems by taking pulsed outputs from the meters.

Graphical display of the readings will be included to the existing central operator’s terminal to allow all HVAC systems to be presented in graphical form to allow the user to interrogate all control points, energy usage and functions.

The existing controllers serving the building will be retained together with any field wiring and controllers not affected by the works.

The BMS will provide good control of the building engineering services to maintain the desired levels of service, comfort, and safety in an energy efficient manner.

8.0 Electrical Services

8.1 Scope of Works

The electrical services installation will comprise the following elements:

- Incoming Electrical Supply
- LV Distribution & Metering
- Containment & Wiring Systems
- External Lighting
- Fire Alarm System
- Lightning protection system
- Earthing & Bonding system

Design Philosophy

The design life of the electrical services plant and equipment will be a minimum of 20 years. The cable installation life will be a minimum of 25 years.

Load Estimate

Initial Air Source Heat Pump selections indicate that the site electrical load will increase by approximately 400kVA (i.e., 270kVA Blocks F, G and H; 130kVA Sports Hall) in total. Taking into account the current recorded maximum demand of 341kVA, this would increase the maximum demand for the site to circa 750kVA which will require an application for an increase in supply capacity.

8.2 Electrical Services Strategy

The electrical services strategy is as detailed on the following drawing included within Appendix B of this Report:

- 10131-LIN-XX-XX-DR-E-600001 - LV Distribution Schematic
- 10131-LIN -Z3-ZZ-DR-E-600001 - Block H, Proposed Electrical Services
- 10131-LIN -XX-RF-DR-E-600001 - Blocks F&G, Proposed Electrical Services

The electrical services systems strategies are as described below.

LV Distribution

The existing LV distribution system is to be modified/ extended/reconfigured to suit the supply requirements of the Air Source Heat Pumps (ASHP) being installed.

The new plant enclosure adjacent Block H is intended to be supplied direct from spare ways on the existing main switchboard located within the sub-station client LV switchroom. A number of 200A rated outgoing spare ways may be utilised subject to confirmation of plant selections.

Existing electrical infrastructure within the Sports Hall does not have the capacity to incoprorate the additional supply requirements of the Sports Hall ASHPs. As such, further supplies will need to be derived from the main switchboard in the sub-station client LV switchroom to serve this equipment.

Sub-main cables will be run underground to the new plant enclosures to be formed adjacent both Block H and the Sports Hall for termination as detailed in fig 14 below. All cables will be laid direct in ground following routes used for existing external services.

All new underground cabling shall be coordinated with existing sitewide below ground infrastructure.

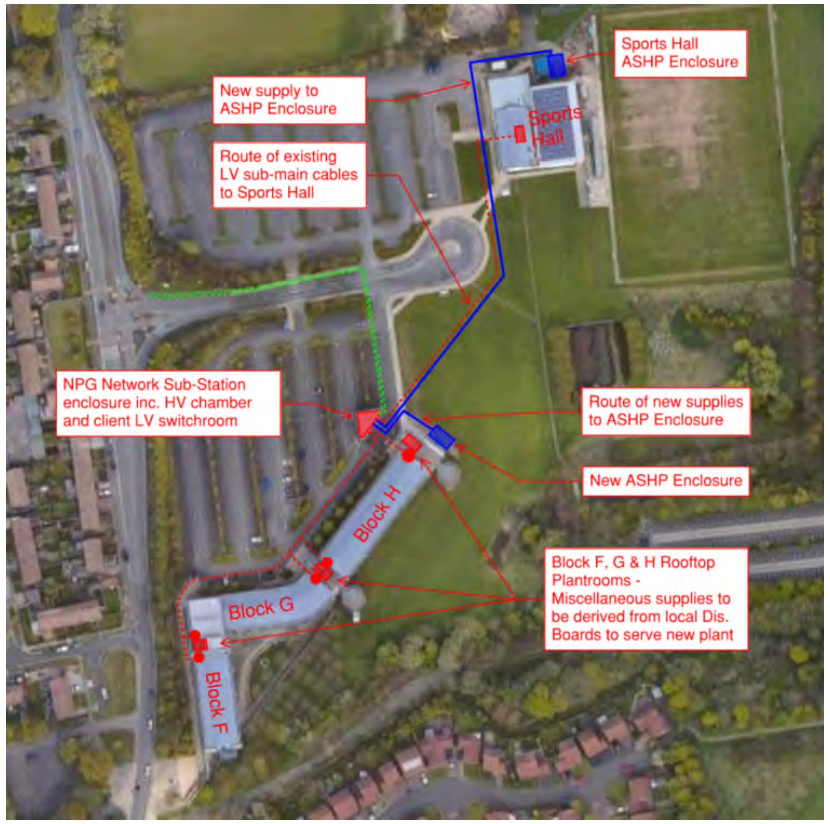


Fig 14: Sub-main Cable Routes – Blocks F, G, H and Sports Hall

Further supplies are to be installed to serve immersion heaters incorporated into new Domestic Hot Water Calorifiers being installed within the rooftop plantrooms. Suitably rated supplies are to be derived from existing distribution boards located within the adjacent rooftop service corridors. Containment routes are to be extended to accommodate these new cables and appropriate weathering and fire stopping incorporated where they pass through existing walls.

Additional surge protection devices will be incorporated on all plant supplies where deemed necessary.

The suitability of proposed supply arrangements will need to be confirmed as part of the next design stage.

Metering

All new supplies will be suitably metered with sub-meters to be incorporated into the existing switchgear where appropriate. Meters appear to have already been fitted to a number of spare ways on the existing main switchboard however any spare ways utilised without metering facilities will be upgraded to incorporate further metering facilities. All new meters will have the facility to be connected to the sitewide BMS to allow logging of data via Modbus interfaces. The final details and strategy to be agreed with NU.

Containment & Wiring Systems

The containment and wiring systems to be utilised for all new supplies and system wiring will be as detailed below:

Description	***Wiring Type***	***Installation Method***
Sub Mains	*External* - PVC/SWA/PVC *Internal* - XLPE/SWA/LSF	*External* – Laid direct in ground, *Internal* – MRF Galvanised Steel Cable Tray
Mechanical Connections	XLPE/SWA/LSF / LSF singles	MRF Galvanised Steel Tray / Trunking/ Conduit
Lighting Final Circuits	XLPE/SWA/LSF / LSF singles	MRF Galvanised Steel Tray / Conduit
Fire Alarms	PH 30 soft skin “Standard” Category 2 fire survival cable red LSF sheath.	Basket Tray/Clipped Direct fire clips (H/L), Galvanised conduit drops to (L/L).

Existing containment systems will be extended/modified to accommodate the supplies to be installed to the new plant in the rooftop plantrooms.

Plantrooms and Distribution

No additional dedicated electrical plant spaces are required. All new equipment is intended to be served from existing designated electrical services/distribution equipment and associated plant spaces.

External Compound Lighting

External lighting will be provided to the new plant compounds to provide safe access and security. The lighting schemes will be designed in accordance with CIBSE and SLL Code for Lighting guidelines.

Lighting will be provided to adequately illuminate the enclosure for maintenance tasks. IP65 rated linear corrosion resistant fittings will be utilised throughout.

No new external lighting for the adjacent pathways, roadways or rooftop areas are proposed for this project.

Emergency lighting will be provided to the external plant compounds. Existing emergency lighting to the buildings is generally via central battery systems. Extension of the installations within block H and the Sports Hall will be required to incorporate the plant enclosures.

The system will be provided as the NU ESS preferred standard.

Fire Alarm

Fire alarm detection and indication equipment will be provided to ensure the existing fire alarm system category can be maintained throughout the new plant enclosures.

Additional weatherproof manual call points will be situated at the entry/exits from the enclosures. Furthermore, weatherproof audio-visual means of alarm notification will also be installed.

The sitewide fire alarm 'Cause and Effect' matrix shall be modified to incorporate the plant enclosures, and the proposals agreed with the design team and client's representatives during the next design stage.

Lightning Protection System

A risk assessment will be undertaken to establish whether the existing lightning protection system needs to be extended to the new plant compound.

As a minimum, surge protection devices will be installed on new supplies to the ASHP's.

Earthing and Bonding

Local earthing and bonding will be provided in accordance with the requirements of BS 7671, The IET Wiring Regulations.

9.0 Load Analysis

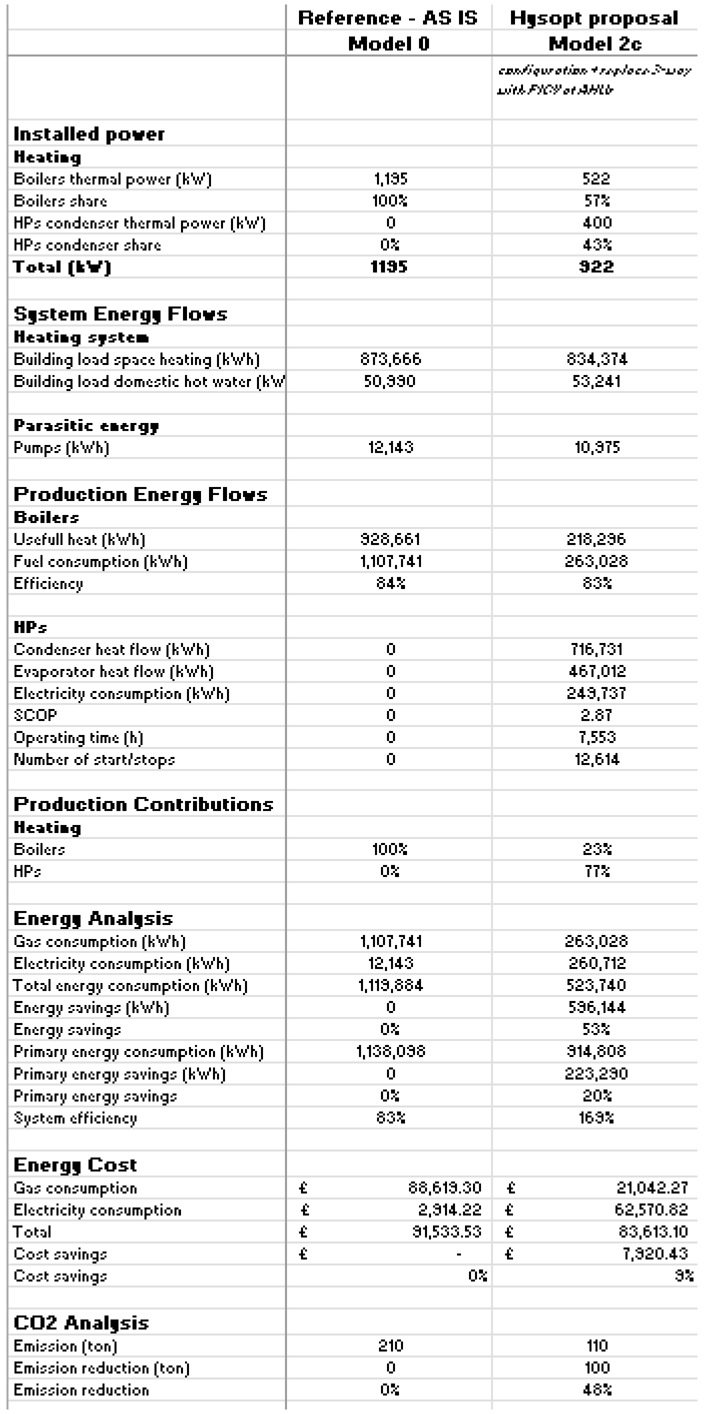
9.1 Revised Energy Consumption

An analysis of the proposals have been undertaken by Hysopt using digital twin software to assess the improved performance of the system following the incorporation of the measures proposed.

Table 3 below indicates the improvements produced by the Hysopt modelling for Blocks F, G and H against the current system operational parameters.

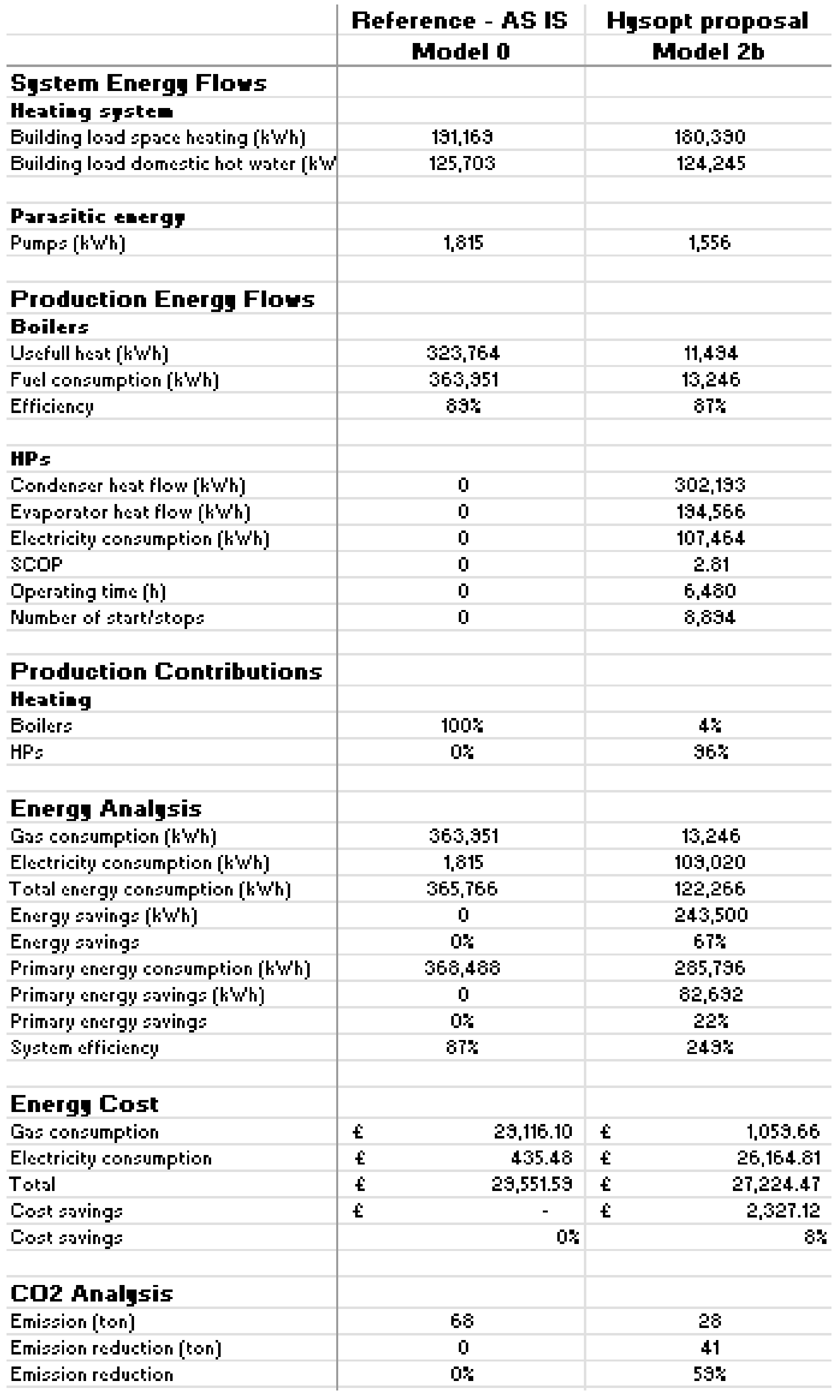
Table 3 indicates the improvements produced by the Hysopt modelling for Blocks F, G and H against the current system operational parameters.

Table 2 – Hysopt Output F, G and H



	Reference - AS IS Model 0	Hysopt proposal Model 2c
		configuration + replace 3-way with PICV at AHUs
Installed power		
Heating		
Boilers thermal power (kW)	1,195	522
Boilers share	100%	57%
HPs condenser thermal power (kW)	0	400
HPs condenser share	0%	43%
Total (kW)	**1195**	**922**
System Energy Flows		
Heating system		
Building load space heating (kWh)	873,666	834,374
Building load domestic hot water (kW	50,990	53,241
Parasitic energy		
Pumps (kWh)	12,143	10,975
Production Energy Flows		
Boilers		
Usefull heat (kWh)	928,661	218,296
Fuel consumption (kWh)	1,107,741	263,028
Efficiency	84%	83%
HPs		
Condenser heat flow (kWh)	0	716,731
Evaporator heat flow (kWh)	0	467,012
Electricity consumption (kWh)	0	249,737
SCOP	0	2.87
Operating time (h)	0	7,553
Number of start/stops	0	12,614
Production Contributions		
Heating		
Boilers	100%	23%
HPs	0%	77%
Energy Analysis		
Gas consumption (kWh)	1,107,741	263,028
Electricity consumption (kWh)	12,143	260,712
Total energy consumption (kWh)	1,119,884	523,740
Energy savings (kWh)	0	596,144
Energy savings	0%	53%
Primary energy consumption (kWh)	1,138,098	914,808
Primary energy savings (kWh)	0	223,290
Primary energy savings	0%	20%
System efficiency	83%	169%
Energy Cost		
Gas consumption	£ 88,619.30	£ 21,042.27
Electricity consumption	£ 2,914.22	£ 62,570.82
Total	£ 91,533.53	£ 83,613.10
Cost savings	£ -	£ 7,920.43
Cost savings	0%	9%
CO2 Analysis		
Emission (ton)	210	110
Emission reduction (ton)	0	100
Emission reduction	0%	48%

Table 3 – Hysopt Output Sports Hall



	Reference - AS IS Model 0	Hysopt proposal Model 2b
System Energy Flows		
Heating system		
Building load space heating (kWh)	191,169	180,390
Building load domestic hot water (kW	125,703	124,245
Parasitic energy		
Pumps (kWh)	1,815	1,556
Production Energy Flows		
Boilers		
Usefull heat (kWh)	323,764	11,494
Fuel consumption (kWh)	363,951	13,246
Efficiency	89%	87%
HPs		
Condenser heat flow (kWh)	0	302,193
Evaporator heat flow (kWh)	0	194,566
Electricity consumption (kWh)	0	107,464
SCOP	0	2.81
Operating time (h)	0	6,480
Number of start/stops	0	8,894
Production Contributions		
Heating		
Boilers	100%	4%
HPs	0%	96%
Energy Analysis		
Gas consumption (kWh)	363,951	13,246
Electricity consumption (kWh)	1,815	109,020
Total energy consumption (kWh)	365,766	122,266
Energy savings (kWh)	0	243,500
Energy savings	0%	67%
Primary energy consumption (kWh)	368,488	285,796
Primary energy savings (kWh)	0	82,692
Primary energy savings	0%	22%
System efficiency	87%	249%
Energy Cost		
Gas consumption	£ 29,116.10	£ 1,059.66
Electricity consumption	£ 435.48	£ 26,164.81
Total	£ 29,551.59	£ 27,224.47
Cost savings	£ -	£ 2,327.12
Cost savings	0%	8%
CO2 Analysis		
Emission (ton)	68	28
Emission reduction (ton)	0	41
Emission reduction	0%	59%

Using Carbon Intensity Figures of 0.187kg/kWh (gas) and 0.233kg/kwh (electricity) the total carbon emission reduction for both buildings are:

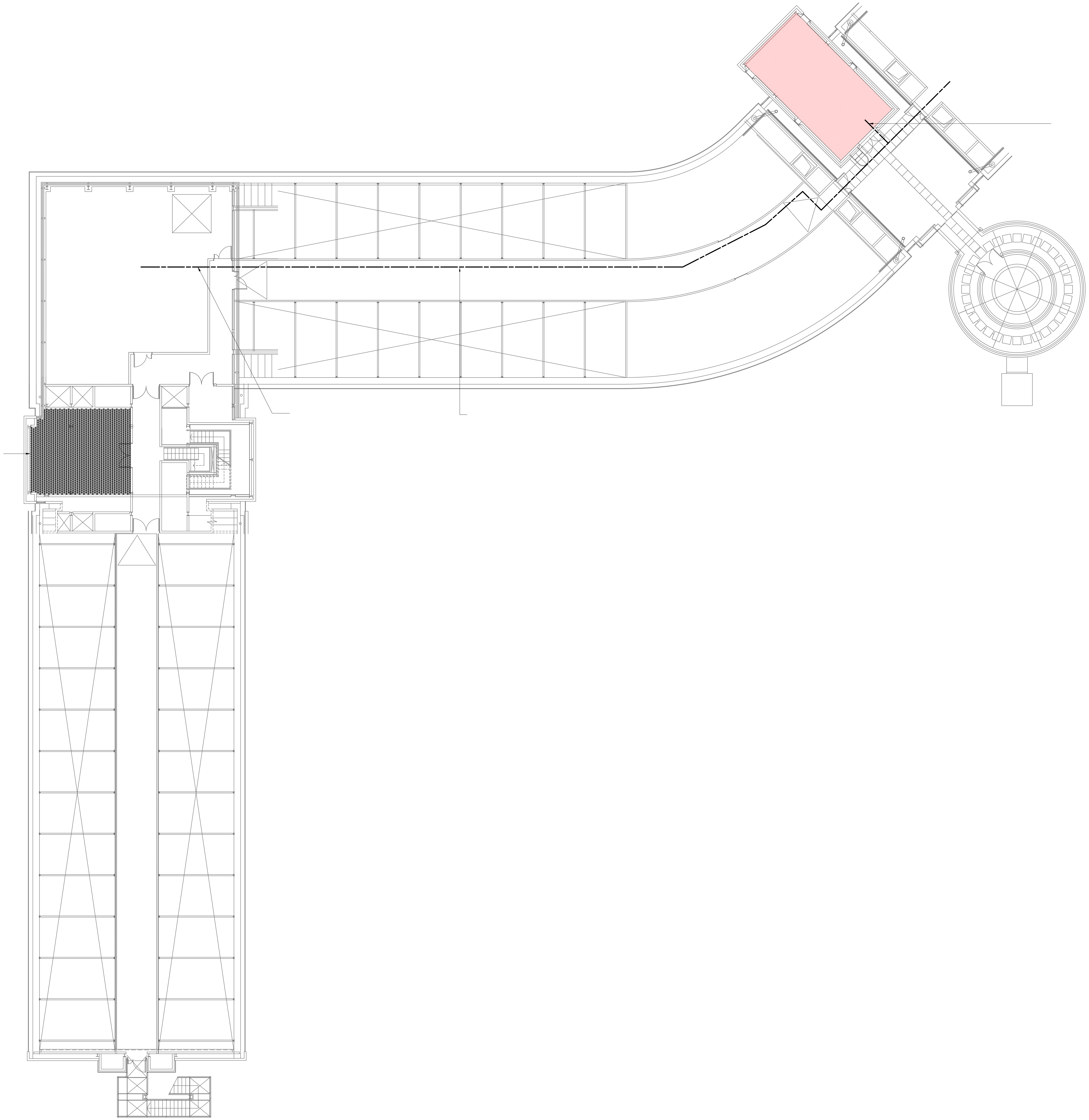
Blocks F, G & H	100 tonne CO_2
Sports Hall	41 tonne CO_2

Using £0.08/kWh gas and £0.24/kWh electricity as the tariff for the cost of energy there is anticipated cost savings of:

Blocks F, G & H	9%
Sports Hall	8%

These figures are subject to fluctuation based on the energy price market and the current rates paid by the University.

Appendix A
Mechanical and Electrical Services Drawings



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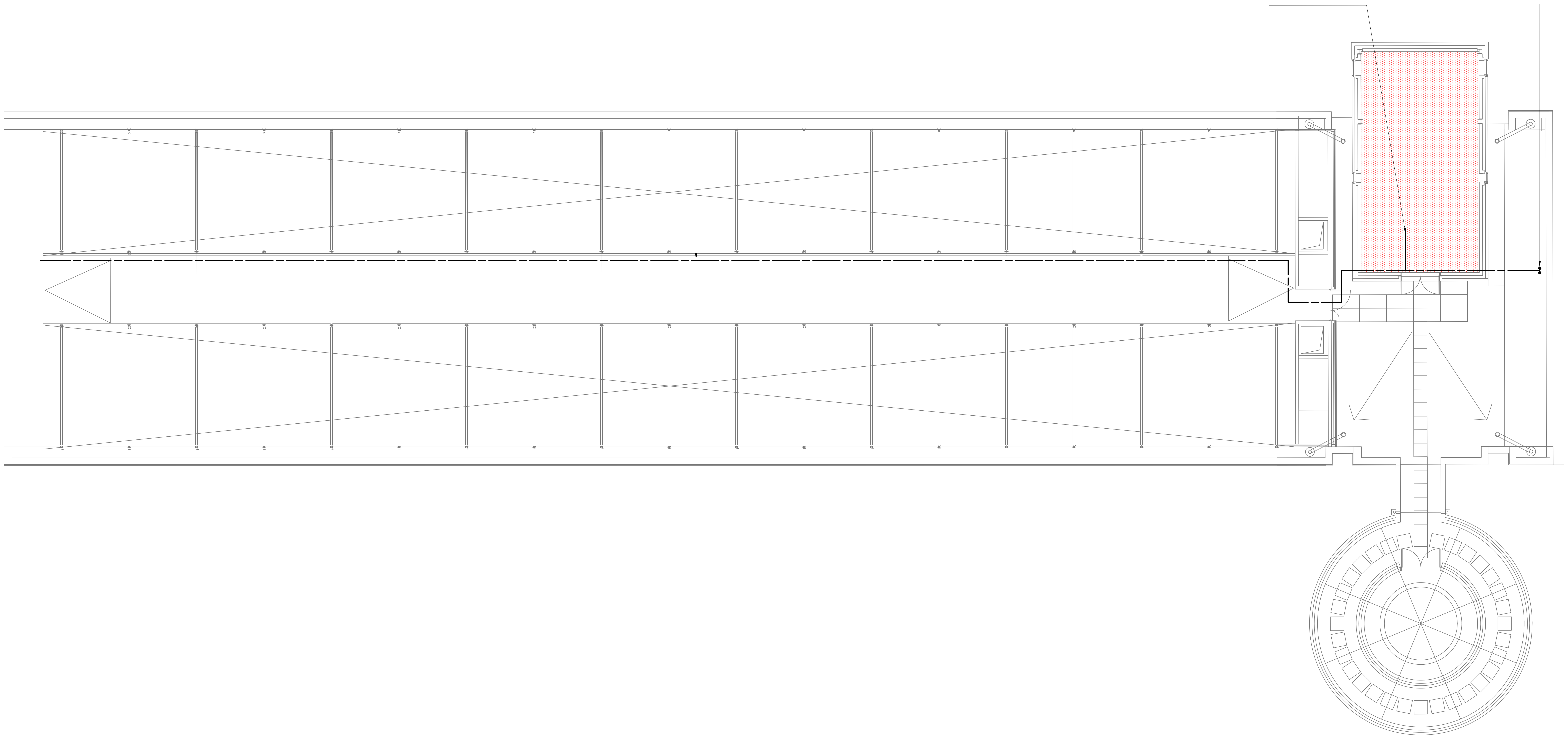

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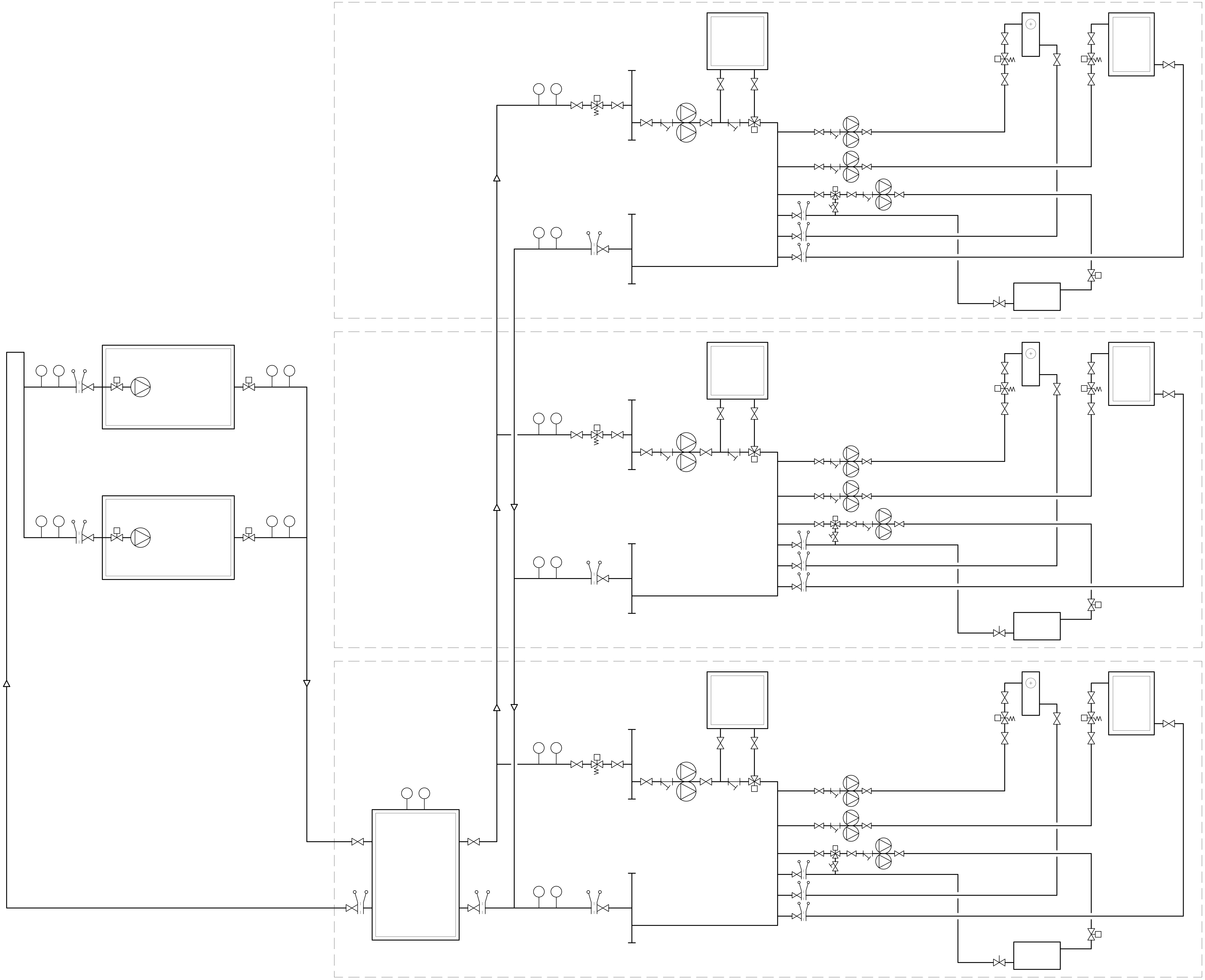

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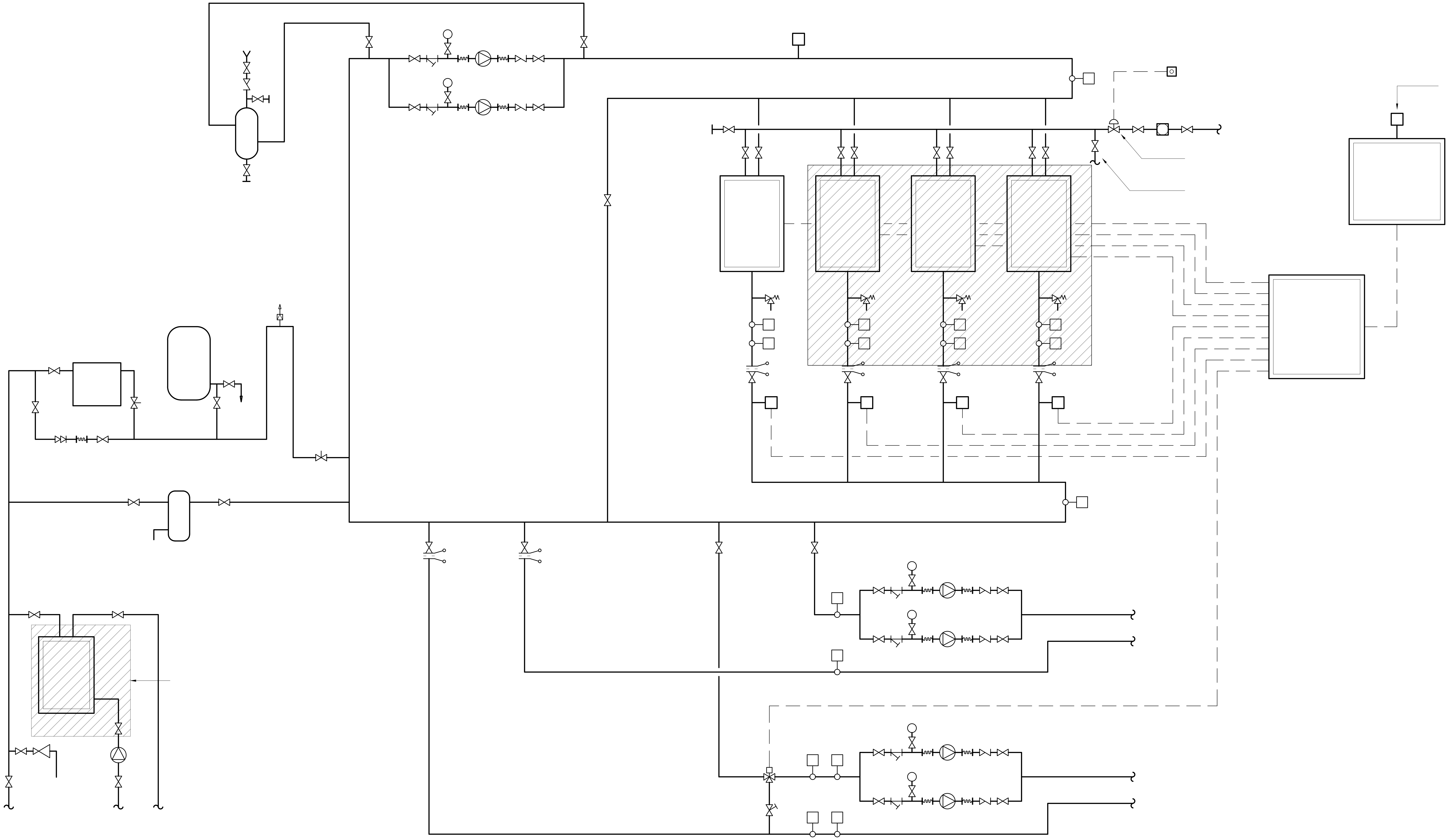

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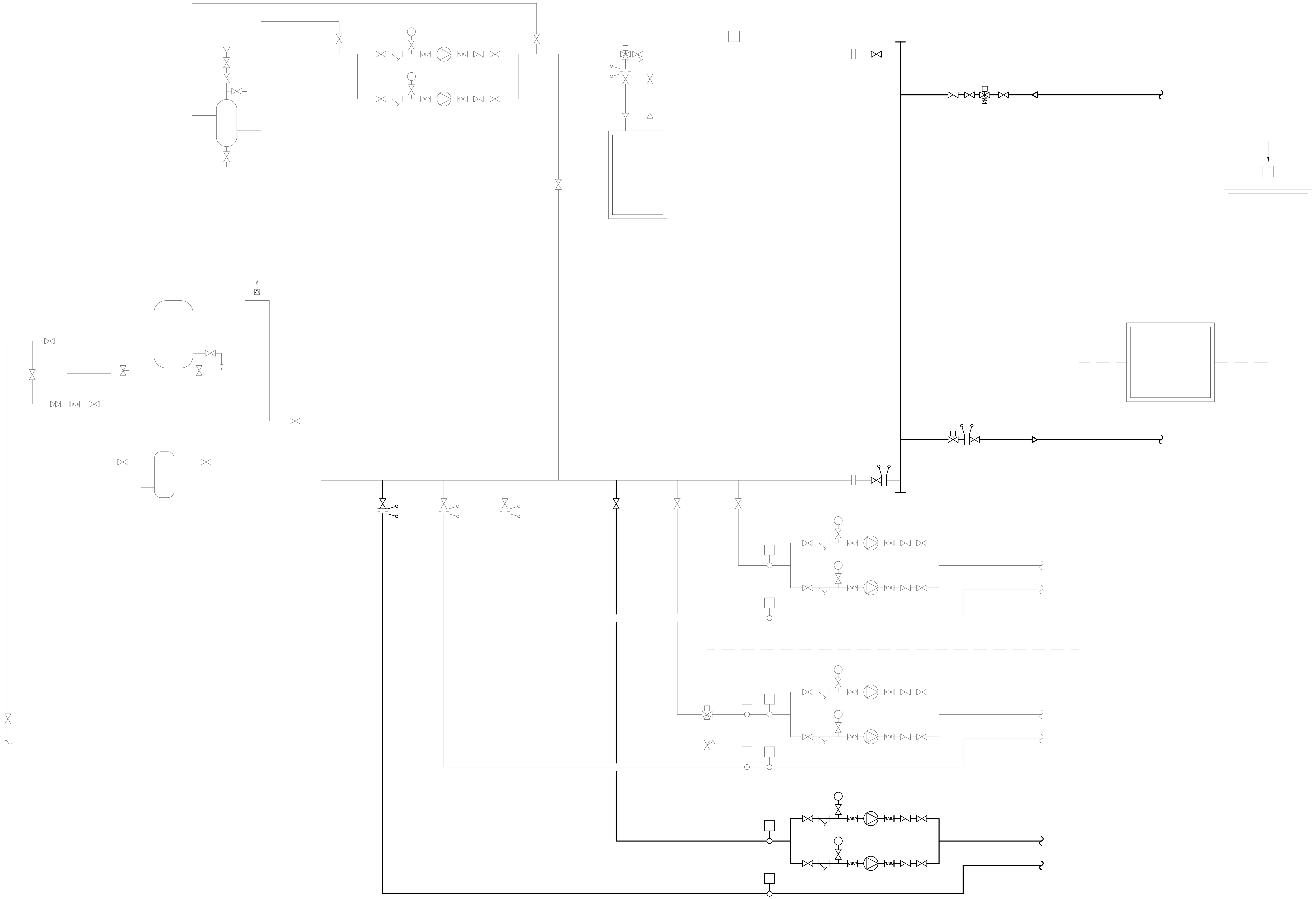

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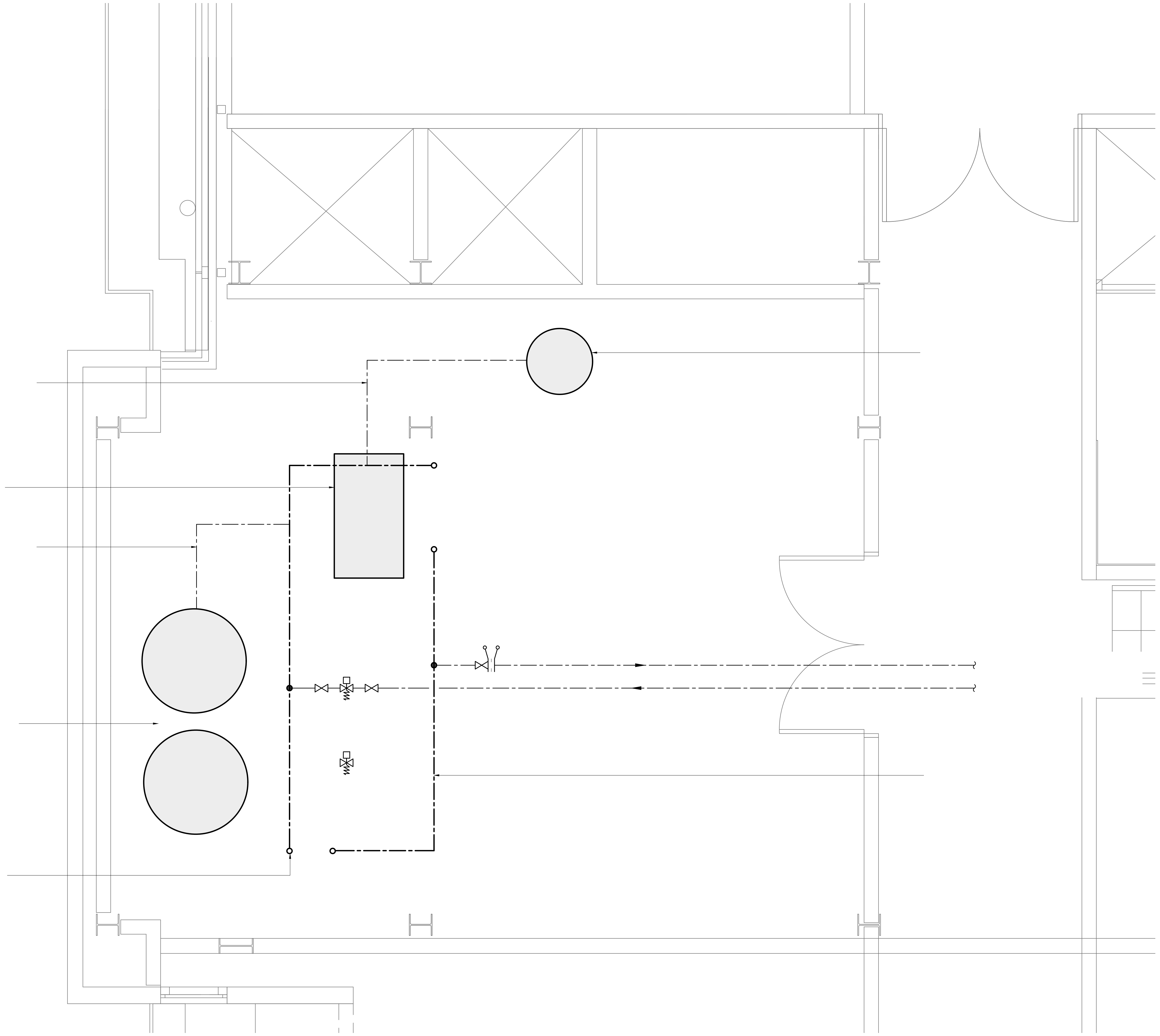

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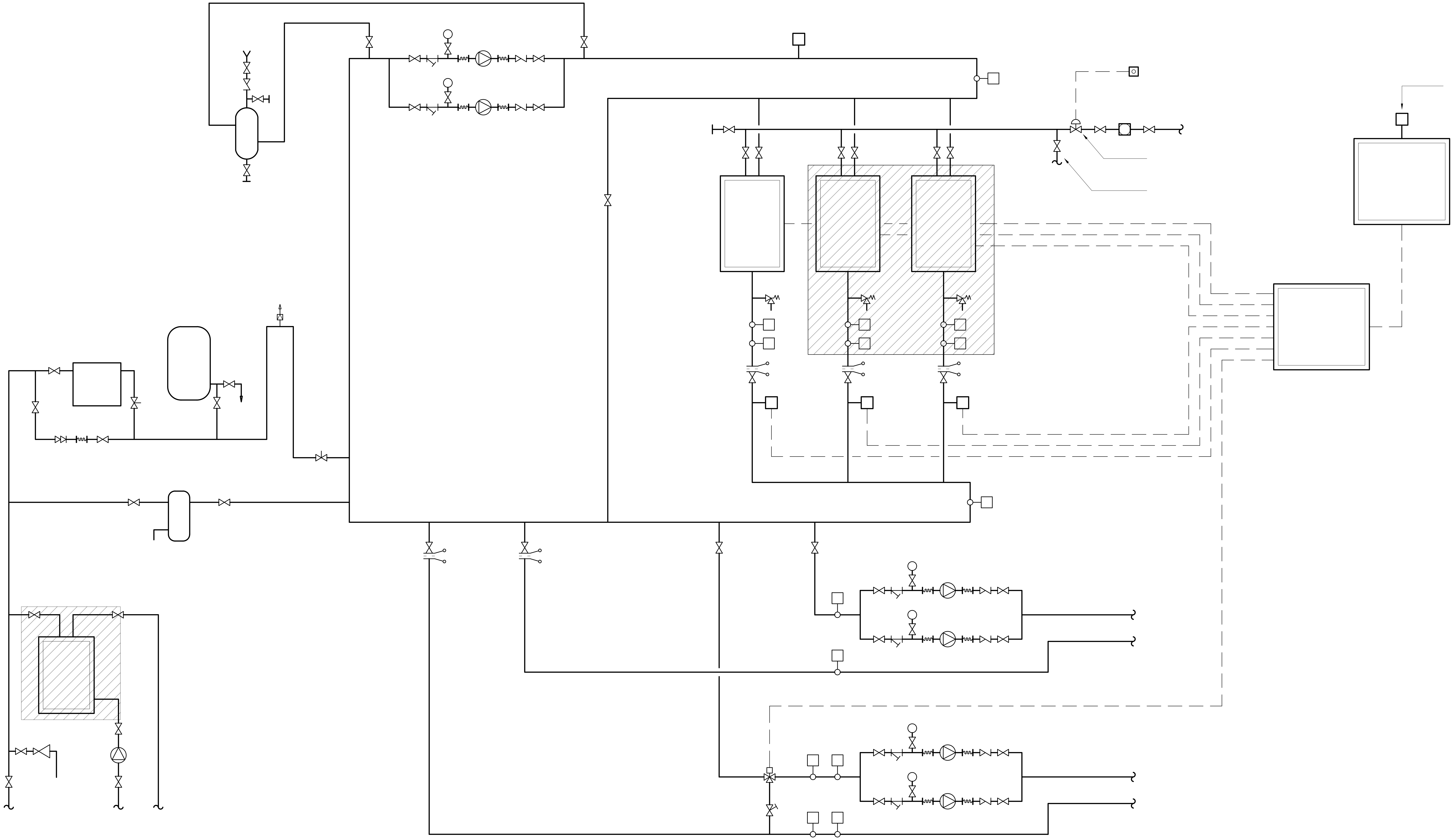

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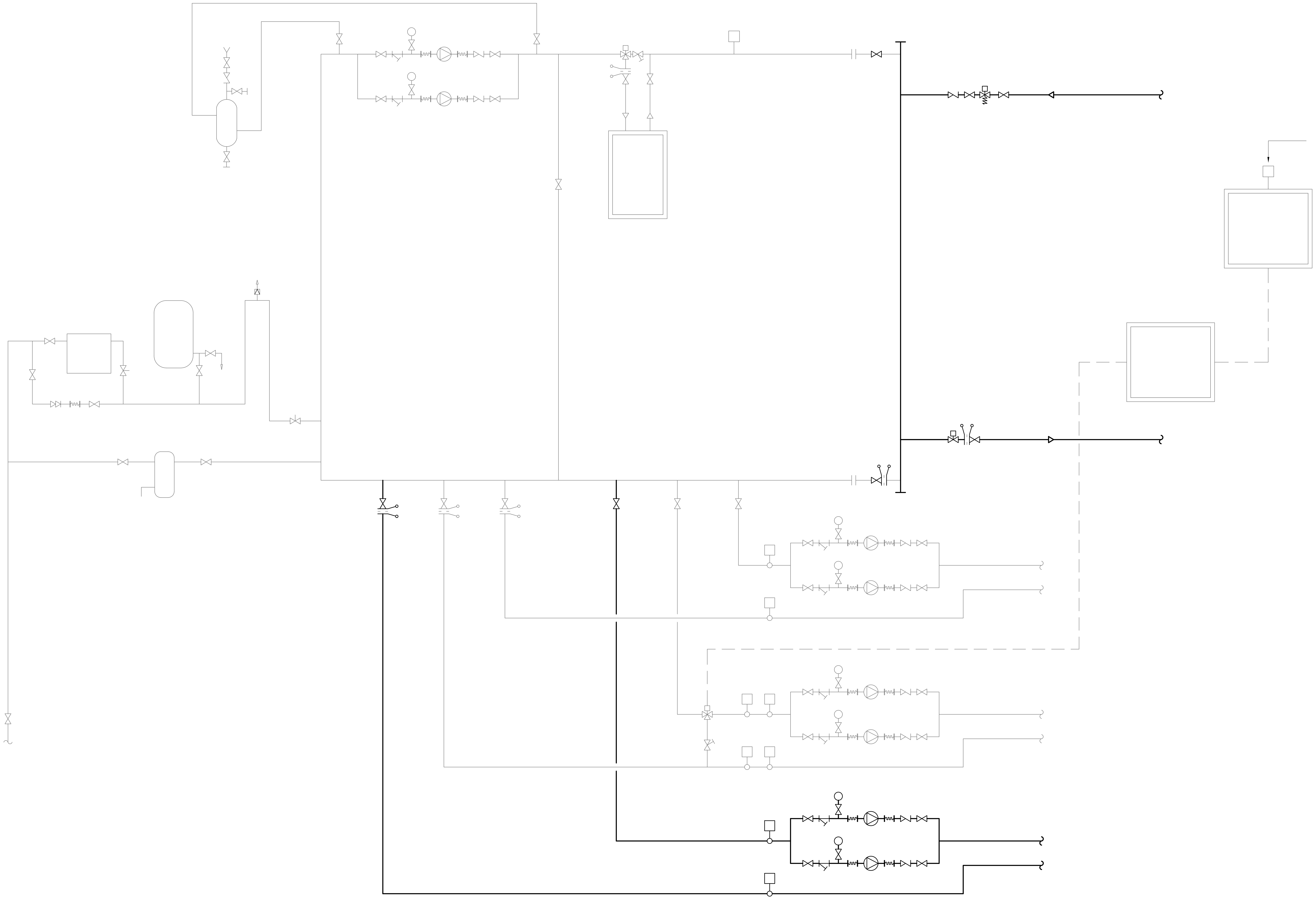

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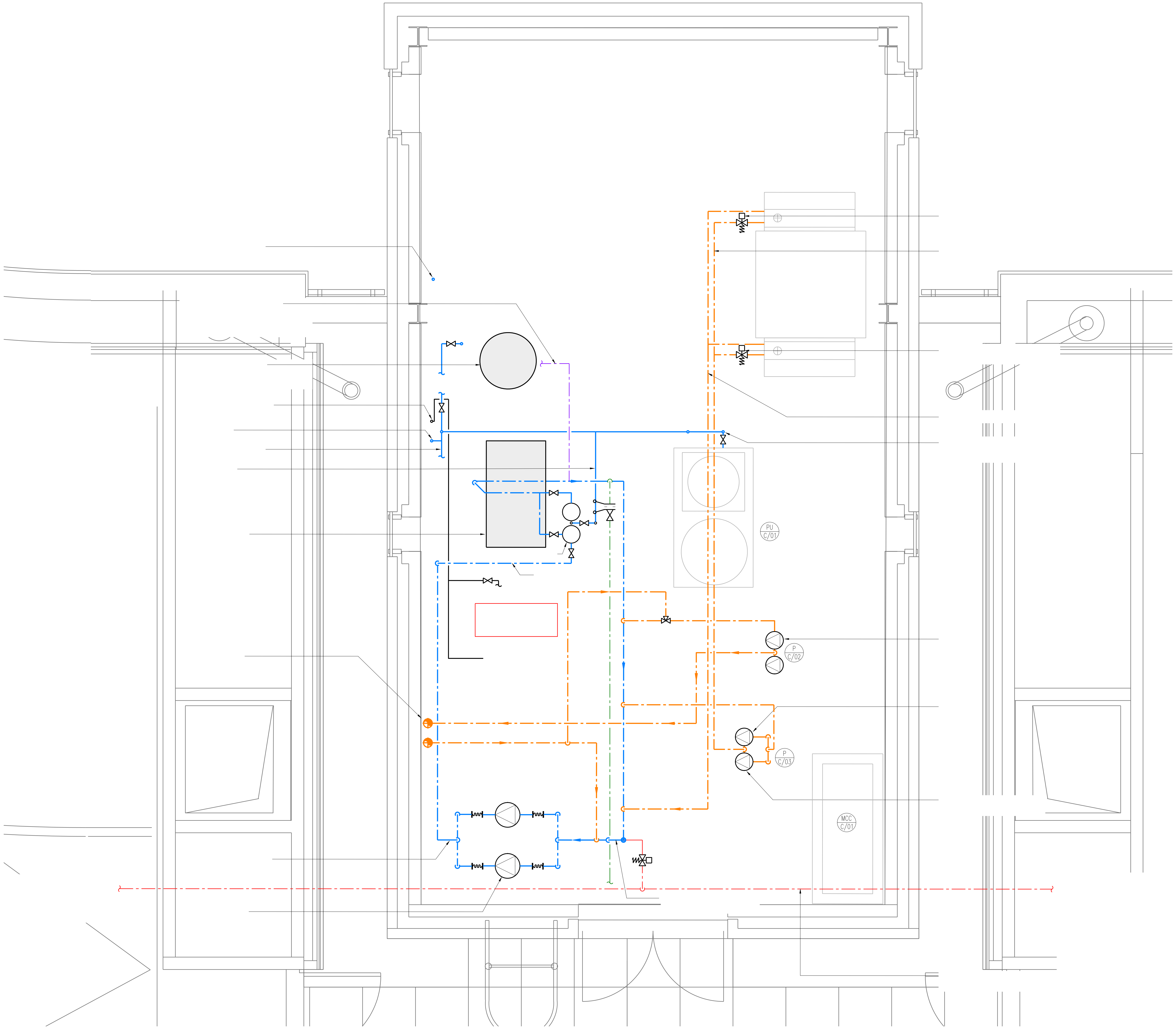

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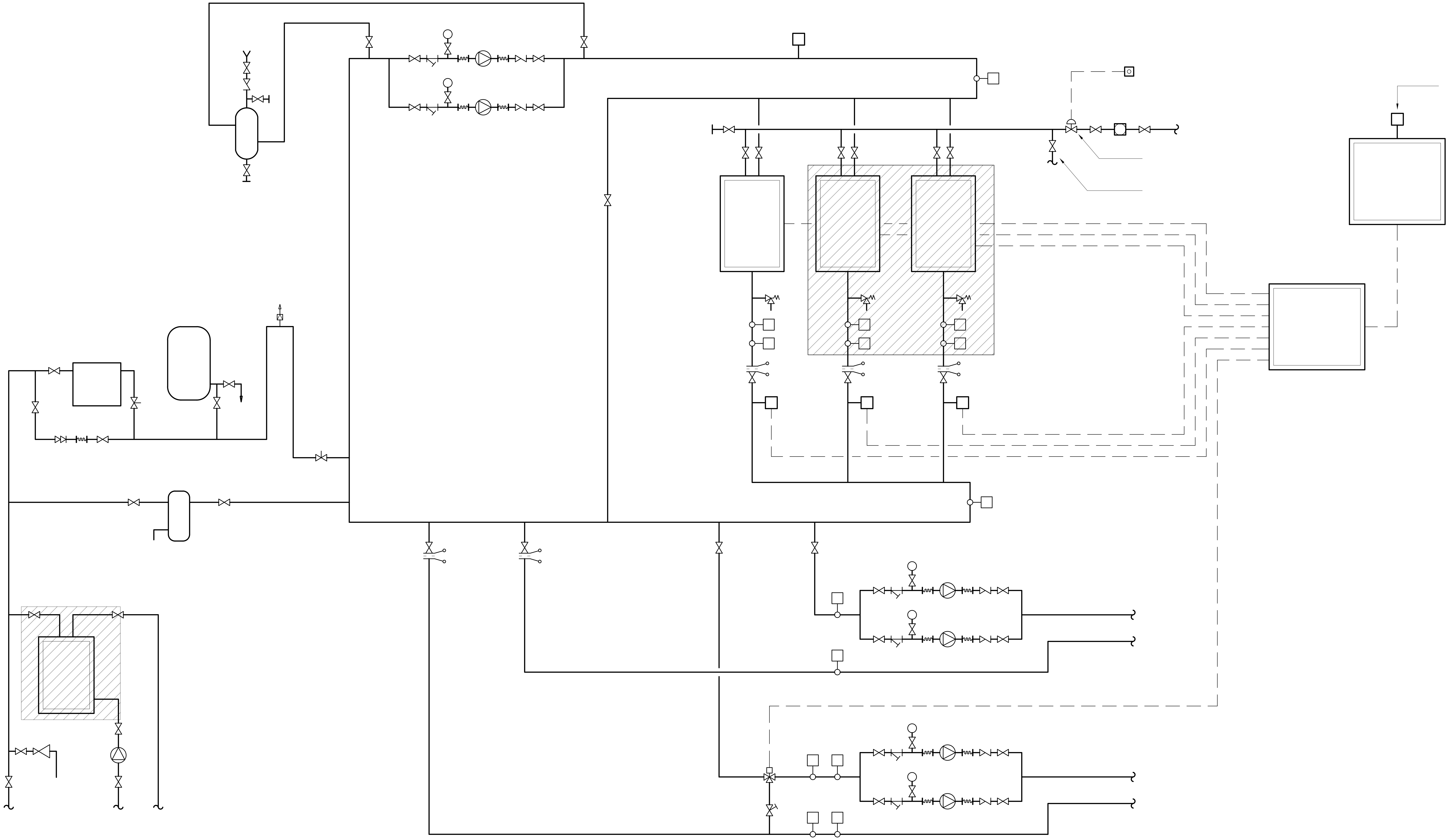

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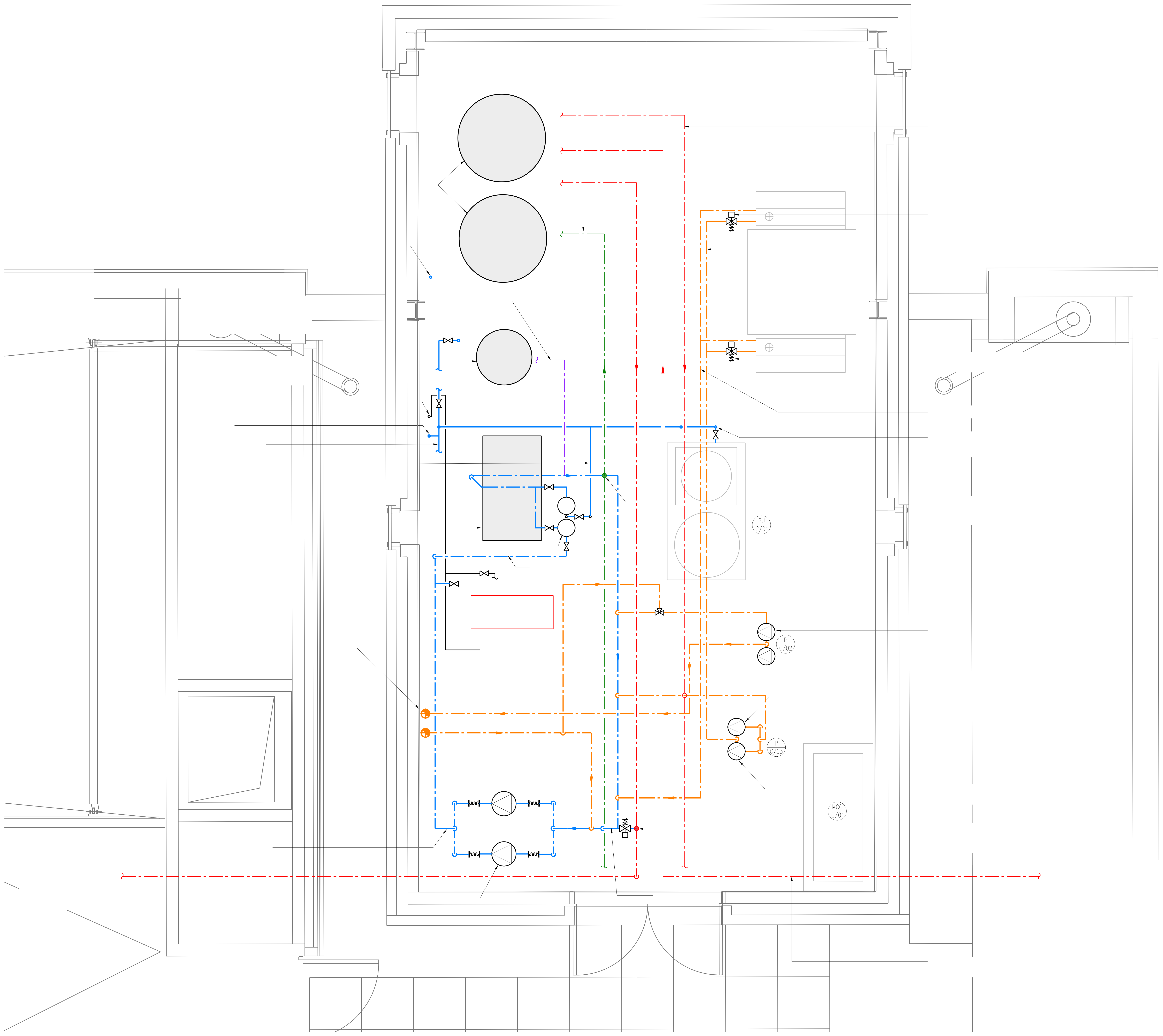

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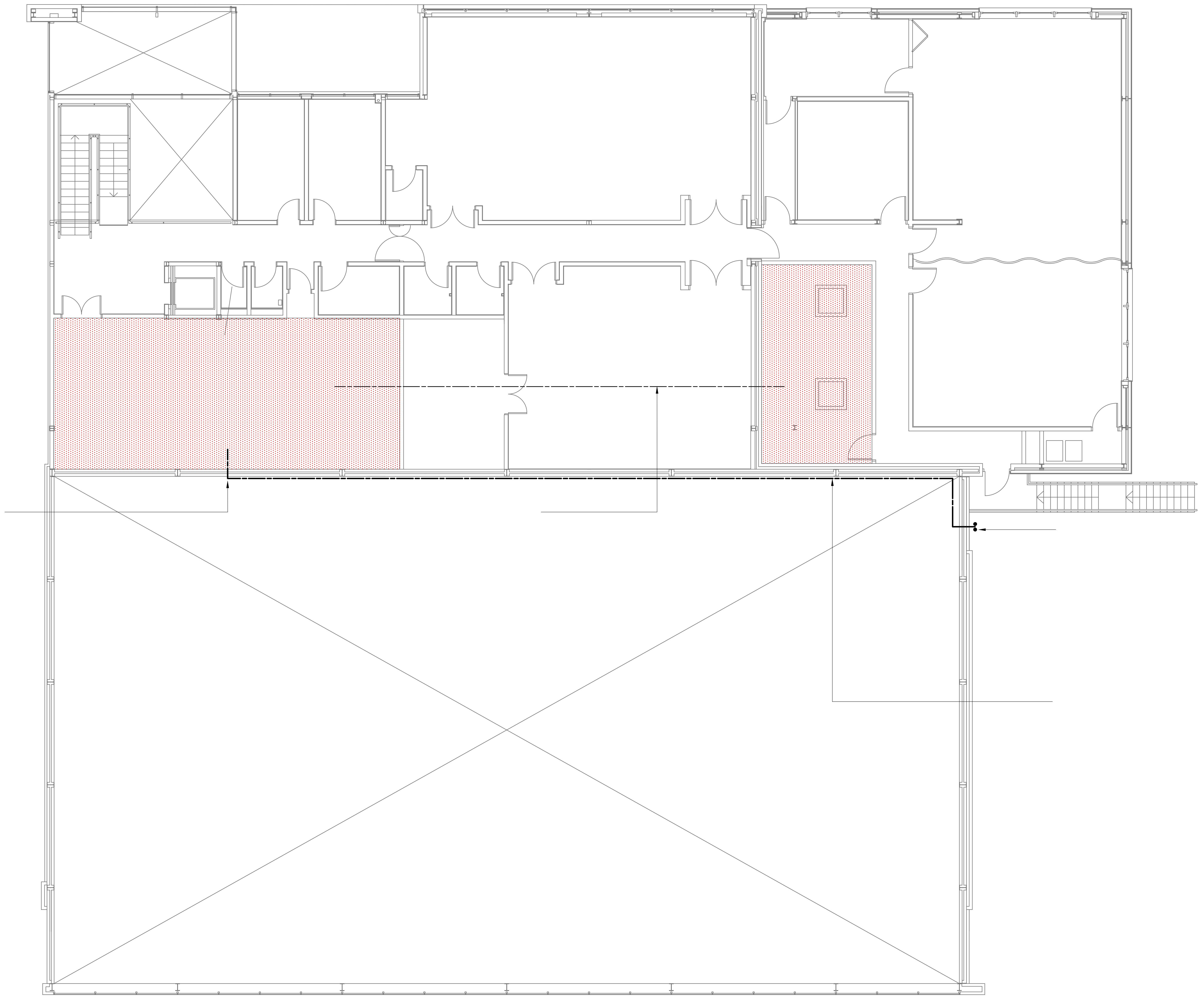

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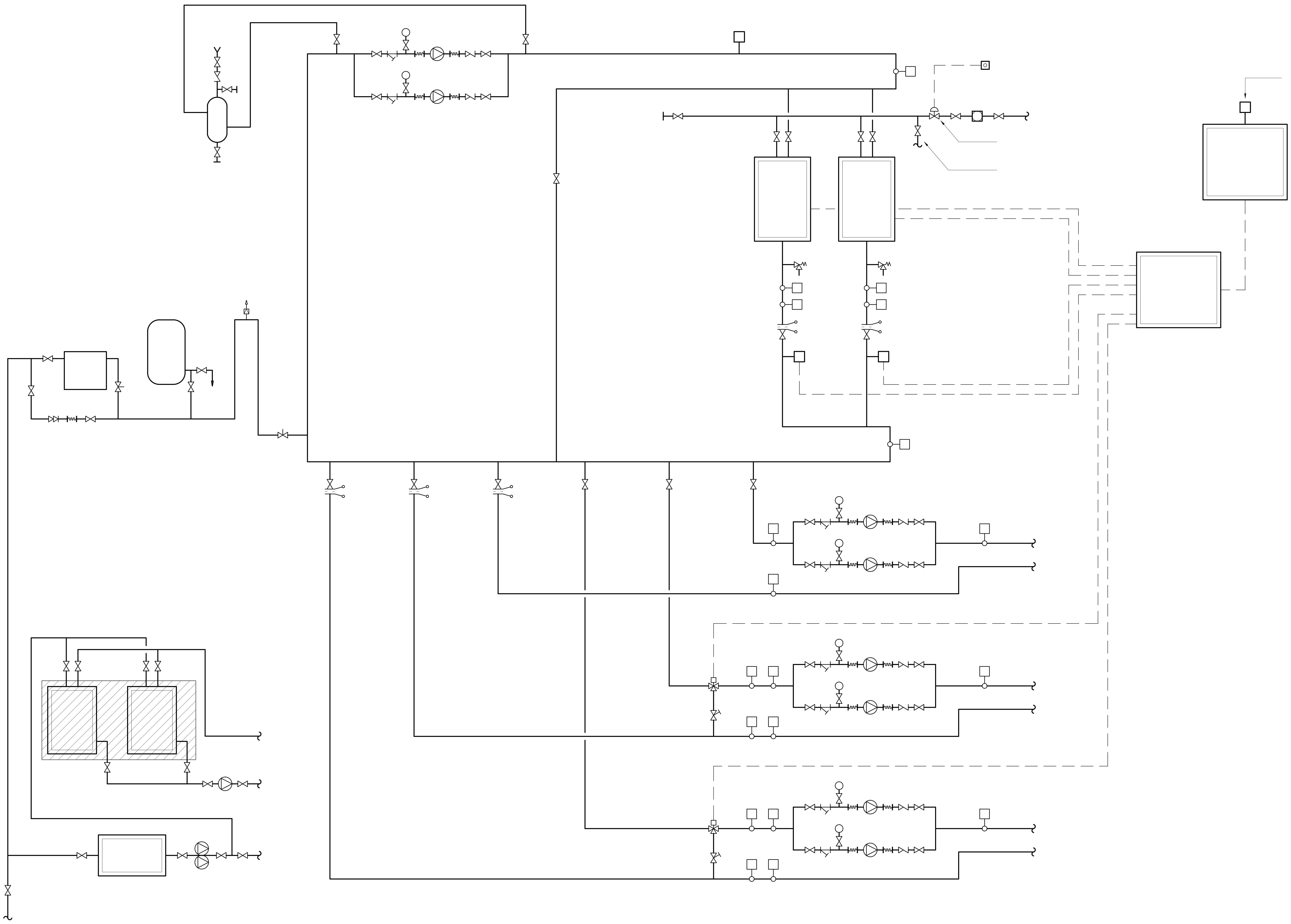

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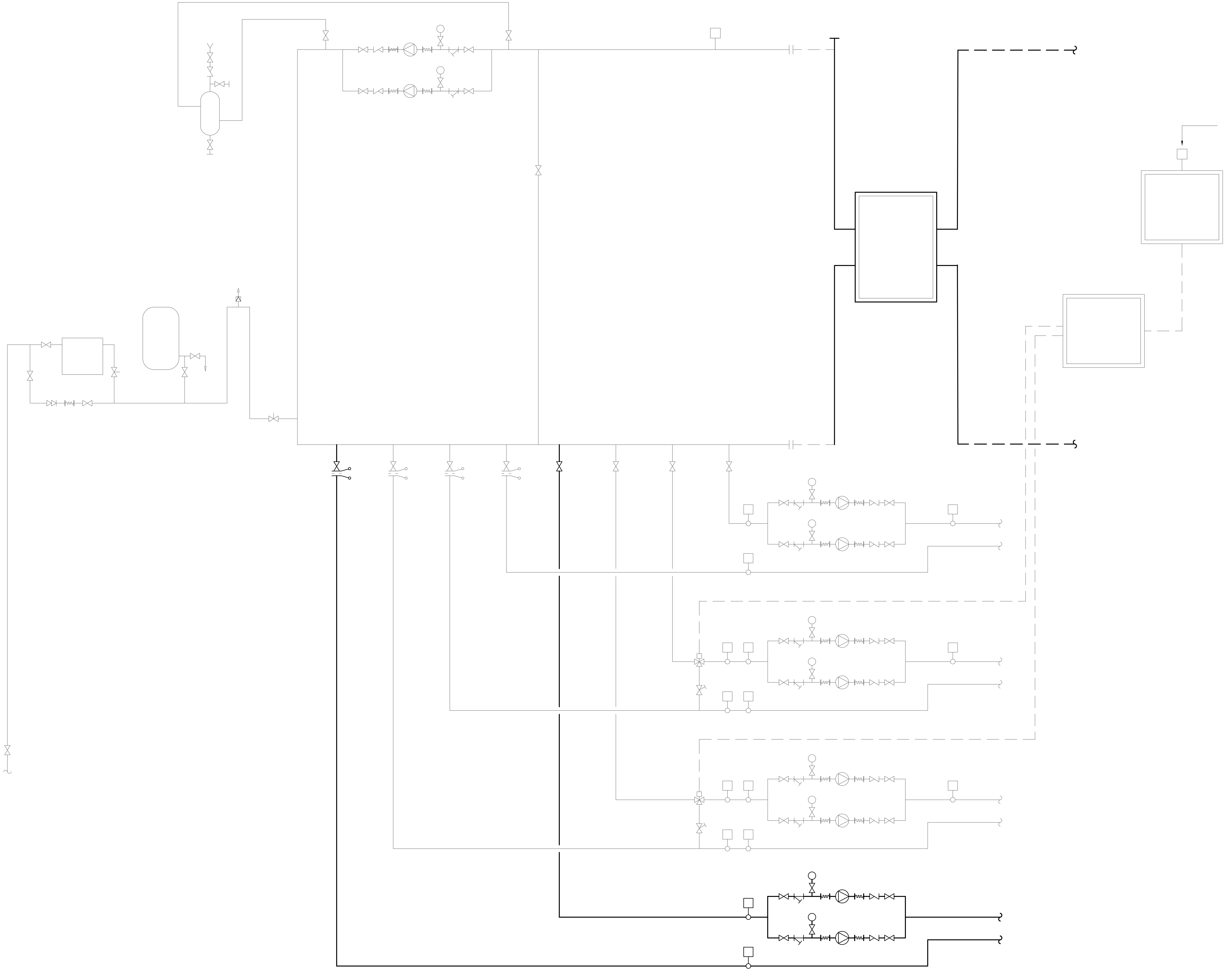

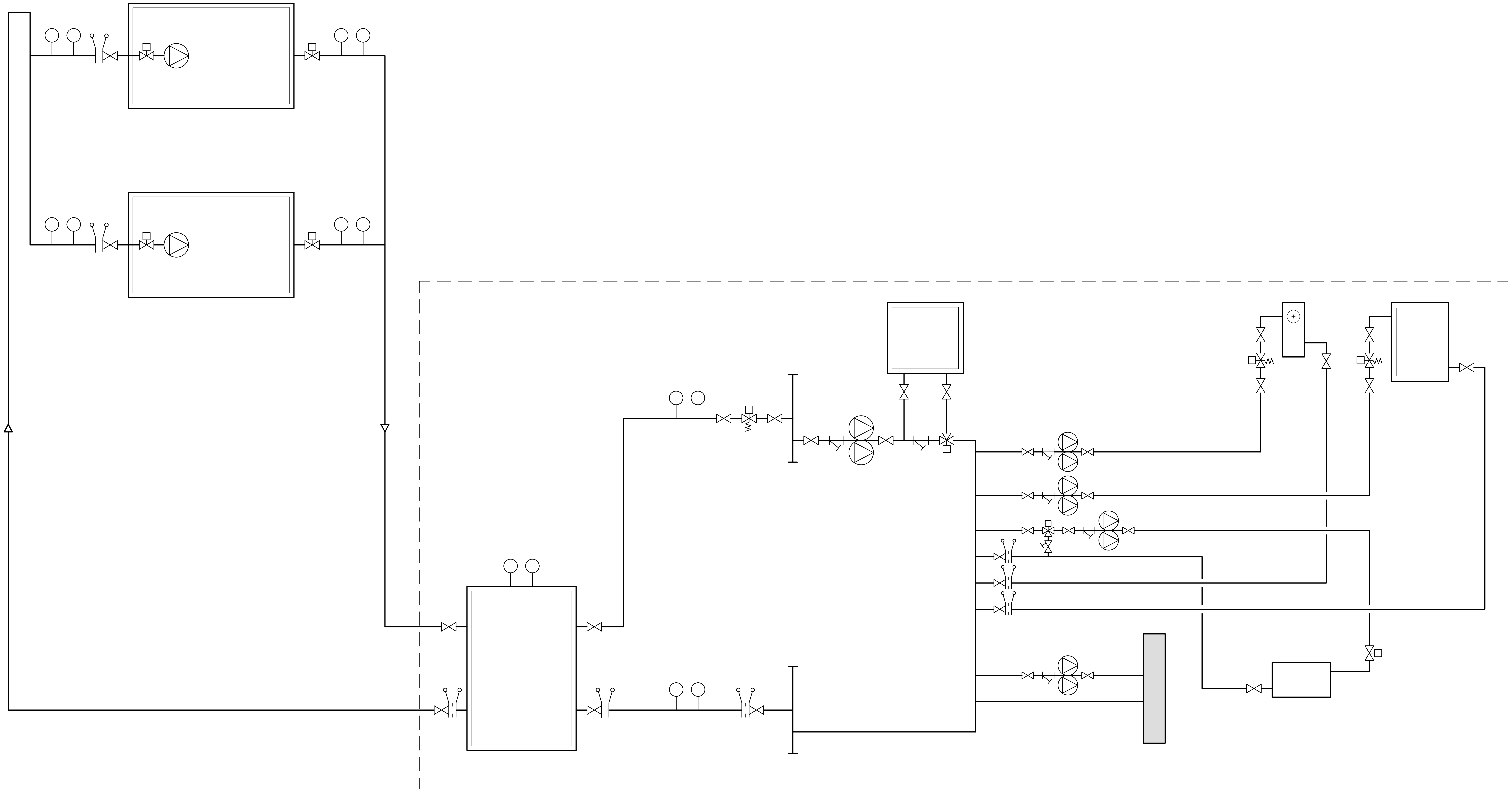

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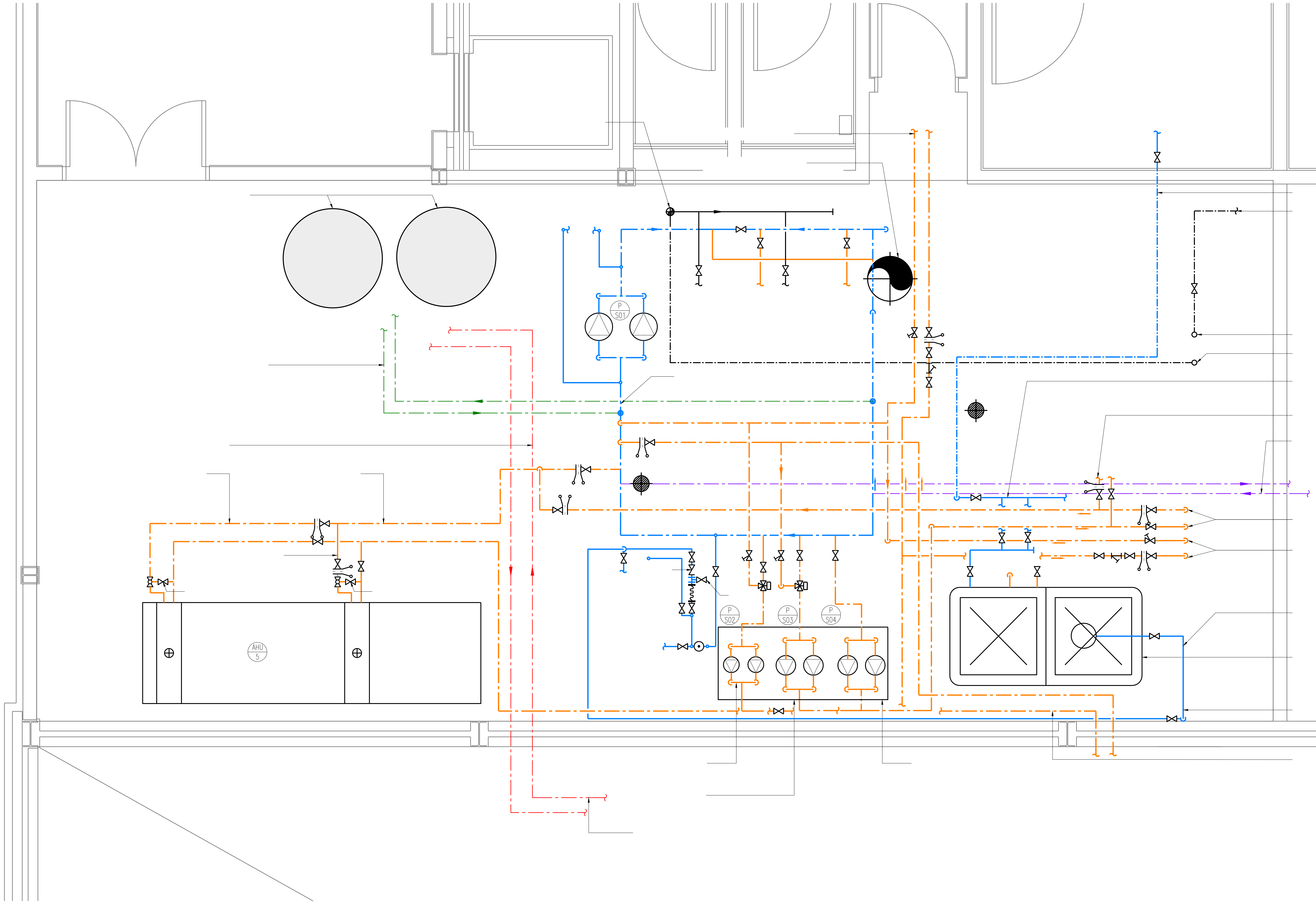

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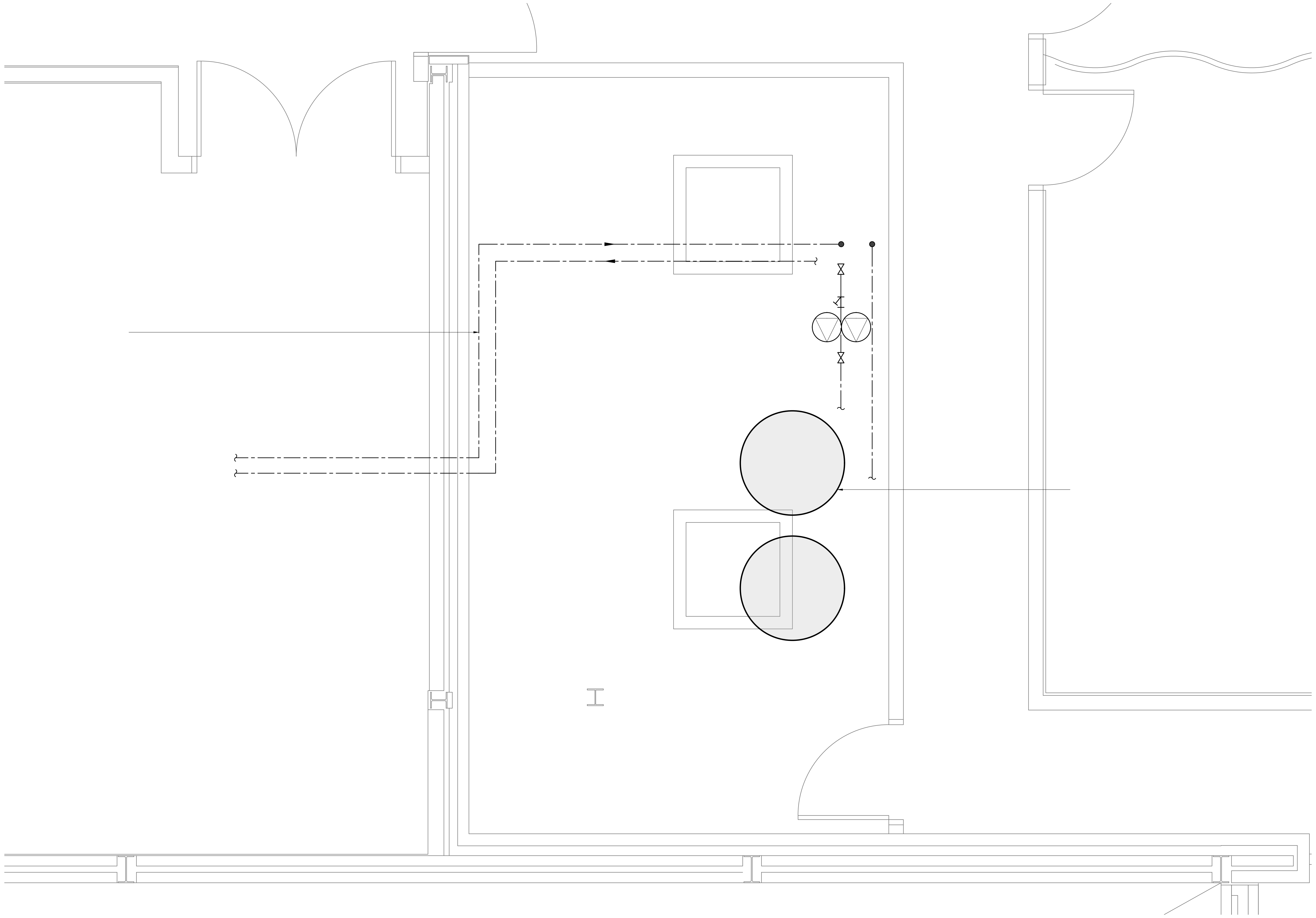

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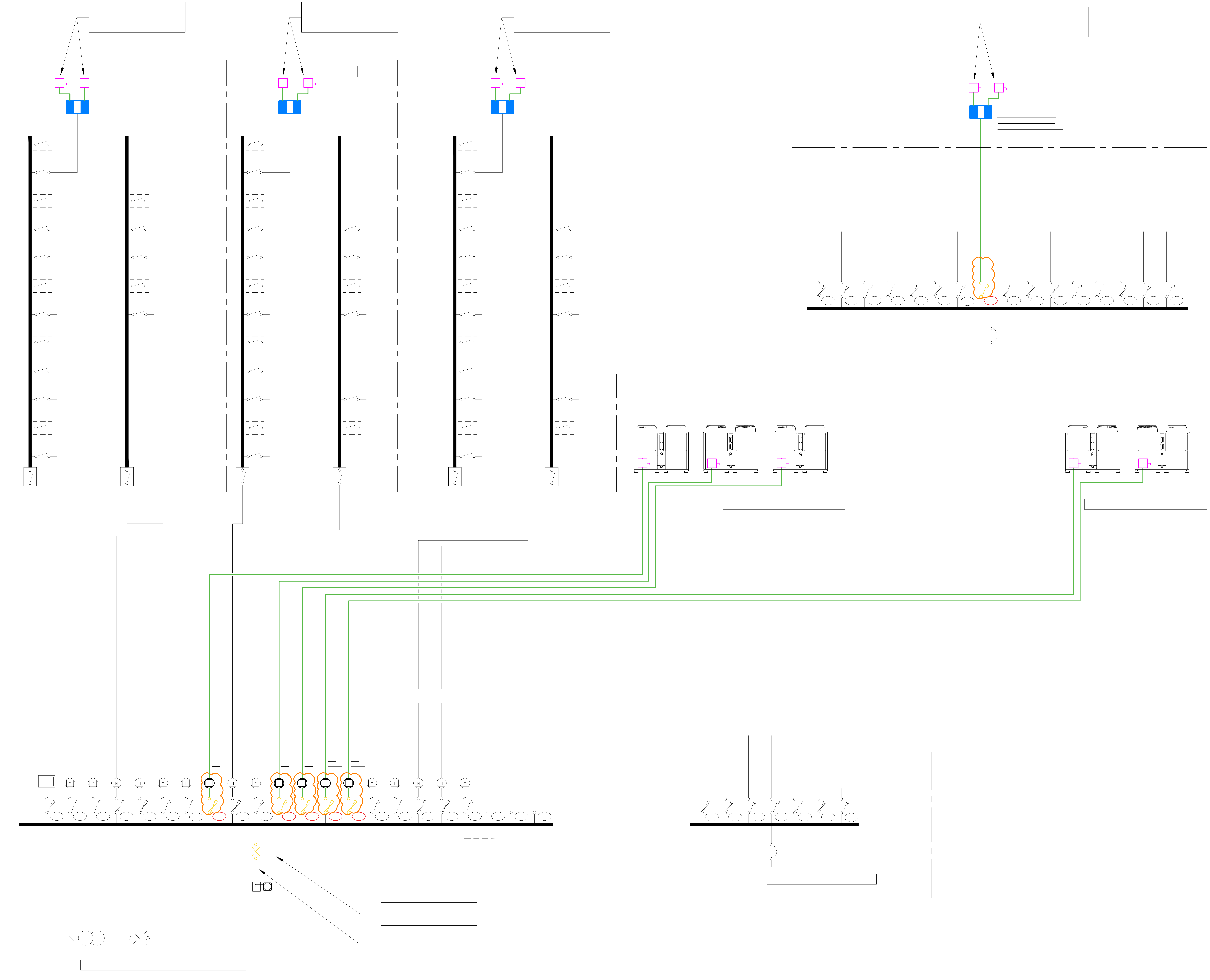

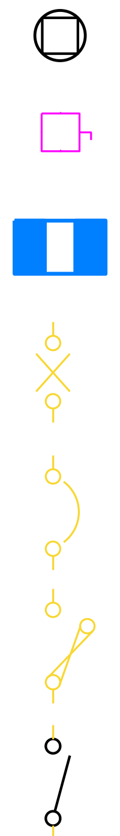

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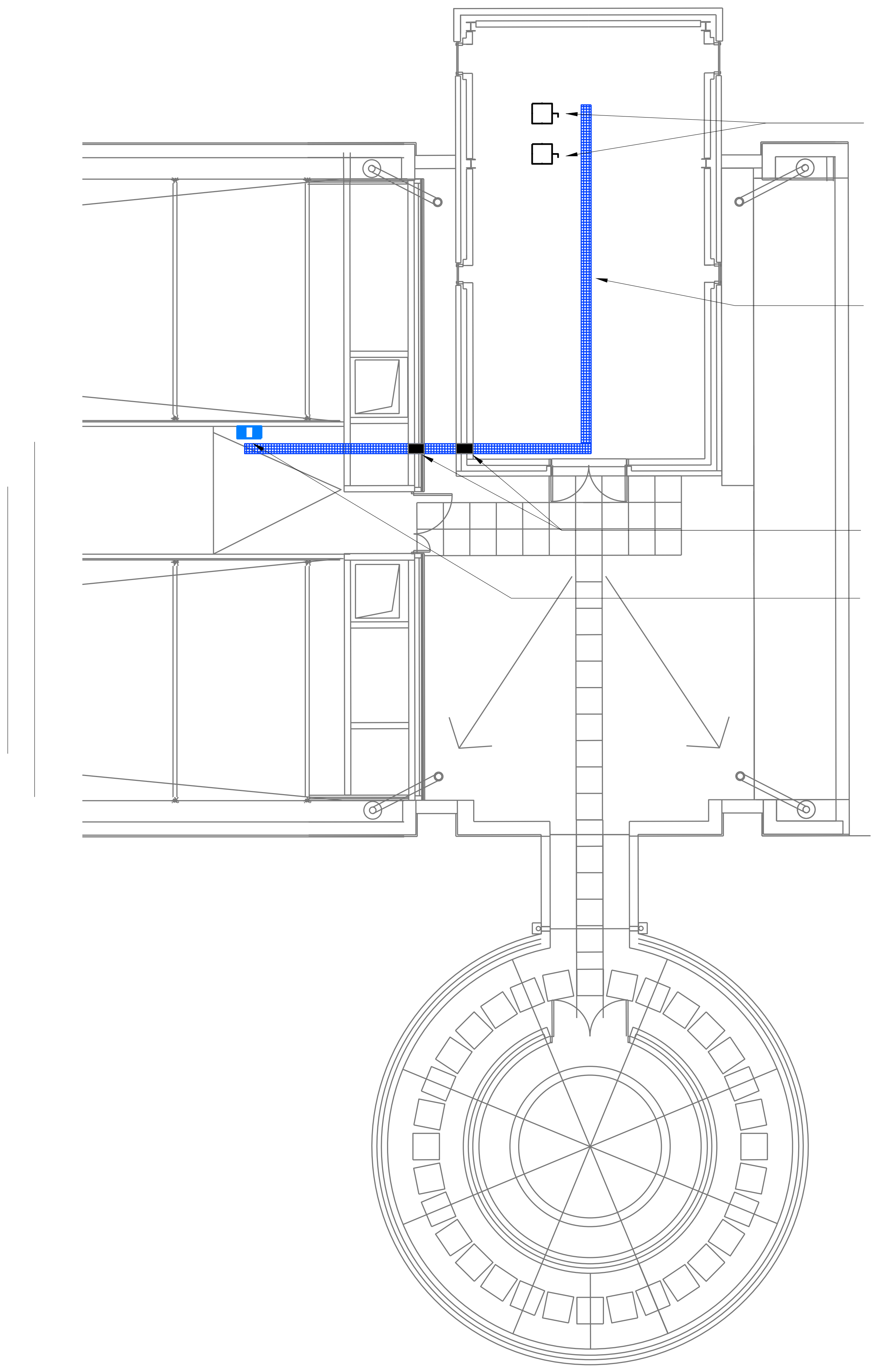

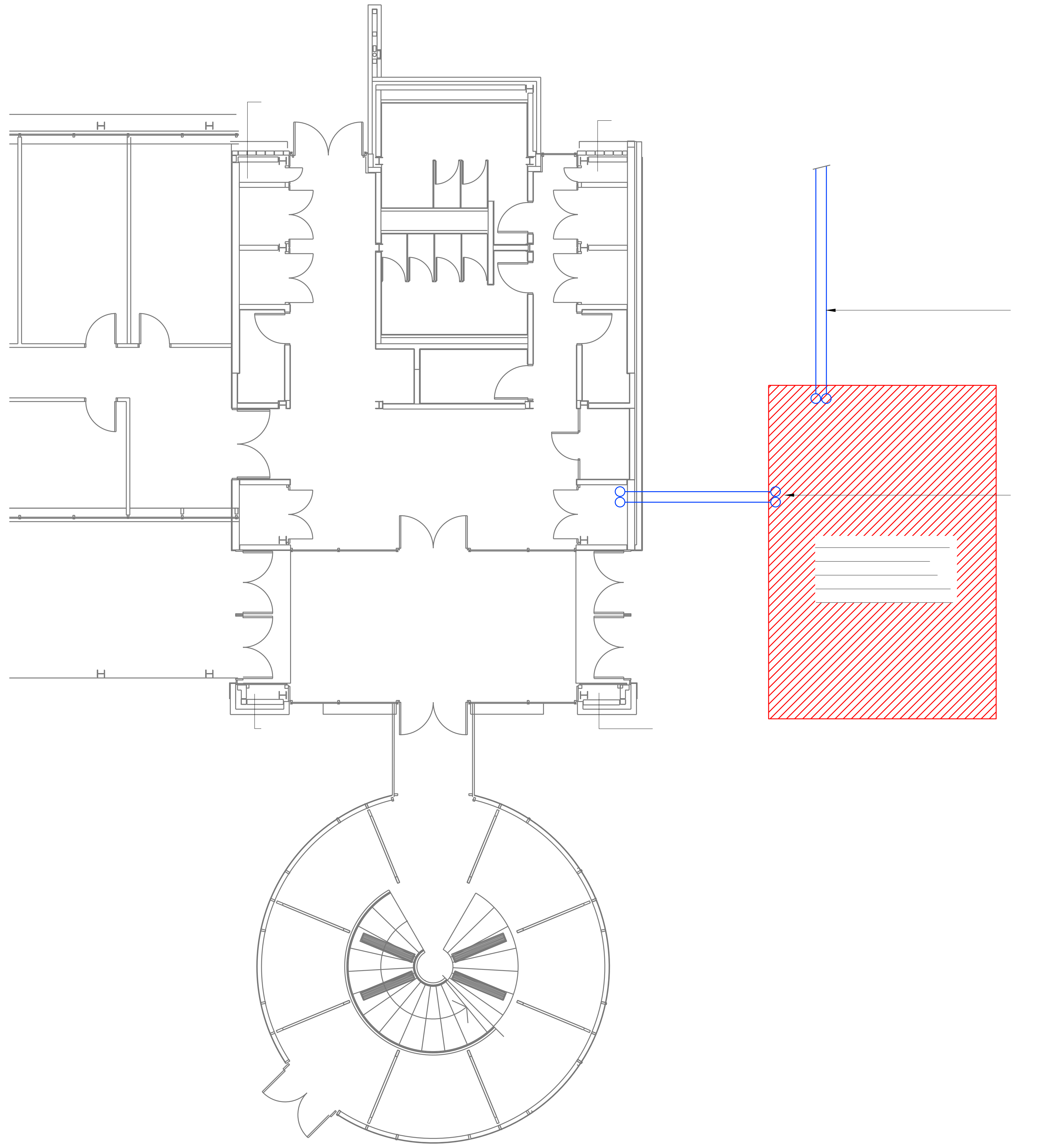

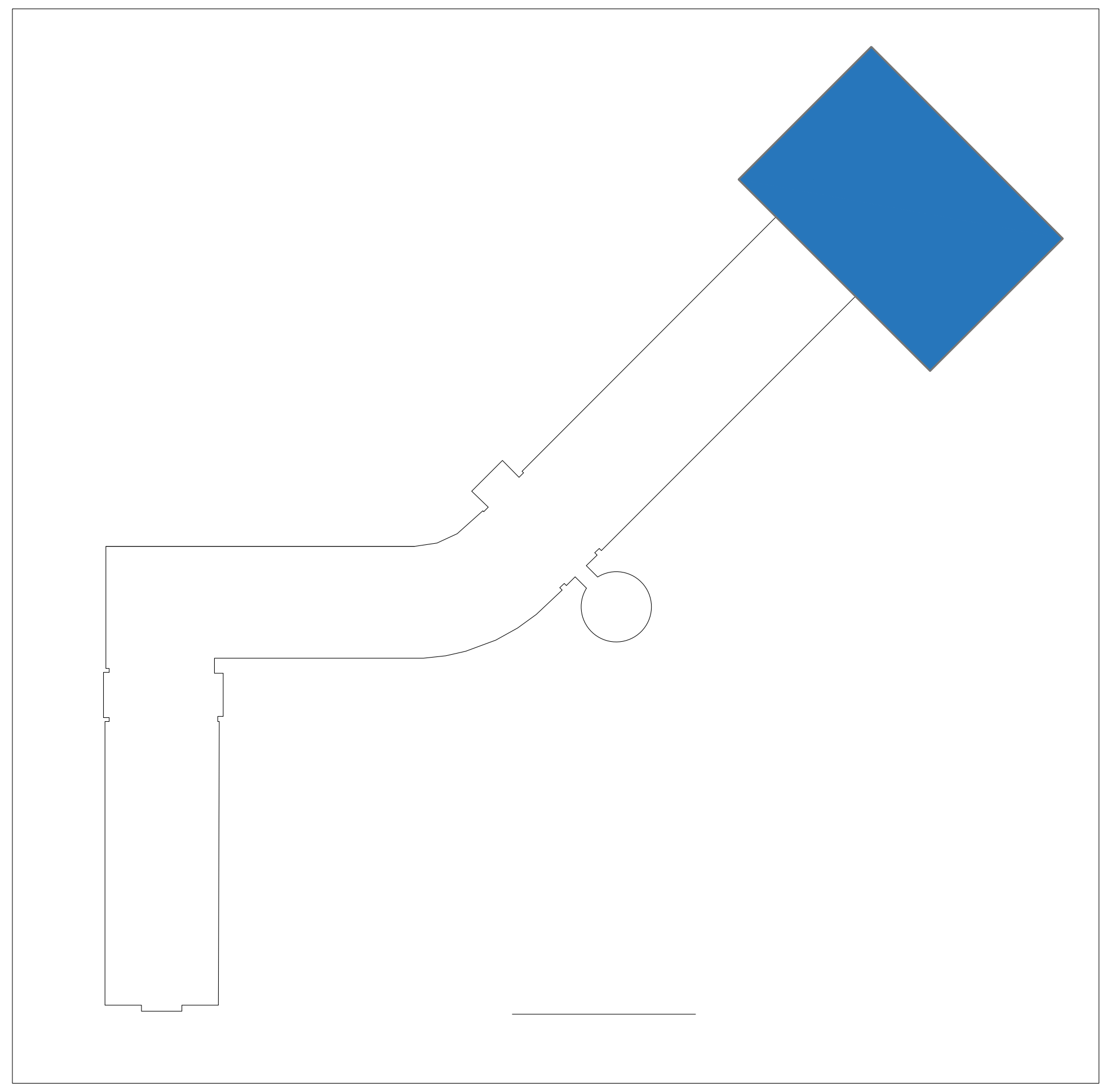

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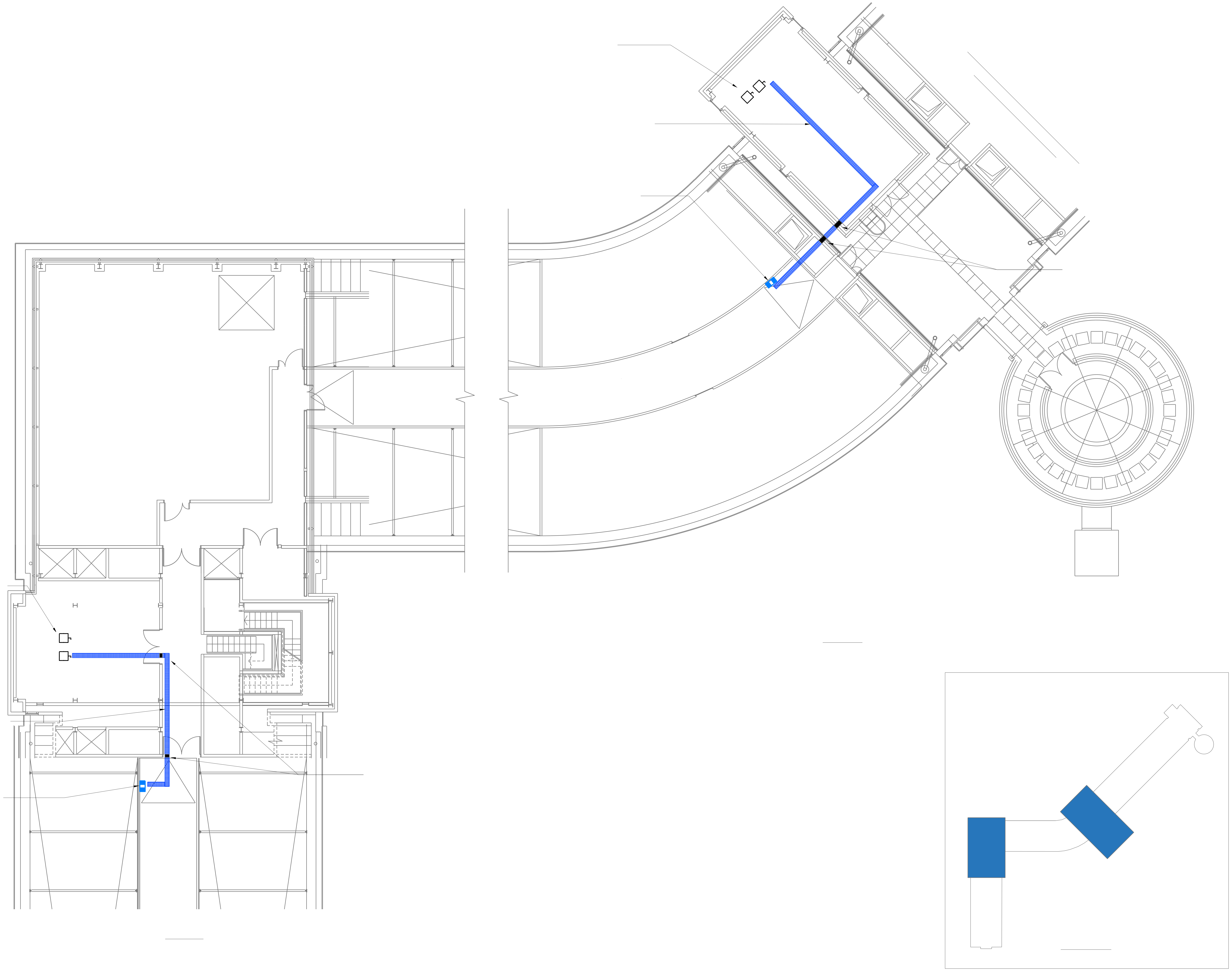

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MEP CONSULTING ENGINEERS

Appendix B

Hysopt Report

Northumbria University – Coach Lane Campus

EQUANS UK

Study Type:	Conceptual
Client:	EQUANS UK
Project Number:	454
Report Date:	22/11/2023
Project manager:	Jeroen Belet
Energy engineers:	Craig Lister

Agenda

1 **Objectives**

Context & scope

2 **Construction of the Digital Twin**

Building & Calibration of model

3 **Optimisations and Alternatives**

Alternatives Explained

4 **Simulation Results**

The Costs, Savings and CO2 Reductions.

5 **Conclusions**

Objectives

Context	▪ Northumbria University with the help of EQUANS have been granted PSDS funding to electrify the Universities Coach Lane Campus. ▪ The aim is to successful reduce Carbon emissions and reduce the gas consumption of the site. ▪ Equans wishes to include the use of Hysopt to validate the optimal hydraulic design option and provide suitable hydraulic changes.
Scope	▪ Upgrade of the existing gas fired boiler heating installations in the buildings (Sports Centre, Block F, Block G, Block H) to include the addition of new air source heat pumps; ▪ Plant rooms of Blocks F, G and H will be combined; The sports centre will be a stand-alone system; ▪ Optimisation of the hydraulic installation to reduce return temperatures and system operating temperatures, in order to provide the best possible conditions for maximum heat pump contribution and efficiency; ▪ Sensitivity analysis of optimal heat pump sizing; ▪ Optimisation of the hydraulic and functional control strategy for optimal heat pump performance.

Agenda

1 **Objectives**
Context & scope

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3 **Optimisations and Alternatives**
Alternatives Explained

4 **Simulation Results**
The Costs, Savings and CO2 Reductions.

5 **Conclusions**

Information Used

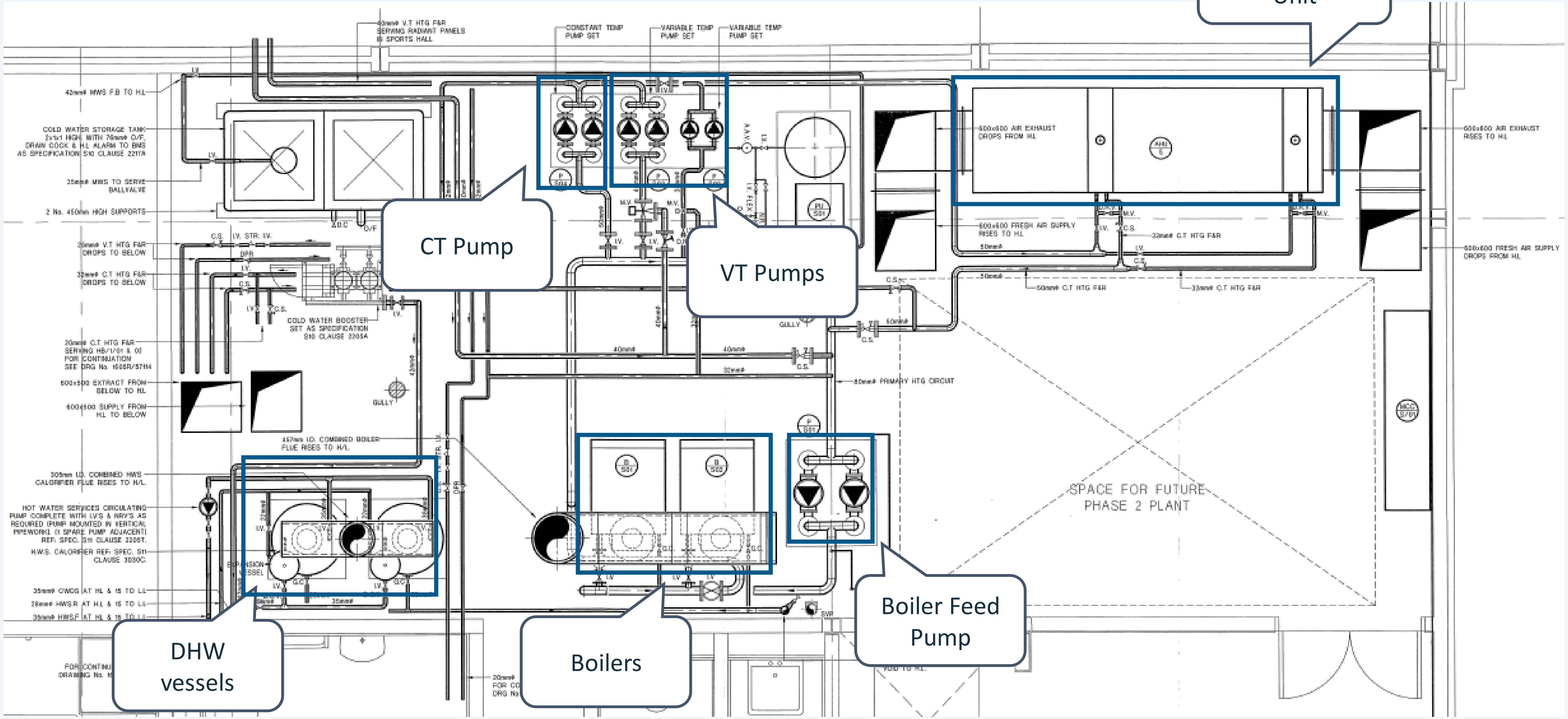
Information Recieved

- 1999 – CLC M&E Services Vol 1 OMM; Description of Installed System:
  - Design Criteria;
  - Description of Heating System;
  - Equipment Schedules;
- 1999 – CLC M&E Services Vol 2B OMM; As Installed Drawings:
  - Plantroom Layouts;
  - Plantroom Schematics;
- Gas Consumption Data:
  - Block F;
  - Block G;
  - Block H;
  - Sports Centre;

Yearly VT Circuit Flow Temperature graph’s (screenshots)

Link MEP Consulting Engineers RIBA Stage 2 Report.

Coach Lane – Plant Room Layout Example



Air Handling Unit

CT Pump

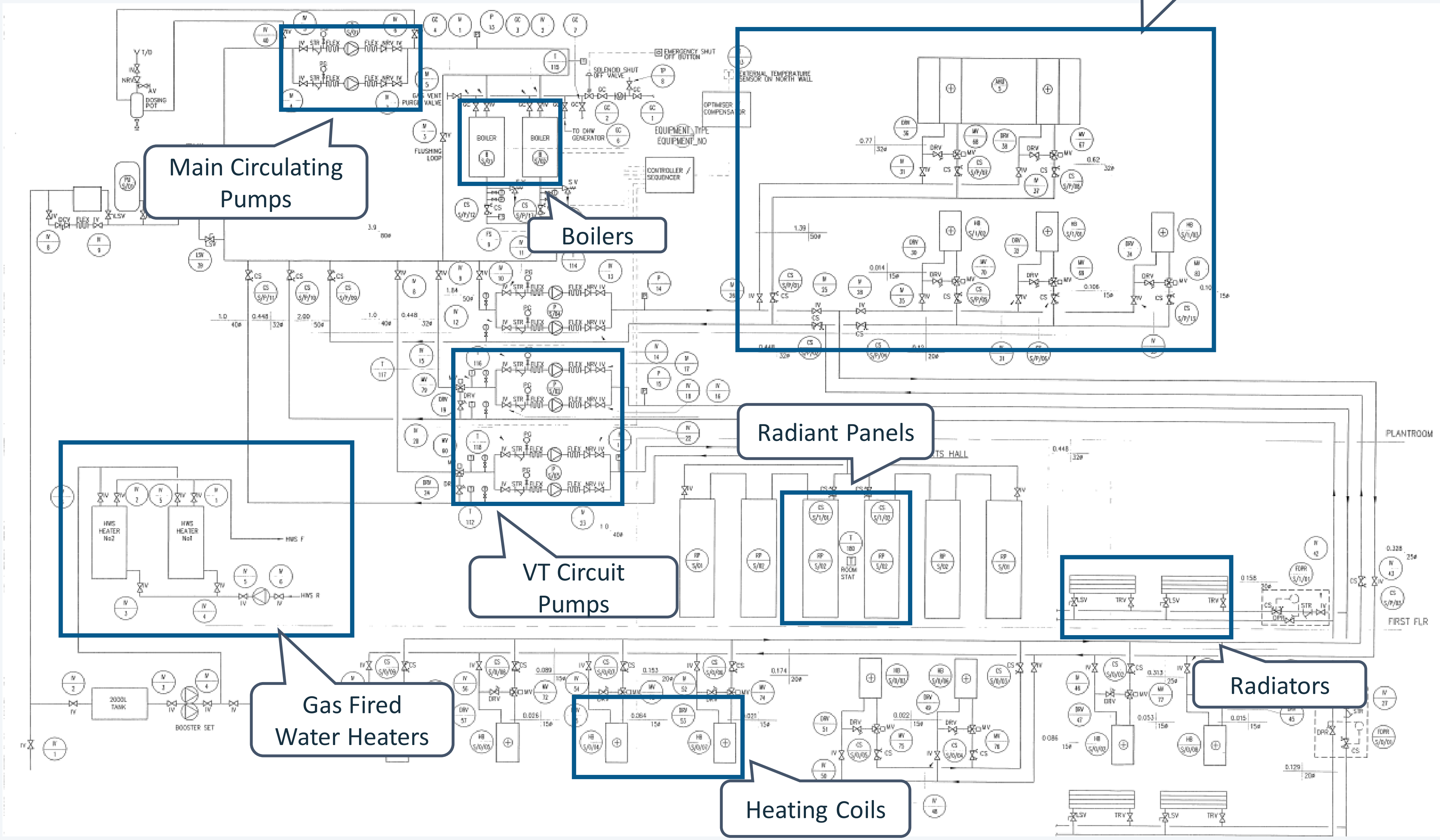
VT Pumps

DHW vessels

Boilers

Boiler Feed Pump

Coach Lane – Plant Room Schematic Example



CT Circuit

Main Circulating Pumps

Boilers

VT Circuit Pumps

Radiant Panels

Gas Fired Water Heaters

Heating Coils

Radiators

Hysopt model – Calibration

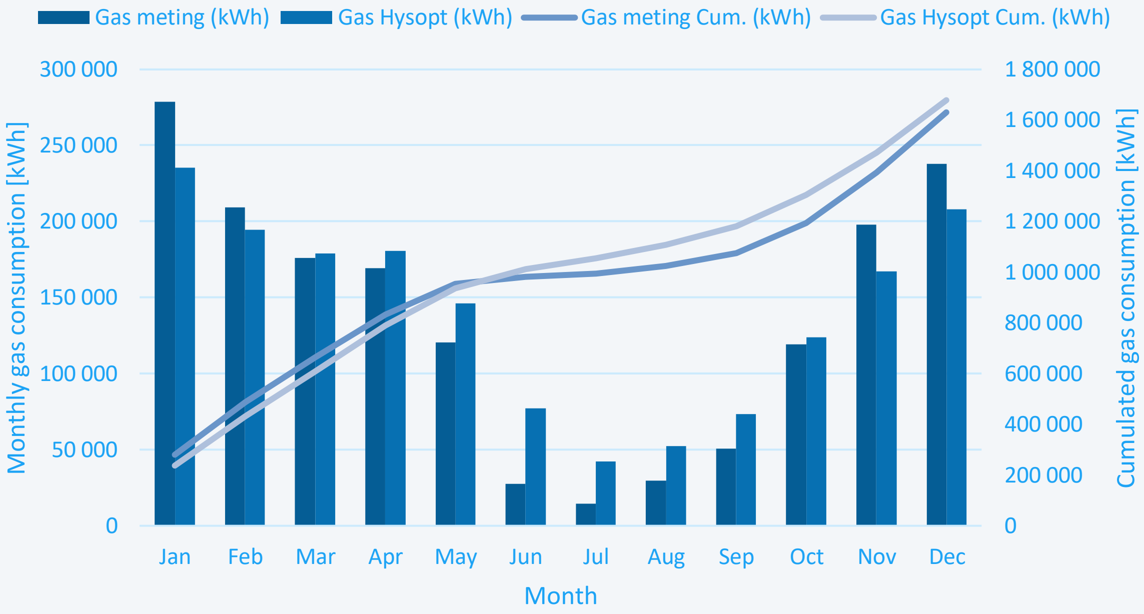
Information utilised in the Hysopt Model

- Circuit Capacities estimated based on schematic flow rates
- Boiler and Heating Coil Capacities
- Calibration of the model using the gas consumption per building received from the client.
- Implemented Heating curves for VT circuits based on screenshots provided.
- Estimating Operating hours from the gas consumption data.

Calibration of Hysopt Model

The Calibration of the model was based on the 2021 monthly gas consumption data and was fine-tuned as follows:

- The heating and hot water consumption was split 95/5 and 50/50. This assumption was carried over at Link MEPs request.
- The VT and CT circuit consumption was apportioned based on the percent of installed capacity for each circuit
- Site gas consumption for 2021: 1,628,992 kWh
- Hysopt Model Consumption: 1,678,741 kWh



Hysopt model – Calibration Continued

Based on the information input into the model (the operating hours, the production capacities and circuit flow rates) we can see the model meets the system set point while also meeting the yearly consumption output.

Agenda

1 **Objectives**
Context & scope

2 **Construction of the Digital Twin**
Building & Calibration of model

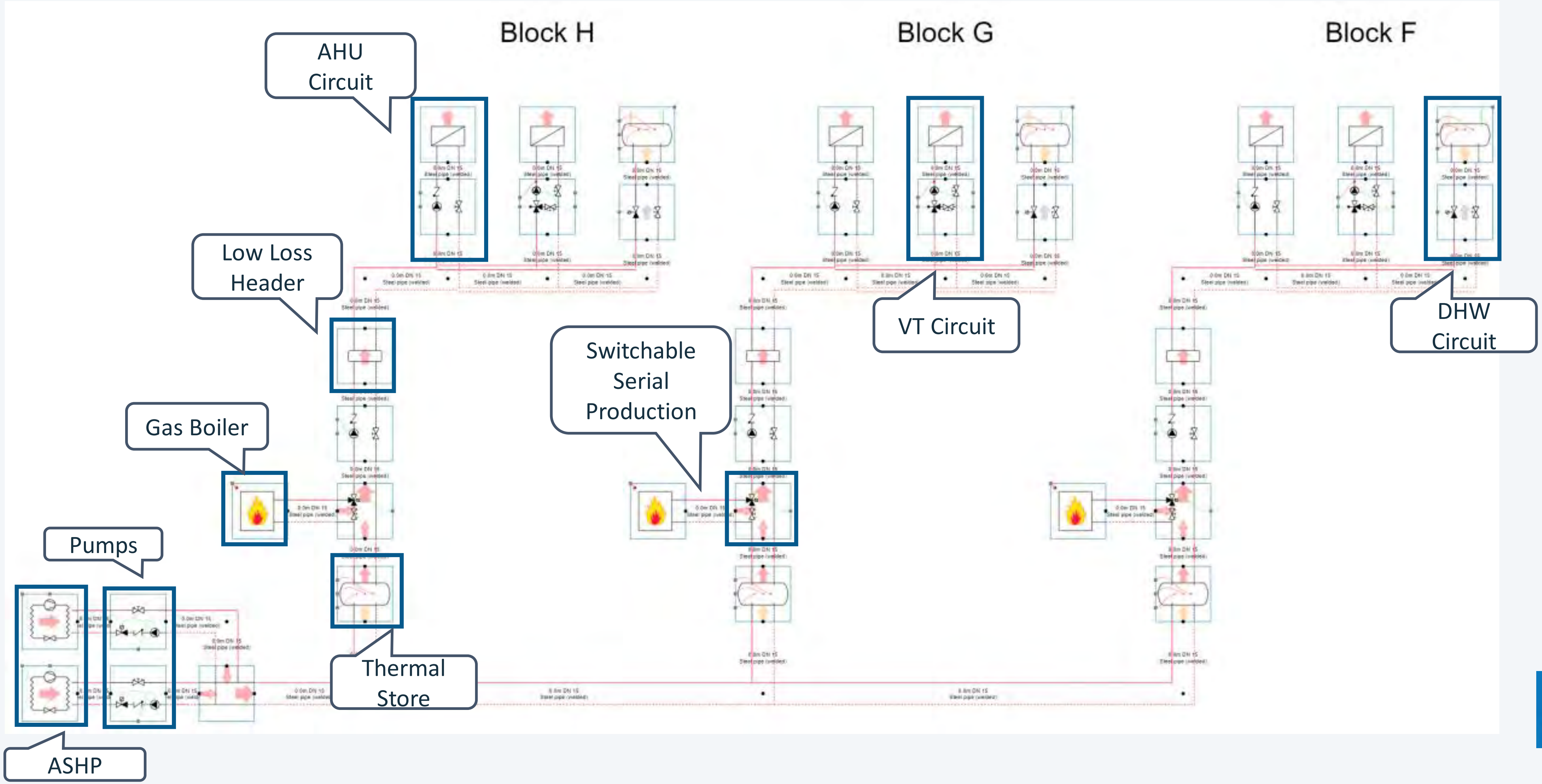
3 **Optimisations and Alternatives**
Alternatives Explained

4 **Simulation Results**
The Costs, Savings and CO2 Reductions.

5 **Conclusions**

Hysopt model – Link Proposal

Note: This is a simplified version of the Hysopt model to show the operating principles. A more extended model was used to run the actual simulations.



AHU Circuit

Low Loss Header

Gas Boiler

Pumps

ASHP

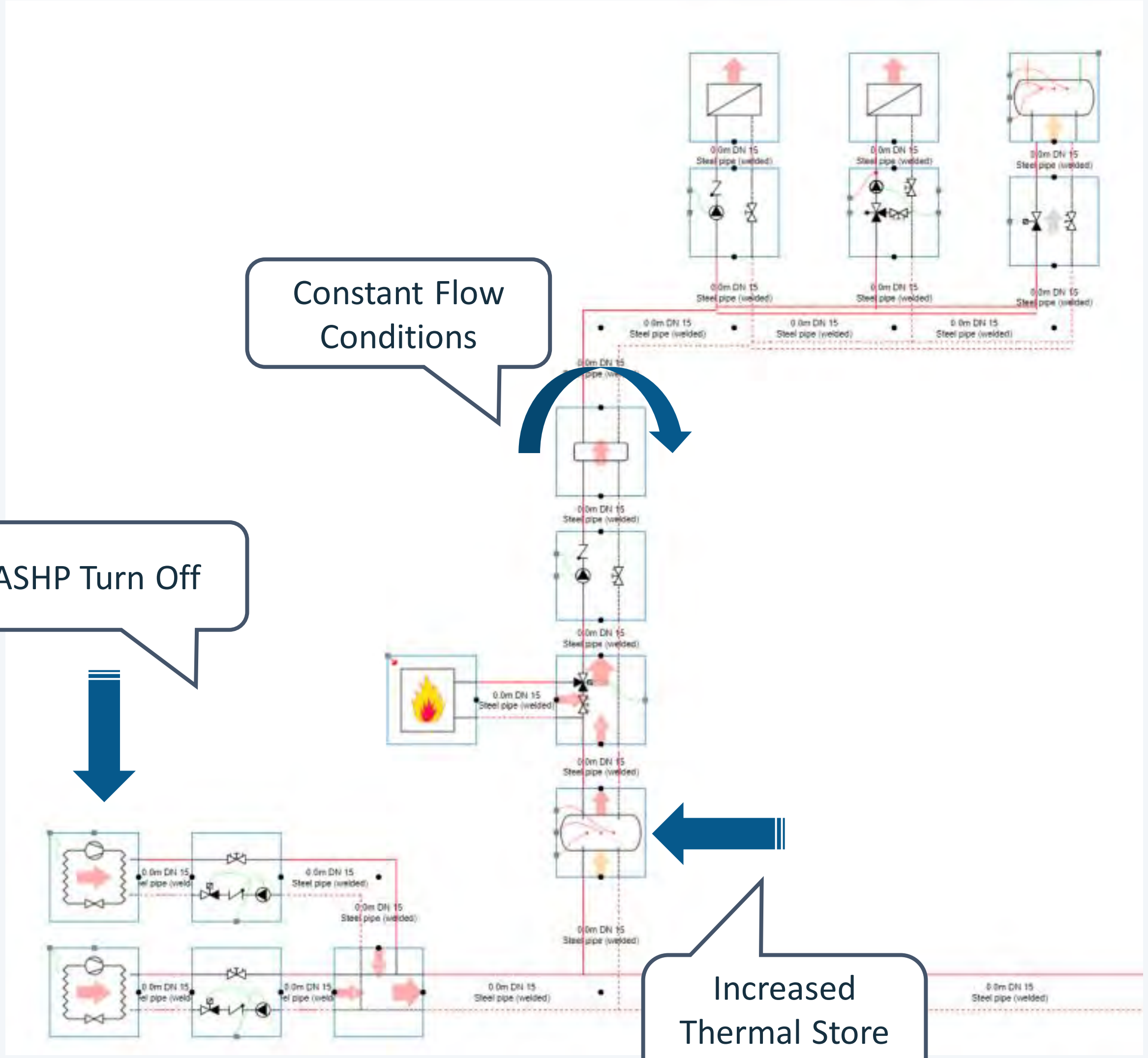
Thermal Store

Switchable Serial Production

VT Circuit

DHW Circuit

Link Proposal – Model Findings



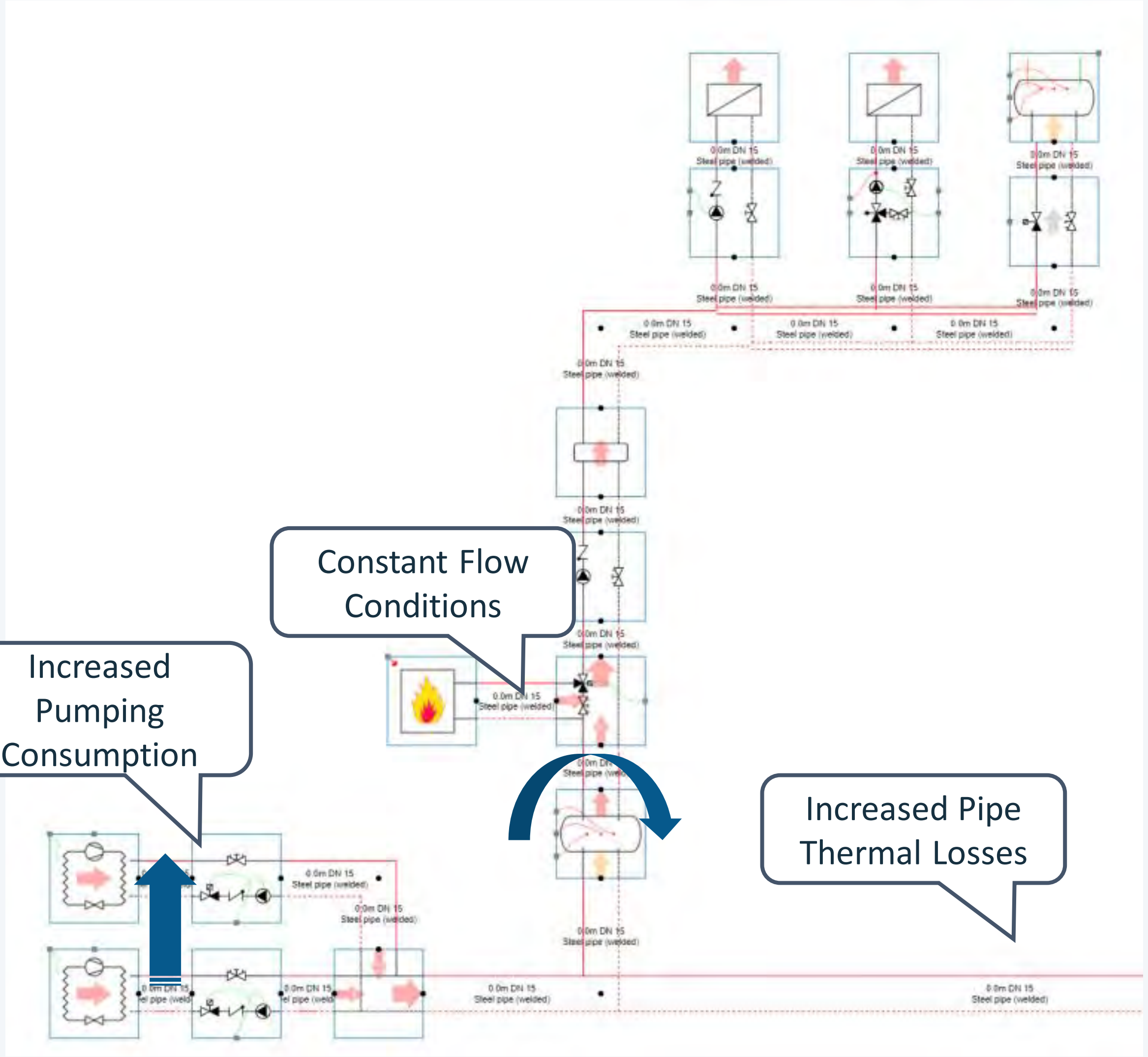
Constant Flow Conditions

ASHP Turn Off

Increased Thermal Store Temperature

- ## Constant Flow Conditions
  - Low Loss Header ➔ Acts as a bypass and reduces the delta T in between the store and the Low loss header.
  - Constant Speed Pump ➔ The constant speed pump creates an overflow in the system causing more water to be bypassed through the LLH and back into the Thermal store
  - ASHP Start/Stops ➔ The small delta T and overflow cause the thermal store to be charged quickly and removes the stratification from the store. This increases the start/stops of the ASHP machine
  - Increased Thermal Store Temperature ➔ The overflow from the LLH enters the Thermal store hotter then when the water left the Thermal store because of the Gas boiler top up. This causes the ASHPs to turn off as they see that the Store is fully charged.
  - Thermal Store Fully charged ➔ With the Store fully charged the ASHPs will remain switched off. However the boiler is still free to top up the CT circuit where required.
  - ASHP switched off ➔ With the ASHPs switched off, the overflow of hot water to the thermal store from the secondary system begins to provide the primary network with excess heat from the store instead of the ASHP. Even if one Boiler remains switched on it can provide heat through the store into every part of the network.

Link Proposal – Model Findings



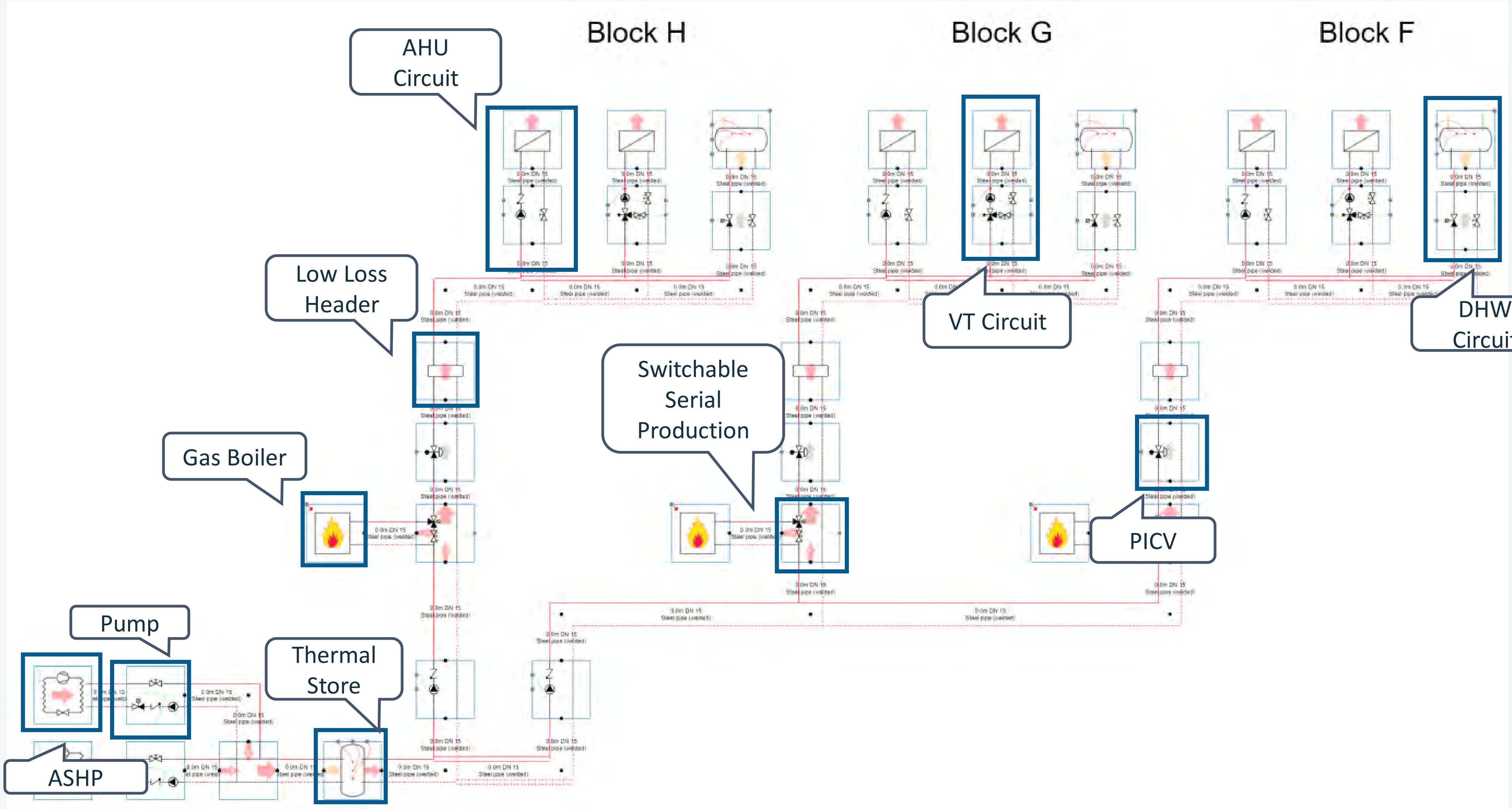
Constant Flow Conditions

Increased Pumping Consumption

Increased Pipe Thermal Losses

- Constant Flow Conditions
  - The Primary Side is currently configured in a way that provides constant flow conditions because of the required flow rate to heat up the store.
  - This creates higher pump consumption due to the constant demand to the thermal stores.
  - The constant demand increases pipe thermal losses.
  - Hysopt proposal aims to create variable flow conditions on the primary side of the network.

Hysopt model – Hysopt Proposal

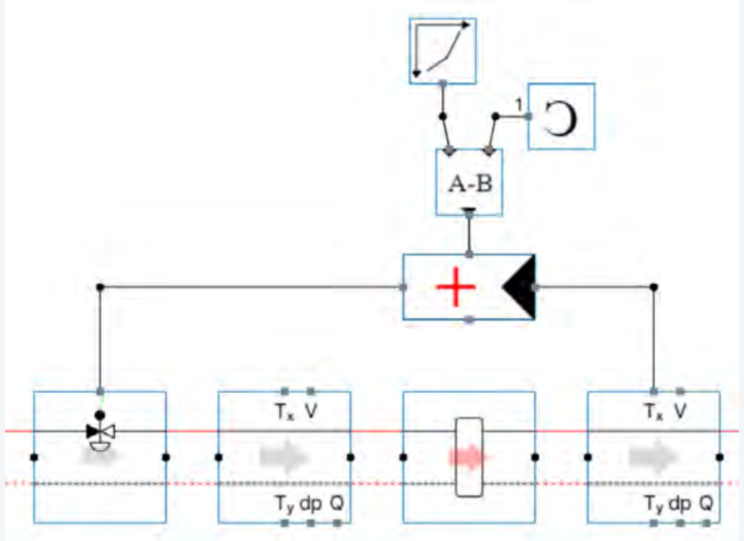


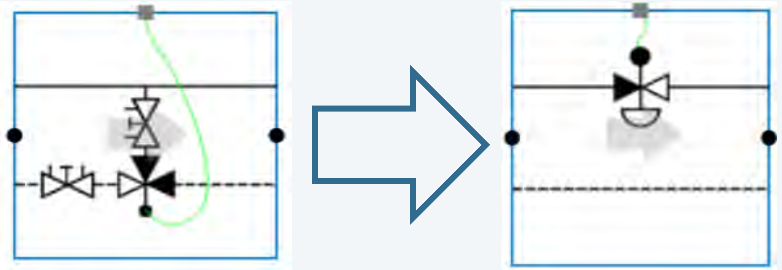
Hydraulic Optimisations

The Following Adjustments have been made in the Hysopt Model:

- Implementation of Low Loss Header Control
  - Low loss headers create constant flow conditions within a system
  - The low loss header works an uncontrolled bypass. The overflow from the constant flow conditions goes through the low loss header and back into the return, raising the return temperature.
  - Adding a control logic to limit the flow over the Low loss header to only what's necessary reduces the energy consumption.
  - The Loss Header Control measures the temperature after the LLH. Utilising the system heating curve and subtracting 1 from the number the PICV modulates to keep the sensor after the LLH within 1 degree of the Heating curve.

- Changing 3 Port Diverting Circuits to two way PICV control (at AHUs and heating coils)
  - The use of 3-way valves creates unnecessary energy consumption and high return temperatures at low demand.
  - This can be solved by replacing these valves with 2-way control valves.
  - A Pressure Independent control valve was chosen as it allows for throttling control of the flowrate but also acts as a pressure balancer for the system leg.
  - This reduction in flow rate not only effective in reducing thermal consumption but it also will reduce pumping consumption.





Agenda

1 **Objectives**
Context & scope

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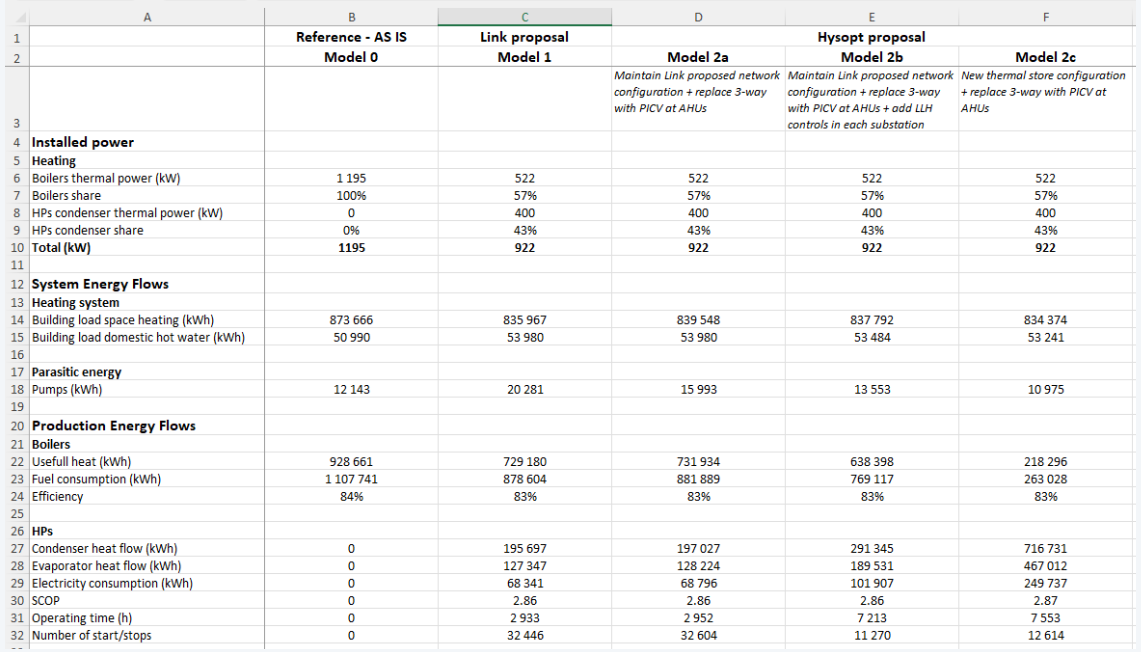
3 **Optimisations and Alternatives**
Alternatives Explained

4 **Simulation Results**
The Costs, Savings and CO2 Reductions.

5 **Conclusions**

Pareto Figures

- Full detailed Pareto report delivered in Excel format
- Summary results included in this report
- Energy tariffs used in report
    - Electricity: 0,24 £/kWh
    - Gas: 0,08 £/kWh
    - Tariffs are adjustable in Excel sheet.
- Carbon factors in report
    - Electricity: 0,233 kg/kWh
    - Gas: 0,187 kg/kWh
    - Carbon factors taken from Link MEP reports



	Reference - AS IS	**Link proposal**	**Hysopt proposal**		
	Model 0	**Model 1**	**Model 2a**	**Model 2b**	**Model 2c**
			Maintain Link proposed network configuration + replace 3-way with PICV at AHUs	*Maintain Link proposed network configuration + replace 3-way with PICV at AHUs + add LLH controls in each substation*	*New thermal store configuration + replace 3-way with PICV at AHUs*
Installed power					
Heating					
Boilers thermal power (kW)	1 195	522	522	522	522
Boilers share	100%	57%	57%	57%	57%
HPs condenser thermal power (kW)	0	400	400	400	400
HPs condenser share	0%	43%	43%	43%	43%
Total (kW)	**1195**	**922**	**922**	**922**	**922**
System Energy Flows					
Heating system					
Building load space heating (kWh)	873 666	835 967	839 548	837 792	834 374
Building load domestic hot water (kWh)	50 990	53 980	53 980	53 484	53 241
Parasitic energy					
Pumps (kWh)	12 143	20 281	15 993	13 553	10 975
Production Energy Flows					
Boilers					
Usefull heat (kWh)	928 661	729 180	731 934	638 398	218 296
Fuel consumption (kWh)	1 107 741	878 604	881 889	769 117	263 028
Efficiency	84%	83%	83%	83%	83%
HPs					
Condenser heat flow (kWh)	0	195 697	197 027	291 345	716 731
Evaporator heat flow (kWh)	0	127 347	128 224	189 531	467 012
Electricity consumption (kWh)	0	68 341	68 796	101 907	249 737
SCOP	0	2.86	2.86	2.86	2.87
Operating time (h)	0	2 933	2 952	7 213	7 553
Number of start/stops	0	32 446	32 604	11 270	12 614

Pareto Figures – Sports Centre

	Reference – AS IS	Link Proposal	Hysopt proposal	
	Existing installation	*HP implementation proposal by Link MEP*	*Maintain Link proposal + replace 3-way with PICV at AHUs*	*Maintain Link proposal + replace 3-way with PICV at AHUs + add LLH controls*
Gas boiler	385 kW	174 kW	174 kW	174 kW
Heat pump		200 kW	200 kW	200 kW
Boiler contribution	100%	9%	9%	4%
Heat pump contribution		91%	91%	96%
Gas consumption	363,951 kWh	31,729 kWh	31,733 kWh	13,246 kWh
Electricity consumption	1,815 kWh	105,499 kWh	105,120 kWh	109,020 kWh

Pareto Figures – Blocks FGH

	Reference AS IS	**Link Proposal**	**Hysopt proposal**		
	Existing installation	*HP implementation proposal by Link MEP*	*Maintain Link proposal + replace 3-way with PICV at AHUs*	*Maintain Link proposal + replace 3-way with PICV at AHUs + add LLH controls*	*New thermal store configuration + replace 3-way with PICV at AHUs*
Gas boiler	1,195 kW	3 x 174 kW	3 x 174 kW	3 x 174 kW	3 x 174 kW
Heat pump		2 x 200 kW	2 x 200 kW	2 x 200 kW	2 x 200 kW
Boiler contribution	100%	79%	79%	69%	23%
Heat pump contribution		21%	21%	31%	77%
Gas consumption	1,107,741 kWh	878,604 kWh	881,889 kWh	769,117 kWh	263,028 kWh
Electricity consumption	12,143 kWh	88,622 kWh	84,789 kWh	115,460 kWh	260,712 kWh

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Conclusions

- A **Hysopt digital twin** was made to analyse the performance of the existing and proposed heating system of the **Northumbria University Coach Lane Campus**

- For the **Sports Centre**:
  - Two 100 kW heat pumps will be able to cover 91% of the building heat load
  - When hydraulicly optimising the secondary side (remove 3-way valves, add variable flow controls over LLH) the heat pump contribution can be increased to 96%
  - Adding the heat pumps will reduce CO2-emission with 59% and reduce energy costs with 8% compared to the existing installation

- For the **Blocks FGH**:
  - Two 200 kW heat pumps will be able to cover 77% of the building heat load (after optimisation)
  - In the first proposal with one separate thermal store per block, there was a constant flow rate in the system, causing the gas-boilers to push the heat pumps out of the heating system (heat pumps only 21% heat contribution)
  - By optimising the heat distribution layout with one central thermal store and optimising the secondary side (same strategy as for Sports Centre), a heat pump contribution of 77% can be obtained
  - Adding the heat pumps will reduce CO2-emission with 48% and reduce energy costs with 9% compared to the existing installation

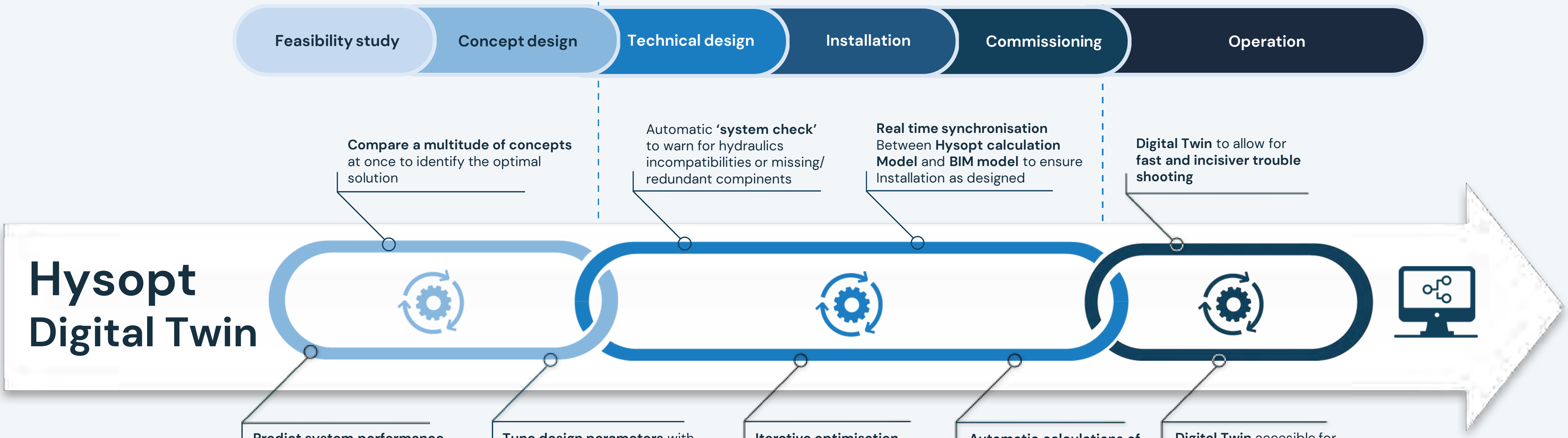
- For both systems, it is still unclear at which ambient temperatures the gas-boiler must be turned on to heat the flow water up to 70°C
  - It is important to turn on the boilers as late as possible (i.e. at low ambient temperatures) to avoid the heat pumps to be pushed out of the heating system
  - We advise to already implement a heating curve on the existing system, to test during the upcoming winter what heating curve the emitter system actually requires

Securing optimal HVAC performance

Design
Explore the options

Build
Optimise the details

Operate
Secure optimal performance



Hysopt Digital Twin

Compare a multitude of concepts at once to identify the optimal solution

Predict system performance (carbon, costs, comfort) with dynamic system simulation

Tune design parameters with automated sensitivity analysis (empowered with cloud computing)

Automatic **'system check'** to warn for hydraulics incompatibilities or missing/ redundant compinents

Iterative optimisation algorithms to optimise all components selections

Real time synchronisation Between **Hysopt calculation Model** and **BIM model** to ensure Installation as designed

Automatic calculations of commissioning presents to improve and speed-up commissioning

Digital Twin to allow for **fast and incisiver trouble shooting**

Digital Twin accesible for **maintenance purposes or future system extensions/ adaptations**

Optimise and adapt

Streamline data

Digital as built

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