# 0 BUSINESS CASE ANALYSIS: SUMMARY

## 0.1 Importance of energy supply

Every office or public building must provide working conditions of a proper quality. Ensuring a certain level of comfort and meeting other demands (e.g. buildings must be equipped with certain installations, hot water, access to data transfer, etc.) requires utilisation of energy. The energy consumption of a building depends on the building itself, installed equipment, as well as the needs, requirements, and behaviour of the users. Excessive energy consumption is reflected in higher costs and creates a negative impact on the environment. Energy audit of a building serves to collect data on the use of certain types of energy for different purposes, and the costs arising from it. At the same time, the energy consumption indicators reveal where the use of energy is higher than in comparable buildings. Possible measures and investment requirement estimates are presented below.

## 0.2 Consumption and costs of energy and water

In the building of Osnovna šola Bičevje (Primary school Bičevje), elementary education is being provided. Continuous supply of energy and water is crucial. The following sections present the structural analysis of energy consumption over the last three calendar years. For the purposes of a more simple comparison, all presented energy cost data in simplified energy audit report do not include VAT (the rate of VAT changed in July 2013). Furthermore, the assessments of the investment value for the implementation of the proposed measures and the assessments of cost savings due to implemented measures exclude VAT. In summary, **all values in the report that represent monetary values (EUR, €) exclude VAT.** Reference values in the analysis of the current state and the analysis of proposed measures have been selected and obtained from energy accounting system (energy products and cold water). **The reference period includes the last three calendar years of 2013, 2014 and 2015.** Individual reference values for the selected periods and the determination of these values are more closely presented in section 9.1.

**Figure 0.1: Average annual energy consumption (left) and costs (right) for energy and water**

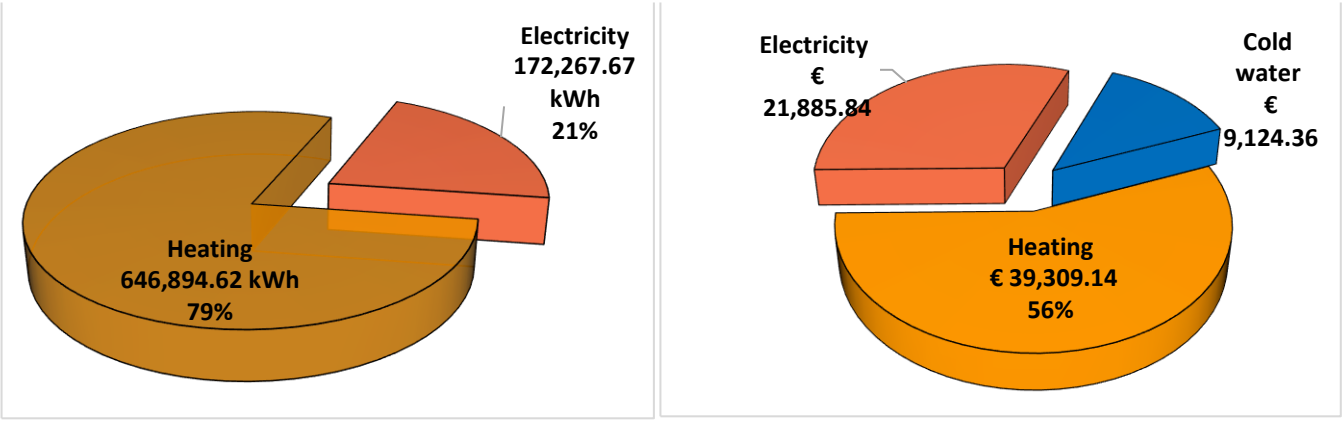

**Table 0.1: Average annual energy consumption and costs in reference period**

| 2013–2015 Average | Consumption of energy | Cost of energy product | $CO_2$ emissions | Primary energy [kWh/m²/yea | Energy rating [kWh/m²/year] |
|---|---|---|---|---|---|
| Heating | 646,894.62 | 39,309.14 | 129.38 | 107.01 | 97.28 |
| Electricity | 172,267.67 | 21,885.84 | 84.41 | 64.76 | 25.90 |
| **Total:** | **819,162.28** | **61,194.97** | **213.79** | **171.77** | **123.18** |
| | **Consumption [m³/year]** | | **Costs [€/year]** | | |
| Cold water | 2,199.33 | | 9,124.36 | | |
| | | | **Total costs 2013–2015 [€/leto]:** | | **70,319.34** |

The data on energy consumption and costs arising from MOL energy accounting suggest that the building, in order to operate and function, consumes about 79% of thermal energy for heating, heating water and food preparation in the kitchen, and 21% of electrical energy for lighting and other devices. Most of the funds (56%) are spent on heat, i.e., natural gas. The remaining costs are distributed in the following proportions: 31% for electricity, 13% for cold water supply from the water supply network.

## 0.3 Key findings

Key findings of the energy audit are as follows:

0.3.1 The building OŠ Bičevje, uses two types of energy carriers: natural gas and electricity. Natural gas is used for space heating, heating of water, and food preparation. Electricity is used for lighting, kitchen appliances, ventilation and other devices required for the building's operation and implementation of activities.

0.3.2 Energy consumption during the analysed reference period is relatively small considering the age and condition of the building.

Energy rating (heating + electricity) of comparable buildings is over 150 kWh/m²/year.

0.3.3 According to users and data obtained from microclimate measurements, the thermal comfort in the building is considered as satisfactory. Radiator heating is carried out based on the outdoor temperature. Room temperature is controlled by radiator valves, mostly without thermostatic heads.

0.3.4 The OŠ Bičevje building comprises the main building and several extensions, which were constructed at various points in time. The envelope of the main building does not feature thermal insulation. Façades are merely plastered with thick cement plaster. The roof features approx. 5 cm of thermal insulation, which does not fulfil the requirements set out in the Rules on efficient use of energy in buildings with a technical guideline (PURES). The doors and windows of the main building were replaced more than 10 years ago and are not energy efficient. The estimated thermal loss of windows exceeds the limits in PURES.

0.3.5 The gym's outer envelope has been renovated and meets the PURES requirements. In 2014, doors and windows were replaced; thermal insulation was installed to the roof and the façade.

0.3.6 The kitchen extension (interior) was renovated in 2014. The past renovation of the interior included additional thermal insulation (15 cm thick) to the roof of the extension. The façade of the extension does not feature thermal insulation. The assessment of the façade showed larger cracks. The manager believes that they were created by subsidence of the extension (a consequence of a new office building in the immediate vicinity).

0.3.7 Thermal energy is generated by two burners, which are mounted on two natural gas boilers (year of manufacture: 2000). The last comprehensive retrofit of the boiler room equipment was performed in 2000; the last retrofit of the boiler room electrical installation was performed in 2009. The boiler room installations are mostly insulated; three-stage pumps are installed.

0.3.8 Electrical installations and power distributors on ground floor, a part of the first floor, and the second floor were retrofitted in 2008. Lighting on ground floor was renovated as well. Kitchen with dining area and ancillary rooms was renovated in 2014. Some electrical installations on first floor need to be retrofitted.

0.3.9 Point of connection is reliable; supply of electricity is impeccable. Electrical systems and low-voltage load shedding distributors have been properly maintained and function normally.

0.3.10 Lighting is relatively effective. Incandescent (filament) lamps are practically non-existent. A large proportion of lighting is made of lamps with fluorescent bulbs and ballasts.

0.3.11 The most suitable investment and technical measures to improve EE of the building concern the building envelope (insulation of façade and roof) and heating system (thermal station renovation and

thermostatic valves).

0.3.12 Building envelope: Thermal insulation of façade (where not present and where it fails to meet the requirements of the Rules on efficient use of energy in buildings with a technical guideline). In addition, we recommend installation of the thermal insulation to the flat roof of the main building, since the insulation in place is insufficient. Replacement of doors and windows is a less suitable measure financially: the payback period is relatively long. The long payback period is caused by a better heat transfer of the existing windows compared to windows of lower quality without inert gas fills.

0.3.13 The installation of thermostatic valves should be the priority measure, as it is one of the more cost-effective measures and significantly affects achieving the optimal thermal environment. A comprehensive retrofit that features renovation of the building's envelope should include a condensing boiler installation, which will yield much better EE than the existing one. The best boiler efficiency can be achieved at lower temperature regimes, so the heat loss due to transmission must be as low as possible.

0.3.14 Retrofit of the building's electricity system (and lighting) carries a smaller, but not insignificant EE potential. At the cursory inspection, we noticed many light bulbs that were either broken or not installed at all. Therefore, it can be expected that the retrofit will yield lower savings (electricity) that could indeed be reached. Lower savings in lighting retrofit can also be expected due to current standards that dictate stricter requirements, increasing the number of lamps, consequently increasing the electrical power, and reducing the actual savings on account of electricity. Nevertheless, this would significantly improve the working conditions in the building, which is essential for its users.

0.3.15 In order to lower the energy consumption, it seems sensible to first implement soft (organisational) measures – systematic steering towards energy efficient user behaviour demands minimum investment and shortest payback period. We have proposed some organisational measures in connection with smaller financial investments (e.g. implementation of energy monitoring).

0.3.16 Other important factors include educating users, technical personnel training, and implementing targeted monitoring of operation and maintenance (energy cost planning, preventive maintenance and repair). Qualified personnel must be familiar with system operation on an hourly level. In this case, the deviations can be discovered as soon as they arise, while it is also possible to review past operations. Therefore, installation of suitable sensors and meters for remote reading are required, and an information system should be established.

### 0.4 Potential savings and required investments

The energy audit points out possible measures for a more efficient energy use (EE), i.e., reducing the costs and consumption of heat, electricity and water. We have analysed economically viable measures and predicted the estimated payback period of an investment. The proposed measures are divided into two sections: the organisational measures and the investment measures. All proposed measures beneficially affect EE and reduction of costs. They differ in payback period of an investment and importance of implementation.

The basic set of anticipated measures has been modified based on our correspondence with the building's manager and owner; technical solutions have been defined with the help of external associates from respective areas. In this way, we have also considered constraints and restrictions relating to the implementation of EE measures and lowering the maintenance cost. Values and planning of individual investments are indicative, as is usual at the level of simplified energy audits. To present detailed technical solutions for specific measures, it is necessary to create implementation project (PZI), wherein the measures are analysed, and a detailed list of necessary works is provided. The retrofit project must include a description of technical measures, a description of possible risks arising from their individual or interactive influence, and guidelines for users to limit the risks through preventive and corrective measures.

The term *comprehensive energy retrofit* applies to a harmonised implementation of measures to ensure energy efficiency (e.g. on façade, roof, flooring) of the building's technical systems (e.g. heating, ventilation, air-conditioning, hot water) in order to make full use (if possible) of the economically viable potential for the energy retrofit.

The main advantage of an integrated approach is the possibility of interactive optimisation of individual measures through a single larger-scale operation. Simplified energy audit report lists several scenarios arising from the financial, organisational and strategic capabilities and policies of the investor.

Four scenarios are included into a simplified energy audit:

- Scenario Zero (0) encompasses measures with minimal investment cost (mostly organisational measures).
- Scenario One (1) encompasses comprehensive energy retrofitting compliant with the Rules on efficient use

of energy in buildings with a technical guideline (PURES) and provides nearly zero-energy buildings, regardless of economic viability.

- Scenario Two (2) encompasses the entire technically feasible and economically viable potential of measures implemented. Scenario 2 represents the selected measures, which were identified as the most beneficial in terms of comprehensive energy retrofitting.

**Table 0.2: Scenario 0: Proposed measures**

| No | Description of measure | Potential annual savings | | | | Implementation | Payback | Priority |
|---|---|---|---|---|---|---|---|---|
| | | Heatin | Electri | $CO_2$ | Costs | Total | | |
| | | MWh | MWh | kg | EUR | EUR | years | |
| **ORGANISATIONAL MEASURES** | | | | | | | | |
| 1. | Organisational measures | | | | | | | I. |
| | Education and promoting | 21.80 | 3.45 | 6,048 | 1,667 | € 1,000 | 1 | I. |
| | Maintenance | | | | | | | I. |
| **SPECIFIC ORGANISATIONAL MEASURES** | | | | | | | | |
| 2. | Monitoring + Energy | 43.60 | 6.89 | 12,096 | 3,333 | 20,000 | 6 | II. |
| **ALL ORG. MEASURES TOTAL** | | **65.40** | **10.34** | **18,144** | **5,000** | **21,000** | **4** | |

NOTE:

All prices exclude VAT.
Price of electricity for 2015: 0.13009 €/kW
The price of end-use thermal energy in 2015 0.05590 €/kW h

**Table 0.3: Scenario 1: Proposed measures**

| No | Description of measure | Potential annual savings | | | | Investment | Payback | Priority |
|---|---|---|---|---|---|---|---|---|
| | | Heating | Electrici | $CO_2$ | Costs | Total | | |
| | | MWh | MWh | kg | EUR | EUR | years | |
| **TECHNICAL INVESTMENT MEASURES** | | | | | | | | |
| 0. | Building envelope | | | | | | | |
| | Monitoring + Energy | 9.47 | 6.89 | 5,270 | 1,426 | 20,000.00 | 14 | I. |
| 1. | Building envelope | | | | | | | |
| | Façade thermal insulation – SCHOOL | 106.37 | | 21,274 | 5,946 | 113,120.0 | 19 | I. |
| | Façade thermal insulation – KITCHEN | 8.00 | | 1,600 | 447 | 19,380.00 | 43 | |
| | Façade thermal insulation – BUILDING | 6.27 | | 1,254 | 350 | 17,040.00 | 49 | |
| | Replacing windows | 38.89 | | 7,779 | 2,174 | 373,450.0 | 172 | I. |
| | Replacing doors | 7.37 | | 1,474 | 412 | 37,000.00 | 90 | I. |
| | Flat roof thermal insulation – SCHOOL | 33.11 | | 6,622 | 1,851 | 128,960.0 | 70 | III. |
| | Flat roof thermal insulation – BUILDING | 3.45 | | 690 | 193 | 9,750.00 | 51 | |
| | Total | 203.47 | | 40,693 | 11,37 | 698,700.0 | 61 | |
| 2. | Mechanical system measures | | | | | | | |
| | Condensing boiler installation | 81.11 | | 16,221 | 4,534 | 45,000.00 | 10 | I. |
| | Installation of thermostat valves and heads and | 13.02 | | 2,604 | 728 | 21,440.00 | 29 | II. |
| | Circulator pump replacement | | 7.24 | 3,548 | 942 | 6,400.00 | 7 | |
| | Air/water heat pump installation (for heating | 26.68 | –8.89 | 978 | 334 | 5,500.00 | 16 | |
| | Installation of a central ventilation system for | 102.27 | –28.00 | 6.733 | 2.074 | 280,000.0 | 135 | III. |
| | Total | 223.07 | –29.65 | 30,084 | 8,612 | 358,340.0 | 42 | |
| 3. | Measures for electrical | | | | | | | |
| | Lighting retrofit and installation of proximity | | 29.70 | 14,553 | 3.864 | 70,600.00 | 18 | I. |
| | | | | | | | | |
| **TOTAL TECH & INV** | | **436.0124** | **6.9355** | **90,601** | **25,27** | **1,147,640.** | **45** | |

NOTE:

All prices exclude VAT.
Price of electricity for 2015: 0.1301 €/kW
Price of heating for 2015: 0.0559 €/kW h

**Table 0.4: Scenario 2: Proposed measures**

| No | Description of measure | Potential annual savings | | | | Investment | Payback | Priority |
|---|---|---|---|---|---|---|---|---|
| | | Heating | Electric | $CO_2$ | Costs | Total | | |
| | | MWh | MWh | kg | EUR | EUR | years | |
| **TECHNICAL INVESTMENT MEASURES** | | | | | | | | |
| 1. | Building envelope | | | | | | | |
| | Monitoring + Energy management | 20.34 | 5.77 | 6,894 | 1,887 | 20,000.00 | 11 | I. |
| 1. | Building envelope | | | | | | | |
| | Façade thermal insulation – SCHOOL | 106.37 | | 21,274 | 5,946 | 113,120.0 | 19 | I. |
| | Façade thermal insulation – KITCHEN | 8.00 | | 1,600 | 447 | 19,380.00 | 43 | |
| | Façade thermal insulation – BUILDING and | 6.27 | | 1,254 | 350 | 17,040.00 | 49 | |
| | Flat roof thermal insulation – SCHOOL | 33.11 | | 6,622 | 1,851 | 128,960.00 | 70 | |
| | Flat roof thermal insulation – BUILDING and EXTENSION | 3.45 | | 690 | 193 | 9,750.00 | 51 | |
| | Total | 157.20 | 0.00 | 31,440.4 | 8,787.6 | 288,250.0 | 33 | |
| 2. | Heating system | | | | | | | |
| | Condensing boiler | 92.09 | 0.00 | 18,419 | 5,148 | 45,000.00 | 9 | I. |
| | Installation of thermostat valves and heads and | 14.78 | | 2,957 | 826 | 21,440.00 | 26 | I. |
| | Circulator pump | | 7.24 | 3,548 | 942 | 6,400.00 | 7 | I. |
| | Air/water heat pump installation (for | 26.68 | –8.89 | 978 | 334 | 5,500.00 | 16 | I. |
| | Total | 133.56 | –1.65 | 25,901 | 7,251 | 78,340.00 | 11 | |
| 3. | Measures for electrical | | | | | | | |
| | Lighting retrofit and installation of proximity | | 29.70 | 14,553 | 3.864 | 70,600.00 | 18 | I. |
| | | | | | | | | |
| **TOTAL TECH & INV** | | **311.096** | **33.8155** | **78,788.79** | **21,789.3** | **457,190.0** | **21** | |

NOTE:

All prices exclude VAT.
Price of electricity for 2015: 0.1301 €/kWh
Price of heating for 2015: 0.0559 €/kWh

## 0.5 Energy indicators before and after the implementation of measures

In accordance with Energy Act (EZ-1) and Rules on the methodology for the production and issuance of energy performance certificates for buildings, all public buildings must have an energy performance certificate that defines the building's rating (band). The building has an energy performance certificate; it is available at the public portal of Ministry for Environment and Spatial Planning.

### 0.5.1 Scenario 1: Energy indicators before and after the implementation of nearly zero-energy retrofit

The red arrow marks the current state of building; the green arrow marks the state after the energy retrofit according to Scenario 1.

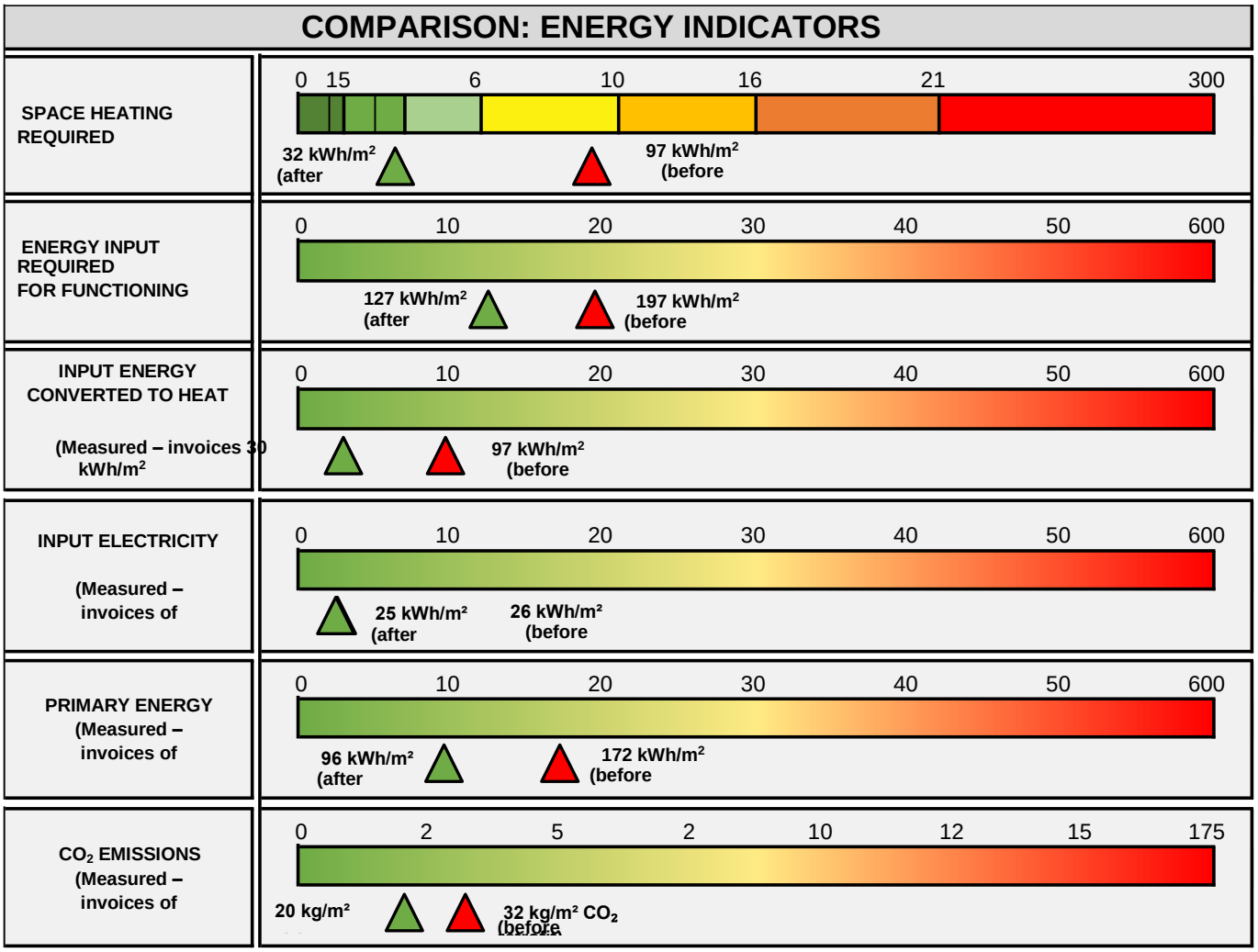


**Figure 0.2: Comparison of energy indicators**