# NEW APPLIED TECHNOLOGY, EFFICIENCY AND LIGHTING INITIATIVE

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# Geothermal Water Use in Multi-Apartment Residential Buildings of Tbilisi

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**Prepared by "World Experience for Georgia"**

Tbilisi

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# 1. Executive Summary

There are several obstacles to the efficient use of geothermal water and the expansion of a customer base to cover all the consumers that potentially might benefit from geothermal energy. The majority of the inquired consumers of geothermal hot water mention the smell as well as the chemical influence of the geothermal water on metal surfaces of silverware and electronic devices as negative factors. Another negative factor is the variation of pressure and the availability of geothermal water due to its unauthorized use for heating by some consumers. The inability to individually meter and control this type of consumption prevents the full commercialization of geothermal water use and stabilization of its consumption to increase the consumer base.

Several measures have been suggested in order to address these issues. A recommended solution is to install a heat exchanger of sufficient capacity to extract the thermal energy from geothermal water and to transfer it to regular city water for further use by residents. Along with installing the heat exchanger, two options of the hot water distribution system were considered. In the first option the hot water outflow from the heat exchanger is supplied to the existing hot water distribution piping in the building. Such a system does not support an individual metering capability but requires minimal capital expenditures and might be supplemented by stricter policies to control the consumption of geothermal water. In the second option a new distribution piping is arranged in the building to supply the hot water to the stairwell landing of each floor. In this case an individual metering and disconnection capability is arranged in the common areas of the entrance stairwells for each residential dwelling. Below the suggested solutions are detailed.

According to conceptual solutions and principles developed during the previous stages of the study the design of the geothermal distribution system has been developed including schematic drawings, hydrodynamic calculations, and final decisions about physical location and appearance of the main components.

The decisions include:

1. Exact location, size, and form of installation of the heat exchanger for geothermal water including water intake and geothermal water discharge arrangements
2. Design of heat pump operation including its sizing, furnishing with discharge valves and microprocessor control unit for their operation. Design of logic of the control board
3. Arrangement of entrance piping, individual metering and disconnection capacity

# 2. Background

The residential building 53/53a Saburtalo St. is supplied by the geothermal well #4, located some 500 meters from the building. The average water temperature at the well is 72$^0$C while the temperature at the building entrance is about 70$^0$C. The GHW is used for hot water supply needs, however instances were detected and eliminated by the supplier when unmetered GHW was used for heating in the winter season, thus causing a deficit for other consumers.

The water is supplied to the building through two main feed pipes and further redistributed to three stairwells of #53 and two entrances of #53a; accordingly the pipe entering 53a is a 1/2" small pipe supplying one particular consumer in the second entrance of the building. The main feed pipe is ruptured underground and as a result there is constantly a pond of geothermal water in the yard.

Internally the geothermal water is distributed through the original hot water distribution piping with three risers in each entrance going vertically from floor to floor in 1-, 2-, and 3-room apartments. The pipes are in most cases embedded in the walls and covered by ceramic tiles. This arrangement does not allow for individual metering or the disconnection of consumers outside their premises, and thus it prevents the establishment of proper commercial practices of water distribution.

The suggested geothermal hot water supply system modification is designed to address the above problems.

## 3. Technical Solutions and Requirements

Specific features and parameters of suggested solutions are presented below:

### 3.1. Heat Exchanger

The heat exchanger shall be a commercially available heat exchanger with a capacity of at least 400kW. The geothermal water would be connected to a heat exchanger located in the vicinity of the building. The flat plate-type high capacity heat exchanger would be used to transfer the thermal energy from geothermal water to regular city water obtained from the city network. The temperature regimes of the heat exchanger would be controlled and monitored by a special microprocessor control unit. The control unit would regulate heat losses by regulating the temperature of discharge water in the interval of 20-25$^0$C.

The heat exchanger is maintenance-free and may require cleaning of its interior surfaces once a year.

### 3.2. Connections

The cold water would be tapped from the building supply cold water pipe after the water supply company installs the commercial meter.

The bypass piping and valves would be furbished in order to allow for an uninterrupted supply of thermal water during heat exchanger maintenance and malfunctioning.

The connection of the heat exchanger would be arranged with the existing main supply pipe for geothermal water. The output geothermal water from the heat exchanger would drain into the sewage system or alternatively be used by the occupants of the building.

The two potential options of using the residual thermal energy are: a. directing the residual warm water for heating some commercial area with the use of a heat pump b. use for warming the soil in a greenhouse. Other potential uses of the residual heat may be suggested by the residents.

The original hot water supply system would be kept in place and would be available for switching back in emergency outages or in case the new system is considered unpractical.

## 3.3. Discharge Valves

Geothermal water flow through the heat exchanger would be controlled by a two-step system with electromagnetic valves of 1/2” and 1-1/4” sizes.
The valves would be commercially available valves of reliable industry standard. The power supply for discharge valves would be arranged from the common entrance light and metered by a separate meter.

## 3.4. Peaking Reservoir

The heat pump would be furnished with a 0.7m3 reservoir for temperature measurements to be taken for valve operation and for immediate short-term response to abrupt demand increases.

## 3.5. Insulation and Protective Cabinets

Both the heat pump and the peak reservoir would have proper thermal insulation and be enclosed in a metal cabinet with the possibility of dismantling for the maintenance of the heat exchanger and the peaking reservoir as well as access to the control unit. The size of the heat exchanger cabinet is moderate and could be easily accommodated in the yard of the building. The cabinet would be of sufficiently strong construction to avoid easy damage from occasional persons or vehicles. It would be assembled with non-standard bolts to avoid interference of third parties.

## 3.6. Control Unit

### 3.6.1. Basic Functions

The optimal use of geothermal energy can be achieved in case the temperature of discharged geothermal water does not exceed 20-250C. To achieve this goal two electromagnetic valves could be installed at the outflow of the heat exchanger. These valves would operate based on the readings of the temperature and pressure of the hot water supplied to the building. The control unit for discharge valve operation would be a customer tailored unit programmed specifically for the current application.

The control unit would allow the following functionality:

- Reading and control of the discharge geothermal water temperature
- Reading and control of hot water temperature supplied to the building
- Manual shut-off and opening of electromagnetic valves
- The control unit would be enclosed within the metal cabinet and protected from external damage
- Pressure measurements at input of geothermal water and input and output of heated city water
- Counting of the timing and number of control signals for valve opening/closing

The control unit would have the capacity for recording the temperature and pressure measurements and downloading to a portable device or computer.

### 3.6.2. Algorithm for Heat Exchanger Control System

The algorithm of operation of these valves could be as follows:

If the temperature of water supplied to the building exceeds 42$^0$C the bigger valve will shut off. In the case of a temperature increase beyond 45$^0$C the smaller valve will also shut off and the discharge of geothermal water to sewage will be stopped.

In the case of a temperature drop beyond 45$^0$C the electromagnetic valves will open in a reverse order.

In the algorithm it is important to take into account the “sleep” regime of hot water use, when at night the consumption of the hot water is practically stopped. In this case the valve operation based on temperature sensor signals is insufficient, because in this case the temperature in the reservoir housing the temperature sensors will drop due to heat loss to the environment. In this case the electromagnetic valves would stay closed to avoid unproductive spillage of geothermal hot water. In order to avoid such a condition, it is necessary to monitor the pressure drop in outgoing hot water pipe and supply this information to the processor. Therefore, the valves will open only when there would be a temperature drop below 45$^0$C and there would be a temperature drop in the outgoing pipe, meaning that there is hot water consumption in the building.

## 3.7. Power Supply

Power supply for the electromagnetic valves and control unit would be arranged from the entrance light with a separated meter located in a metal box in the entrance of the building. The power would be supplied by a protected cable from the entrance lighting circuit and measured by a dedicated meter enclosed in the protective box.

## 3.8. Internal Piping

There are two options suggested for implementation

1. Installation of a heat exchanger for geothermal hot water and connection to existing thermal water distribution piping in the building
2. Installation of new distribution piping and arrangement of individual metering and disconnection capacity for each apartment. *In the second option the original piping would be preserved for backup and water supply during overhauls and outages.*

In option 1 the existing individual supply to a consumer in the second entrance would remain unchanged and would not receive the smell-free hot water, unless the consumers switch to the initial original distribution system of the building.

The distribution piping would be arranged inside or outside the building entrance. Plastic poly-propylene pipes of acceptable quality (PP-R80 SDR7.4 or equivalent) suited for operation under the expected conditions.

The piping would be properly insulated to minimize the heat loss to ambience but also would be aesthetically acceptable.

Insulated parts in easily accessible locations would be protected by foil in order to avoid easy damage to insulation.

## 3.9. Apartment Connection

It is up to tender participants to suggest optimal ways of connecting apartments to distribution piping.

## 3.10. Consumer Metering

Separate meters and disconnection valves would be arranged for each apartment. Meters would be regular commercially proven flow meters allowing the metering of total water consumption. The meters would be certified and sealed to avoid tempering. Heat flow meters are not included in the scope of installation except for monitoring purposes.

Disconnection valves would be enclosed in protected metal boxes to only allow access to geothermal water supply company.

### 3.11. Monitoring Capacity

Since this is a first pilot project of its kind there are multiple issues that may need to be addressed and resolved during its implementation and operation. The adequate monitoring and adjustment mechanisms would be foreseen at the stage of implementation.

The monitoring and control system would address the following tasks:

1. Monitoring the adequacy of hot water supply to the consumers
2. Control and minimization of heat losses through minimizing the residual temperatures of geothermal water
3. Collecting reliable information about the daily and seasonal patterns of hot water use by residents
4. Monitoring the reliability of operation of the suggested system

In order to monitor the performance of a geothermal system and the amount of energy supplied to consumers, the capacity for temperature measurement would be provided at selected locations in the buildings:

1. Temperature sensors would be installed at the closest, intermediate and furthest location of hot water distribution network to compare the temperatures supplied to different consumers.

Flow meters for incoming geothermal water and incoming city water would be installed for monitoring purposes. The latter would be used for balancing the consumption with individual meters during the commercial process, to protect against unauthorized use and possible meter tampering.

### 3.12. Criteria for Tender Evaluation:

The suggested criteria for tender evaluation are as follows:

| | Criterion | weight |
|---|---|---|
| 1 | Bid price | 60% |
| 2 | Adequacy of the proposal and technical solutions | 20% |
| 3 | Warranty period on the system | 10% |
| 4 | Impact on living environment and exterior | 10% |

## 4. Tender Documentation

# Installation of Geothermal Heat Distribution System

# for Hot Water Application

# 53/53a Saburtalo St.

### 4.1. Task Description

Works to be carried out consist of construction-installation works related to the upgrade of the existing geothermal hot water supply system of a five-storey residential building at the following address: Tbilisi, 53/53a Sulkhan Tsintsadze (former Saburtalo) Street.

The tender participants should review the provided Scope of Work and schematic drawings. This Scope of Work contains information about the quantities of materials and equipment needed for each type of work, but the Construction Sub-contractor shall check all these quantities on site himself. The Construction Sub-contractor shall provide all needed materials and equipment (fittings, fixing gear, etc.) that are needed for full completion of works, even if they are not indicated in the given Scope of Work. The Construction Sub-contractor shall perform all works needed for satisfactory completion of the Contract and proper functioning of the completed installations even if they are not indicated in this description of work. All materials and equipment supplied by the Construction Sub-contractor should be accompanied by the manufacturer's certificate of quality and certificate of registration of goods in Georgia.

The tender participants should submit their Bid Proposals according to the attached form. Their Bid Proposal should be accompanied by a written description of a proposed method for carrying out the needed works and a tentative time-schedule.

All equipment and systems installed by the Sub-contractor should be tested according to manufacturers recommendations prior to handing over to the Purchaser.

All construction-installation works carried out by the Sub-contractor shall be performed according to requirements of the Georgian Construction Norms and Standards (SNIPs). All requirements of Safety Regulations shall be strictly observed during construction and installation works performed by the Sub-contractor.

### 4.2. Description and Scope of Work

# Bid Proposal

**Part A. Upgrade of geothermal hot water supply system by installation of heat exchanger**

| ## | Description of work and its scope | Cost (GEL) |
|---|---|---|
| | **1. Dismounting Works** | |
| 1.1 | Demolition of asphalt cover along the routes of existing underground piping GHW∅50mm and new piping GCW∅50mm, S=13.5 $m^2$ | |
| 1.2 | Digging of trenches in ground along the routes of existing underground piping GHW∅50mm and new piping GCW∅50mm, V=9.0 $m^3$ | |
| 1.3 | Dismounting of existing steel pipes GHW∅50mm, L=23.0 m. | |
| | **2. Installation of New Piping, Valves and Meters** | |
| 2.1 | Installation of steel valve PN16 D=100 mm on aboveground section of steel piping GHW∅100mm, 1 it. | |
| 2.2 | Installation of polypropylene pipes PP-R80 SDR7.4 DN=40 mm on section of new piping GHW, L=16.0 m.<br>- Steel sleeves D=100 mm, L=11.0 m.<br>- Ball valve D=40 mm, 1 it.<br>- Bypass DN=40mm with ball valve D=40mm between GHW and PHW piping<br>- Hot water meter D=40 mm, 1 it.<br>- Connection to steel piping ∅50 mm, 1 point.<br>- Thermal insulation of pipes on underground section of piping with use of porolone insulation material (thickness 10mm) and wrapping with airtight film, L=30.0 m. | |
| 2.3 | Installation of polypropylene pipes PP-R80 SDR7.4 DN=40 mm on section of new piping PHW, L=14.5 m.<br>- Ball valve D=40 mm, 2 it.<br>- Connection to steel piping ∅50 mm, 1 point.<br>- Thermal insulation of pipes on underground section of piping with use of porolone insulation material (thickness 10mm) and wrapping with airtight film, L=7.0 m. | |
| 2.4 | Installation of polypropylene pipes PP-R80 SDR7.4 DN=40 mm on | |

| | | |
|---|---|---|
| | section of new piping GCW, L=10.0 m.<br><br>- Ball valve D=40 mm, 1 it.<br>- Cold water meter D=40 mm, 1 it.<br>- Connection to steel piping ∅40 mm, 1 point. | |
| 2.5 | Installation of polypropylene pipes PP-R80 SDR7.4 DN=50 mm on section of new piping GCW, L=8.5 m.<br><br>- Steel sleeves D=100 mm, L=8.5 m.<br>- Connection to underground reinforced concrete sewage well, 2 points. | |
| | **3. Installation of Plate Heat Exchanger and Control Unit** | |
| 3.1 | Installation of "MASTAS" MAS2 type (or similar) P=400 kW capacity plate heat exchanger with stainless steel plates and NITRIL (NBR) or EPDM type gaskets, with working pressure up to 9 bars, 1 set.<br><br>- Connection joints with DN=40 mm sleeves, 4 it.<br>- Thermal insulation with glass-fiber or mineral wool insulation material (thickness 80mm), S=3.0 $m^2$<br>- Protective cabinet, 1 it. | |
| 3.2 | Installation of control unit and connecting piping with valves and meter instruments:<br><br>- Connecting piping PP-R80 SDR7.4 DN=16-40mm, L=5.0 m.<br>- Steel tank D=300 mm, L=1.0 m.<br>- Steel pipe D=40 mm, L=1.4 m.<br>- Ball valve DN=40 mm, 2 it.<br>- Ball valve DN=25 mm, 2 it.<br>- Electromagnetic valve "normal – open" ∅25mm<br>- Electromagnetic valve "normal – open" ∅16mm<br>- Temperature sensor, 7 it.<br>- Pressure sensor, 2 it.<br>- Temperature and pressure controller, 1 it.<br>- Connecting cables, L=8.0 m.<br>- Thermal insulation with glass-fiber or mineral wool insulation material (thickness 80mm), S=2.0 $m^2$<br>- Thermal insulation with porolone insulation sleeves (thickness 10mm), L=5.0 m.<br>- Protective cabinet, 1 it. | |
| | **4. Installation of power supply system** | |
| 4.1 | Installation of direct connection electric meter with nominal voltage 230V 10A and connection to power supply line for lighting of staircase, 1 it.<br><br>- Single-pole automatic circuit breaker, nominal voltage 230V, 2A – 1 it<br>- Cabinet with connection bus, 1 it. | |

| | | |
|---|---|---|
| 4.2 | Installation of power cable with copper conductors 2X0.75 $mm^2$ (with double insulation), L=11.0 m. | |
| 4.3 | Installation of grounding circuit for protective cabinets (steel strips 20X2 mm and steel electrodes ∅20mm), 2 sets. | |
| | **5. Finishing Works** | |
| 5.1 | Backfilling of trench with gravel and compacting layer-by-layer, V=9.0 $m^3$ | |
| 5.2 | Laying of small-grain asphalt cover (thickness 50mm), S=15.0 $m^2$ | |
| 5.3 | Cleaning of the territory and removal of construction debris to permitted waste dumping site | |
| | Total Cost of Part A | |

**Part B. Installation of Hot Water Distribution System with Individual Meter Units**

| ## | Description of work and its scope | Cost (GEL) |
|---|---|---|
| | **6. Installation of Hot Water Distribution Piping with Location of Vertical Sections on the Façade Wall of the Building (Option I)** | |
| 6.1 | Installation of polypropylene pipes PP-R80 SDR7.4 DN=40 mm of horizontal sections of distribution piping with fixing on external walls of the building with brackets at up to 4.5m height, L=82.0 m.<br>- Thermal insulation of pipes with use of porolone insulation material (thickness 10mm) and wrapping with airtight film, L=82.0 m. | |
| 6.2 | Installation of polypropylene pipes PP-R80 SDR7.4 DN=32 mm of vertical sections of distribution piping with fixing on external walls of the building with brackets at up to 14m height, L=48.0 m.<br>- Ball valve D=32 mm, 5 it.<br>- Thermal insulation of pipes with use of porolone insulation material (thickness 10mm) and wrapping with airtight film, L=48.0 m. | |
| 6.3 | Installation of polypropylene pipes PP-R80 SDR7.4 DN=20 mm of distribution piping on entry sections to staircases, L=50.0 m. | |

| | | |
|---|---|---|
| | - Making ∅40mm holes in brick walls (thickness up to 0.4m), 40 it.<br><br>- Installation of ∅32mm bush sleeves L=0.5m, 40 it.<br><br>- Thermal insulation of pipes with use of porolone insulation material (thickness 10mm) and wrapping with airtight film, L=40.0 m. | |
| 6.4 | Installation of polypropylene pipes PP-R80 SDR7.4 DN=16 mm on staircase landings and installation of individual water meter units, L=36.0 m.<br><br>- Ball valve D=16 mm, 60 it.<br>- Hot water meters D=16 mm, 60 it.<br>- Thermal insulation of pipes with use of porolone insulation material (thickness 10mm) and wrapping with airtight film, L=36.0 m.<br>- Protective cabinets, 20 it. | |
| | | |
| | Total Cost of Part B (Option I) | |
| | | |
| | **7. Installation of Hot Water Distribution Piping with Location of Vertical Sections in Staircases (Option II)** | |
| 7.1 | Installation of polypropylene pipes PP-R80 SDR7.4 DN=40 mm of horizontal sections of distribution piping with fixing on external walls of the building with brackets at up to 4.5m height, L=82.0 m.<br><br>- Thermal insulation of pipes with use of porolone insulation material (thickness 10mm) and wrapping with airtight film, L=82.0 m. | |
| 7.2 | Installation of polypropylene pipes PP-R80 SDR7.4 DN=32 mm of vertical sections of distribution piping in staircases, L=48.0 m.<br><br>- Ball valves D=32 mm, 5 it.<br><br>- Making of ∅60mm holes in brick walls (thickness up to 0.4m), 5 it.<br><br>- Making of ∅60mm holes in reinforced concrete floor slabs (thickness 0.2 m), 15 it.<br><br>- Installation of ∅50mm bush sleeves L=0.5m, 5 it.<br><br>- Installation of ∅50mm bush sleeves L=0.3m, 15 it.<br><br>- Thermal insulation of pipes with the use of porolone insulation material (thickness 10mm) and wrapping with airtight film, L=41.0 m. | |
| 7.3 | Installation of polypropylene pipes PP-R80 SDR7.4 DN=32 mm on sections between distribution piping risers and individual meter units, | |

| | | |
|---|---|---|
| | L=40.0 m.<br><br>- Thermal insulation of pipes with use of porolone insulation material (thickness 10mm) and wrapping with airtight film, L=40.0 m. | |
| 7.4 | Installation of polypropylene pipes PP-R80 SDR7.4 DN=16 mm on staircase landings and installation of individual water meter units, L=36.0 m.<br><br>- Ball valve D=16 mm, 60 it.<br>- Hot water meters D=16 mm, 60 it.<br>- Thermal insulation of pipes with use of porolone insulation material (thickness 10mm) and wrapping with airtight film, L=36.0 m.<br>- Protective cabinets, 20 it. | |
| | | |
| | Total Cost of Part B (Option II) | |
| | | |

**Part C. Connection of Single Customer to Hot Water Distribution System**

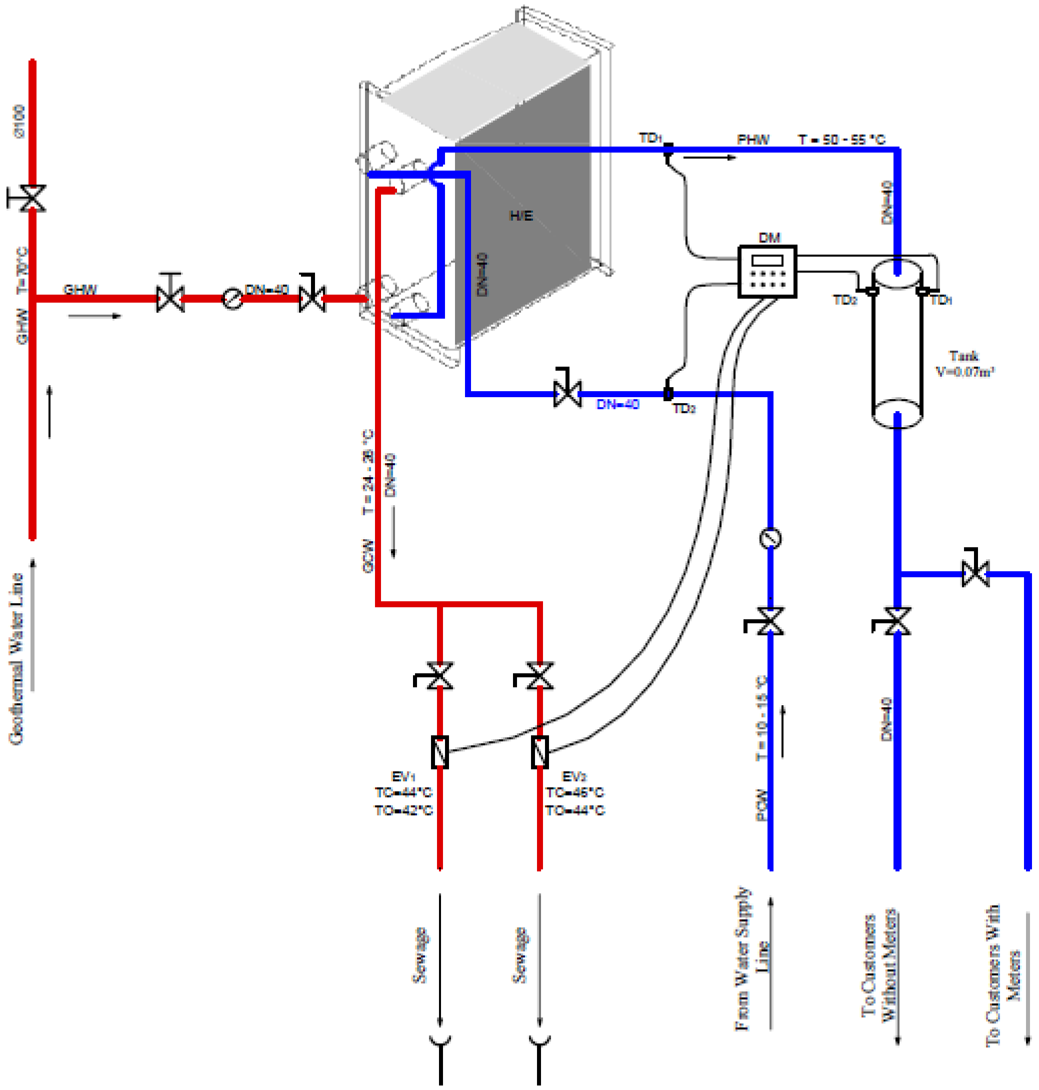
| ## | Description of work and its scope | Cost (GEL) |
|---|---|---|
| | **8. Installation of Piping to Individual Flat (with Connection to Hot Water Distribution Piping Inside the Flat) (Option I)** | |
| 8.1 | Installation of polypropylene pipes PP-R80 SDR7.4 DN=16 mm from individual meter unit to existing distribution piping inside the flat, L=3.0 m.<br><br>- Making ∅40mm holes in brick walls (thickness up to 0.4m), 1 it.<br><br>- Installation of ∅25mm bush sleeve L=0.5m, 1 it.<br><br>- Ball valve D=16 mm, 1 it.<br><br>- Thermal insulation of pipes with use of porolone insulation material (thickness 10mm) and wrapping with airtight film, L=3.0 m. | |
| 8.2 | Installation of polypropylene pipes PP-R80 SDR7.4 DN=16 mm (per each additional 1 m. of pipe), 1 m. | |

| | | |
|---|---|---|
| | **9. Installation of Piping to Individual Flat (with Connection to Hot Water Distribution Piping Inside the Flat) (Option II)** | |
| 9.1 | Installation of polypropylene pipes PP-R80 SDR7.4 DN=16 mm from metering units to distribution piping inside the flat, L=3.0 m.<br>- Making of ∅40mm holes in brick walls (thickness up to 0.4m), 1 it.<br>- Installation of ∅25mm bush sleeves L=0.5m, 1 it.<br>- Three-way valve D=16 mm, 1 it.<br>- Thermal insulation of pipes with use of porolone insulation material (thickness 10mm) and wrapping with airtight film, L=3.0 m. | |
| 9.2 | Installation of polypropylene pipes PP-R80 SDR7.4 DN=16 mm (per each additional 1 m. of pipe), 1 m. | |

Name of Tender Participant Company:

## 4.3. Drawings

Diagram of Hot Water Supply System with Heat Exchanger




LEGEND:

GHW - Geothermal Hot Water
GCW - Cooled Geothermal Water
PCW - Cold Water
PHW - Heated Water
T/O - Plate Heat Exchanger
- Regulating Valve
- Lock Valve
$EV_1$ - Electromagnetic Valve Ø =1"
$EV_2$ - Electromagnetic Valve Ø =1/2"
TD - Temperature Sensor
PD - Pressure Sensor
DM - Controller

Plan. Existing Piping

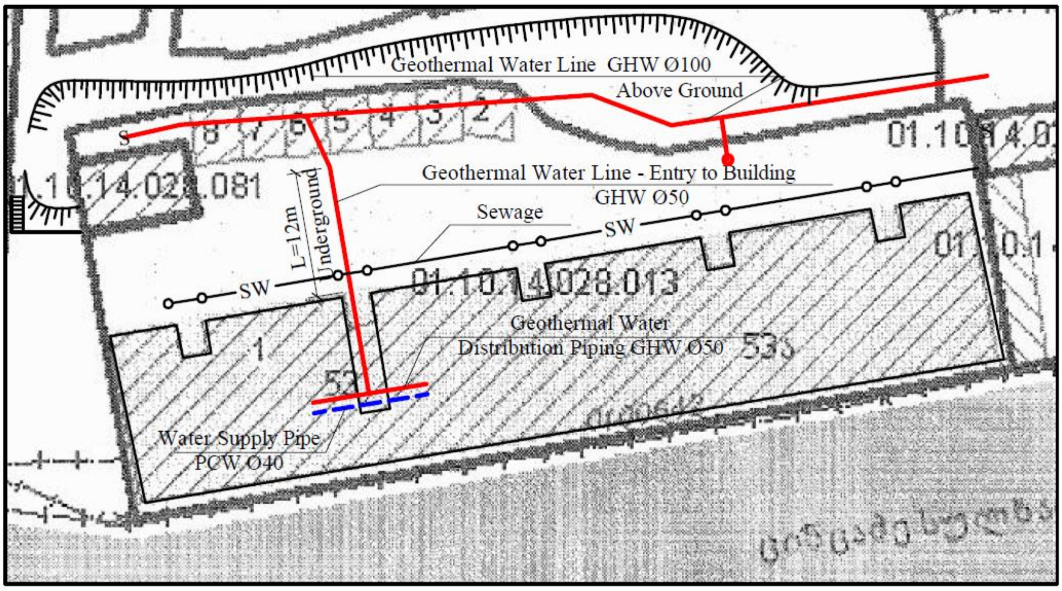



Fig. 2 Current scheme of geothermal water supply to building 53/53a Sulkhan Tsintsadze Str.

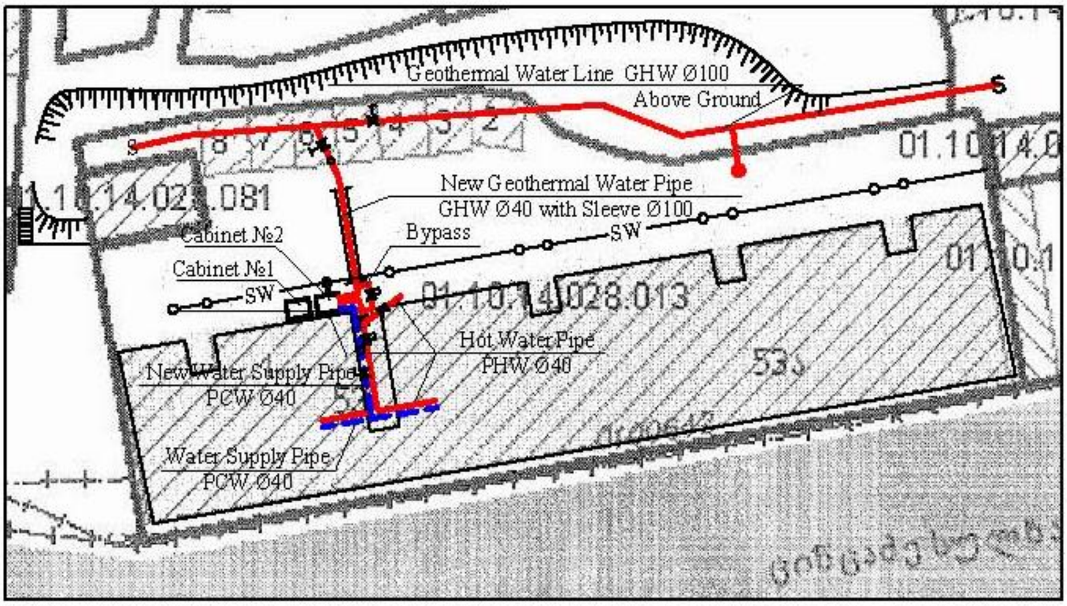



Fig. 3 Suggested scheme of geothermal water supply to building 53/53a Sulkhan Tsintsadze Str.

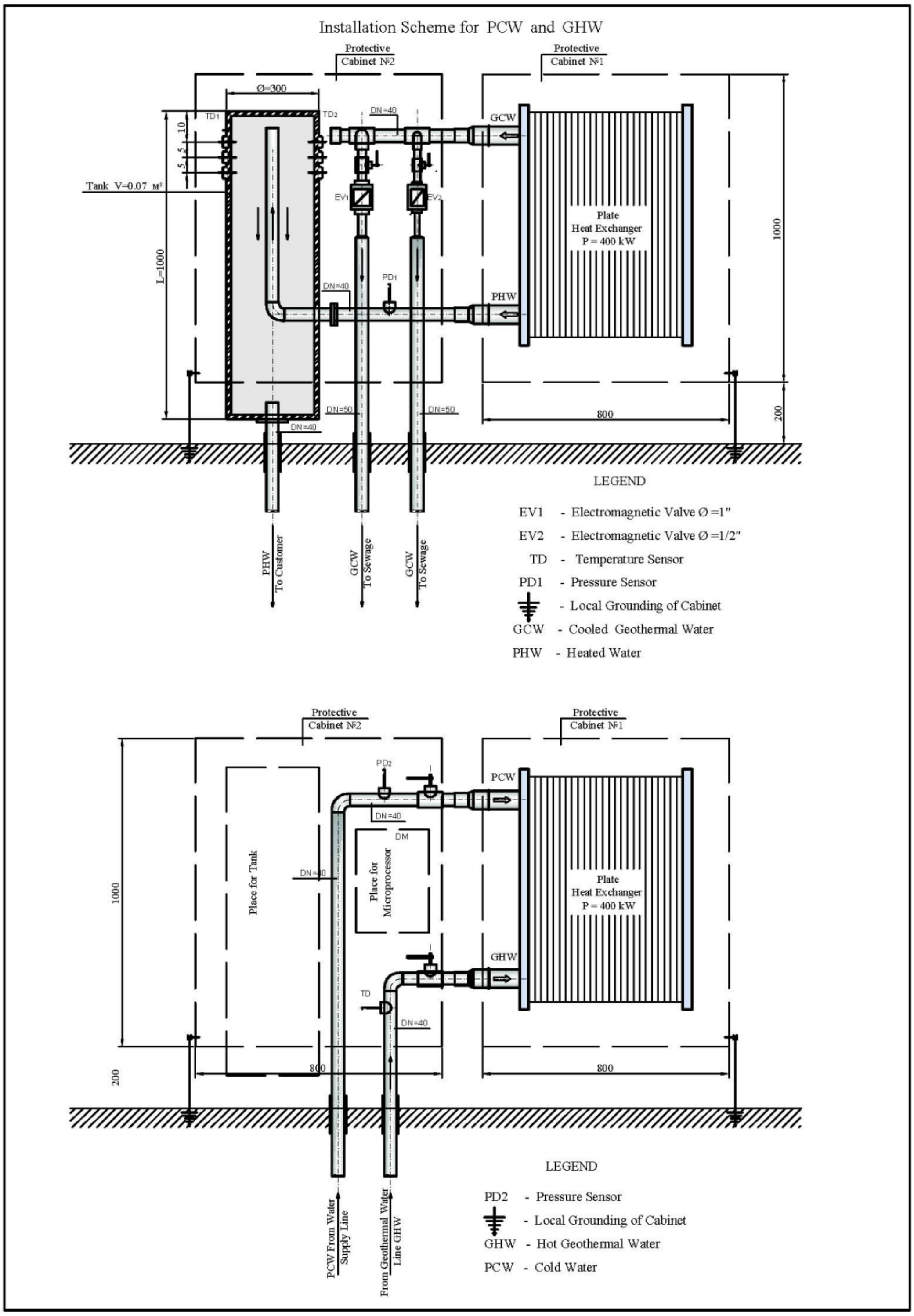
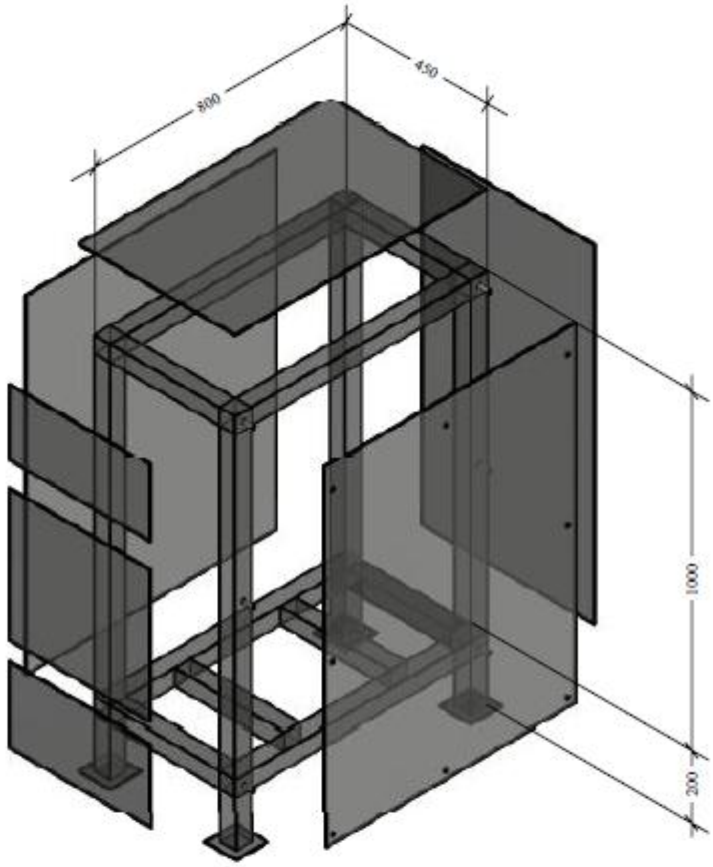



Fig. 4 a,b – Arrangement of heat exchanger cabinet #1 and metering @ control cabinet #2

Assembly Scheme for #1 and #2 Protective Cabinets




Notes:

1. Frame of cabinet should be made of square section steel pipes 50x50mm
2. Cabinet walls should be made of 1.5mm thick steel plates and fixed on frame with screws.
3. Front wall of cabinet should be fixed on frame with screws.
4. Size of cabinet should be adjusted according to dimensions of equipment.

Fig. 5 Drawing of protective cabinets

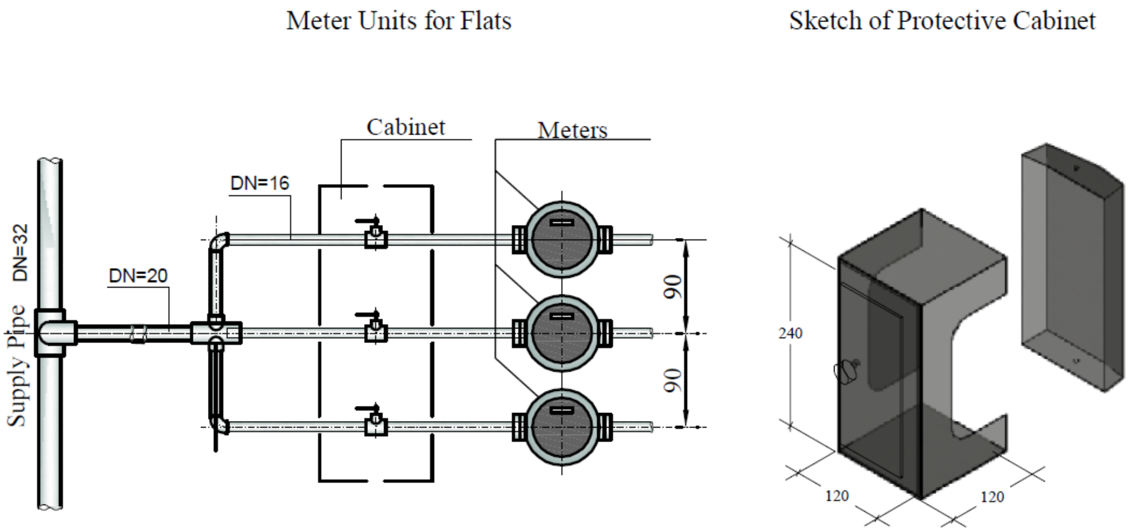



Fig. 6 Scheme of shut-off valve and meter installation in entrances on each floor

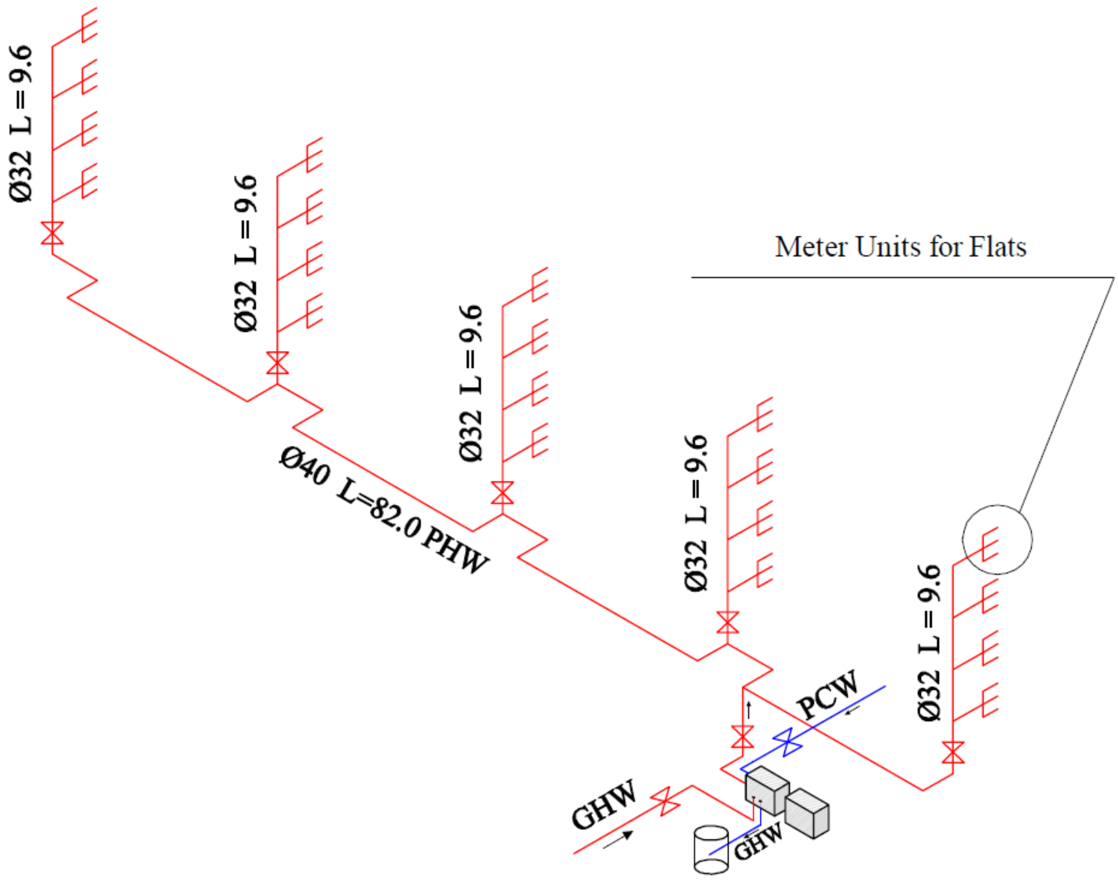



Fig. 7 Axonometric diagram of distribution piping in the building

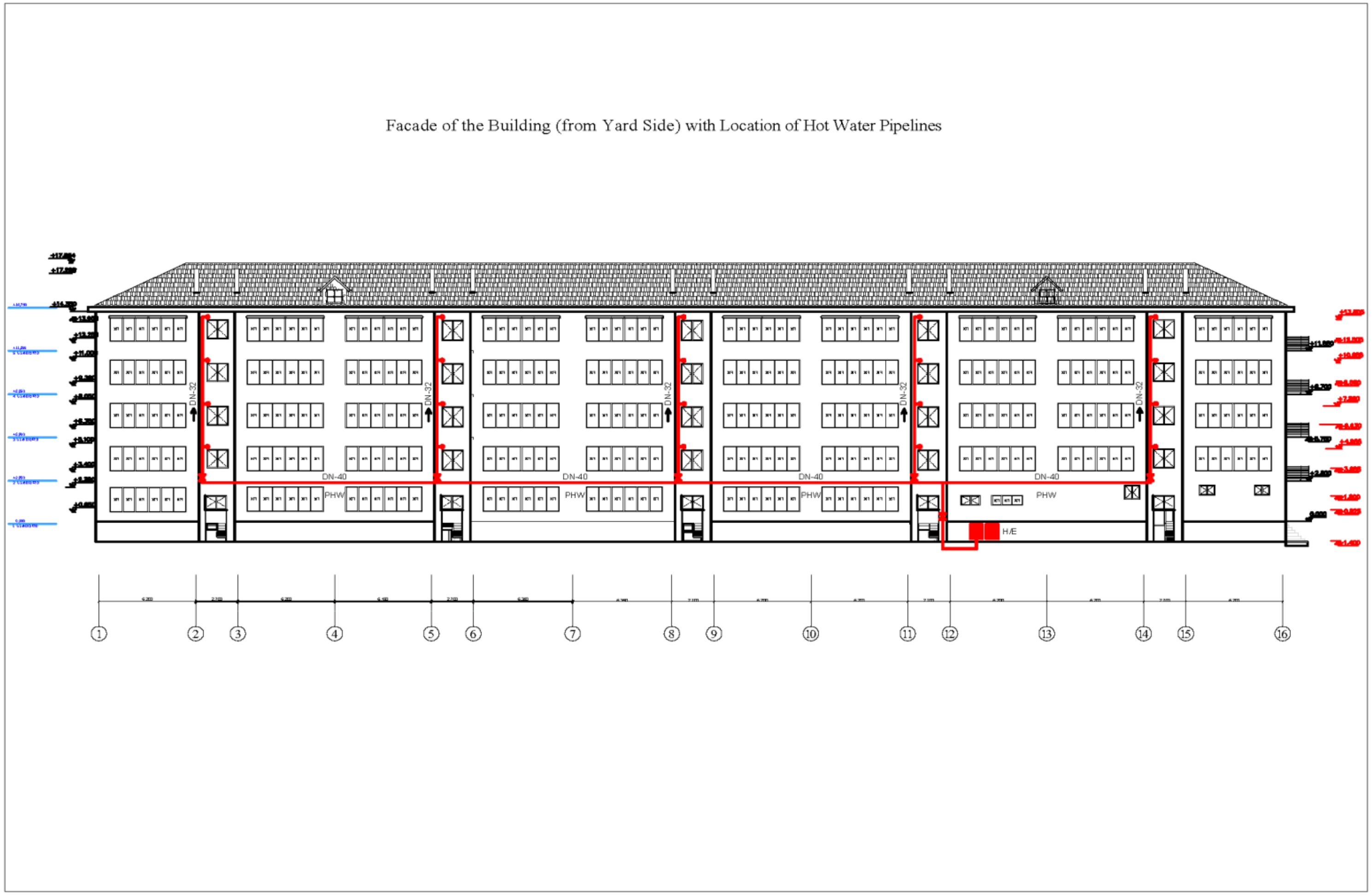



Fig. 8 Design of distribution piping for hot water

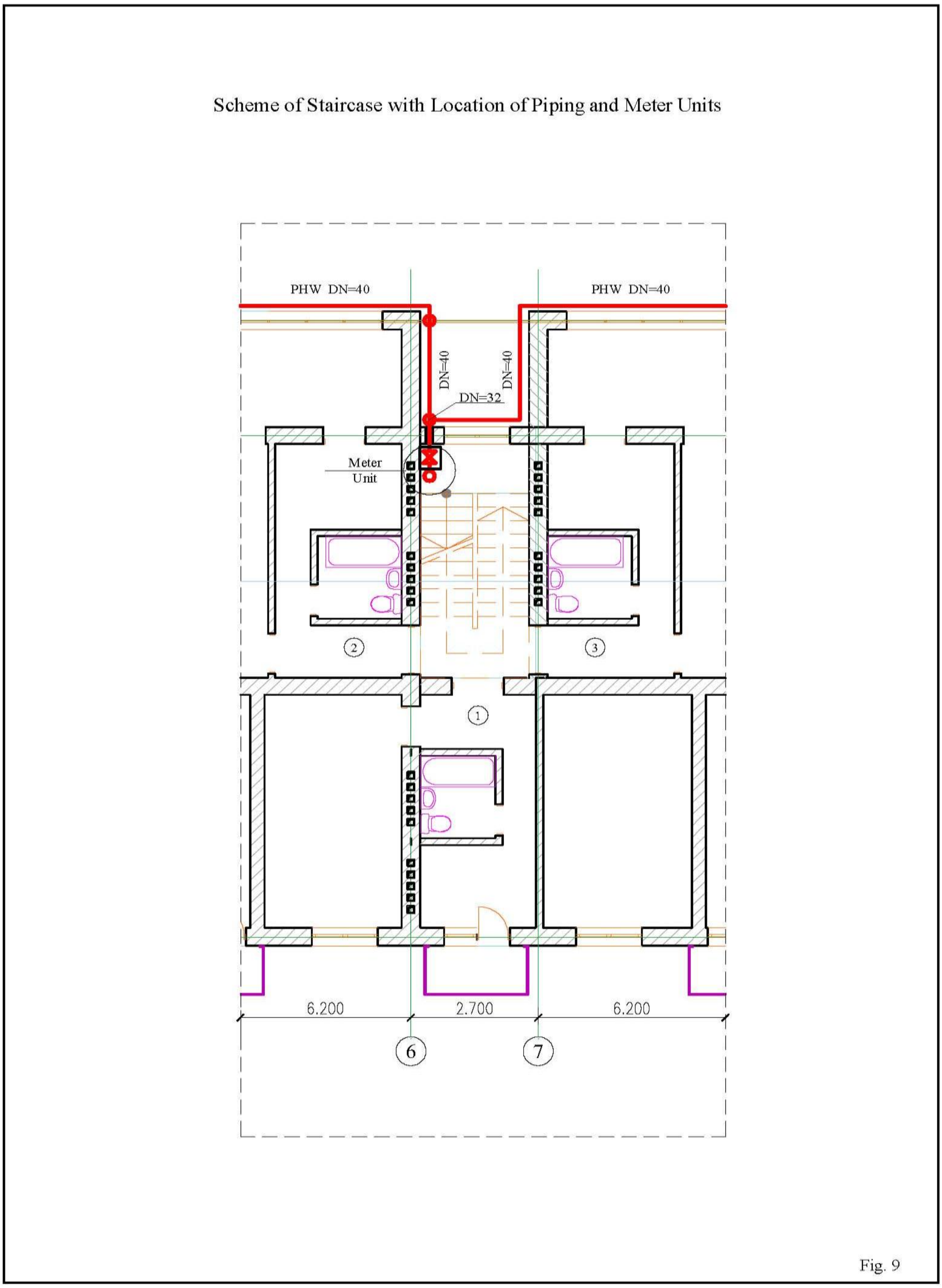



Fig. 9 Scheme of geothermal water supply to stairwell landing

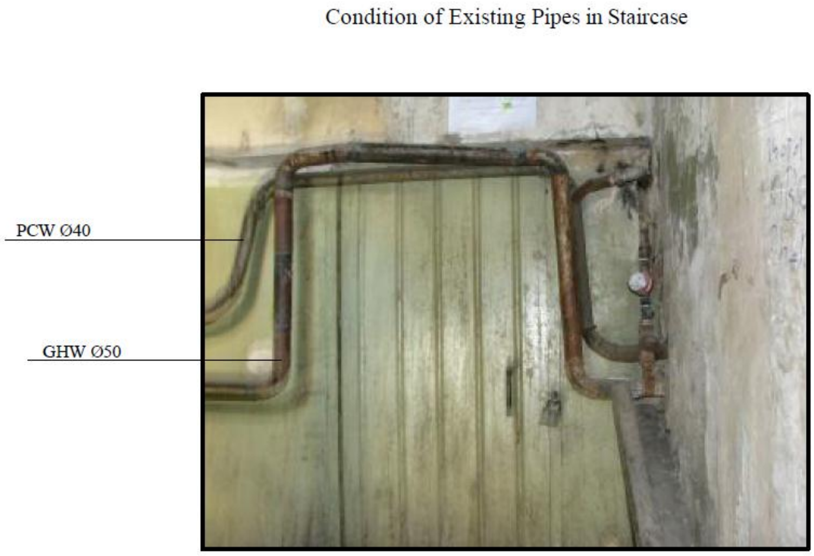



Fig. 10 Current geothermal water supply piping

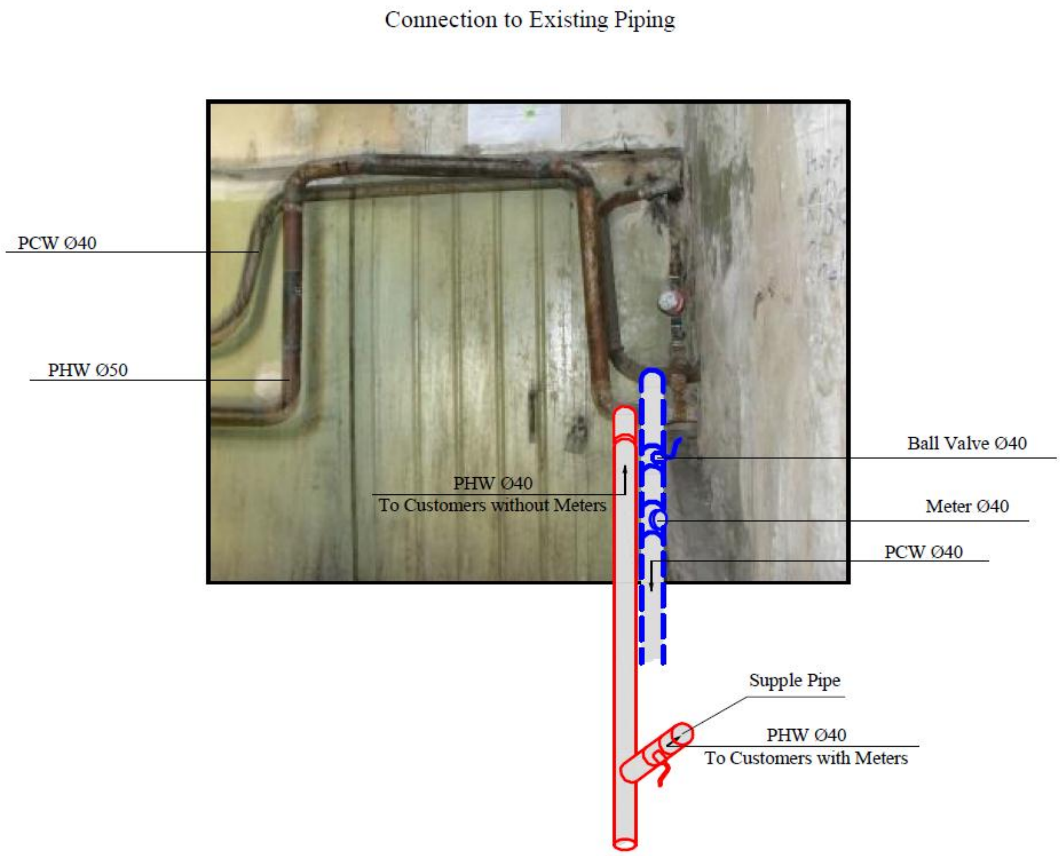



Fig. 11 Connection of new hot water supply piping

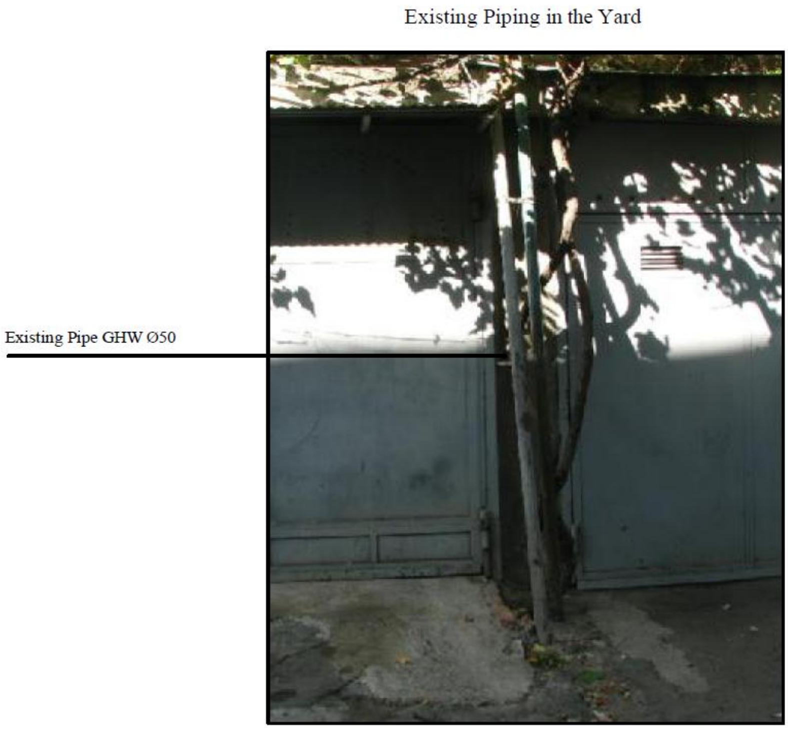



Fig. 12 Existing main geothermal water supply pipe

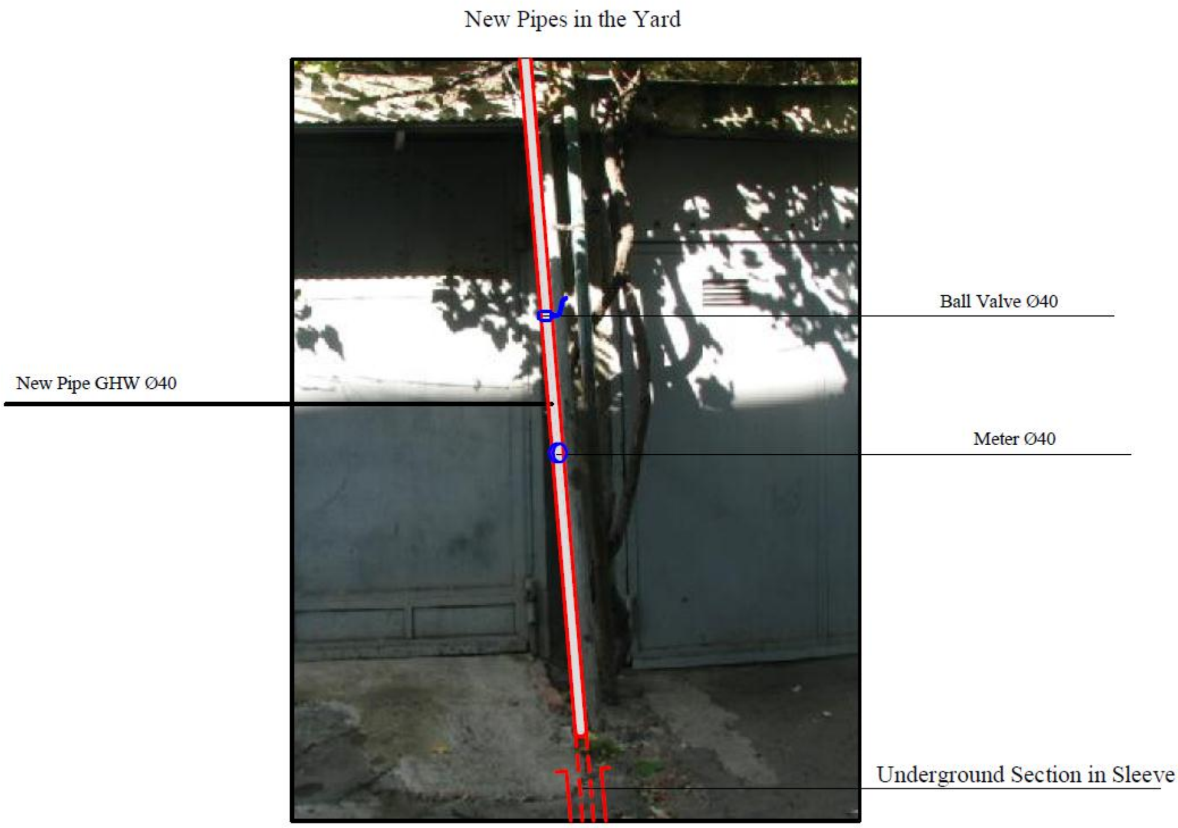



Fig.12 Suggested modification of the supply pipe