# EE measures and Implementation - Training Program for Construction Companies and Supervisors

## Results of the public building analysis and typical measures identified

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# Content

- Considered EE & RE measures
- On energy audits…
- Typical EE measures identified
- Summary results of energy audits

# Considered EE & RE measures

- CONSTRUCTION MEASURES
  - Outside walls insulation
  - Roof insulation
  - Floor (on the ground) insulation - special cases
  - Replacement of windows and doors

# Considered EE & RE measures

- MECHANICAL ENGINEERING MEASURES
  - Improvement of the heating system
    - Installation of TRVs
    - Replacement of pumps
    - Replacement, fixing and cleaning the existing heating distribution system
  - Fuel switch - district heating, biomass, *heat pumps*
  - Sanitary hot water preparation - Solar thermal systems

# Considered EE & RE measures

- ELECTRICAL ENGINEERING MEASURES
  - Lighting system
    - Improvement of the existing lighting system
    - Replacement of the existing lighting system
  - Other electrical devices
    - Pumps, appliances, etc. (depending on the situation)
    - Removal of electric heaters

# On energy audits…

- An energy audit is:

> *…an inspection, survey and analysis of energy flows, for energy conservation in a building, process or system to reduce the amount of energy input into the system without negatively affecting the output(s).*
>
> *Wikipedia*

- For preparing and energy audit, one needs:
  - General information about the building
  - Information on building usage patterns
    - Building occupancy
    - Heating/cooling operation regimes
    - Electrical systems usage patterns

# On energy audits…

- Building layouts and designs
  - Civil engineering/architecture
  - Mechanical engineering
  - Electrical engineering
  - Other (if helpful)
- Information on building energy consumption
  - Heating energy carrier consumption and cost
  - Electricity consumption and cost
- Information/confirmation on installed devices in the building
  - HVAC
  - SHW system
  - Electrical consumers

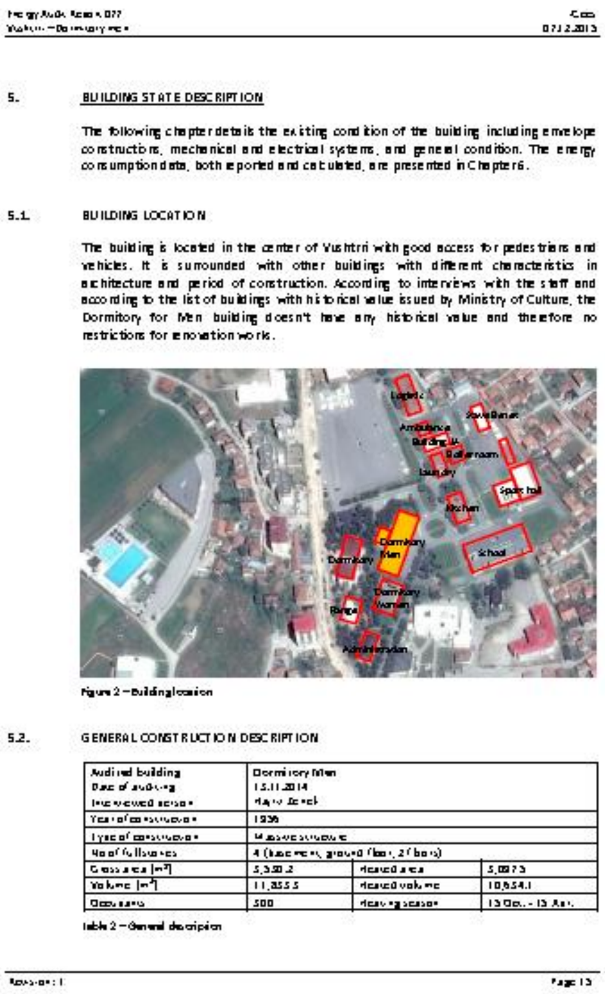
# On energy audits…

- WORKFLOW
  - Preparation
    - Gathering available information related to the building(s)
      - Designs, usage patterns, consumption, cost, etc…
    - Planning the site visit
    - Agreement on the site visit
  - Site visit
    - Collection of on-site information related to building equipment
    - Gathering information from the technical staff
    - Confirmation/check of the preparatory phase information
    - Collection of other important information

# On energy audits…

- WORKFLOW
  - Desk work
    - Preparation of all information for a report
      - … envelope characteristics
      - … HVAC system characteristics
      - … electrical systems characteristics
    - Preparation of energy consumption analysis
    - Preparation of energy cost analysis
    - Preparation of building energy model
    - Establishment of a baseline
    - Identification of EE measures
    - Assessment of the potential impact of EE measures
      - Energy consumption
      - Energy costs

# On energy audits…



## 5. BUILDING STATE DESCRIPTION

The following chapter details the existing condition of the building including envelope constructions, mechanical and electrical systems, and general condition. The energy consumption data, both reported and calculated, are presented in Chapter 6.

### 5.1. BUILDING LOCATION

The building is located in the center of Vushtrri with good access for pedestrians and vehicles. It is surrounded with other buildings with different characteristics in architecture and period of construction. According to interviews with the staff and according to the list of buildings with historical value issued by Ministry of Culture, the Dormitory for Men building doesn't have any historical value and therefore no restrictions for renovation works.

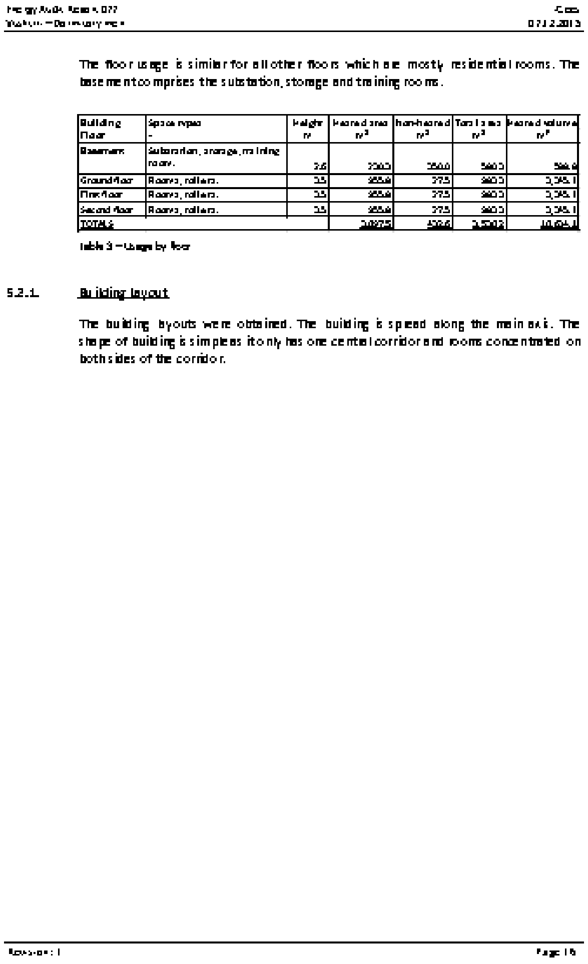
Figure 2 – Building location

### 5.2. GENERAL CONSTRUCTION DESCRIPTION

| | | | |
|---|---|---|---|
| Audited building<br>Date of auditing<br>Interviewed person | Dormitory Men<br>15.11.2014<br>[illegible] | | |
| Year of construction | 1936 | | |
| Type of construction | Massive structure | | |
| No of full stories | 4 (basement, ground floor, 2 floors) | | |
| Gross area [m²] | 5,550.2 | Heated area | 5,097.5 |
| Volume [m³] | 11,855.5 | Heated volume | 10,654.1 |
| Occupants | 500 | Heating season | 15 Oct. - 15 Apr. |

Table 2 – General description

# On energy audits…



The floor usage is similar for all other floors which are mostly residential rooms. The basement comprises the substation, storage and training rooms.

| Building floor | Space types - | Height m | Heated area m² | Non-heated m² | Total area m² | Heated volume m³ |
|---|---|---|---|---|---|---|
| Basement | Substation, storage, training room. | 3.6 | [illegible] | [illegible] | [illegible] | [illegible] |
| Ground floor | Rooms, toilets. | 3.5 | [illegible] | 27.5 | [illegible] | [illegible] |
| First floor | Rooms, toilets. | 3.5 | [illegible] | 27.5 | [illegible] | [illegible] |
| Second floor | Rooms, toilets. | 3.5 | [illegible] | 27.5 | [illegible] | [illegible] |
| TOTALS | | | [illegible] | [illegible] | [illegible] | [illegible] |

Table 3 – Usage by floor

### 5.2.1. Building layout

The building layouts were obtained. The building is spread along the main axis. The shape of building is simple as it only has one central corridor and rooms concentrated on both sides of the corridor.

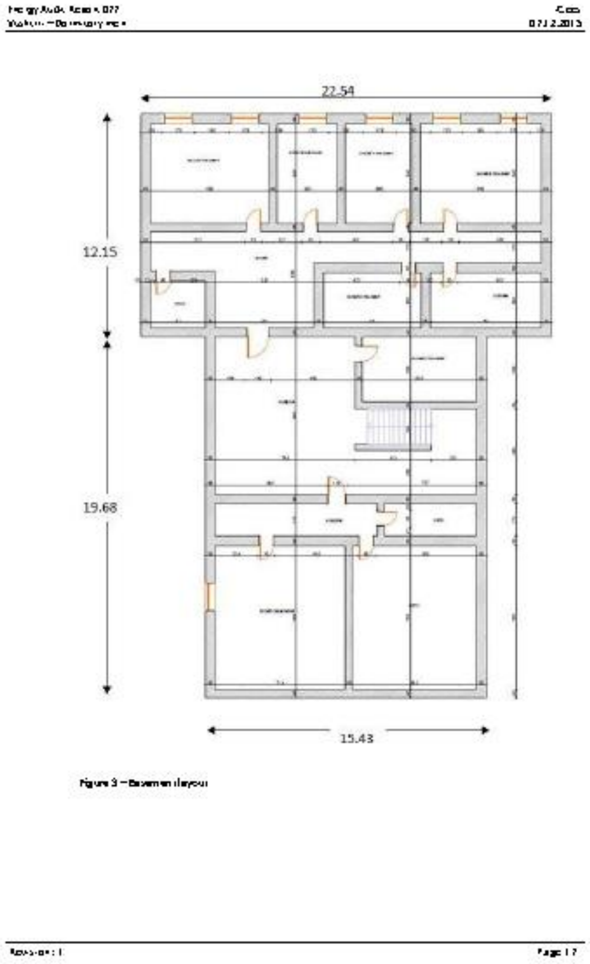
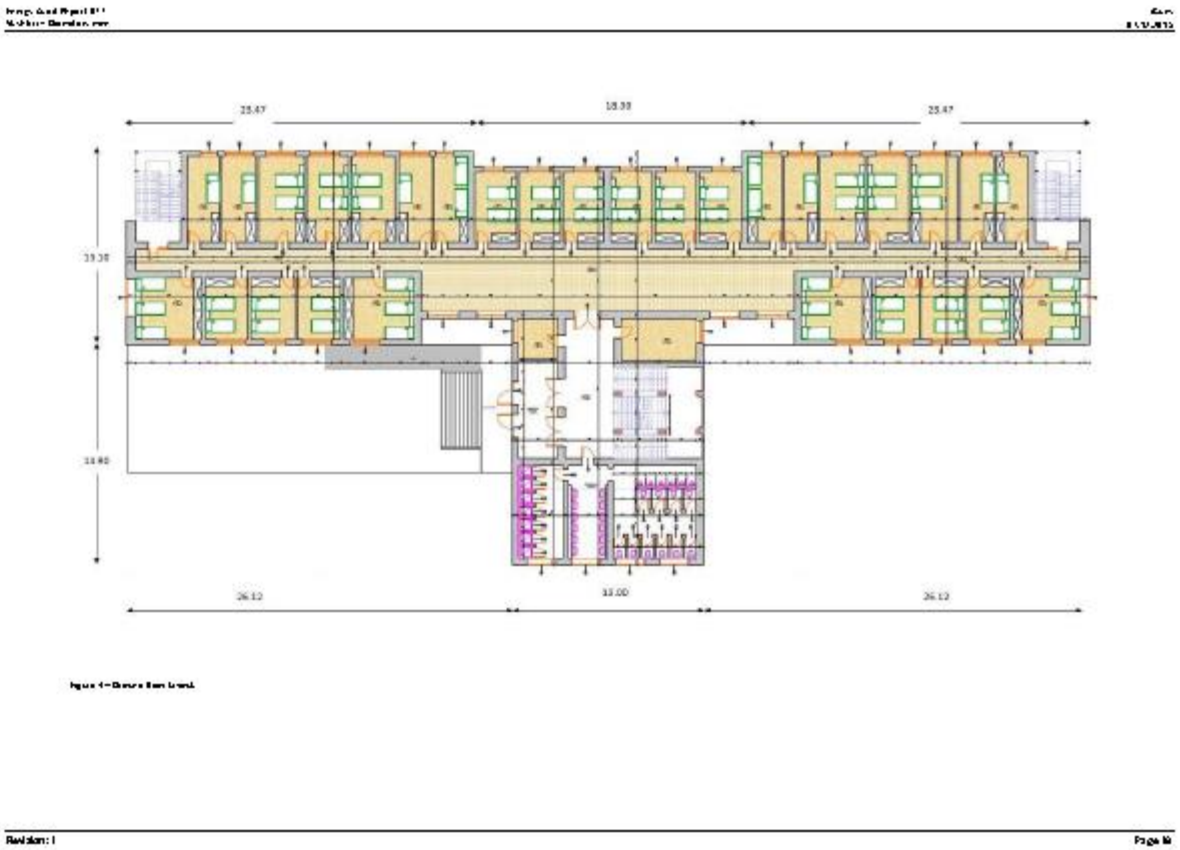


Figure 3 – Basement layout

# On energy audits…



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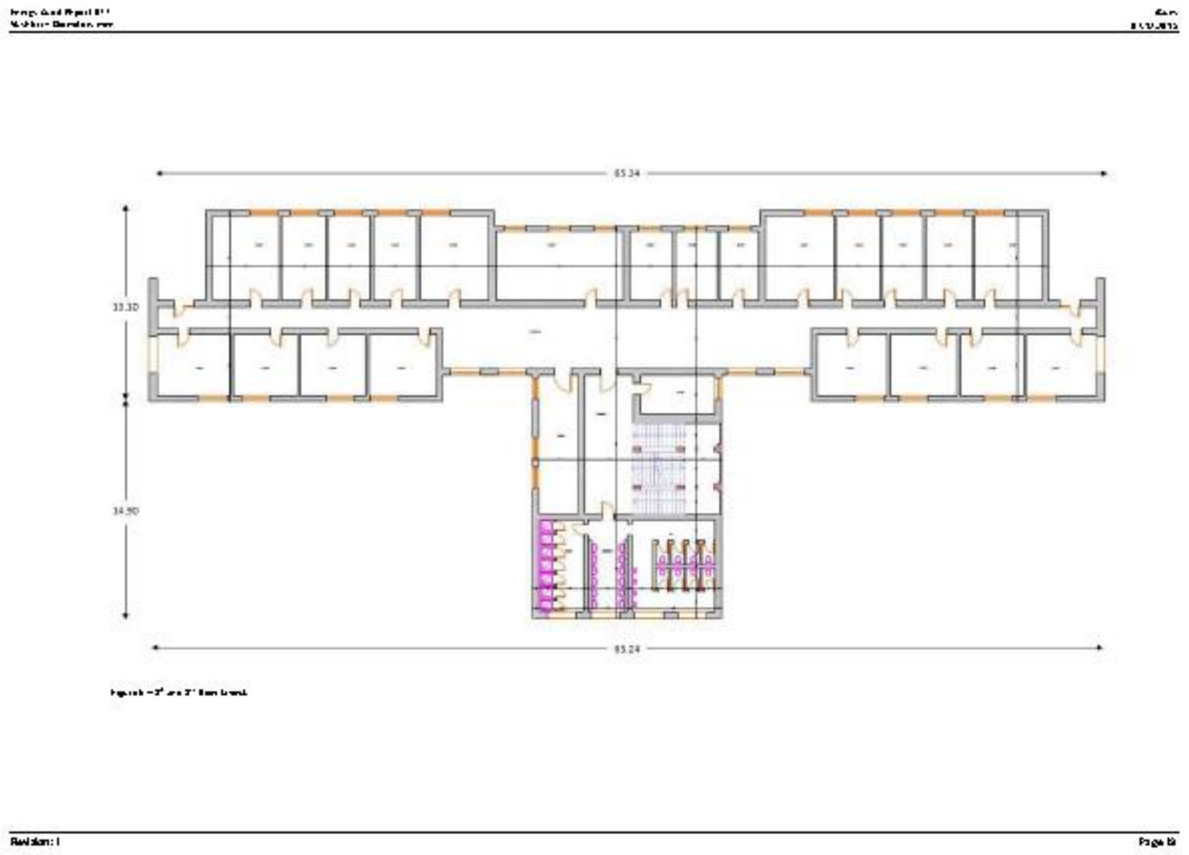
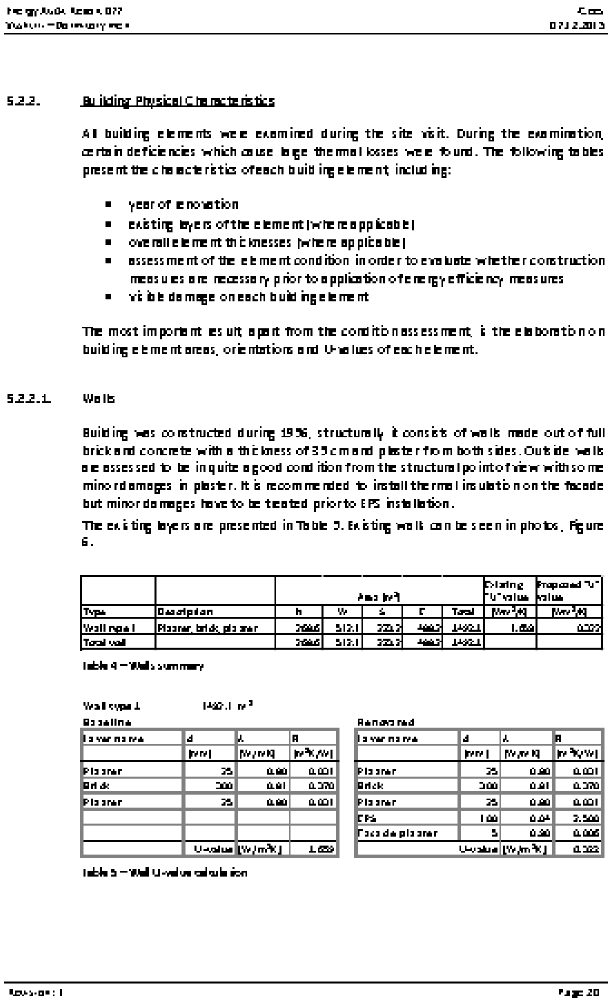


# On energy audits…



5.2.2. Building Physical Characteristics

All building elements were examined during the site visit. During the examination, certain deficiencies which cause large thermal losses were found. The following tables present the characteristics of each building element, including:

- year of renovation
- existing layers of the element (where applicable)
- overall element thicknesses (where applicable)
- assessment of the element condition in order to evaluate whether construction measures are necessary prior to application of energy efficiency measures
- visible damage on each building element

The most important result, apart from the condition assessment, is the elaboration on building element areas, orientations and U-values of each element.

5.2.2.1. Walls

Building was constructed during 1956, structurally it consists of walls made out of full brick and concrete with a thickness of 35 cm and plaster from both sides. Outside walls are assessed to be in quite a good condition from the structural point of view with some minor damages in plaster. It is recommended to install thermal insulation on the facade but minor damages have to be treated prior to EPS installation.

The existing layers are presented in Table 5. Existing wall can be seen in photos, Figure 6.

|  |  | Area (m²) |  |  |  |  | Existing "U" value | Proposed "U" value |
|---|---|---|---|---|---|---|---|---|
| Type | Description | N | W | S | E | Total | (W/m²K) | (W/m²K) |
| Wall type 1 | Plaster, brick, plaster | 268.6 | 512.1 | 221.3 | [illegible] | 1492.1 | 1.658 | 0.322 |
| Total wall |  | 268.6 | 512.1 | 221.3 | [illegible] | 1492.1 |  |  |

Table 4 – Walls summary

Wall type 1 1492.1 m²

Baseline

| Layer name | d | λ | R |
|---|---|---|---|
|  | (mm) | (W/mK) | (m²K/W) |
| Plaster | 25 | 0.80 | 0.031 |
| Brick | 300 | 0.81 | 0.370 |
| Plaster | 25 | 0.80 | 0.031 |
|  |  |  |  |
|  |  |  |  |
|  | U-value | (W/m²K) | 1.658 |

Renovated

| Layer name | d | λ | R |
|---|---|---|---|
|  | (mm) | (W/mK) | (m²K/W) |
| Plaster | 25 | 0.80 | 0.031 |
| Brick | 300 | 0.81 | 0.370 |
| Plaster | 25 | 0.80 | 0.031 |
| EPS | 100 | 0.04 | 2.500 |
| Facade plaster | 5 | 0.90 | 0.006 |
|  | U-value | (W/m²K) | 0.322 |

Table 5 – Wall U-value calculation

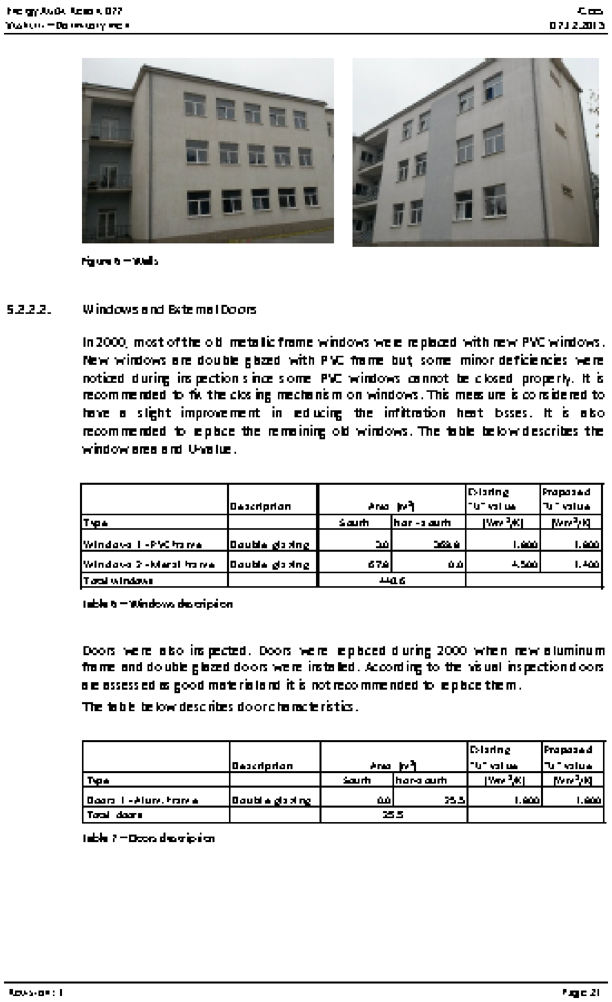


Figure 6 – Walls

5.2.2.2. Windows and External Doors

In 2000, most of the old metallic frame windows were replaced with new PVC windows. New windows are double glazed with PVC frame but, some minor deficiencies were noticed during inspection since some PVC windows cannot be closed properly. It is recommended to fix the closing mechanism on windows. This measure is considered to have a slight improvement in reducing the infiltration heat losses. It is also recommended to replace the remaining old windows. The table below describes the window area and U-value.

|  | Description | Area (m²) |  | Existing "U" value | Proposed "U" value |
|---|---|---|---|---|---|
| Type |  | South | Non-south | (W/m²K) | (W/m²K) |
| Windows 1 - PVC frame | Double glazing | 0.0 | [illegible] | 1.800 | 1.800 |
| Windows 2 - Metal frame | Double glazing | 67.8 | 0.0 | 4.500 | 1.400 |
| Total windows |  | 440.6 |  |  |  |

Table 6 – Windows description

Doors were also inspected. Doors were replaced during 2000 when new aluminum frame and double glazed doors were installed. According to the visual inspection doors are assessed as good material and it is not recommended to replace them.

The table below describes door characteristics.

|  | Description | Area (m²) |  | Existing "U" value | Proposed "U" value |
|---|---|---|---|---|---|
| Type |  | South | Non-south | (W/m²K) | (W/m²K) |
| Doors 1 - Alum. frame | Double glazing | 0.0 | 25.5 | 1.800 | 1.800 |
| Total doors |  | 25.5 |  |  |  |

Table 7 – Doors description

# On energy audits…

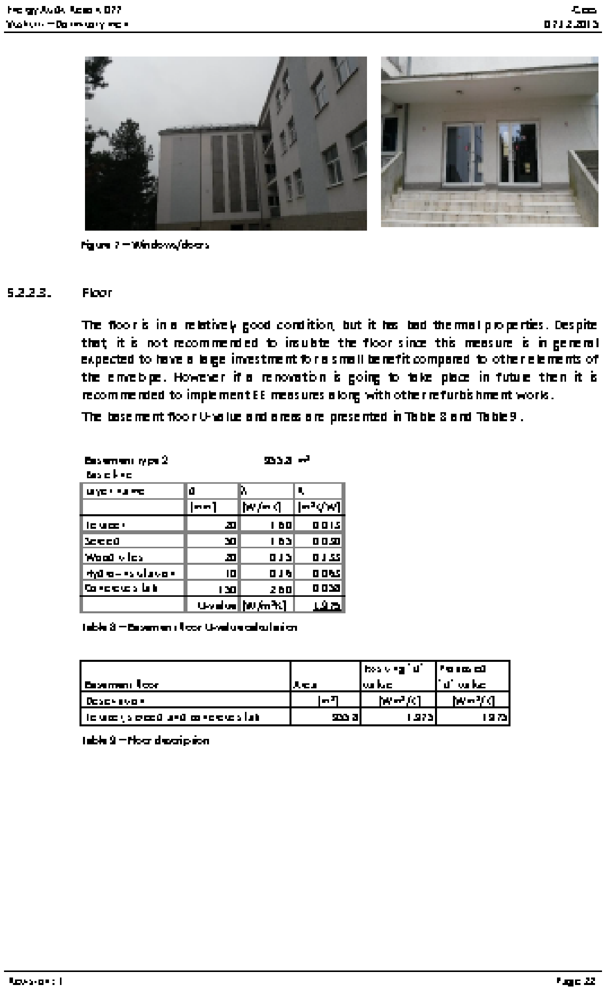


Figure 7 – Windows/doors

5.2.2.3. Floor

The floor is in a relatively good condition, but it has bad thermal properties. Despite that, it is not recommended to insulate the floor since this measure is in general expected to have a large investment for a small benefit compared to other elements of the envelope. However if a renovation is going to take place in future then it is recommended to implement EE measures along with other refurbishment works.

The basement floor U-value and areas are presented in Table 8 and Table 9.

Basement type 2 253.3 m²
Baseline

| Layer name | d | λ | R |
|---|---|---|---|
| | [mm] | [W/mK] | [m²K/W] |
| Terrazzo | 20 | 1.30 | 0.015 |
| Screed | 30 | 1.63 | 0.050 |
| Wood tiles | 20 | 0.13 | 0.155 |
| Hydro-insulation | 10 | 0.18 | 0.055 |
| Concrete slab | 150 | 2.60 | 0.058 |
| | U-value | [W/m²K] | 1.973 |

Table 8 – Basement floor U-value calculation

| Basement floor | Area | Existing 'U' value | Proposed 'U' value |
|---|---|---|---|
| Description | [m²] | [W/m²K] | [W/m²K] |
| Terrazzo, screed and concrete slab | 253.3 | 1.973 | 1.973 |

Table 9 – Floor description

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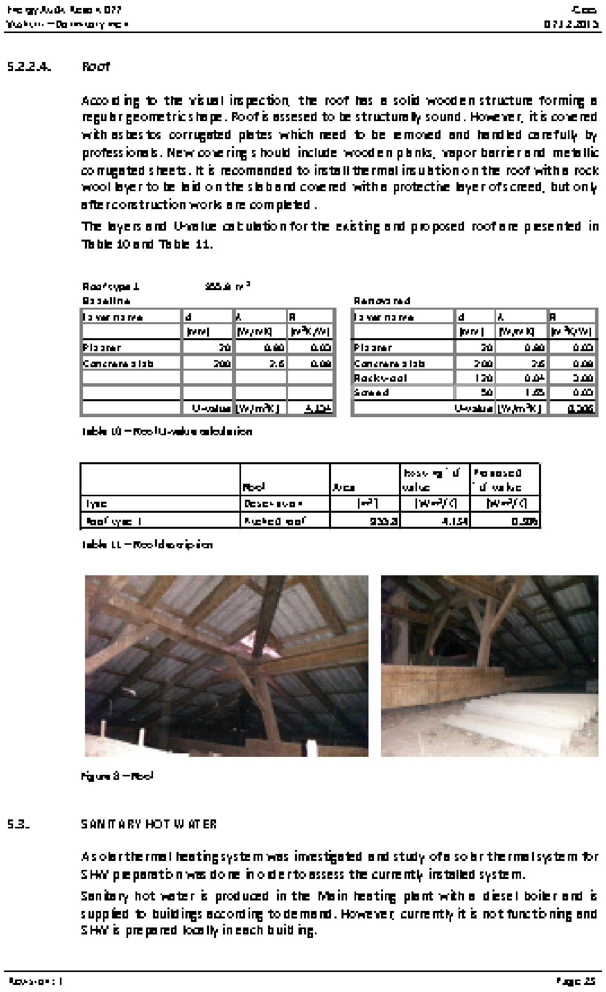

5.2.2.4. Roof

According to the visual inspection, the roof has a solid wooden structure forming a regular geometric shape. Roof is assessed to be structurally sound. However, it is covered with asbestos corrugated plates which need to be removed and handled carefully by professionals. New covering should include wooden planks, vapor barrier and metallic corrugated sheets. It is recomanded to install thermal insulation on the roof with a rock wool layer to be laid on the slab and covered with a protective layer of screed, but only after construction works are completed.

The layers and U-value calculation for the existing and proposed roof are presented in Table 10 and Table 11.

Roof type 1 255.6 m²

Baseline

| Layer name | d | λ | R |
|---|---|---|---|
| | [mm] | [W/mK] | [m²K/W] |
| Plaster | 20 | 0.80 | 0.03 |
| Concrete slab | 200 | 2.6 | 0.08 |
| | | | |
| | | | |
| | U-value | [W/m²K] | 4.154 |

Renovated

| Layer name | d | λ | R |
|---|---|---|---|
| | [mm] | [W/mK] | [m²K/W] |
| Plaster | 20 | 0.80 | 0.03 |
| Concrete slab | 200 | 2.6 | 0.08 |
| Rock-wool | 120 | 0.04 | 3.00 |
| Screed | 50 | 1.65 | 0.03 |
| | U-value | [W/m²K] | 0.306 |

Table 10 – Roof U-value calculation

| | Roof | Area | Existing 'U' value | Proposed 'U' value |
|---|---|---|---|---|
| Type | Description | [m²] | [W/m²K] | [W/m²K] |
| Roof type 1 | Pitched roof | 233.3 | 4.154 | 0.306 |

Table 11 – Roof description

Figure 8 – Roof

5.3. SANITARY HOT WATER

A solar thermal heating system was investigated and study of a solar thermal system for SHW preparation was done in order to assess the currently installed system.

Sanitary hot water is produced in the Main heating plant with a diesel boiler and is supplied to buildings according to demand. However, currently it is not functioning and SHW is prepared locally in each building.

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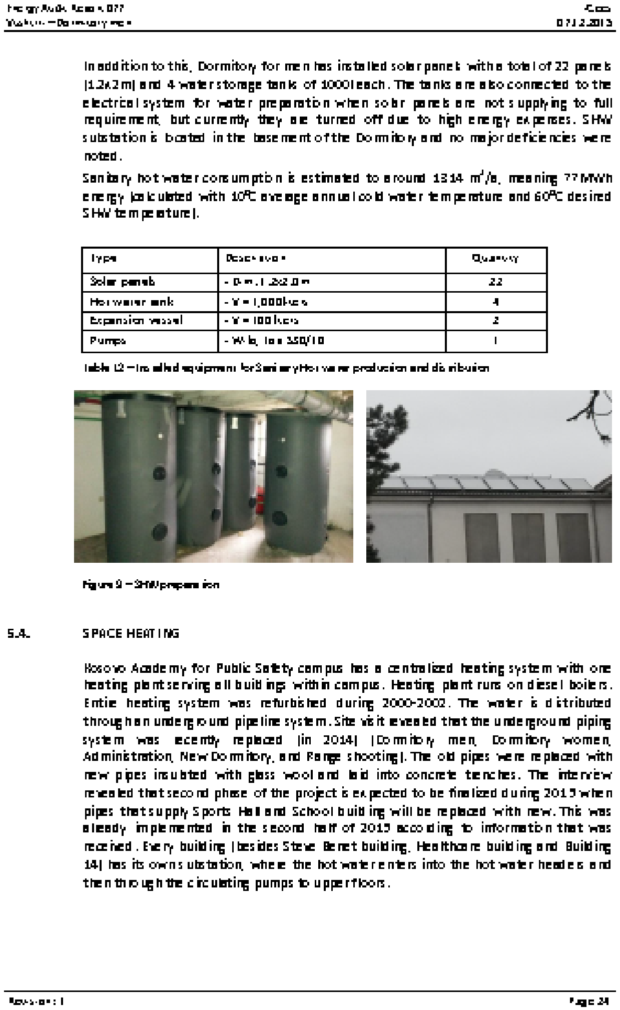
# On energy audits…



In addition to this, Dormitory for men has installed solar panels with a total of 22 panels (1.2x2 m) and 4 water storage tanks of 1000 l each. The tanks are also connected to the electrical system for water preparation when solar panels are not supplying to full requirement, but currently they are turned off due to high energy expenses. SHW substation is located in the basement of the Dormitory and no major deficiencies were noted.

Sanitary hot water consumption is estimated to around 1314 m³/a, meaning 77 MWh energy (calculated with 10°C average annual cold water temperature and 60°C desired SHW temperature).

| Type | Description | Quantity |
|---|---|---|
| Solar panels | - Dim. 1.2x2.0 m | 22 |
| Hot water tank | - V = 1,000 liters | 4 |
| Expansion vessel | - V = 100 liters | 2 |
| Pumps | - Wilo, Top S50/10 | 1 |

Table 12 – Installed equipment for Sanitary Hot water production and distribution

Figure 9 – SHW preparation

### 5.4. SPACE HEATING

Kosovo Academy for Public Safety campus has a centralized heating system with one heating plant serving all buildings within campus. Heating plant runs on diesel boilers. Entire heating system was refurbished during 2000-2002. The water is distributed through an underground pipeline system. Site visit revealed that the underground piping system was recently replaced (in 2014) (Dormitory men, Dormitory women, Administration, New Dormitory, and Range shooting). The old pipes were replaced with new pipes insulated with glass wool and laid into concrete trenches. The interview revealed that second phase of the project is expected to be finalized during 2015 when pipes that supply Sports Hall and School building will be replaced with new. This was already implemented in the second half of 2015 according to information that was received. Every building (besides Steve Benet building, Healthcare building and Building 14) has its own substation, where the hot water enters into the hot water headers and then through the circulating pumps to upper floors.

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Figure 10 – Technological scheme of heating

#### 5.4.1. Hot Water Preparation and Distribution

Substation is located in the basement covering an area of 18 m², which is sufficient for the current heating system and storages around it would allow placement of potential additional equipment.

Heating substation has been renovated in 2000 when new pumps, valves and piping were installed. Heating hot water is circulated with one Wilo pump without VFD. A three way valve is installed and working properly. The distribution pipes within the substation are well insulated with some minor deficiencies caused during some construction works. However, personnel didn't report any leakages in the system.

The installed equipment for heating preparation and distribution is listed below:

| Type | Description | Quantity |
|---|---|---|
| Pumps | - Top S40/7, type Wilo | 1 |

Table 13 – Installed equipment for heating preparation and distribution

Figure 11 – Substation

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# On energy audits…

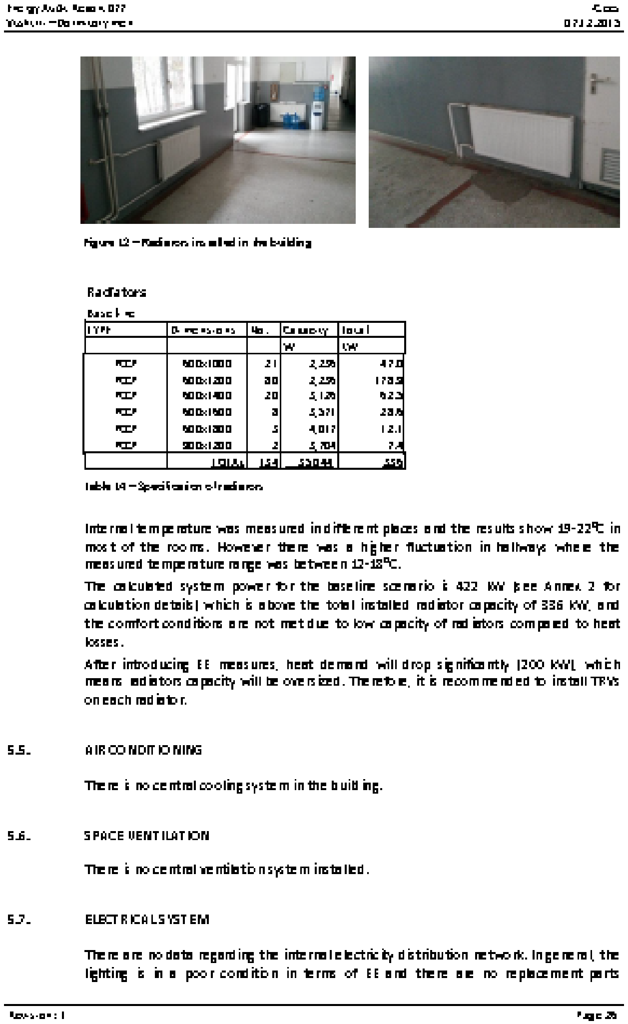


Figure 12 – Radiators installed in the building

Radiators

Baseline

| TYPE | Dimensions | No. | Capacity | Total |
|---|---|---|---|---|
| | | | W | kW |
| PKKP | 600x1000 | 21 | 2,239 | 47.0 |
| PKKP | 600x1200 | 80 | 2,239 | 179.5 |
| PKKP | 600x1400 | 20 | 3,126 | 62.5 |
| PKKP | 600x1600 | 8 | 3,571 | 28.6 |
| PKKP | 600x1800 | 5 | 4,017 | 12.1 |
| PKKP | 900x1200 | 2 | 3,704 | 7.4 |
| | TOTAL | [illegible] | [illegible] | 336 |

Table 14 – Specification of radiators

Internal temperature was measured in different places and the results show 19-22°C in most of the rooms. However there was a higher fluctuation in hallways where the measured temperature range was between 12-18°C.

The calculated system power for the baseline scenario is 422 kW (see Annex 2 for calculation details) which is above the total installed radiator capacity of 336 kW, and the comfort conditions are not met due to low capacity of radiators compared to heat losses.

After introducing EE measures, heat demand will drop significantly (200 kW), which means radiators capacity will be oversized. Therefore, it is recommended to install TRVs on each radiator.

5.5. AIR CONDITIONING

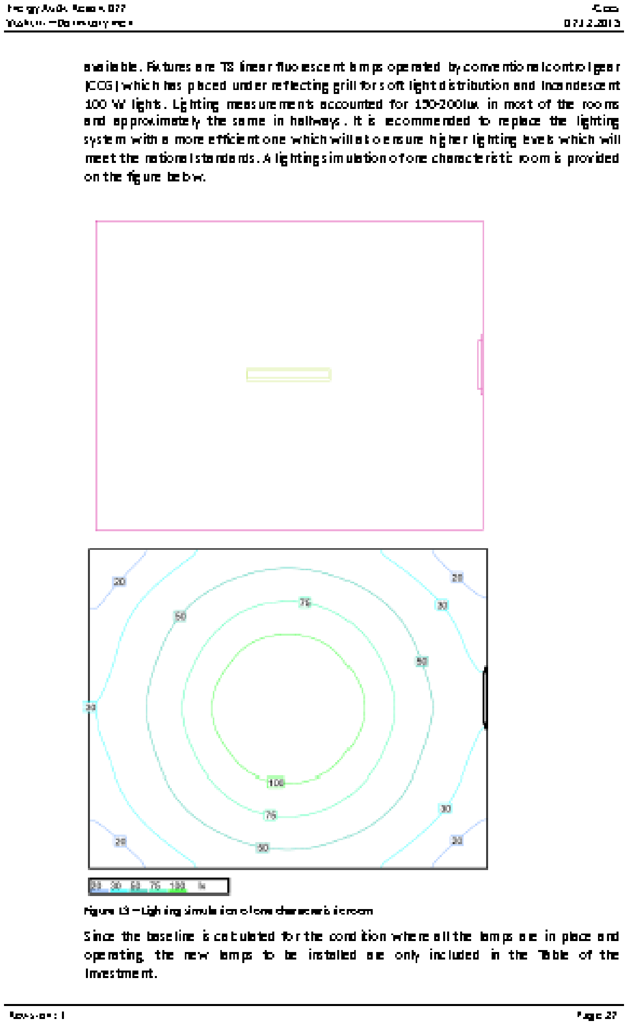
There is no central cooling system in the building.

5.6. SPACE VENTILATION

There is no central ventilation system installed.

5.7. ELECTRICAL SYSTEM

There are no data regarding the internal electricity distribution network. In general, the lighting is in a poor condition in terms of EE and there are no replacement parts



available. Fixtures are T8 linear fluorescent lamps operated by conventional control gear (CCG) which has placed under reflecting grill for soft light distribution and incandescent 100 W lights. Lighting measurements accounted for 150-200lux in most of the rooms and approximately the same in hallways. It is recommended to replace the lighting system with a more efficient one which will also ensure higher lighting levels which will meet the national standards. A lighting simulation of one characteristic room is provided on the figure below.

Figure 13 – Lighting simulation of one characteristic room

Since the baseline is calculated for the condition where all the lamps are in place and operating, the new lamps to be installed are only included in the Table of the Investment.

# On energy audits…

Table below describes identified lighting fixtures and their rated power.

*Lighting*
Baseline

| TYPE | No. | Bulbs | Watts | Ballast | kWh/a |
|---|---|---|---|---|---|
| T8 Fluorescent 2x58W | 4 | 2 | 58 | 15% | 531.1 |
| T8 Fluorescent 1x58W | 127 | 1 | 58 | 15% | 5,575.5 |
| T8 Fluorescent 2x58W | 11 | 2 | 58 | 15% | 963.4 |
| Incandescent 100W | 25 | 1 | 100 | 0% | 2,458.0 |
| TOTAL | 165 | | 208 | | 9,527.8 |

Table 15 – Lighting specification

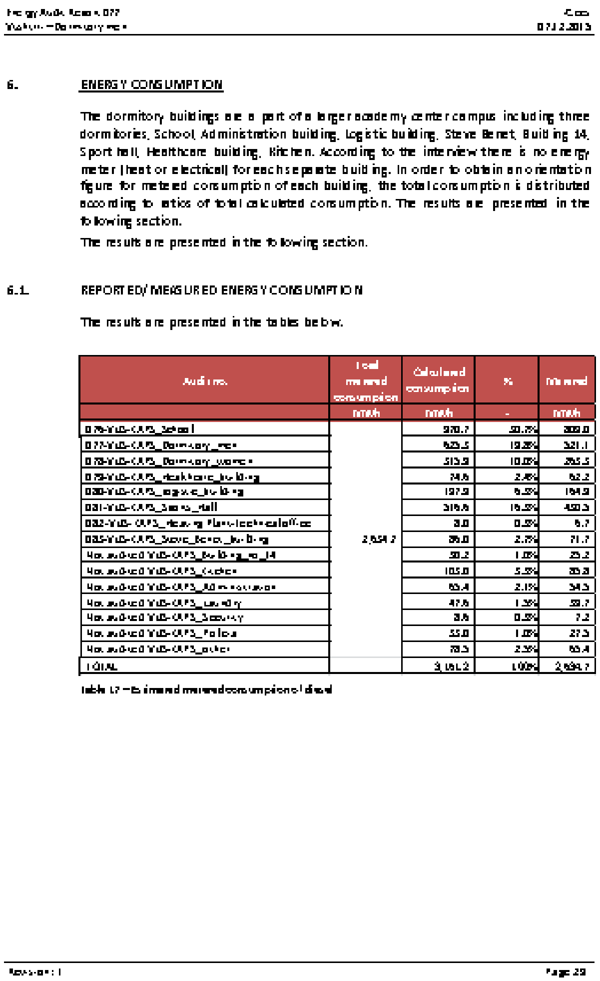
Figure 14 – Lighting fixtures

Electrical equipment is mostly PCs, TV, and technical equipment.

*Equipment*
Baseline

| TYPE | No. | Watts | kWh/a |
|---|---|---|---|
| PC | 10 | 550 | 3,365 |
| TV | 1 | 550 | 742 |
| Kettle | 2 | 2,000 | 5,180 |
| Pumps | 2 | 590 | 702 |
| Fan | 6 | 1,500 | 5,310 |
| TOTAL | | 4,040 | 15,[illegible] |

Table 16 – Electric equipment specification



## 6. ENERGY CONSUMPTION

The dormitory buildings are a part of a larger academy center campus including three dormitories, School, Administration building, Logistic building, Steve Benet, Building 14, Sport hall, Healthcare building, Kitchen. According to the interview there is no energy meter (heat or electrical) for each separate building. In order to obtain an orientation figure for metered consumption of each building, the total consumption is distributed according to ratios of total calculated consumption. The results are presented in the following section.

The results are presented in the following section.

### 6.1. REPORTED/ MEASURED ENERGY CONSUMPTION

The results are presented in the tables below.

| Audit no. | Total metered consumption | Calculated consumption | % | Metered |
|---|---|---|---|---|
| | MWh | MWh | - | MWh |
| 076-YUG-CAPS_School | 2,634.7 | 970.7 | 30.7% | 809.0 |
| 077-YUG-CAPS_Dormitory_men | | 625.5 | 19.8% | 521.1 |
| 078-YUG-CAPS_Dormitory_women | | 313.9 | 10.0% | 265.5 |
| 079-YUG-CAPS_Healthcare_building | | 74.6 | 2.4% | 62.2 |
| 080-YUG-CAPS_Logistic_building | | 197.9 | 6.3% | 164.9 |
| 081-YUG-CAPS_Sports_hall | | 516.6 | 16.3% | 430.3 |
| 082-YUG-CAPS_Heating Plant-technical office | | 8.0 | 0.3% | 6.7 |
| 085-YUG-CAPS_Steve_Benet_building | | 86.0 | 2.7% | 71.7 |
| Not audited YUG-CAPS_building_no_14 | | 30.2 | 1.0% | 25.2 |
| Not audited YUG-CAPS_Kitchen | | 105.0 | 3.3% | [illegible] |
| Not audited YUG-CAPS_Administration | | 65.4 | 2.1% | 54.5 |
| Not audited YUG-CAPS_Laundry | | 47.6 | 1.5% | 39.7 |
| Not audited YUG-CAPS_Security | | 8.6 | 0.3% | 7.2 |
| Not audited YUG-CAPS_Police | | 33.0 | 1.0% | 27.5 |
| Not audited YUG-CAPS_other | | 78.5 | 2.5% | 65.4 |
| TOTAL | | 3,161.2 | 100% | 2,634.7 |

Table 17 – Estimated metered consumption distributed

# On energy audits…

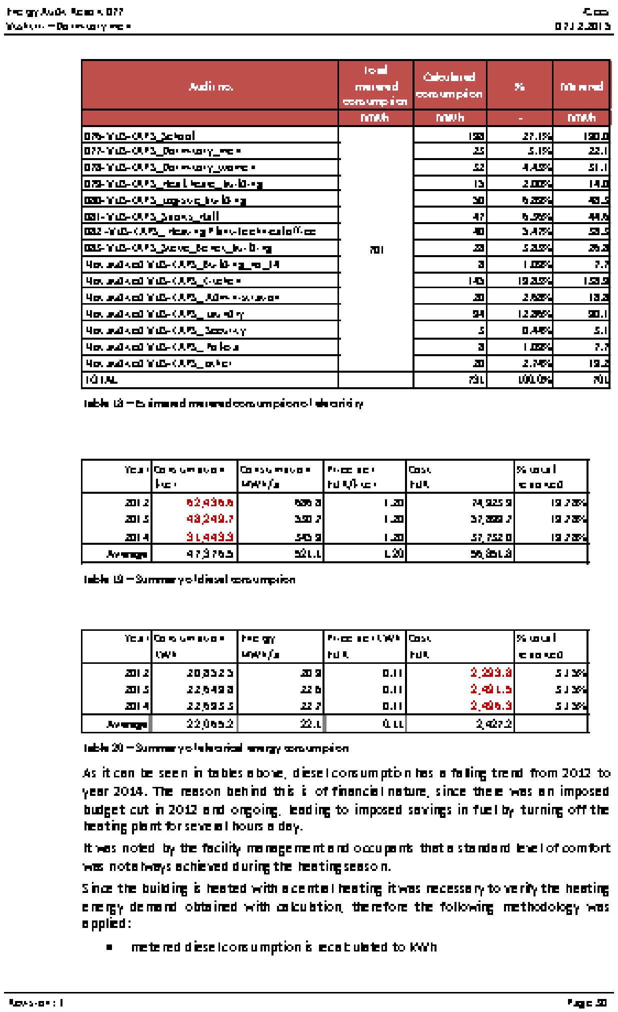


Table 18 – Estimated metered consumption of electricity

Table 19 – Summary of diesel consumption

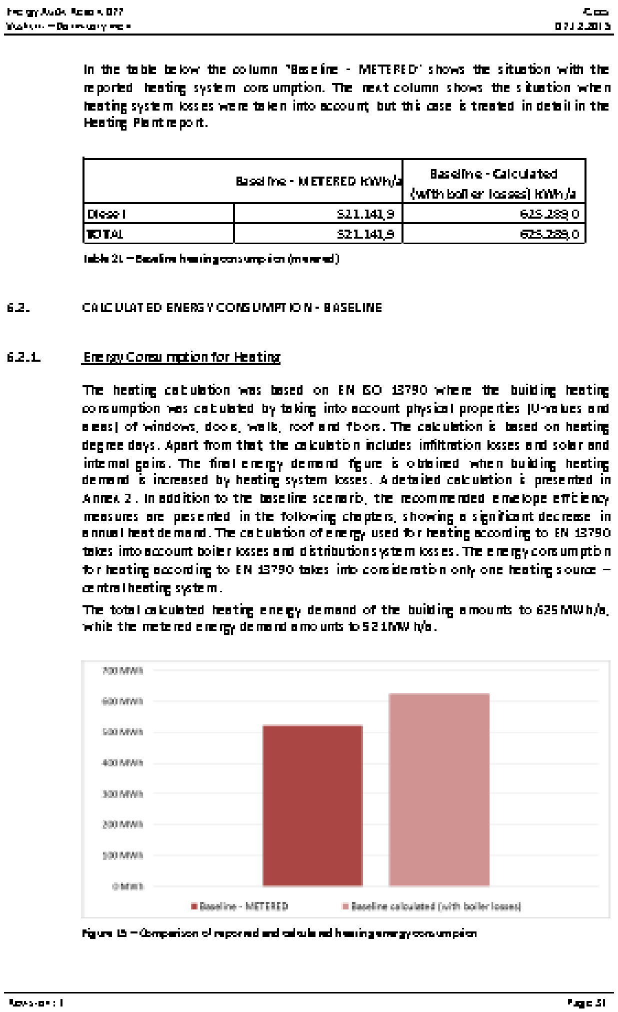
Table 20 – Summary of electrical energy consumption

As it can be seen in tables above, diesel consumption has a falling trend from 2012 to year 2014. The reason behind this is of financial nature, since there was an imposed budget cut in 2012 and ongoing, leading to imposed savings in fuel by turning off the heating plant for several hours a day.

It was noted by the facility management and occupants that a standard level of comfort was not always achieved during the heating season.

Since the building is heated with a central heating it was necessary to verify the heating energy demand obtained with calculation, therefore the following methodology was applied:

- metered diesel consumption is recalculated to KWh


In the table below the column "Baseline - METERED" shows the situation with the reported heating system consumption. The next column shows the situation when heating system losses were taken into account, but this case is treated in detail in the Heating Plant report.

| | Baseline - METERED KWh/a | Baseline - Calculated (with boiler losses) KWh/a |
|---|---|---|
| Diesel | 521.141,9 | 625.289,0 |
| TOTAL | 521.141,9 | 625.289,0 |

Table 21 – Baseline heating consumption (metered)

### 6.2. CALCULATED ENERGY CONSUMPTION - BASELINE

#### 6.2.1. Energy Consumption for Heating

The heating calculation was based on EN ISO 13790 where the building heating consumption was calculated by taking into account physical properties (U-values and areas) of windows, doors, walls, roof and floors. The calculation is based on heating degree days. Apart from that, the calculation includes infiltration losses and solar and internal gains. The final energy demand figure is obtained when building heating demand is increased by heating system losses. A detailed calculation is presented in Annex 2. In addition to the baseline scenario, the recommended envelope efficiency measures are presented in the following chapters, showing a significant decrease in annual heat demand. The calculation of energy used for heating according to EN 13790 takes into account boiler losses and distribution system losses. The energy consumption for heating according to EN 13790 takes into consideration only one heating source – central heating system.

The total calculated heating energy demand of the building amounts to 625 MWh/a, while the metered energy demand amounts to 521 MWh/a.

Figure 15 – Comparison of reported and calculated heating energy consumption

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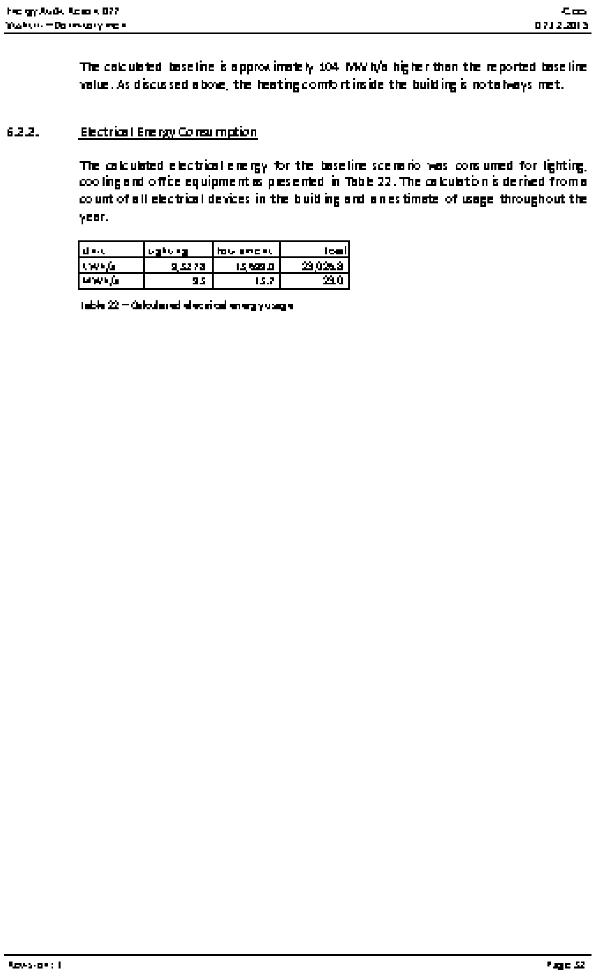

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The calculated baseline is approximately 104 MWh/a higher than the reported baseline value. As discussed above, the heating comfort inside the building is not always met.

### 6.2.2. Electrical Energy Consumption

The calculated electrical energy for the baseline scenario was consumed for lighting, cooling and office equipment as presented in Table 22. The calculation is derived from a count of all electrical devices in the building and an estimate of usage throughout the year.

| Unit | Lighting | Equipment | Total |
|---|---|---|---|
| kWh/a | 9,527.8 | 15,699.0 | 25,026.8 |
| MWh/a | 9.5 | 15.7 | 25.0 |

Table 22 – Calculated electrical energy usage

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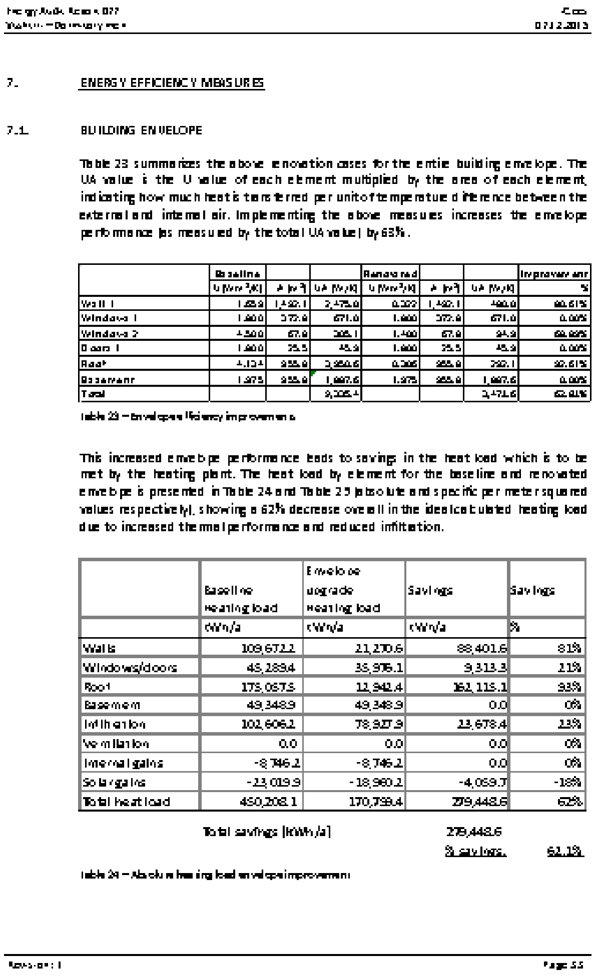

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### 7. ENERGY EFFICIENCY MEASURES

### 7.1. BUILDING ENVELOPE

Table 23 summarizes the above renovation cases for the entire building envelope. The UA value is the U value of each element multiplied by the area of each element, indicating how much heat is transferred per unit of temperature difference between the external and internal air. Implementing the above measures increases the envelope performance (as measured by the total UA value) by 63%.

| | Baseline | | | Renovated | | | Improvement |
|---|---|---|---|---|---|---|---|
| | U [W/m²K] | A [m²] | UA [W/K] | U [W/m²K] | A [m²] | UA [W/K] | % |
| Wall 1 | 1.659 | 1,492.1 | 2,475.0 | 0.322 | 1,492.1 | 480.0 | 80.61% |
| Windows 1 | 1.800 | 372.8 | 671.0 | 1.800 | 372.8 | 671.0 | 0.00% |
| Windows 2 | 4.500 | 67.8 | 305.1 | 1.400 | 67.8 | 94.9 | 68.89% |
| Doors 1 | 1.800 | 25.5 | 45.9 | 1.800 | 25.5 | 45.9 | 0.00% |
| Roof | 4.134 | 955.8 | 3,950.6 | 0.306 | 955.8 | 292.1 | 92.61% |
| Basement | 1.975 | 955.8 | 1,887.6 | 1.975 | 955.8 | 1,887.6 | 0.00% |
| Total | | | 9,335.4 | | | 3,471.6 | 62.81% |

Table 23 – Envelope efficiency improvements

This increased envelope performance leads to savings in the heat load which is to be met by the heating plant. The heat load by element for the baseline and renovated envelope is presented in Table 24 and Table 25 (absolute and specific per meter squared values respectively), showing a 62% decrease overall in the ideal calculated heating load due to increased thermal performance and reduced infiltration.

| | Baseline Heating load | Envelope upgrade Heating load | Savings | Savings |
|---|---|---|---|---|
| | kWh/a | kWh/a | kWh/a | % |
| Walls | 109,672.2 | 21,270.6 | 88,401.6 | 81% |
| Windows/doors | 45,289.4 | 35,976.1 | 9,313.3 | 21% |
| Roof | 175,057.5 | 12,942.4 | 162,115.1 | 93% |
| Basement | 49,348.9 | 49,348.9 | 0.0 | 0% |
| Infiltration | 102,606.2 | 78,927.9 | 23,678.4 | 23% |
| Ventilation | 0.0 | 0.0 | 0.0 | 0% |
| Internal gains | -8,746.2 | -8,746.2 | 0.0 | 0% |
| Solar gains | -23,019.9 | -18,960.2 | -4,059.7 | -18% |
| Total heat load | 450,208.1 | 170,759.4 | 279,448.6 | 62% |

| | |
|---|---|
| Total savings [kWh/a] | 279,448.6 |
| % savings. | 62.1% |

Table 24 – Absolute heating load envelope improvement

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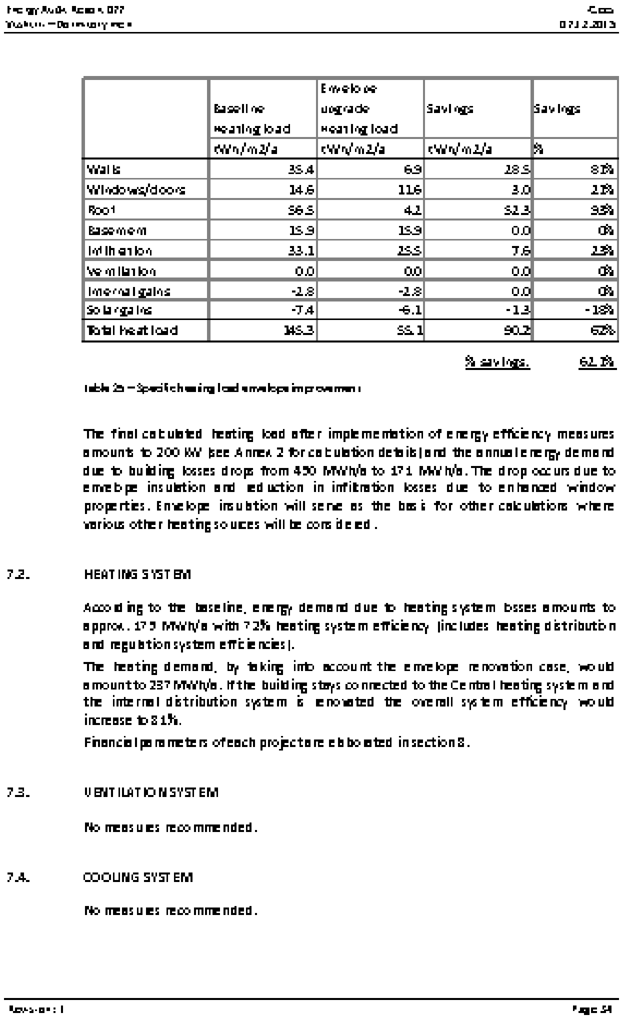


| | Baseline heating load | Envelope upgrade heating load | Savings | Savings |
|---|---|---|---|---|
| | kWh/m2/a | kWh/m2/a | kWh/m2/a | % |
| Walls | 35.4 | 6.9 | 28.5 | 81% |
| Windows/doors | 14.6 | 11.6 | 3.0 | 21% |
| Roof | 56.5 | 4.2 | 52.3 | 93% |
| Basement | 15.9 | 15.9 | 0.0 | 0% |
| Infiltration | 33.1 | 25.5 | 7.6 | 23% |
| Ventilation | 0.0 | 0.0 | 0.0 | 0% |
| Internal gains | -1.8 | -1.8 | 0.0 | 0% |
| Solar gains | -7.4 | -6.1 | -1.3 | -18% |
| Total heat load | 145.3 | 55.1 | 90.2 | 62% |

% savings. 62.1%

Table 25 – Specific heating load envelope improvement

The final calculated heating load after implementation of energy efficiency measures amounts to 200 kW (see Annex 2 for calculation details) and the annual energy demand due to building losses drops from 450 MWh/a to 171 MWh/a. The drop occurs due to envelope insulation and reduction in infiltration losses due to enhanced window properties. Envelope insulation will serve as the basis for other calculations where various other heating sources will be considered.

## 7.2. HEATING SYSTEM

According to the baseline, energy demand due to heating system losses amounts to approx. 175 MWh/a with 72% heating system efficiency (includes heating distribution and regulation system efficiencies).

The heating demand, by taking into account the envelope renovation case, would amount to 237 MWh/a. If the building stays connected to the Central heating system and the internal distribution system is renovated the overall system efficiency would increase to 81%.

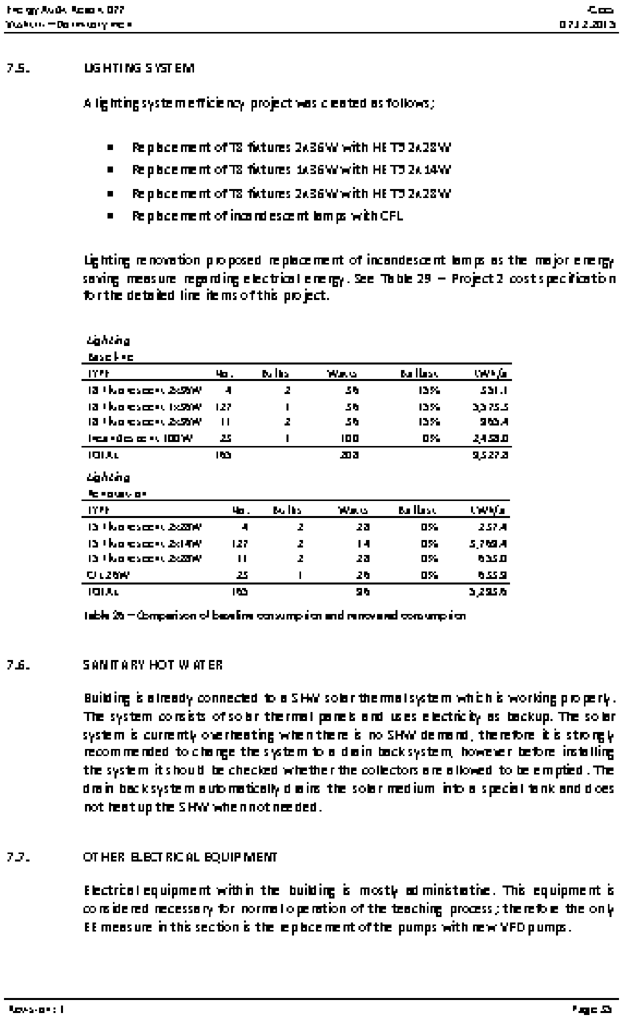
Financial parameters of each project are elaborated in section 8.

## 7.3. VENTILATION SYSTEM

No measures recommended.

## 7.4. COOLING SYSTEM

No measures recommended.



## 7.5. LIGHTING SYSTEM

A lighting system efficiency project was created as follows;

- Replacement of T8 fixtures 2x36W with HE T5 2x28W
- Replacement of T8 fixtures 1x36W with HE T5 2x14W
- Replacement of T8 fixtures 2x36W with HE T5 2x28W
- Replacement of incandescent lamps with CFL

Lighting renovation proposed replacement of incandescent lamps as the major energy saving measure regarding electrical energy. See Table 29 – Project 2 cost specification for the detailed line items of this project.

Lighting Baseline

| TYPE | No. | Bulbs | Watts | Ballast | kWh/a |
|---|---|---|---|---|---|
| T8 Fluorescent 2x36W | 4 | 2 | 36 | 15% | 331.1 |
| T8 Fluorescent 1x36W | 127 | 1 | 36 | 15% | 3,375.5 |
| T8 Fluorescent 2x36W | 11 | 2 | 36 | 15% | 955.4 |
| Incandescent 100W | 25 | 1 | 100 | 0% | 2,450.0 |
| TOTAL | 165 | | 208 | | 9,527.3 |

Lighting Renovation

| TYPE | No. | Bulbs | Watts | Ballast | kWh/a |
|---|---|---|---|---|---|
| T5 Fluorescent 2x28W | 4 | 2 | 28 | 0% | 257.4 |
| T5 Fluorescent 2x14W | 127 | 2 | 14 | 0% | 5,768.4 |
| T5 Fluorescent 2x28W | 11 | 2 | 28 | 0% | 635.0 |
| CFL 20W | 25 | 1 | 20 | 0% | 655.9 |
| TOTAL | 165 | | 96 | | 3,295.6 |

Table 26 – Comparison of baseline consumption and renovated consumption

## 7.6. SANITARY HOT WATER

Building is already connected to a SHW solar thermal system which is working properly. The system consists of solar thermal panels and uses electricity as backup. The solar system is currently overheating when there is no SHW demand, therefore it is strongly recommended to change the system to a drain back system, however before installing the system it should be checked whether the collectors are allowed to be emptied. The drain back system automatically drains the solar medium into a special tank and does not heat up the SHW when not needed.

## 7.7. OTHER ELECTRICAL EQUIPMENT

Electrical equipment within the building is mostly administrative. This equipment is considered necessary for normal operation of the teaching process; therefore the only EE measure in this section is the replacement of the pumps with new VFD pumps.

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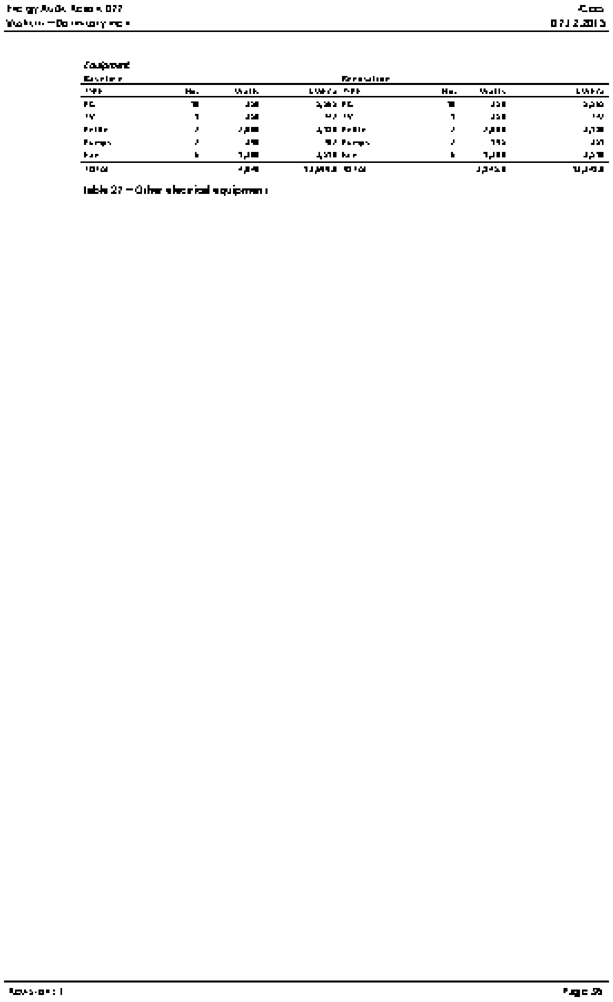

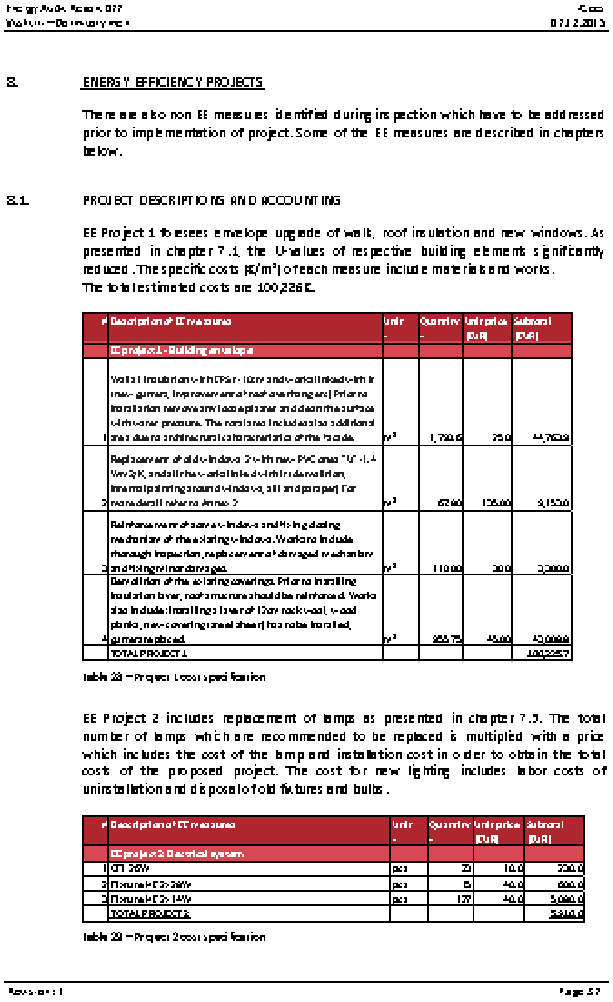

8. ENERGY EFFICIENCY PROJECTS

There are also non EE measures identified during inspection which have to be addressed prior to implementation of project. Some of the EE measures are described in chapters below.

8.1. PROJECT DESCRIPTIONS AND ACCOUNTING

EE Project 1 foresees envelope upgrade of walls, roof insulation and new windows. As presented in chapter 7.1, the U-values of respective building elements significantly reduced. The specific costs [€/m²] of each measure include materials and works.
The total estimated costs are 100,226 €.

| # | Description of EE measures | Unit | Quantity | Unit price [EUR] | Subtotal [EUR] |
|---|---|---|---|---|---|
| | EE project 1 - Building envelope | | | | |
| 1 | [illegible] | m² | 1,790.6 | 25.0 | 44,765.0 |
| 2 | [illegible] | m² | 67.80 | 135.00 | 9,153.0 |
| 3 | [illegible] | m² | 110.00 | 30.0 | 3,300.0 |
| 4 | [illegible] | m² | 955.75 | 45.00 | 43,008.8 |
| | TOTAL PROJECT 1 | | | | 100,225.7 |

Table 28 – Project 1 cost specification

EE Project 2 includes replacement of lamps as presented in chapter 7.3. The total number of lamps which are recommended to be replaced is multiplied with a price which includes the cost of the lamp and installation cost in order to obtain the total costs of the proposed project. The cost for new lighting includes labor costs of uninstallation and disposal of old fixtures and bulbs.

| # | Description of EE measures | Unit | Quantity | Unit price [EUR] | Subtotal [EUR] |
|---|---|---|---|---|---|
| | EE project 2 Electrical system | | | | |
| 1 | CFL 26W | pcs | 22 | 10.0 | 220.0 |
| 2 | Fixture FC 2x36W | pcs | 15 | 40.0 | 600.0 |
| 3 | Fixture FC 2x14W | pcs | 127 | 40.0 | 5,080.0 |
| | TOTAL PROJECT 2 | | | | 5,900.0 |

Table 29 – Project 2 cost specification

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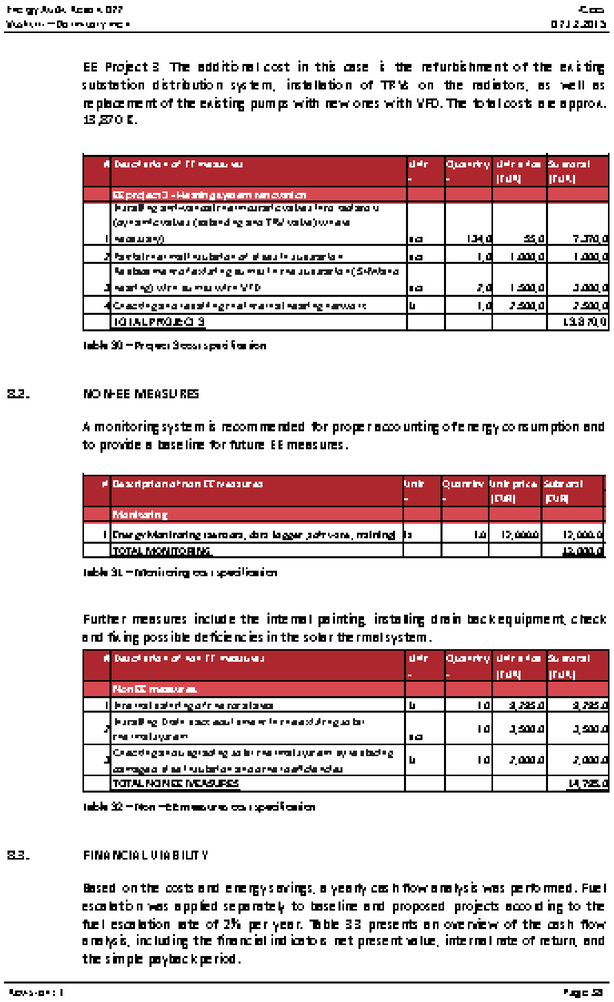
# On energy audits…



EE Project 3: The additional cost in this case is the refurbishment of the existing substation distribution system, installation of TRVs on the radiators, as well as replacement of the existing pumps with new ones with VFD. The total costs are approx. 13,870 €.

| # | Description of EE measures | Unit | Quantity | Unit price [EUR] | Subtotal [EUR] |
|---|---|---|---|---|---|
| | EE project 3 - Heating system renovation | | | | |
| 1 | [illegible] | pcs | 134,0 | 55,0 | 7.370,0 |
| 2 | [illegible] | pcs | 1,0 | 1.000,0 | 1.000,0 |
| 3 | [illegible] with new pumps with VFD | pcs | 2,0 | 1.500,0 | 3.000,0 |
| 4 | [illegible] | ls | 1,0 | 2.500,0 | 2.500,0 |
| | TOTAL PROJECT 3 | | | | 13.870,0 |

Table 30 – Project 3 cost specification

8.2. NON-EE MEASURES

A monitoring system is recommended for proper accounting of energy consumption and to provide a baseline for future EE measures.

| # | Description of non EE measures | Unit | Quantity | Unit price [EUR] | Subtotal [EUR] |
|---|---|---|---|---|---|
| | Monitoring | | | | |
| 1 | Energy Monitoring (sensors, data logger, software, training) | ls | 1,0 | 12,000.0 | 12,000.0 |
| | TOTAL MONITORING | | | | 12,000.0 |

Table 31 – Monitoring cost specification

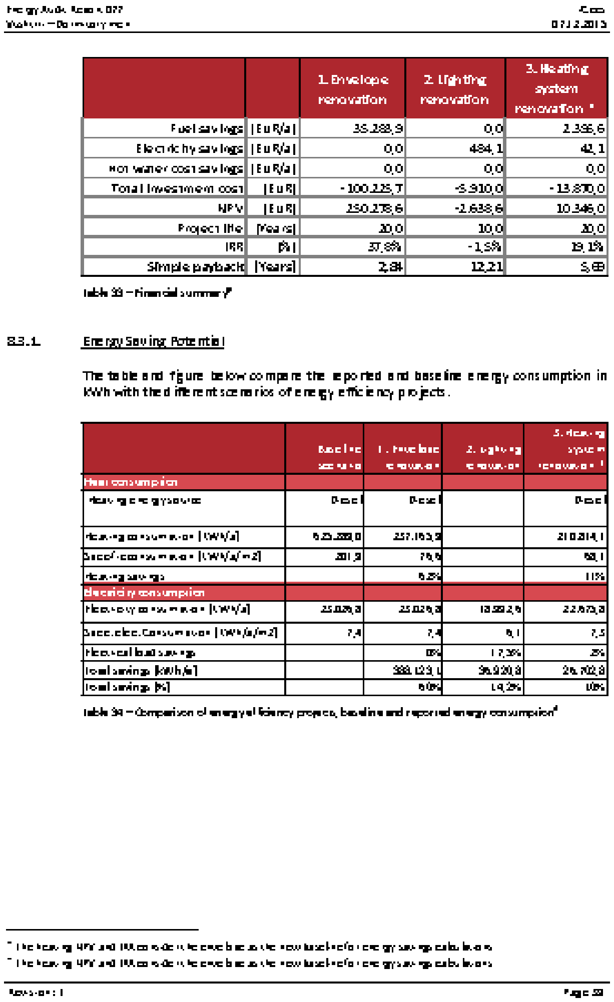
Further measures include the internal painting, installing drain back equipment, check and fixing possible deficiencies in the solar thermal system.

| # | Description of non EE measures | Unit | Quantity | Unit price [EUR] | Subtotal [EUR] |
|---|---|---|---|---|---|
| | Non EE measures | | | | |
| 1 | [illegible] | ls | 1,0 | 9,225.0 | 9,225.0 |
| 2 | Installing Drain back equipment [illegible] thermal system | pcs | 1,0 | 3,500.0 | 3,500.0 |
| 3 | [illegible] | ls | 1,0 | 2,000.0 | 2,000.0 |
| | TOTAL NON EE MEASURES | | | | 14,725.0 |

Table 32 – Non-EE measures cost specification

8.3. FINANCIAL VIABILITY

Based on the costs and energy savings, a yearly cash flow analysis was performed. Fuel escalation was applied separately to baseline and proposed projects according to the fuel escalation rate of 2% per year. Table 33 presents an overview of the cash flow analysis, including the financial indicators net present value, internal rate of return, and the simple payback period.



| | | 1. Envelope renovation | 2. Lighting renovation | 3. Heating system renovation |
|---|---|---|---|---|
| Fuel savings | [EUR/a] | 35.288,9 | 0,0 | 2.396,6 |
| Electricity savings | [EUR/a] | 0,0 | 484,1 | 42,1 |
| Hot water cost savings | [EUR/a] | 0,0 | 0,0 | 0,0 |
| Total investment cost | [EUR] | -100.225,7 | -5.910,0 | -13.870,0 |
| NPV | [EUR] | 250.278,6 | -1.638,6 | 10.346,0 |
| Project life | [Years] | 20,0 | 10,0 | 20,0 |
| IRR | [%] | 37,8% | -1,5% | 19,1% |
| Simple payback | [Years] | 2,84 | 12,21 | 5,69 |

Table 33 – Financial summary

8.3.1. Energy Saving Potential

The table and figure below compare the reported and baseline energy consumption in kWh with the different scenarios of energy efficiency projects.

| | Baseline scenario | 1. Envelope renovation | 2. Lighting renovation | 3. Heating system renovation |
|---|---|---|---|---|
| Heat consumption | | | | |
| Heating energy source | Diesel | Diesel | | Diesel |
| Heating consumption [kWh/a] | 625.280,0 | 257.153,9 | | 210.214,1 |
| Specific consumption [kWh/a/m2] | 201,9 | 79,9 | | 68,1 |
| Heating savings | | 62% | | 11% |
| Electricity consumption | | | | |
| Electricity consumption [kWh/a] | 25.026,3 | 25.026,3 | 18.592,5 | 22.673,3 |
| Spec.elec.Consumption [kWh/a/m2] | 7,4 | 7,4 | 6,1 | 7,5 |
| Electrical load savings | | 0% | 17,3% | 2% |
| Total savings [kWh/a] | | 338.123,1 | 36.920,8 | 26.702,8 |
| Total savings [%] | | 60% | 14,2% | 10% |

Table 34 – Comparison of energy efficiency projects, baseline and reported energy consumption

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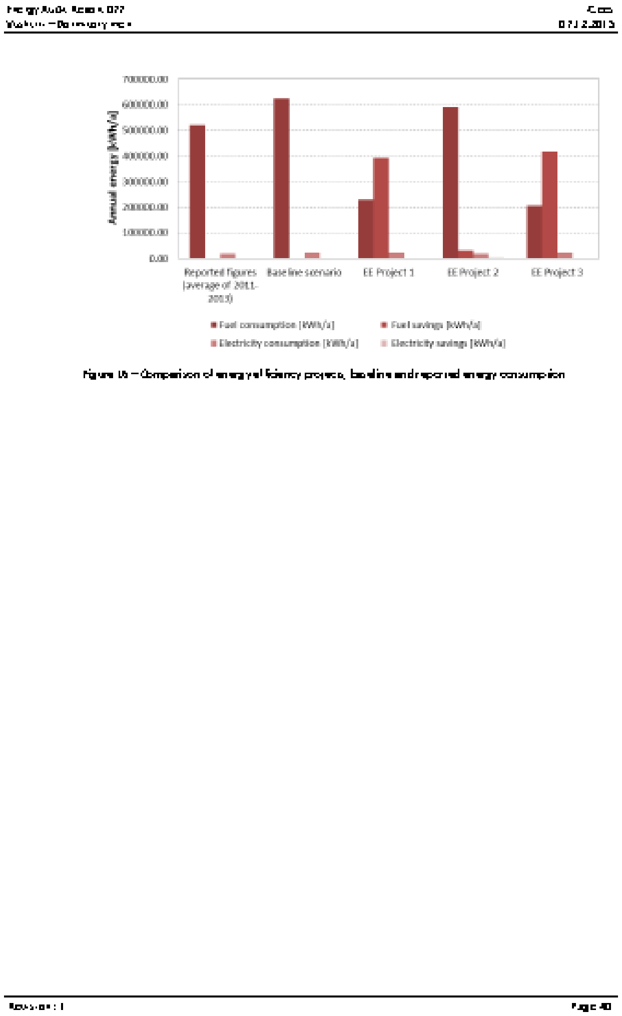

Figure 16 – Comparison of energy efficiency projects, baseline and reported energy consumption

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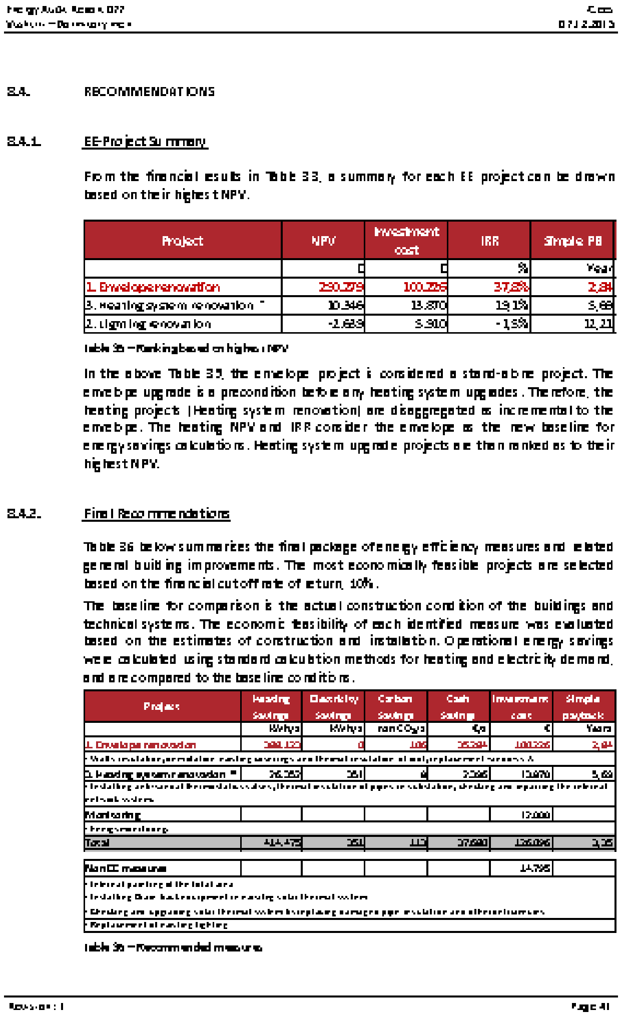

8.4. RECOMMENDATIONS

8.4.1. EE-Project Summary

From the financial results in Table 33, a summary for each EE project can be drawn based on their highest NPV.

| Project | NPV | Investment cost | IRR | Simple PB |
|---|---|---|---|---|
| | € | € | % | Year |
| 1. Envelope renovation | 230.279 | 100.226 | 37,8% | 2,84 |
| 3. Heating system renovation * | 10.346 | 13.870 | 19,1% | 5,69 |
| 2. Lighting renovation | -2.623 | 5.310 | -1,5% | 12,21 |

Table 35 – Ranking based on highest NPV

In the above Table 35, the envelope project is considered a stand-alone project. The envelope upgrade is a precondition before any heating system upgrades. Therefore, the heating projects (Heating system renovation) are disaggregated as incremental to the envelope. The heating NPV and IRR consider the envelope as the new baseline for energy savings calculations. Heating system upgrade projects are then ranked as to their highest NPV.

8.4.2. Final Recommendations

Table 36 below summarizes the final package of energy efficiency measures and related general building improvements. The most economically feasible projects are selected based on the financial cutoff rate of return, 10%.

The baseline for comparison is the actual construction condition of the buildings and technical systems. The economic feasibility of each identified measure was evaluated based on the estimates of construction and installation. Operational energy savings were calculated using standard calculation methods for heating and electricity demand, and are compared to the baseline conditions.

| Project | Heating Savings | Electricity Savings | Carbon Savings | Cash Savings | Investment cost | Simple payback |
|---|---|---|---|---|---|---|
| | kWh/a | kWh/a | ton CO2/a | €/a | € | Years |
| 1. Envelope renovation | 388.122 | 0 | 106 | 35.294 | 100.226 | 2,84 |
| [illegible] | | | | | | |
| 3. Heating system renovation * | 26.353 | 251 | 6 | 2.396 | 13.870 | 5,69 |
| [illegible] | | | | | | |
| Monitoring | | | | | 12.000 | |
| [illegible] | | | | | | |
| Total | 414.475 | 251 | 112 | 37.690 | 126.096 | 3,35 |
| | | | | | | |
| Non EE measures | | | | | 14.795 | |
| [illegible] | | | | | | |

Table 36 – Recommended measures

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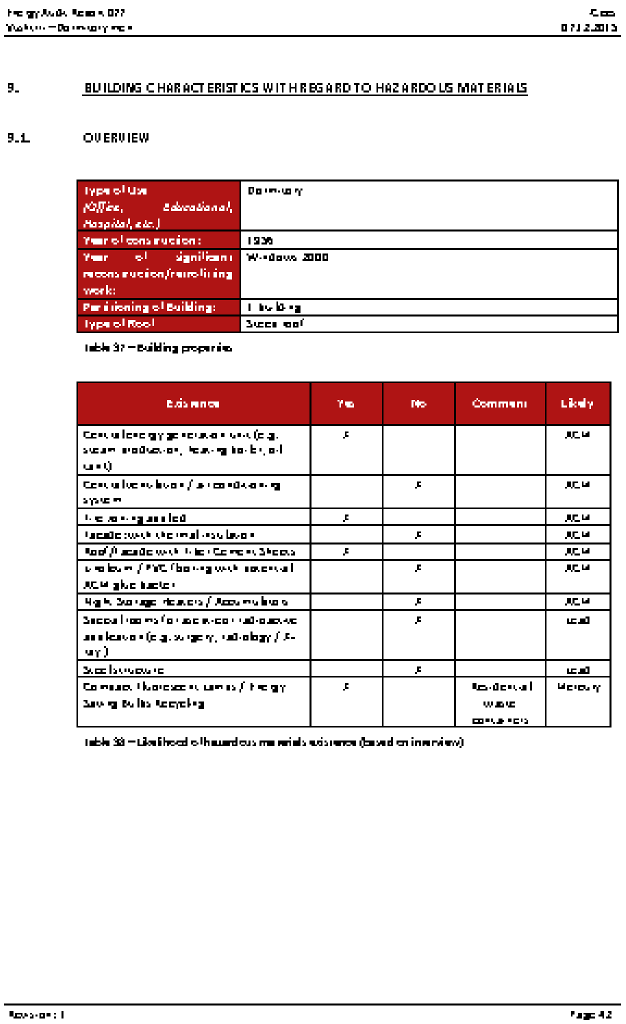

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## 9. BUILDING CHARACTERISTICS WITH REGARD TO HAZARDOUS MATERIALS

### 9.1. OVERVIEW

| | |
|---|---|
| **Type of Use** *(Office, Educational, Hospital, etc.)* | Dormitory |
| **Year of construction:** | 1936 |
| **Year of significant reconstruction/retrofitting work:** | Windows 2000 |
| **Partitioning of Building:** | 1 building |
| **Type of Roof** | Steep roof |

Table 37 – Building properties

| Existence | Yes | No | Comment | Likely |
|---|---|---|---|---|
| Central energy generation unit (e.g. steam production, heating boiler, oil tank) | x | | | ACM |
| Central ventilation / air conditioning system | | x | | ACM |
| Fire zoning applied | x | | | ACM |
| Facade with thermal insulation | | x | | ACM |
| Roof / Facade with Fiber Cement Sheets | x | | | ACM |
| Linoleum / PVC flooring with potential ACM glue factor | | x | | ACM |
| Night Storage Heaters / Accumulators | | x | | ACM |
| Special rooms for use in radioactive ambience (e.g. surgery, radiology / X-ray) | | x | | Lead |
| Steel structure | | x | | Lead |
| Compact Fluorescent Lamps / Energy Saving Bulbs Recycling | x | | Residential waste containers | Mercury |

Table 38 – Likelihood of hazardous materials existence (based on interview)

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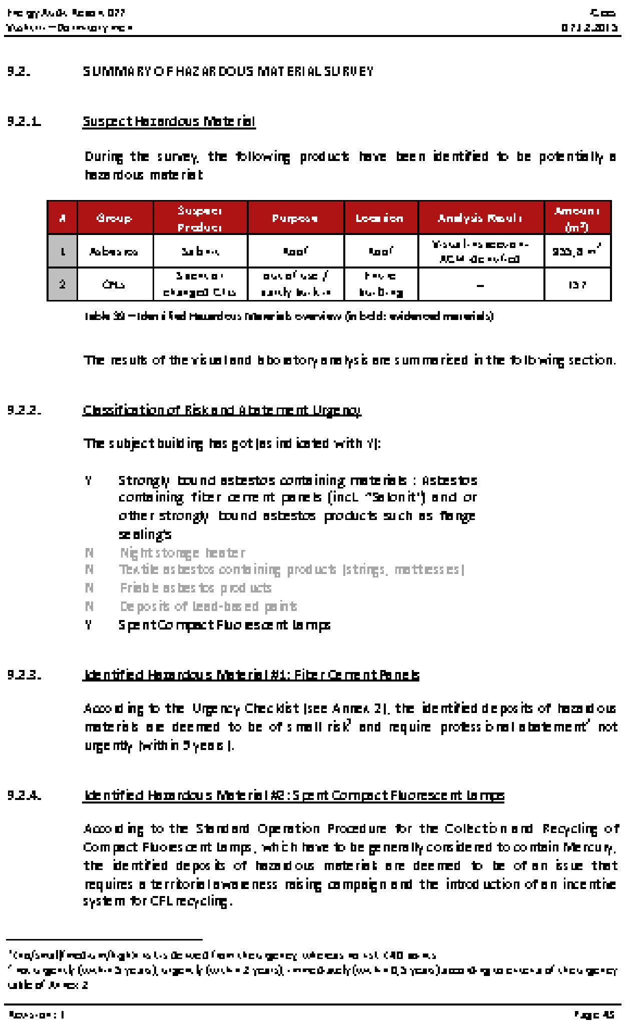

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### 9.2. SUMMARY OF HAZARDOUS MATERIAL SURVEY

#### 9.2.1. Suspect Hazardous Material

During the survey, the following products have been identified to be potentially a hazardous material:

| # | Group | Suspect Product | Purpose | Location | Analysis Result | Amount (m²) |
|---|---|---|---|---|---|---|
| 1 | Asbestos | Salonit | Roof | Roof | Visual inspection - ACM identified | 333,3 m² |
| 2 | CFLs | Spent or changed CFLs | out of use / partly broken | Entire building | – | 137 |

Table 39 – Identified Hazardous Materials overview (in bold: evidenced materials)

The results of the visual and laboratory analysis are summarized in the following section.

#### 9.2.2. Classification of Risk and Abatement Urgency

The subject building has got (as indicated with Y):

Y Strongly bound asbestos containing materials : Asbestos containing fiber cement panels (incl. "Salonit") and or other strongly bound asbestos products such as flange sealings
N Night storage heater
N Textile asbestos containing products (strings, mattresses)
N Friable asbestos products
N Deposits of lead-based paints
Y Spent Compact Fluorescent Lamps

#### 9.2.3. Identified Hazardous Material #1: Fiber Cement Panels

According to the Urgency Checklist (see Annex 2), the identified deposits of hazardous materials are deemed to be of small risk[1] and require professional abatement[2] not urgently (within 5 years).

#### 9.2.4. Identified Hazardous Material #2: Spent Compact Fluorescent Lamps

According to the Standard Operation Procedure for the Collection and Recycling of Compact Fluorescent Lamps, which have to be generally considered to contain Mercury, the identified deposits of hazardous materials are deemed to be of an issue that requires a territorial awareness raising campaign and the introduction of an incentive system for CFL recycling.

---

[1] Low/small/medium/high risk is derived from the urgency [illegible]
[2] not urgently (within 5 years), urgently (within 2 years), immediately (within 0,5 years) according to [illegible] of the urgency table of Annex 2

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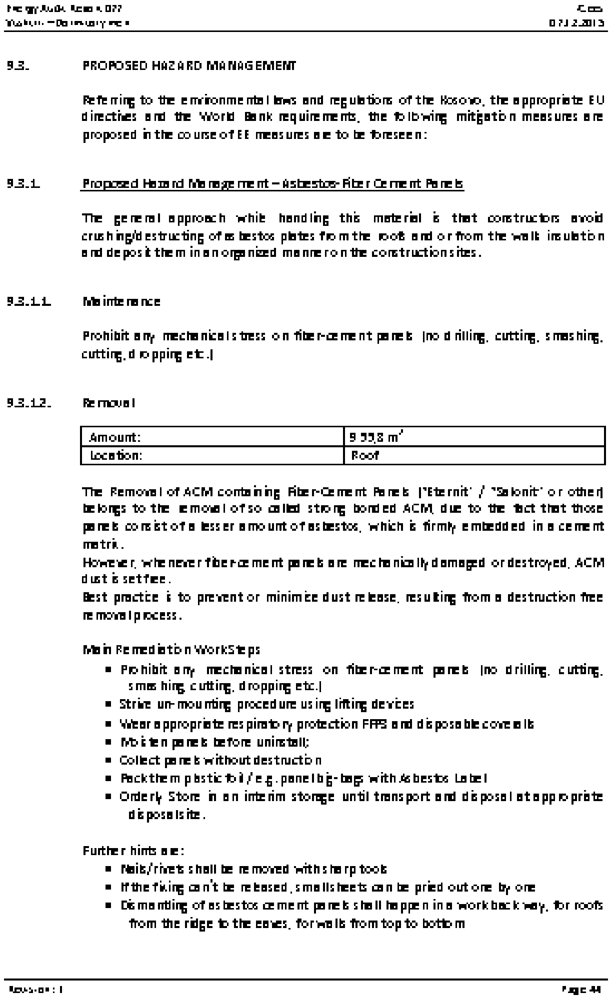

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9.3. PROPOSED HAZARD MANAGEMENT

Referring to the environmental laws and regulations of the Kosovo, the appropriate EU directives and the World Bank requirements, the following mitigation measures are proposed in the course of EE measures are to be foreseen:

9.3.1. Proposed Hazard Management – Asbestos-Fiber Cement Panels

The general approach while handling this material is that constructors avoid crushing/destructing of asbestos plates from the roofs and or from the walls insulation and deposit them in an organized manner on the construction sites.

9.3.1.1. Maintenance

Prohibit any mechanical stress on fiber-cement panels (no drilling, cutting, smashing, cutting, dropping etc.)

9.3.1.2. Removal

| | |
|---|---|
| Amount: | 999,8 m² |
| Location: | Roof |

The Removal of ACM containing Fiber-Cement Panels ("Eternit" / "Salonit" or other) belongs to the removal of so called strong bonded ACM, due to the fact that those panels consist of a lesser amount of asbestos, which is firmly embedded in a cement matrix.
However, whenever fiber-cement panels are mechanically damaged or destroyed, ACM dust is set free.
Best practice is to prevent or minimize dust release, resulting from a destruction free removal process.

Main Remediation WorkSteps

- Prohibit any mechanical stress on fiber-cement panels (no drilling, cutting, smashing, cutting, dropping etc.)
- Strive un-mounting procedure using lifting devices
- Wear appropriate respiratory protection FFP3 and disposable coveralls
- Moisten panels before uninstall;
- Collect panels without destruction
- Pack them plastic foil / e.g. panel big-bags with Asbestos Label
- Orderly Store in an interim storage until transport and disposal at appropriate disposal site.

Further hints are:

- Nails/rivets shall be removed with sharp tools
- If the fixing can't be released, small sheets can be pried out one by one
- Dismantling of asbestos cement panels shall happen in a work back way, for roofs from the ridge to the eaves, for walls from top to bottom

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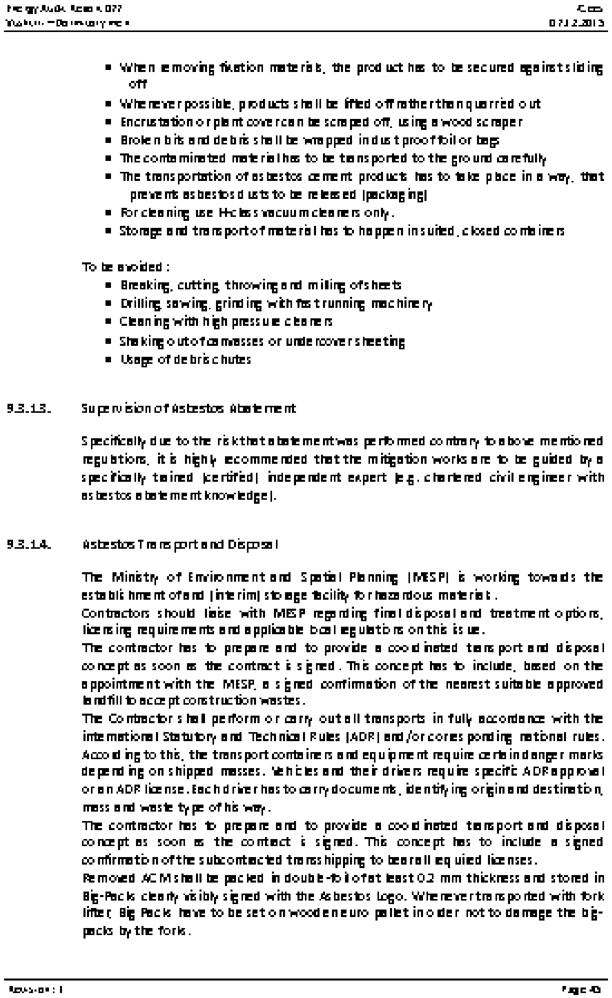

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- When removing fixation materials, the product has to be secured against sliding off
- Whenever possible, products shall be lifted off rather than quarried out
- Encrustation or plant cover can be scraped off, using a wood scraper
- Broken bits and debris shall be wrapped in dust proof foil or bags
- The contaminated material has to be transported to the ground carefully
- The transportation of asbestos cement products has to take place in a way, that prevents asbestos dusts to be released (packaging)
- For cleaning use H-class vacuum cleaners only.
- Storage and transport of material has to happen in suited, closed containers

To be avoided:

- Breaking, cutting, throwing and milling of sheets
- Drilling, sawing, grinding with fast running machinery
- Cleaning with high pressure cleaners
- Shaking out of canvasses or undercover sheeting
- Usage of debris chutes

9.3.1.3. Supervision of Asbestos Abatement

Specifically due to the risk that abatement was performed contrary to above mentioned regulations, it is highly recommended that the mitigation works are to be guided by a specifically trained (certified) independent expert (e.g. chartered civil engineer with asbestos abatement knowledge).

9.3.1.4. Asbestos Transport and Disposal

The Ministry of Environment and Spatial Planning (MESP) is working towards the establishment of and (interim) storage facility for hazardous materials.
Contractors should liaise with MESP regarding final disposal and treatment options, licensing requirements and applicable local regulations on this issue.
The contractor has to prepare and to provide a coordinated transport and disposal concept as soon as the contract is signed. This concept has to include, based on the appointment with the MESP, a signed confirmation of the nearest suitable approved landfill to accept construction wastes.
The Contractor shall perform or carry out all transports in fully accordance with the international Statutory and Technical Rules (ADR) and/or corresponding national rules.
According to this, the transport containers and equipment require certain danger marks depending on shipped masses. Vehicles and their drivers require specific ADR approval or an ADR license. Each driver has to carry documents, identifying origin and destination, mass and waste type of his way.
The contractor has to prepare and to provide a coordinated transport and disposal concept as soon as the contract is signed. This concept has to include a signed confirmation of the subcontracted transshipping to bear all required licenses.
Removed ACM shall be packed in double-foil of at least 0.2 mm thickness and stored in Big-Packs clearly visibly signed with the Asbestos Logo. Whenever transported with fork lifter, Big Packs have to be set on wooden euro pallet in order not to damage the big-packs by the forks.

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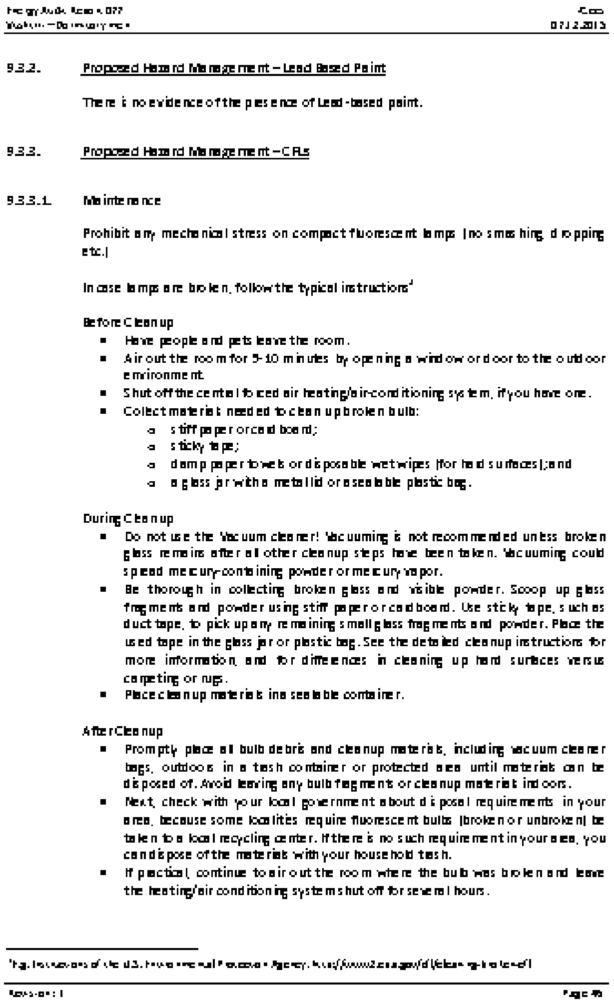
# On energy audits…



9.3.2. Proposed Hazard Management – Lead Based Paint

There is no evidence of the presence of Lead-based paint.

9.3.3. Proposed Hazard Management – CFLs

9.3.3.1. Maintenance

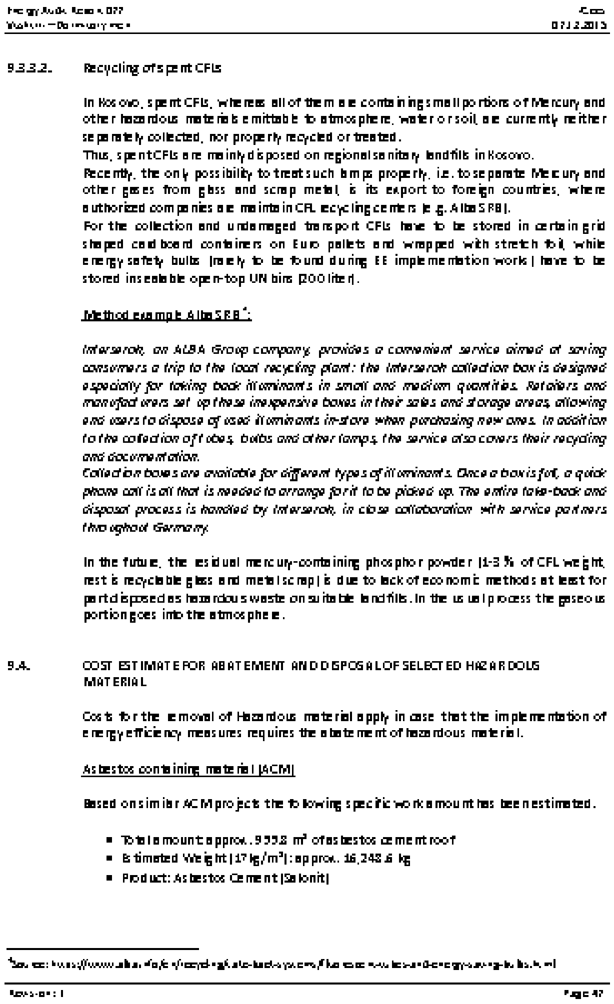
Prohibit any mechanical stress on compact fluorescent lamps (no smashing, dropping etc.)

In case lamps are broken, follow the typical instructions

Before Cleanup
- Have people and pets leave the room.
- Air out the room for 5-10 minutes by opening a window or door to the outdoor environment.
- Shut off the central forced air heating/air-conditioning system, if you have one.
- Collect materials needed to clean up broken bulb:
  - stiff paper or cardboard;
  - sticky tape;
  - damp paper towels or disposable wet wipes (for hard surfaces); and
  - a glass jar with a metal lid or a sealable plastic bag.

During Cleanup
- Do not use the Vacuum cleaner! Vacuuming is not recommended unless broken glass remains after all other cleanup steps have been taken. Vacuuming could spread mercury-containing powder or mercury vapor.
- Be thorough in collecting broken glass and visible powder. Scoop up glass fragments and powder using stiff paper or cardboard. Use sticky tape, such as duct tape, to pick up any remaining small glass fragments and powder. Place the used tape in the glass jar or plastic bag. See the detailed cleanup instructions for more information, and for differences in cleaning up hard surfaces versus carpeting or rugs.
- Place cleanup materials in a sealable container.

After Cleanup
- Promptly place all bulb debris and cleanup materials, including vacuum cleaner bags, outdoors in a trash container or protected area until materials can be disposed of. Avoid leaving any bulb fragments or cleanup materials indoors.
- Next, check with your local government about disposal requirements in your area, because some localities require fluorescent bulbs (broken or unbroken) be taken to a local recycling center. If there is no such requirement in your area, you can dispose of the materials with your household trash.
- If practical, continue to air out the room where the bulb was broken and leave the heating/air conditioning system shut off for several hours.



9.3.3.2. Recycling of spent CFLs

In Kosovo, spent CFLs, whereas all of them are containing small portions of Mercury and other hazardous materials emittable to atmosphere, water or soil, are currently neither separately collected, nor properly recycled or treated.
Thus, spent CFLs are mainly disposed on regional sanitary landfills in Kosovo.
Recently, the only possibility to treat such lamps properly, i.e. to separate Mercury and other gases from glass and scrap metal, is its export to foreign countries, where authorized companies are maintain CFL recycling centers (e.g. Alba SRB).
For the collection and undamaged transport CFLs have to be stored in certain grid shaped cardboard containers on Euro pallets and wrapped with stretch foil, while energy safety bulbs (rarely to be found during EE implementation works) have to be stored in sealable open-top UN bins (200 liter).

Method example Alba SRB:

*Interseroh, an ALBA Group company, provides a convenient service aimed at saving consumers a trip to the local recycling plant: the Interseroh collection box is designed especially for taking back illuminants in small and medium quantities. Retailers and manufacturers set up these inexpensive boxes in their sales and storage areas, allowing end users to dispose of used illuminants in-store when purchasing new ones. In addition to the collection of tubes, bulbs and other lamps, the service also covers their recycling and documentation.*
*Collection boxes are available for different types of illuminants. Once a box is full, a quick phone call is all that is needed to arrange for it to be picked up. The entire take-back and disposal process is handled by Interseroh, in close collaboration with service partners throughout Germany.*

In the future, the residual mercury-containing phosphor powder (1-3 % of CFL weight, rest is recyclable glass and metal scrap) is due to lack of economic methods at least for part disposed as hazardous waste on suitable landfills. In the usual process the gaseous portion goes into the atmosphere.

9.4. COST ESTIMATE FOR ABATEMENT AND DISPOSAL OF SELECTED HAZARDOUS MATERIAL

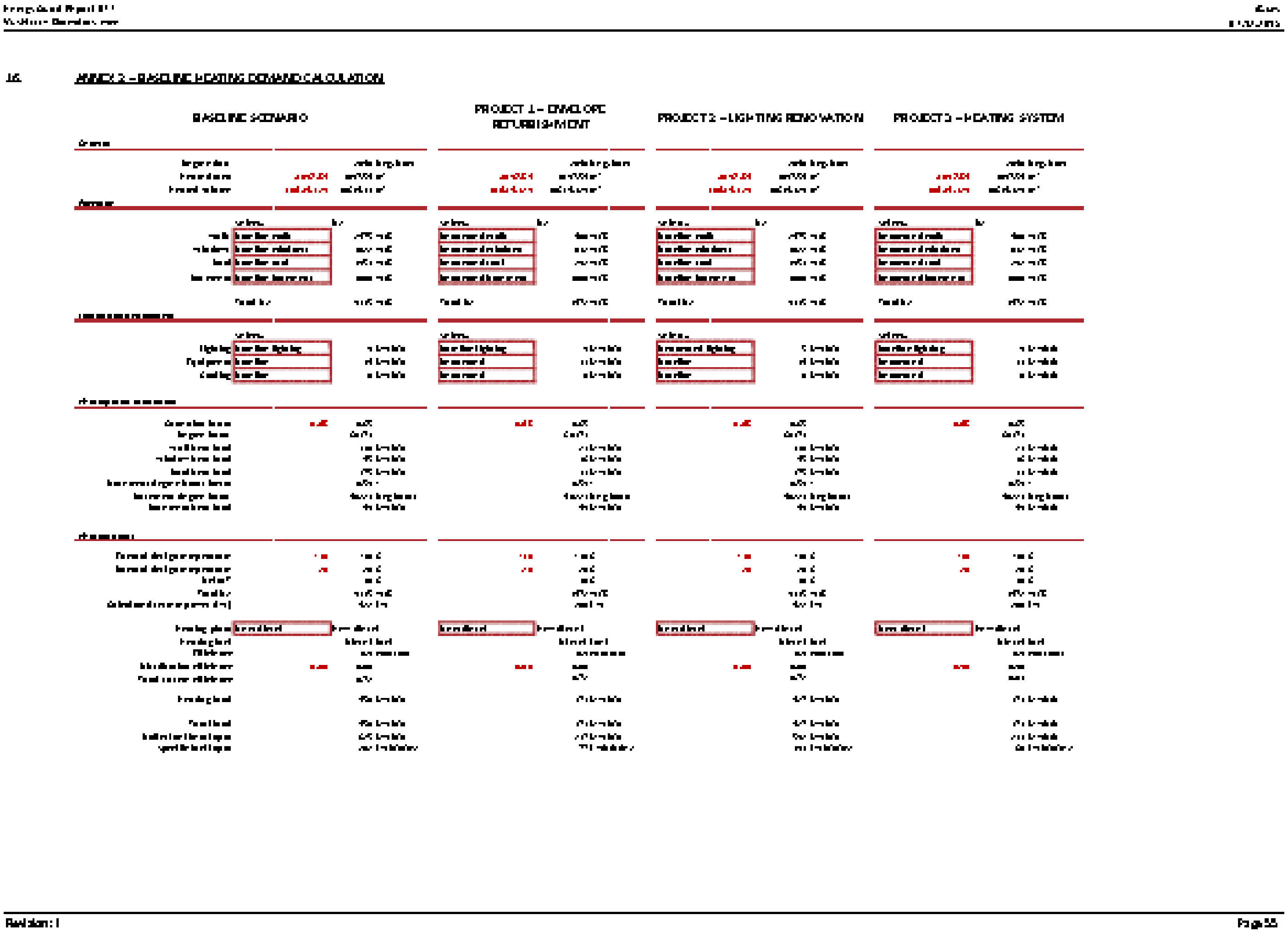
Costs for the removal of Hazardous material apply in case that the implementation of energy efficiency measures requires the abatement of hazardous material.

Asbestos containing material (ACM)

Based on similar ACM projects the following specific work amount has been estimated.

- Total amount approx. 955.8 m² of asbestos cement roof
- Estimated Weight (17 kg/m²): approx. 16,248.6 kg
- Product: Asbestos Cement (Salonit)

# On energy audits…



16. ANNEX 2 – BASELINE HEATING DEMAND CALCULATION

BASELINE SCENARIO

PROJECT 1 – ENVELOPE REFURBISHMENT

PROJECT 2 – LIGHTING RENOVATION

PROJECT 3 – HEATING SYSTEM

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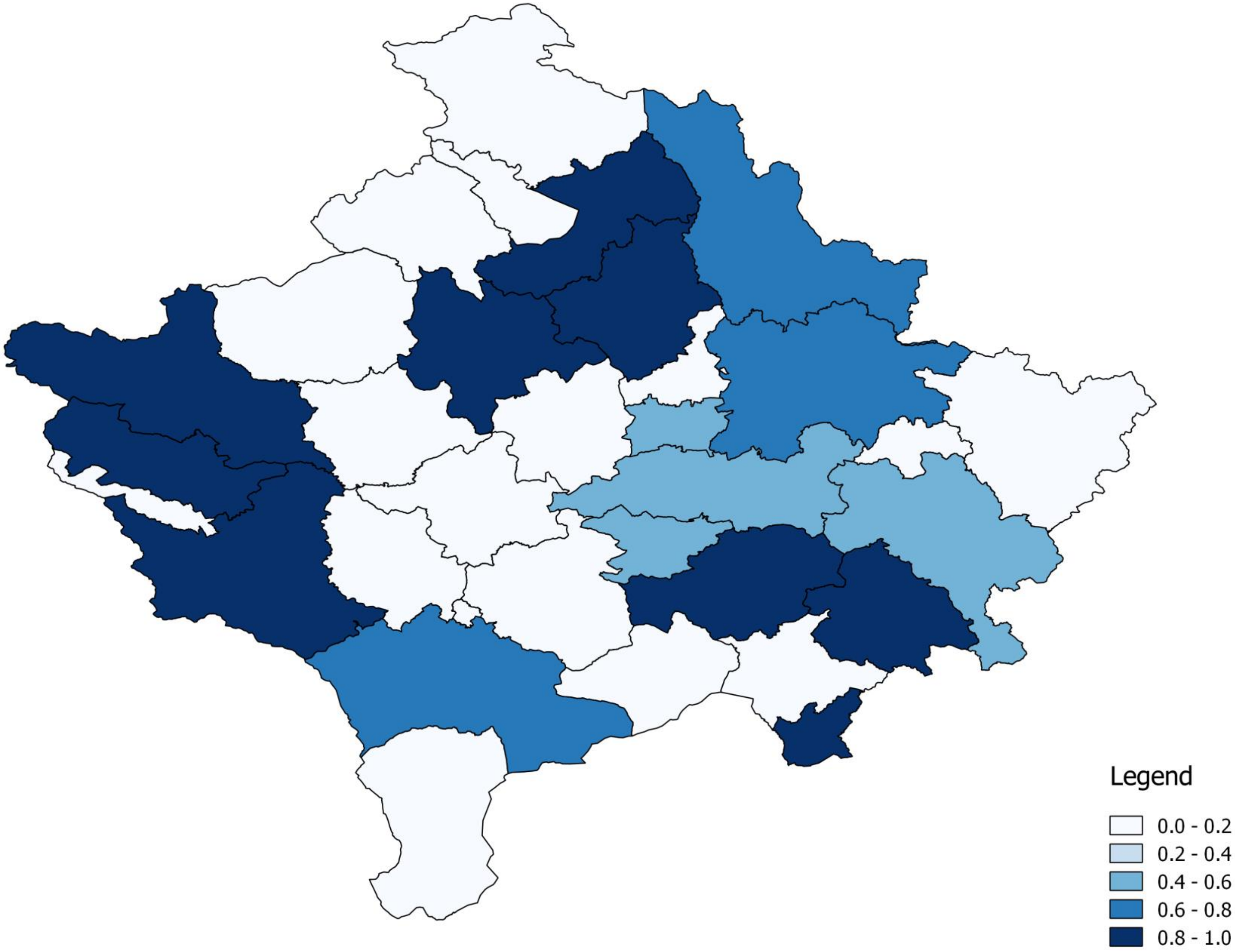
# Typical EE measures identified

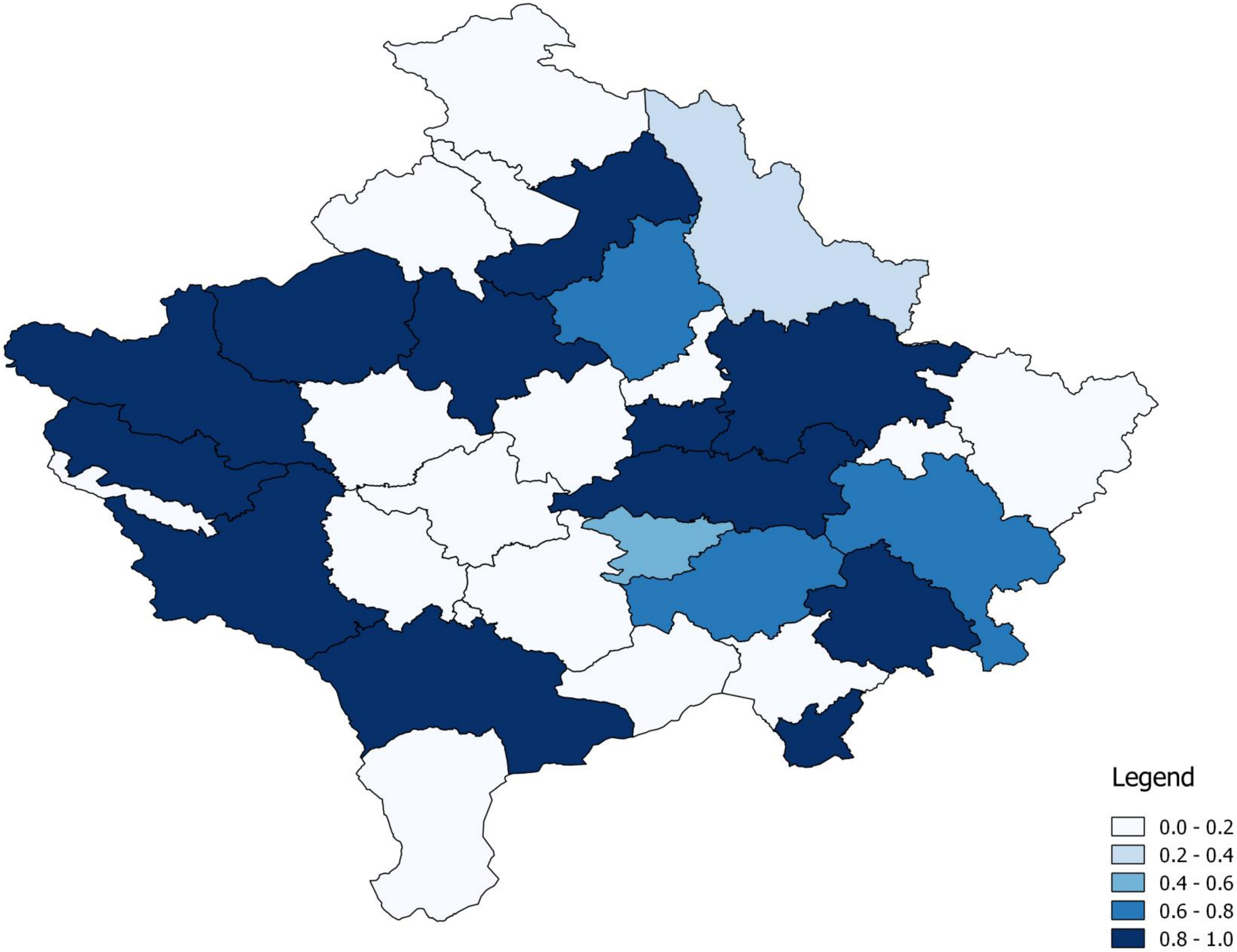
- Wall renovation
- Roof renovation
- Windows and doors replacement
- Fuel switch
- Heating system improvement
- Lighting renovation
- Solar thermal

- All figures shown in percentages:
  - Number of buildings where the measure is applied divided by total number of buildings

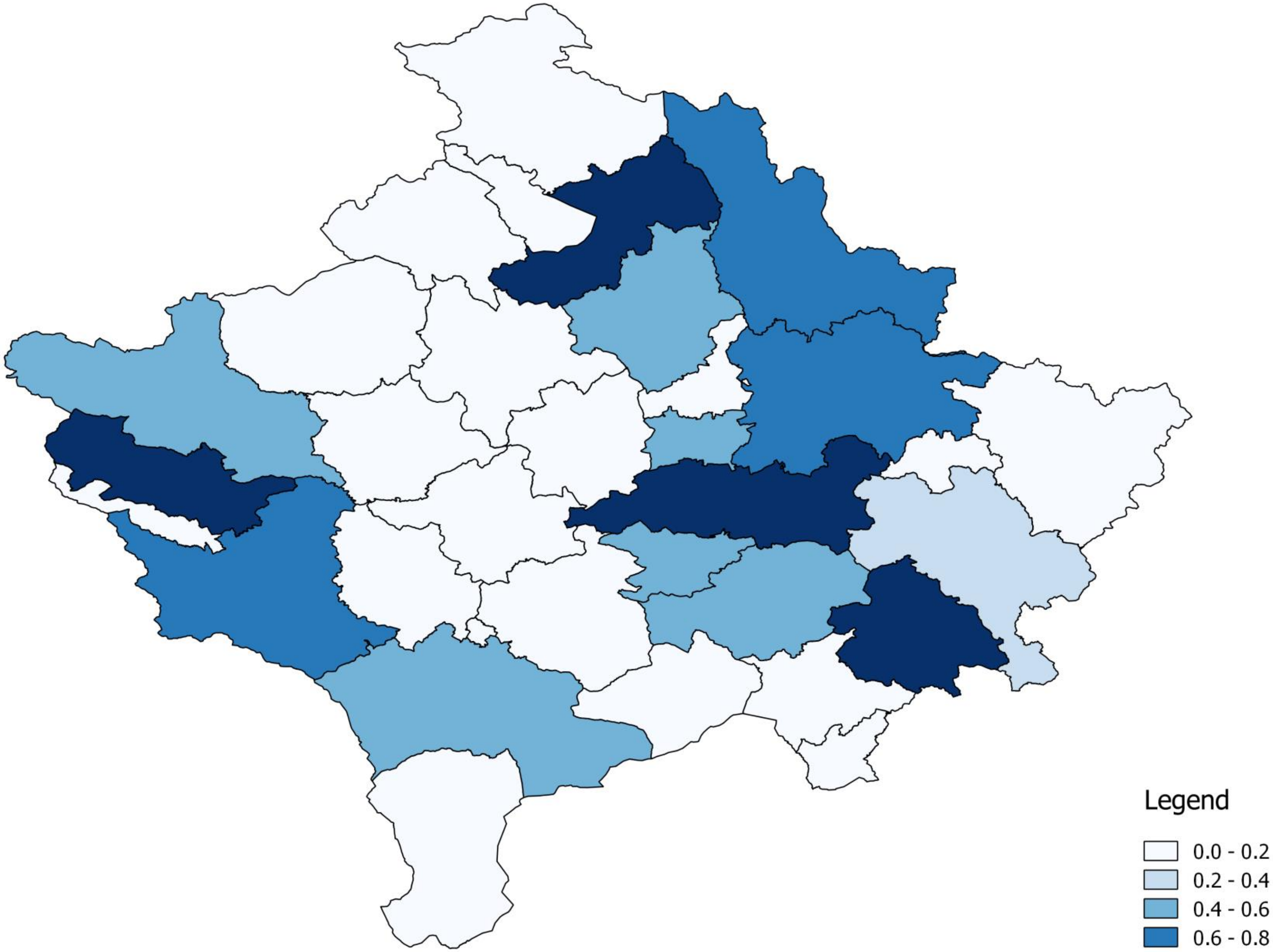
# Typical EE measures identified - wall renovation



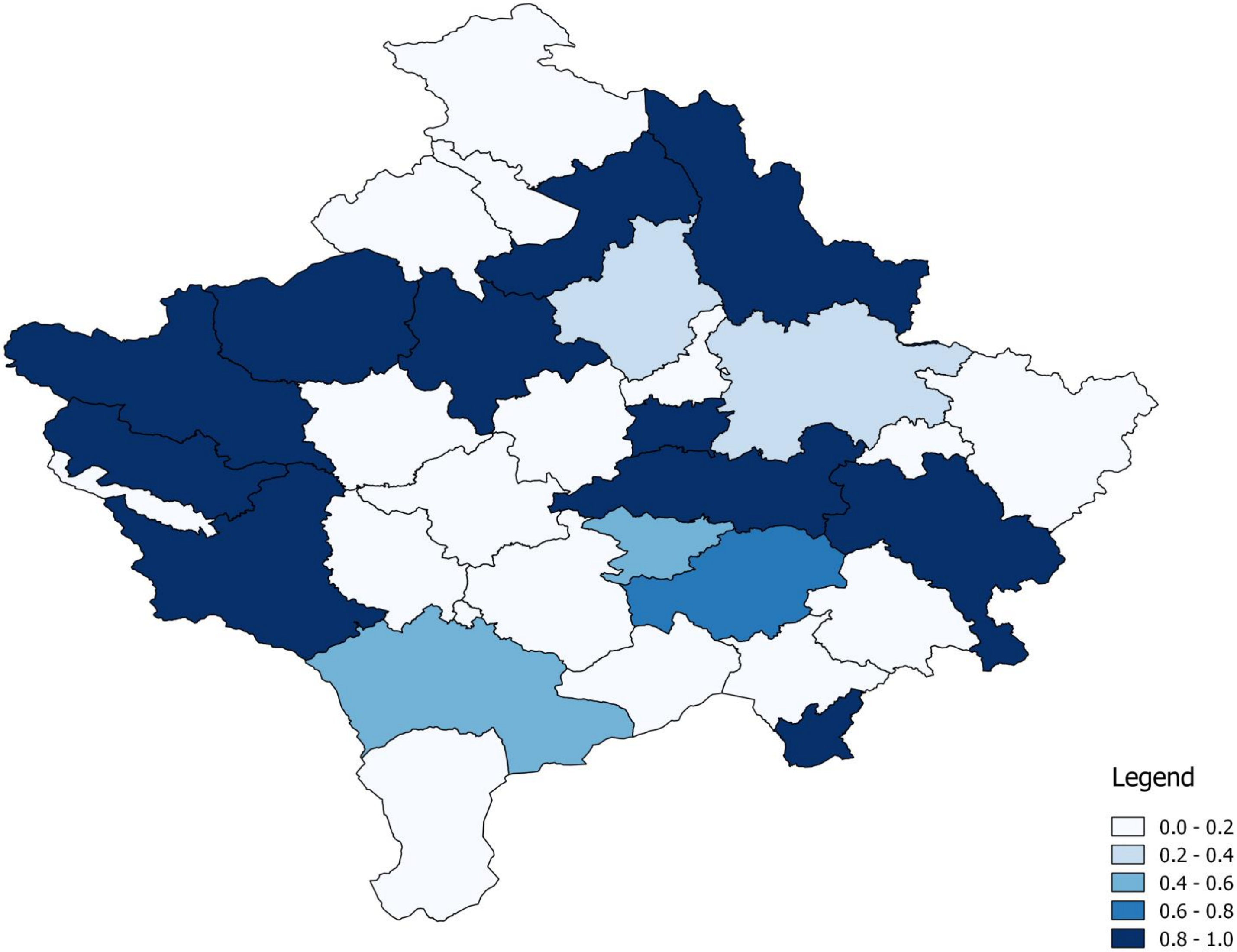
# Typical EE measures identified - roof renovation



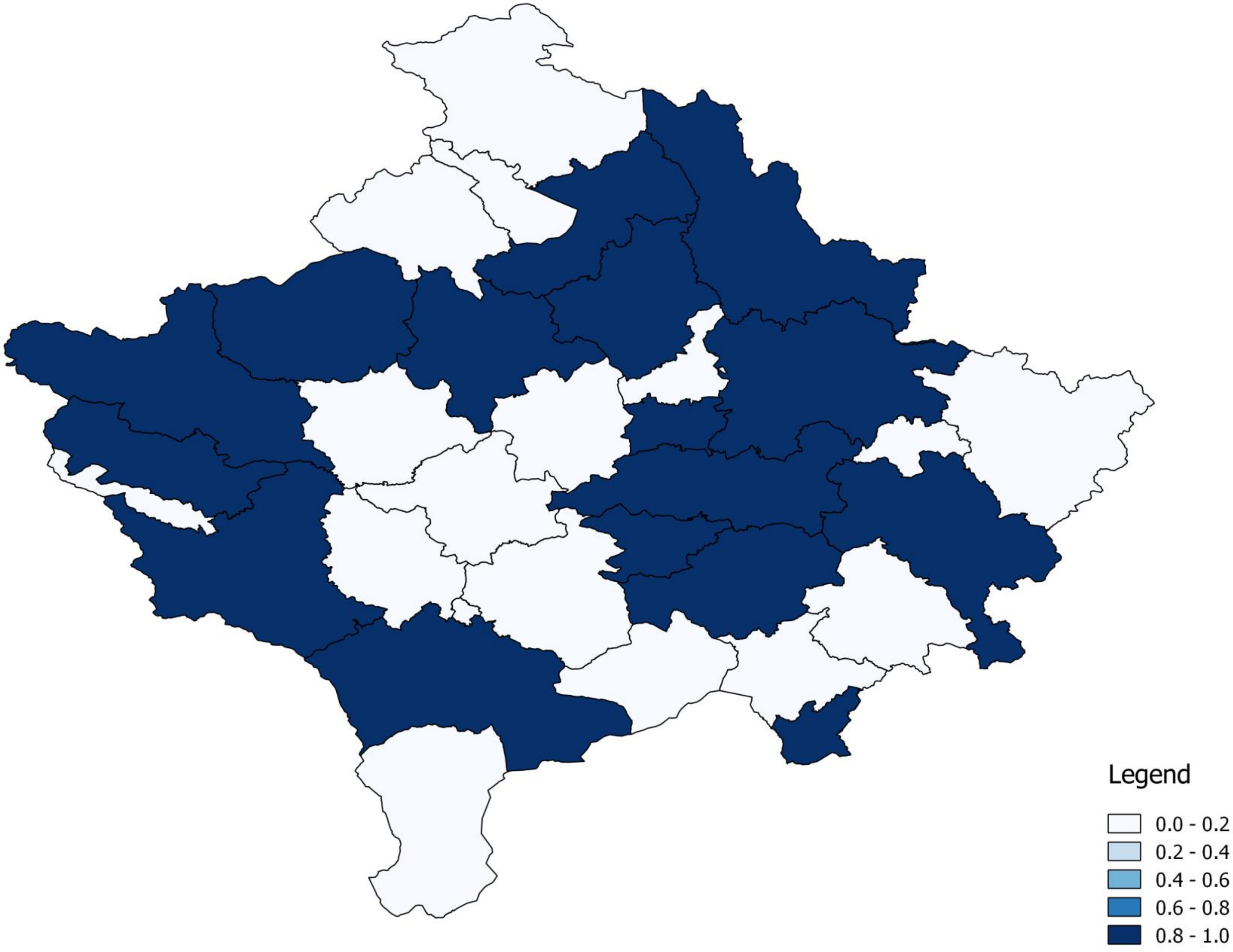
# Typical EE measures identified - windows renovation



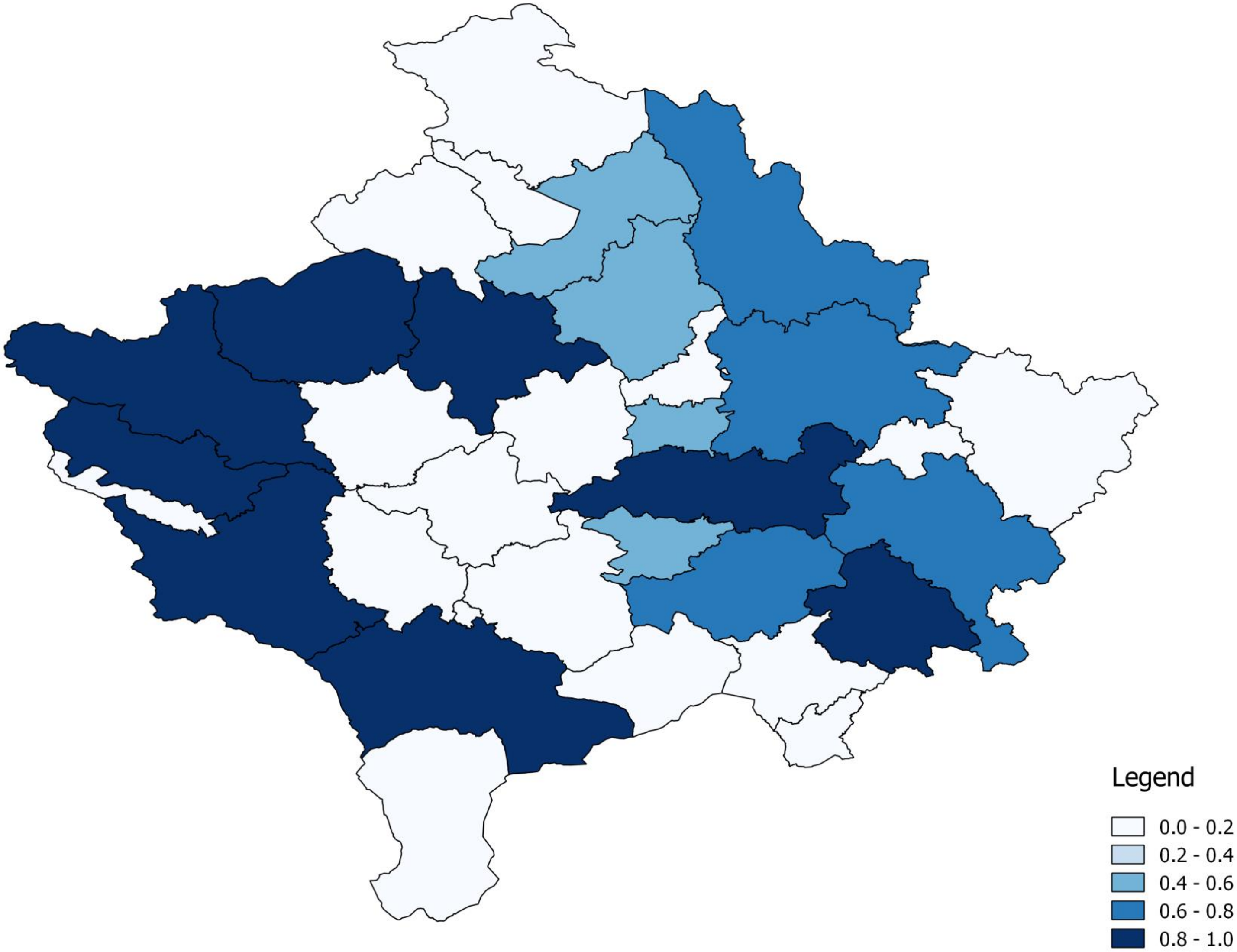
# Typical EE measures identified - fuel switch



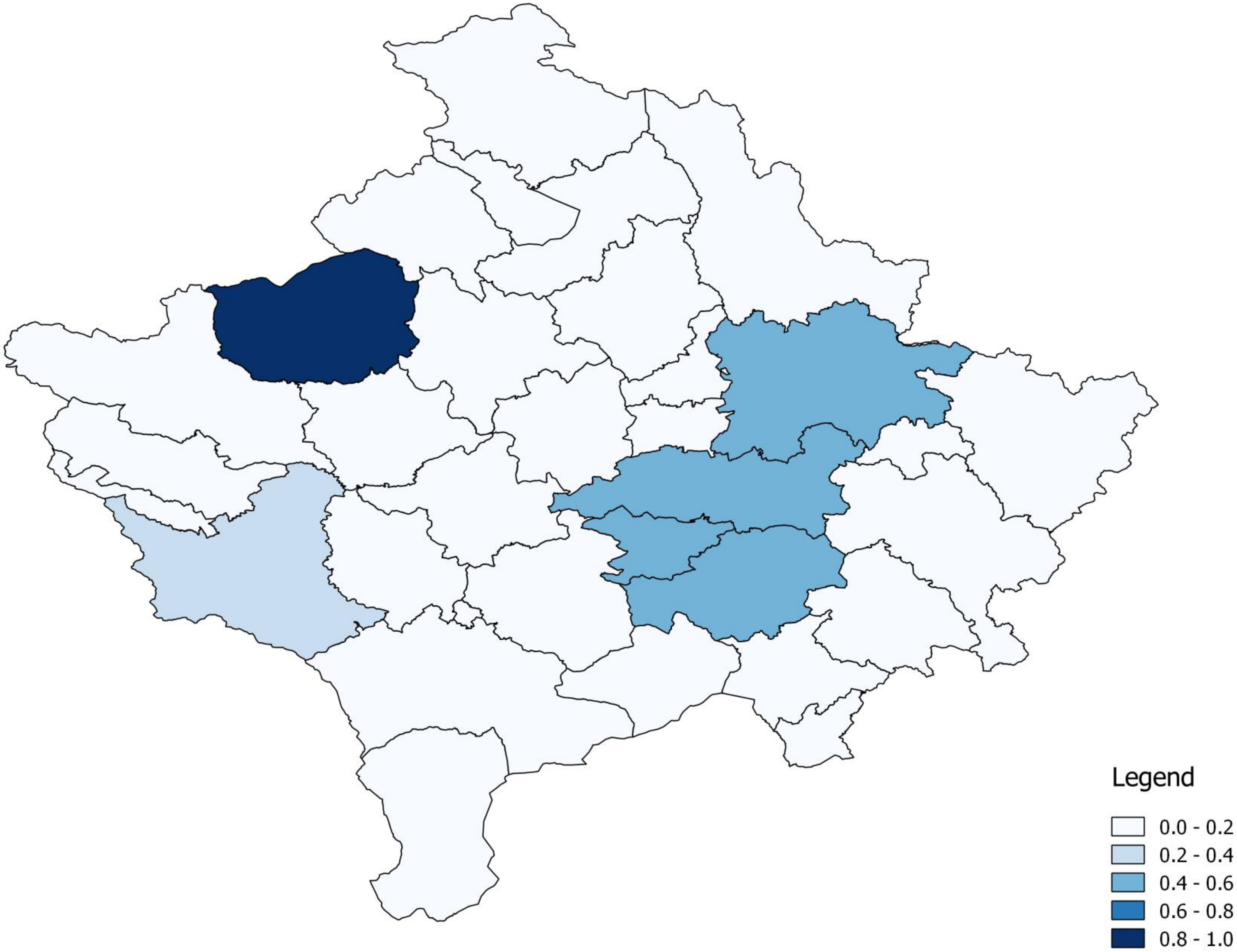
# Typical EE measures identified - heating system



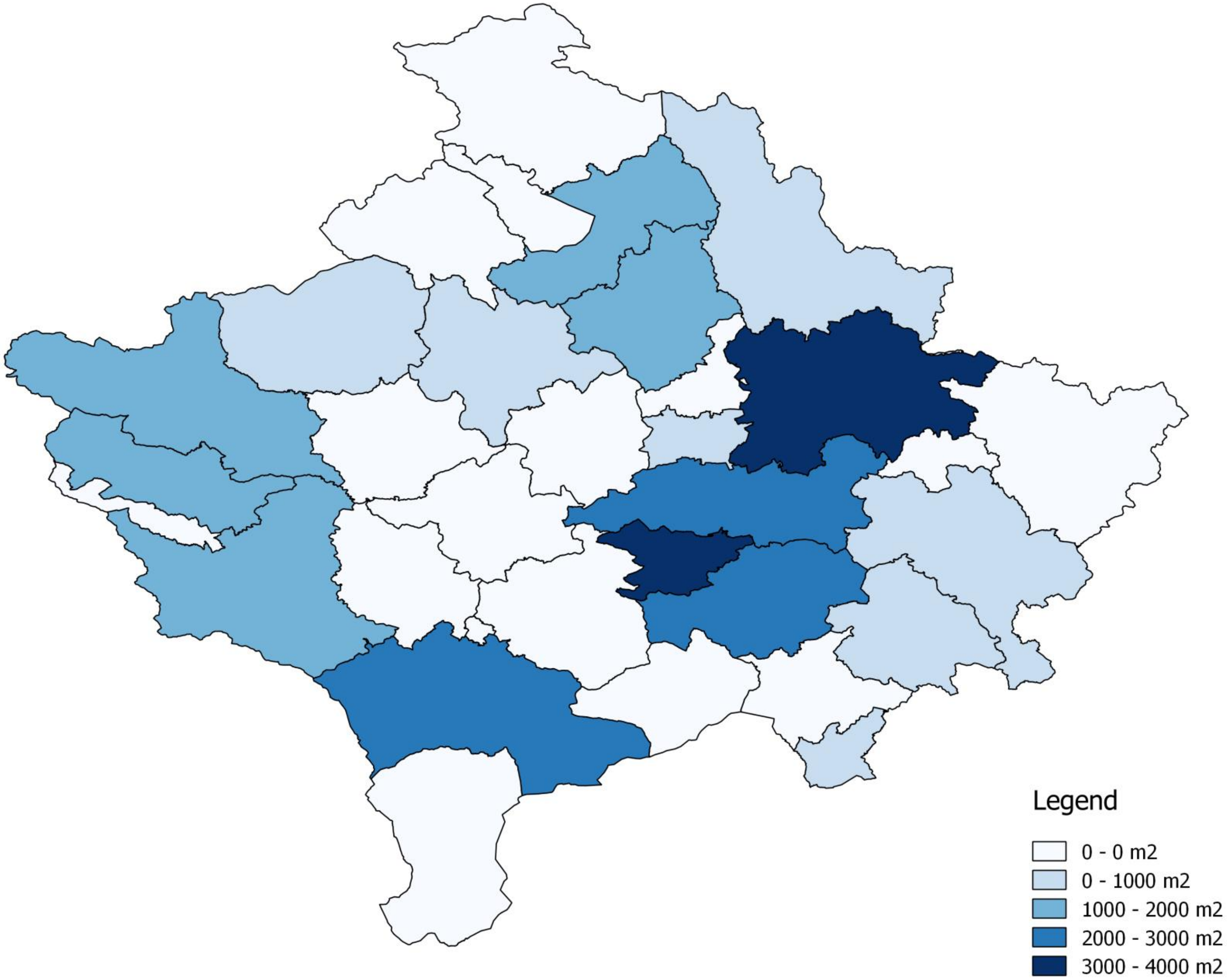
# Typical EE measures identified - lighting system



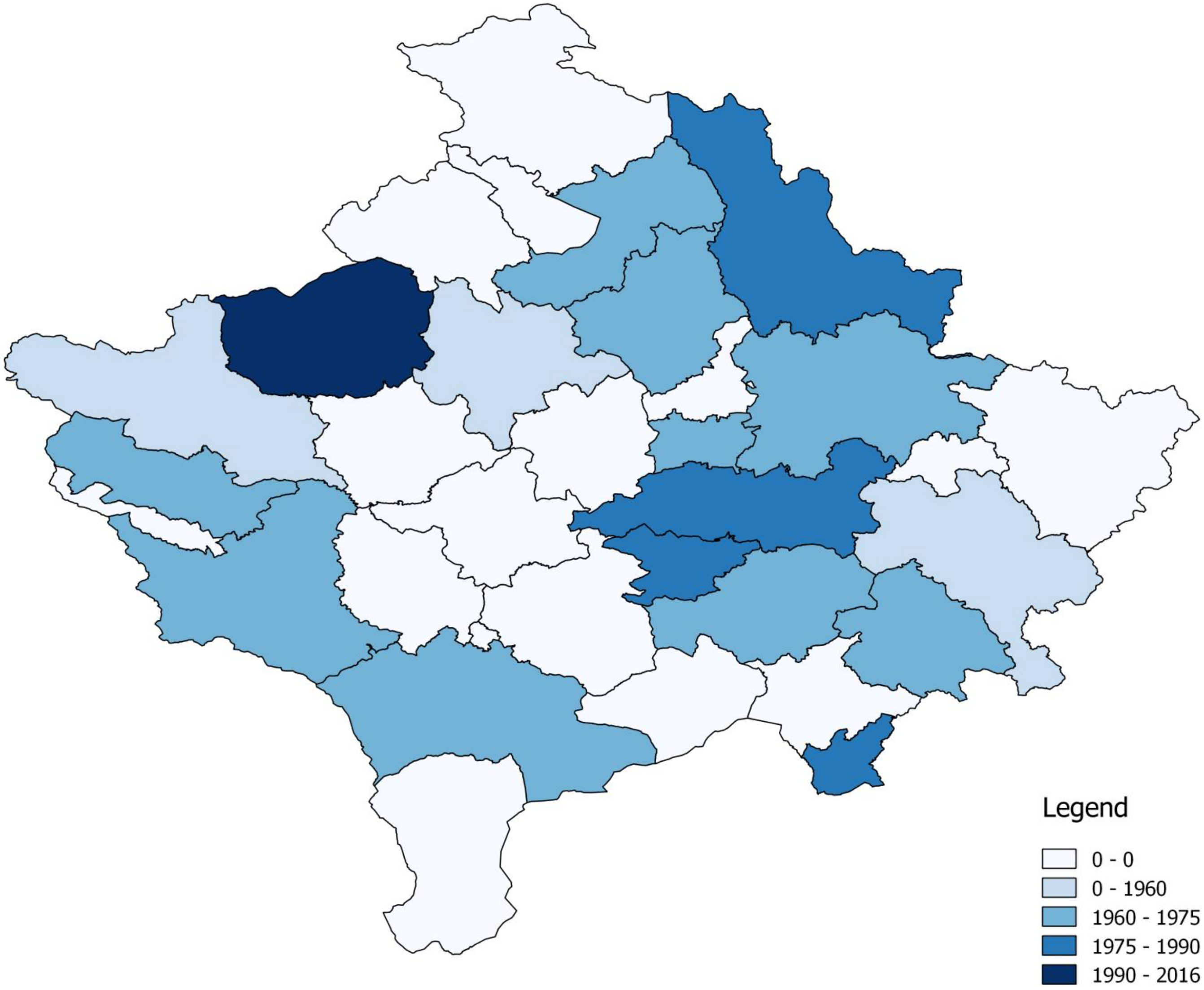
# Typical EE measures identified - solar thermal



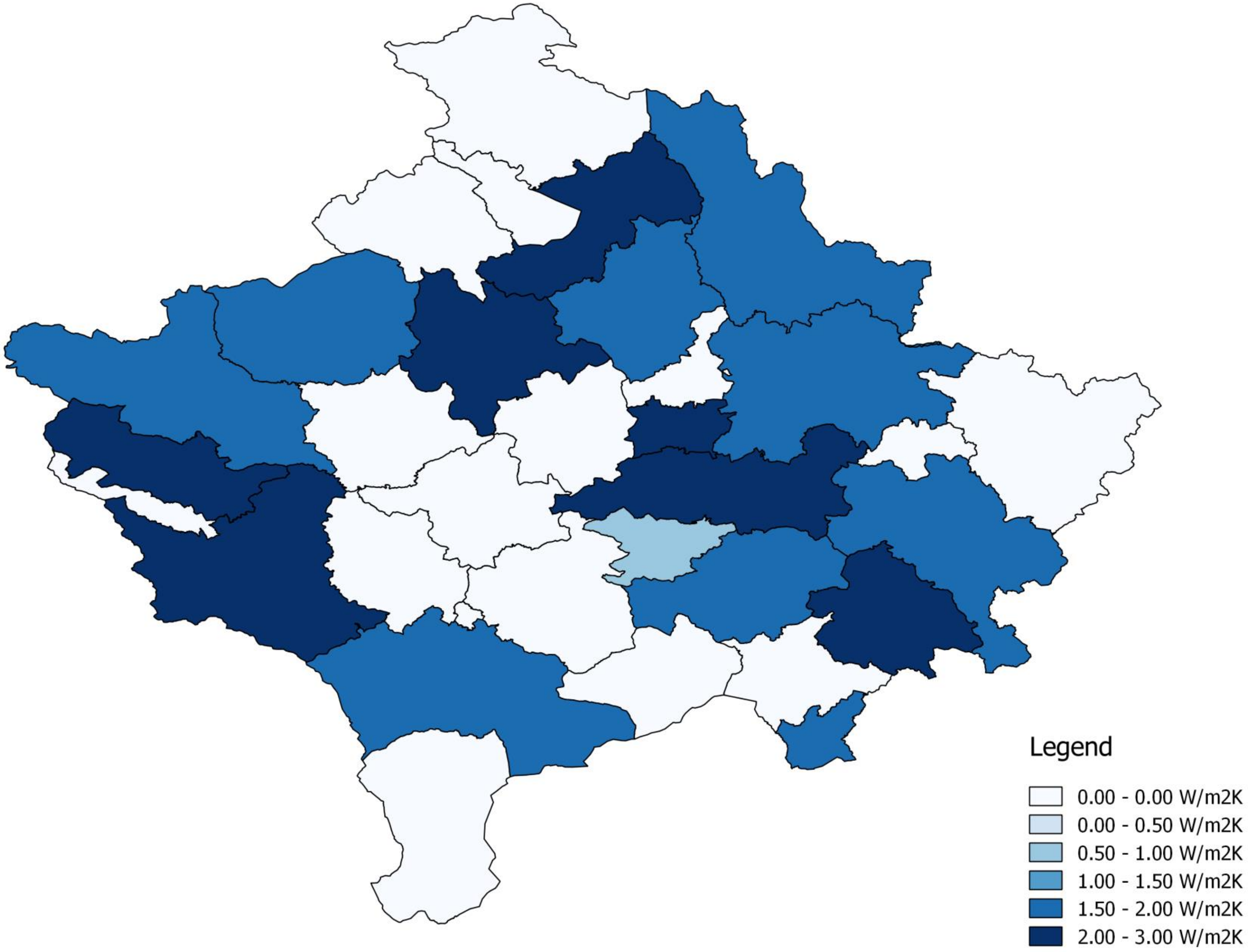
# Summary results - average building heated area



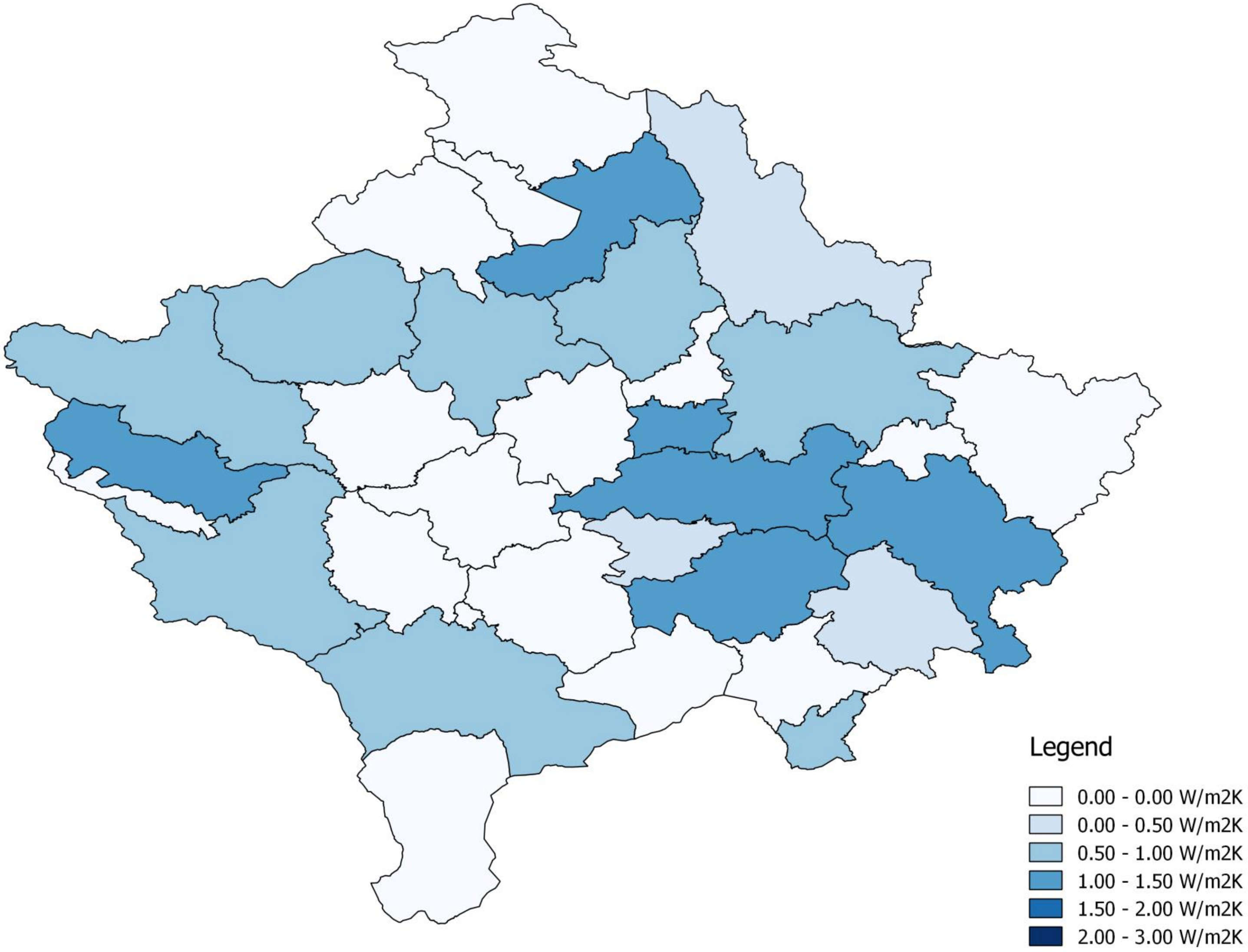
# Summary results - average construction year



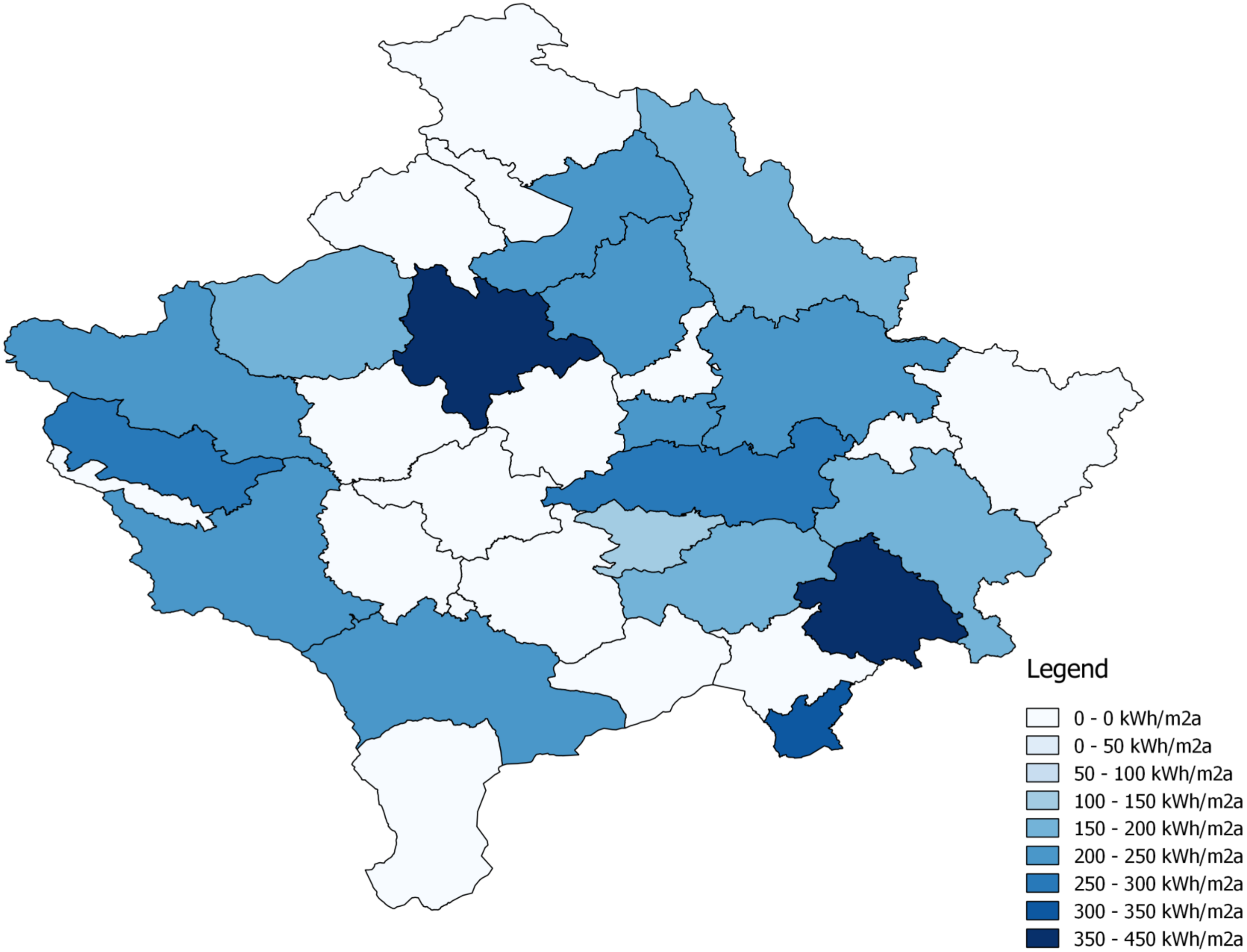
# Summary results - average U-values before



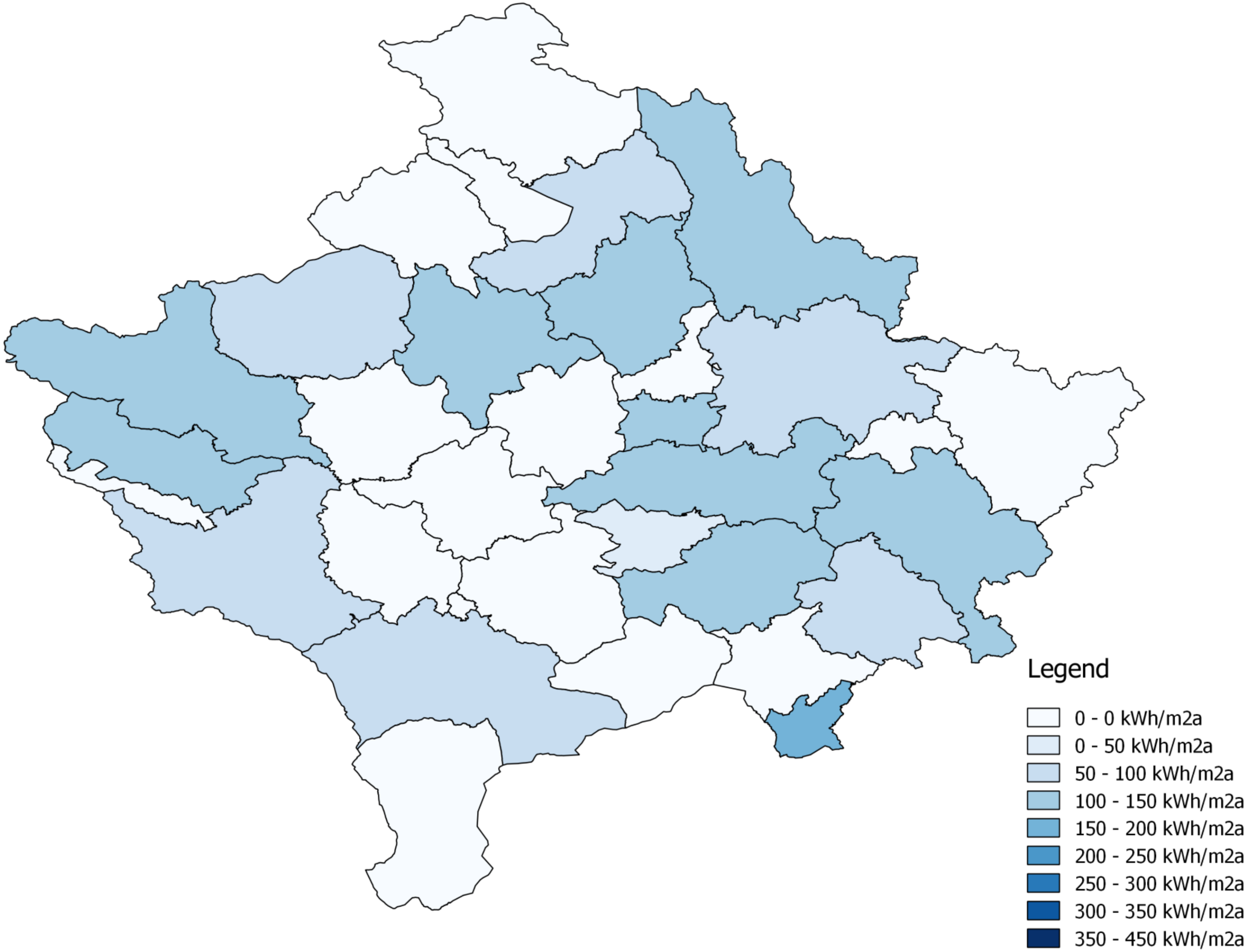
# Summary results - average U-values after



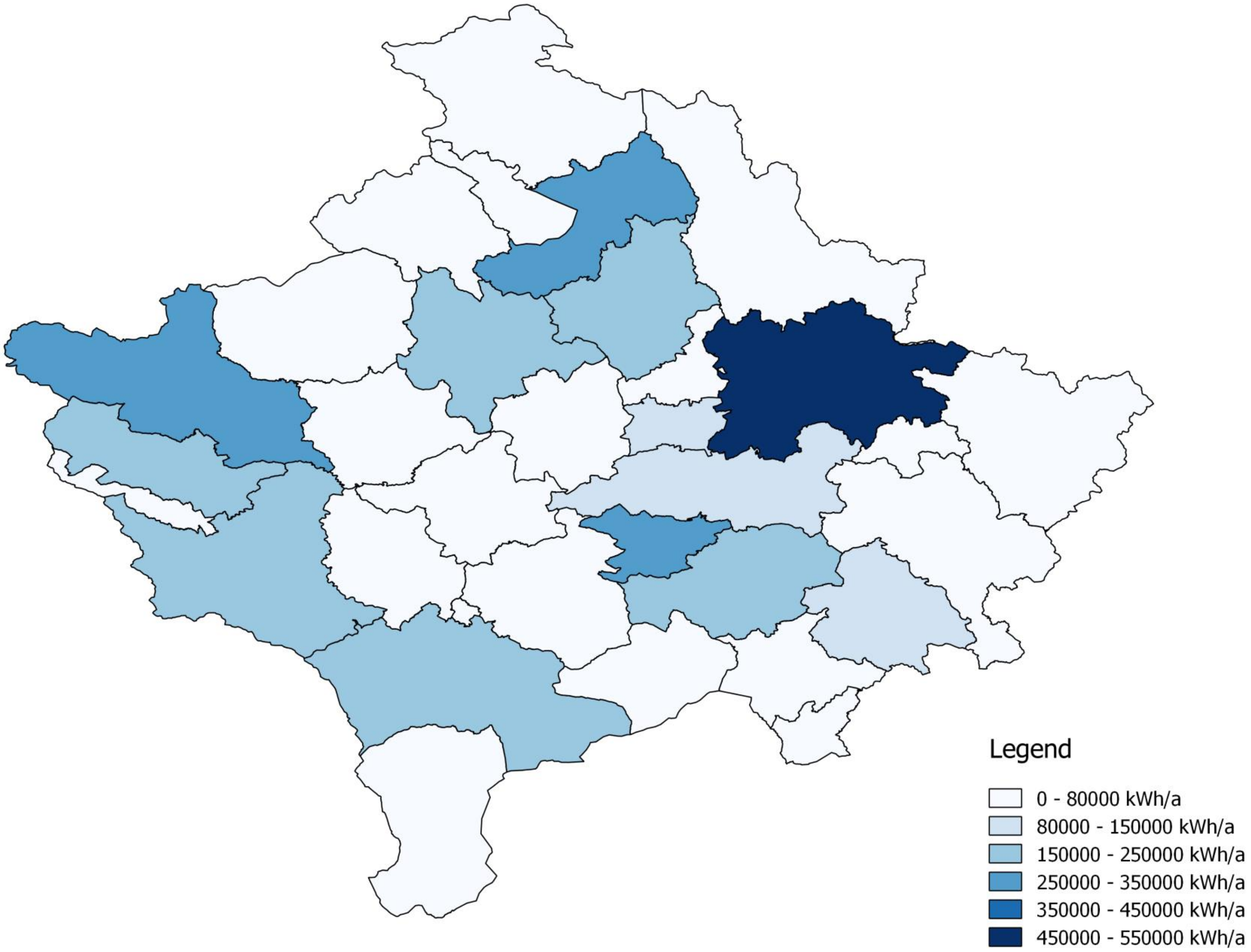
# Summary results - average heating cons. before



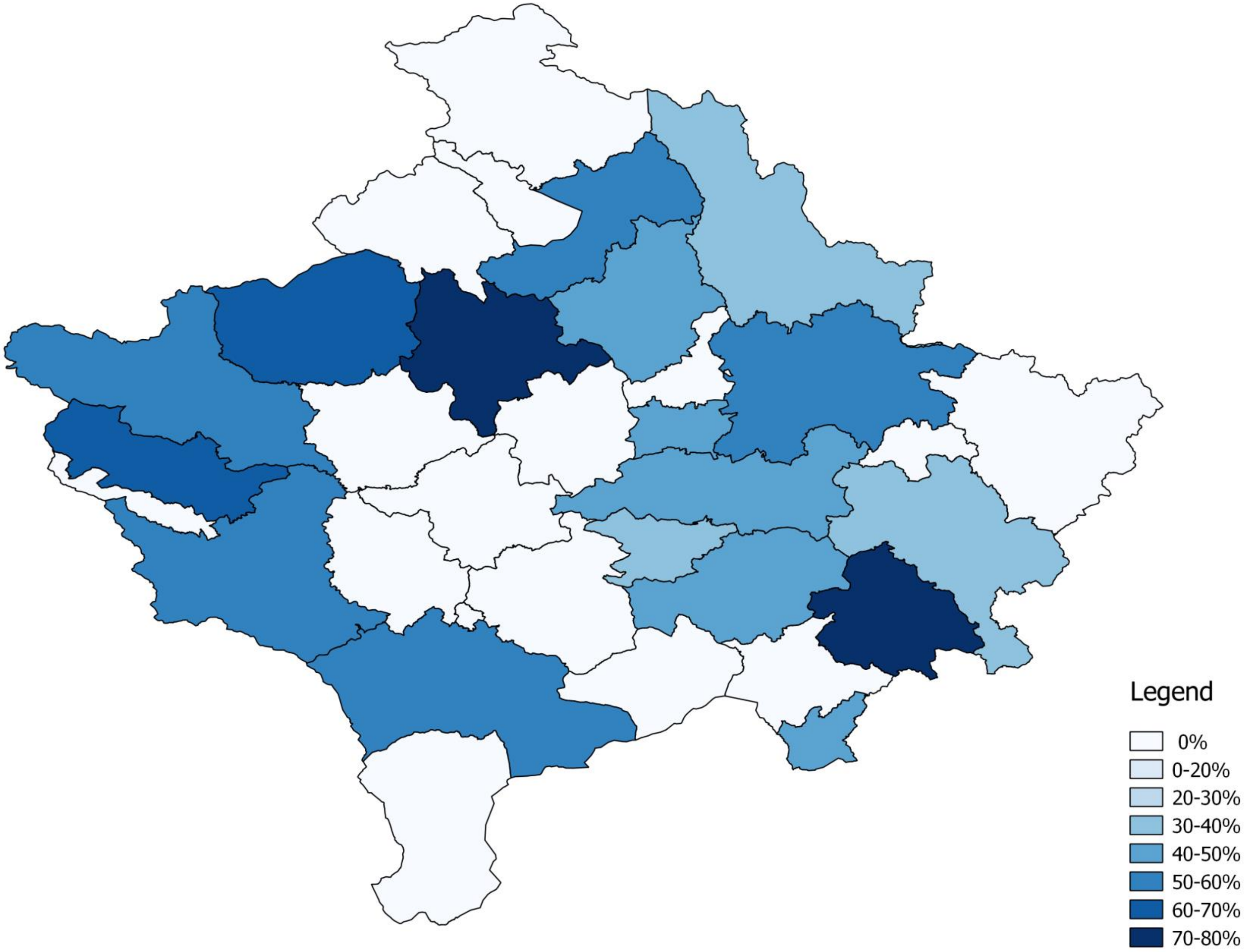
# Summary results - average heating cons. after



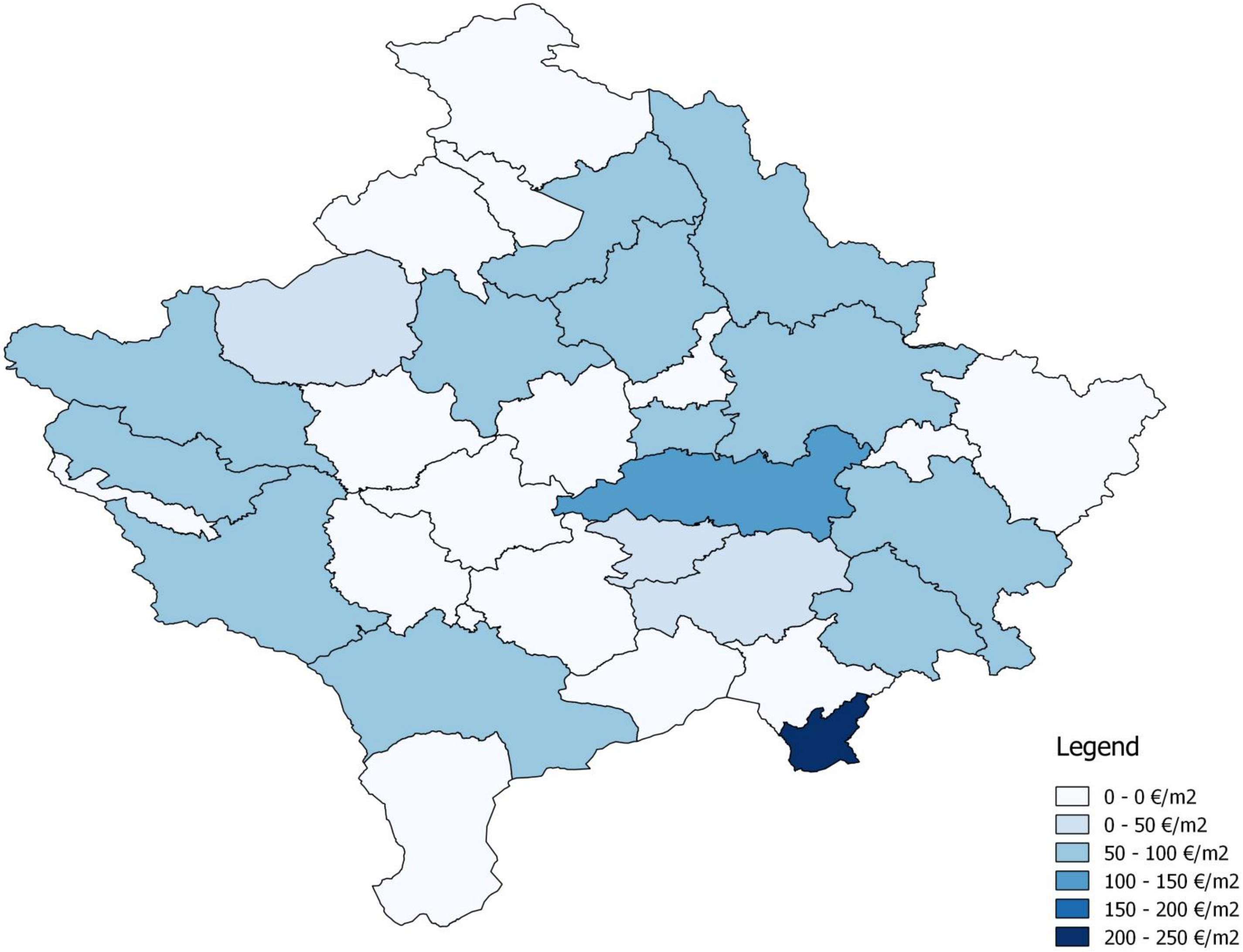
# Summary results - average energy savings



# Summary results - average energy savings %



# Summary results - average spec. EE investment



# Profile

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- Experience in team management and project coordination in energy efficiency, renewable energy and new technologies implementation
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- Extensive experience in technical modeling and preparation of financial analyses for energy efficiency and renewable energy projects
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- Expertise in analysis and assessment of energy sectors, including energy planning
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