RESULT ORIENTED REPORT
PROJECT ZagEE

MLEI ZagEE
ENERGY EFFICIENT CITY
The City of Zagreb, as the capital of the Republic of Croatia, acknowledged the importance of the implementation of EU energy policy for sustainable development of urban areas. By joining the initiative of the Covenant of Mayors and many European initiatives with the goal of realising high energy goals set by the European Union, the City of Zagreb has clearly shown its commitment towards energy sustainable development as well as its readiness to provide assistance, as a Supporting structure of the European Commission, in the implementation of the initiative to other local and regional self-governments.

The responsible energy policy of sustainable development of the City of Zagreb was confirmed through the acceptance of the new Covenant of Mayors for climate and energy initiated by the European Commission, by which the City accepted to reduce the emission of greenhouse gases by 40% until 2030. The rational use of energy, application of energy efficiency measures, the use of renewable energy sources and ecologically acceptable fuels and the implementation of new green technologies have strong and favourable impact on economic development, protection of natural resources, and safe future of our planet.

As responsible city administration, in co-ordination of the City Office for Energy, Environment and Sustainable Development of the City of Zagreb and in co-operation with the North-West Croatia Regional Energy Agency (REGEA), the realisation of the ZagEE project (Zagreb – Energy Efficient City) was launched in 2013, with the ambitious goal of achieving significant energy savings and reduction of CO₂ gas emissions through energy refurbishment of public buildings and partial modernisation of the public lighting system of the City of Zagreb.

Following the launch of the project ZagEE, concrete initial steps were undertaken in the realisation of the transformation of urban areas of the City into ecologically sustainable areas and in the realisation of the vision of development of the City of Zagreb as a smart, energy and ecologically sustainable city.

Thanks to the realisation of the ZagEE project, today we can proudly talk about the initiation of an investment of complete energy refurbishment of 87 public buildings – kindergartens, primary and secondary schools, homes for the elderly, health care homes and city administration buildings, with expected energy savings of over 50%. In the process of partial modernisation of the public lighting system by replacement of ball energy inefficient lamps with new energy efficient LED lamps at over 3,000 locations, significant energy savings of over 76% per lighting unit were achieved, with significant decreases in light pollution.

In our committed work on the energy refurbishment of buildings, we have not neglected the human factor – in addition to satisfied users and employees who work in renewed buildings, we co-operated successfully with numerous representatives of cities, local and regional self-government, we relayed positive experiences and know-how and worked on raising the awareness about the need of rational energy use of many of our fellow citizens in the Republic of Croatia and in the wider region. It is our priority to continue to work on quality projects of energy and ecologically sustainable development, because only through their implementation we can achieve high ranking goals which enable sustainable development of the City. By our example we wish to show and prove that such projects are doable and that they result in positive results that benefit us all.

Projects such as ZagEE are important drivers of local and regional development. I hope that this material will help and encourage you to accept the challenges we all face in our endeavours to make our cities “green, energy efficient and ecologically sustainable”.

Milan Bandić, Mayor of the City of Zagreb
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Project Acronym: MLEI ZagEE - City of Zagreb (HR)
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Implementation of the ZagEE project (Zagreb – Energy Efficient City) serves to achieve significant energy savings via economically justified, energy efficient technologies and measures in 87 public buildings. The energy refurbishment programme includes city administration buildings, primary and secondary schools, kindergartens, home for elderly and disabled persons, health care homes, and local self-government buildings owned by the City of Zagreb, and the modernisation of 3,000 public lighting units through their replacement with LED lights and a control management system.

11. Project goals and purpose

The proactive energy policy of the City of Zagreb sets high goals in order to perform the obligations from the Covenant of Mayors and the City of Zagreb Sustainable Energy Action Plan (SEAP), with a view of reducing the CO₂ emissions by at least 21% until 2020 through energy efficiency measures and the use of renewable energy sources. The building sector holds a 58% share in the energy consumption of the City of Zagreb and a great potential for energy savings lies precisely in that sector. Certain short-term measures can have an important role in the achievement of EU goals 20-20-20. They consist of only simple, quick-paying investments. However, in order to achieve the set goals, significantly lower the emissions of CO₂, greater investments are needed in the integrated measures of energy refurbishment. Specific consumption of thermal and electrical energy for most buildings owned by the City exceeds the national and European standards set for new buildings; it must be reduced considerably, and it is necessary to come closer to the standards.

THE GENERAL GOALS OF THE PROJECT:
— to increase the functionality, energy and economic efficiency of public buildings through the application of energy efficiency measures, use of renewable energy sources, and ecologically acceptable fuels
— to train public administration employees in management of complete energy refurbishment projects
— to define legislative, financial and technical problems that might arise during the project in order to launch initiatives for changes to the legislation, regulations, and/or improvement of the existing financial instruments
— to ensure healthier and more pleasant environment for public building users, i.e. employees, children, and the elderly
— to encourage other economic sectors by creating new business opportunities, new workplaces, contributing to positive economic movements, and encouraging economic development as a whole
— to raise awareness of the need to reduce greenhouse gases and to protect the environment through rational use of energy, renewable energy sources, and ecologically acceptable fuels
— the possibility of using the same project in other parts of Croatia and in the wider region
THE SPECIFIC GOALS OF THE PROJECT:

- Energy refurbishment of 87 buildings owned by the City of Zagreb and modernisation of 3,000 lighting units
- 49% of average energy savings in buildings and 72% in public lighting
- Realisation of energy savings of 33,526 MWh/a
- 290 MWh/a of energy produced from renewable sources
- Reduction of greenhouse gas emission by 8,390 tCO$_2$ annually
1.2. Key indicators of project success

— A complete set of technical documents for the purpose of investments and implementation of public tenders for works on the energy refurbishment and modernisation of the public lighting system has been prepared;
— The investment plan for energy refurbishment of buildings and modernisation of the public lighting system included in the ZagEE project (Programme ZagEE 2013-2017) in the amount of HRK 223 million (EUR 29.38 MIL) was adopted by the City of Zagreb City Assembly in November 2013;
— The co-ordinating body consisting of the representatives of project partners and the competent city offices for buildings subject to refurbishment raised its level of skills, knowledge and capacity in the implementation of complete public building and public lighting systems energy refurbishment projects;
— The ZagEE project became a role model applicable to local and regional self-gover-

ment and it was a positive influence in the adoption of decisions at national level concerning the need of supporting energy efficiency, the use of renewable energy sources and ecologically acceptable fuels in the building and public lighting sector within the OP “Competitiveness and Cohesion” for the period 2014-2020;
— Positive reactions of the policy, financial institutions, and the experts in the field from the commencement of project implementation were key not only for the successful realisation of the project, but they also had an impact on rising public awareness. Significant progress was also noted in the energy refurbishment of public and private buildings in the City of Zagreb;
— By March 2017, a significant investment was launched to perform energy refurbishment on 48 public buildings (total heated area of 110,396 m²) and modernisation of the public lighting system:

**Energy refurbishment of 28 buildings** is completed, works on **13 further buildings** were contracted and are in progress, and **tenders** were announced for **7 new buildings**.

**Modernisation** of the **public lighting** system for **1,106 lighting units** was performed and tender for works on the following **231 public lighting** positions published.

**Tender documents** for the remaining buildings and public lighting are being prepared for the announcement of **new tenders in 2017 and 2018**.

**Energy produced** from renewable energy sources amounts to **287 MWh/a**.

**Achieved energy savings** in buildings amounts to **12,773 MWh/a** and in the system of **public lighting up to 552 MWh/a**.

**CO₂ emissions are reduced** by **3,572 tCO₂/a**.
1.3. Lessons learned

— For the realization of the ZagEE project, given the size of the investment and its complexity in implementation, it was essential to have the support of city administration. In order to achieve the aforementioned, concrete indicators have been developed to show multiple benefits that the implementation of the ZagEE project brings to city administration, managers and building users as well as the entire society;

— Any investment project must demonstrate its feasibility through economic-financial analyses that proves the economic justifiability of the investment in energy efficient technological solutions;

— Development of an investment project requires initial investments that are risky. The programme MLEI-PDA enables for the risk of initial investments to be reduced and for a project with a high likelihood of realisation to be prepared;

— Quality organisation and co-ordination of project implementation is key for its success. The co-ordinating team must have professional knowledge and responsibility, but also the opportunity to adopt implementation decisions and it is therefore important that the appointment of the co-ordinating team be confirmed by the mayor;

— In order to launch the complex investment of the ZagEE project, it was primarily important to draw up an investment plan – Programme for the Energy Refurbishment of Buildings and Public Lighting Systems (ZagEE - Zagreb Energy Efficient City). Following its adoption by the City Assembly, the ZagEE programme became the key document for planning the required financial means for energy refurbishment works within the budget of the City of Zagreb;

— Investment plan – Programme ZagEE is also important for opening opportunities for the co-financing of energy refurbishment works by other financial institutions and funds that co-finance such types of projects through their programmes;

— For the realisation of work on the energy refurbishment of buildings, other than budgetary funds, other sources of co-financing available to the City were
used. Preliminary activities on the realisation of opportunities to obtain such funds, and later the very withdrawal of funds, present complex administrative work that requires special professional skills and abilities, especially within the framework of regulations governing local self-government and other financial institutions;

— **The public procurement procedure is a particularly complex and long-term process, unavoidable in the implementation of investments.** Although tender documents are carefully prepared and the commencement of the public procurement procedure is planned on the basis of a schedule guided by the construction season, it is difficult to foresee the duration of the procedure itself and of the term of energy refurbishment realisation. Namely, it is almost a rule that certain tenderers pose questions and require additional explanations several times, which results in the prolongation of the deadline for submission of tenders. Such extensions of the procurement process have multiple negative consequences: the works proceed in an unfavourable time framework, the building must be used to full capacity, which makes working conditions more difficult, and the foregoing affects the terms of realisation and increases costs. Furthermore, the investment will be carried forward to the next budgetary year. These indicators show the size of the impact of public procurement procedure implementation on the successfulness and term deadlines of project implementation;

— **Energy refurbishment is an interdisciplinary approach** ranging from an analysis of the current situation, design, to completion, i.e. the targeted energy savings and reduction of CO₂ emissions can be achieved only through inclusion of all relevant professions;

— **Any object undergoing energy refurbishment is complex on its own.** Namely, although the technology of material and equipment installation is known, in the case of installation in existing buildings there are a number of details that remain invisible at the time of design or that are not included in the design. Along with prompt reactions and an adequate solution, such problems affect the deadline and price of energy refurbishment;

— In case of energy refurbishment, **small mistakes become big problems** during the use of the building. Therefore, it is necessary to perform all controls that prove good workmanship;

— **Remote energy consumption reading** is a tool that enables monitoring of energy refurbishment results and a prompt reaction in case of observed omissions;

— **Satisfied users are the greatest boost** to the implementation of energy refurbishment in other buildings. They relay their experiences to others within the framework of their working environment, but they also relay it to their homes and to the wider community;

— **A satisfied user is not necessarily a responsible user!** For that reason, education, awareness, and change of behavioural patterns of the user towards energy consumption are indispensable within the framework of energy refurbishment of buildings.
Even after the ZagEE project has been formally finished, there are obligations to complete energy refurbishment on all objects included in the project in 2017 and 2018, but also to analyse the results, and further apply and disseminate the lessons learned:

— **continued implementation of public procurement** for works and services of professional supervision,
— **applications to open tenders** for co-financing energy efficiency measures and renewable energy sources,
— **monitoring energy consumption** on renovated buildings and the production of energy and financial analyses,
— **drawing up energy audits** and energy certificates for renewed buildings,
— **continued training** of building users,
— **encouraging energy refurbishment** on other public buildings owned by and in the area of the City of Zagreb whose energy consumption is greater than the referential value for such types of buildings,
— **continued dissemination** of project results at national and international level.
The City of Zagreb is the leading city in Croatia in terms of recognizing the importance of sustainable energy development. By the decision of the Zagreb City Assembly on October 30th, 2008, the City of Zagreb became one of the first European capitals to adopt the Covenant of Mayors and state its support to the great initiative of joining the mayors of European cities committed to energy efficiency in a permanent network with the aim of exchanging experiences in the implementation of effective measures for the improvement of efficiency in urban areas.

The City Office for Energy, Environment and Sustainable Development was established in 2009 and is responsible, inter alia, for activities relating to: energy and planning energy development, heating energy and ensuring a continuous distribution of heating energy, efficient use of energy in immediate consumption, gas market and the development of its distribution system in the Zagreb area, sustainable development, renewable energy sources and ecologically acceptable energy sources, environment protection, protection of air and waters, protection from noise and other activities in its competence.

North-West Croatia Regional Energy Agency (REGEA) is the leading energy agency in Croatia and one of the most successful organisations of its kind in South-East Europe. REGEA was founded in 2008 by four Croatian counties, the City of Zagreb being one of them. The main goal and role of the Agency is to promote and encourage regional sustainable development in the field of energy and environment protection through the use of renewable energy sources and the introduction of measures to increase energy efficiency. Furthermore, the Agency also implements the good practices of energy management, encourages the sustainable development, and provides information and advice as well as many other services based on specific local needs for energy.

1.5. Project partners
2.1. Background

The City of Zagreb is trying to achieve the ambitious goal of the European Union of reducing greenhouse gas emissions by 40% (in relation to the referential 1990) by 2030 via the implementation of energy projects and innovative concepts and joint actions, with active participation of many interest groups, economic operators, educational and scientific institutions, NGOs, and citizens in as many ecologically-aware cities and towns of the Republic of Croatia and of the European Union as possible.

A number of strategic documents, such as the Sustainable Energy Action Plan (SEAP) for the City of Zagreb 2010-2020, Energy Efficiency Programme in the Immediate Consumption, Protection and Improvement of Air Quality Programme in the City of Zagreb, Climate Change Adaptation Plan for the City of Zagreb, development strategy “ZagrebPlan”, and other documents indispensable for the implementation of a proactive energy policy confirm the complexity and seriousness of Zagreb’s approach to the energy policy.

In order to achieve the goal of reducing the CO\textsubscript{2} emissions set out in the SEAP of the City of Zagreb, there is great potential for energy savings in the building sector in view of its significant share of 58% in the total consumed energy of the City of Zagreb.

Furthermore, the ZagEE project meets the requirements stipulated in the Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, which was transposed in the national legislation, and relates to energy refurbishment of 3% of the total floor area of heated and/or cooled buildings owned and occupied by central government, at annual level.

IN ORDER TO LAUNCH A COMPLEX PROJECT SUCH AS ZAGEE, IT IS NECESSARY TO MEET THE FOLLOWING PRECONDITIONS:

- collection of data on energy consumption in buildings via the information system
- drawing up energy reviews of buildings,
- a sufficient number of experts to implement the project
- good co-operation with stakeholders
2.2. Structure of the project

Implementation of the project was structured in six working packages (WP); the City of Zagreb, as the lead partner, is in charge of the co-ordination and control of project implementation and is the main link towards EC EASME (European Commission – Executive Agency for Small and Medium-sized Enterprises).

MAIN STEPS IN THE IMPLEMENTATION OF THE PROJECT:

— to establish a co-ordinating project implementation committee, which is to be appointed by the mayor and consist of the representatives of project partners and experts from various city offices competent for the maintenance of buildings included in the ZagEE project
— to draw up the Buildings Register
— to draw up the Public Lighting Masterplan
— to include the investment plan – ZagEE programme into the budget of the City of Zagreb
— to implement public procurement and to draw up technical documents for the energy refurbishment of buildings and for the modernisation of the public lighting system
— to examine potential sources of financing and use of acceptable financial models
— to announce/publish public tenders for works and services for the professional supervision for the energy refurbishment of buildings
— to perform works – the obligation to realise works within three years of the completion of the project
2.3. Project management

For the implementation of the ZagEE programme to be successful, co-operation and co-ordination by and between all relevant stakeholders who are technologically involved in its realisation is extremely important. The project co-ordinator, City Office for Energy, Environment and Sustainable Development, is responsible for daily monitoring of the realisation and coordination of the project on behalf of the City of Zagreb and in accordance with the Grant Agreement for the Implementation of the ZagEE Project, and is the main link with the European Commission – EASME; it also makes key decisions throughout the term of the project, initiates activities, manages and supervises its progress. The co-ordinator is responsible that the phases of the project are completed on time, based on the planned schedule and, taking into consideration the challenging nature of the project and its strictly defined terms, that experts from all relevant city offices and representatives of project partners are involved in the working body of the project.
Further to the conclusion of the mayor of 15 April 2013, a Co-ordinating Committee for the Implementation of Activities within the ZagEE – Zagreb Energy Efficient City project was appointed. The Co-ordinating Committee consists of representatives from the City Office for Energy, Environment and Sustainable Development, City Office for Physical Planning, Construction of the City, Utility Services and Transport, The Mayor’s Office, City Office for Finances, City Office for Education, Culture and Sports, City Office for Social Protection and People with Disabilities, City Office for Health, City Office for Strategic Planning and Development of the City, and representatives of the project partner, i.e. the North-West Croatia Regional Energy Agency. The Co-ordinating Committee is responsible for co-operation by and between all city offices and other relevant stakeholders in the performance of their specific project tasks within the defined costs and time-related limitations.

The ZagEE project is conducted within the framework of the IEE Technical Assistance Programme 2012 – Mobilising Local Energy Investments (MLEI-PDA) and includes the financing of technical assistance and the drawing up of the required documents for the energy refurbishment of buildings, via the award of grants. Quality implementation of energy refurbishment requires investments in preliminary activities, such as the monitoring and analysis of energy consumption, the drawing up of energy examinations and certificates, feasibility analyses, and the drawing up of project documents. It is precisely the MLEI-PDA Programme that enables initial investments, indispensable for the preparation of major investments launch, are mitigated via the coverage of 75% of the amount of costs through grants, provided that the planned investment is realised within a reasonable term by local or regional self-government. It is well-known that energy refurbishment projects, such as the ZagEE Project, have direct influence on mobilising local energy investments and that they serve to encourage other economic sectors and the development of clusters, the opening of new workplaces, and that they also serve to encourage economic development, which is increasingly relevant in view of the on-going economic crisis. The IEE MLEI Programme enables local self-government to implement their own energy policies and yields a major contribution to energy development, but also economically sustainable development of local self-government.

2.4. Mobilising Local Energy Investments (MLEI)
Energy refurbishment of public buildings includes the implementation of economically viable, energy-efficient technologies and energy efficiency measures, as well as the application of renewable energy sources (solar collectors and photovoltaic systems) in these buildings. Responsible planning of energy refurbishment of buildings must be a synergy of a sustainable financial model, professional engineering work, integrated design, proper supervision, and monitoring of the achieved energy efficiency, usability and maintenance of building and installation systems during the life cycle of materials and equipment items. The quality of energy efficient refurbishment is directly dependent on the timely interdisciplinary professional collaboration in decision-making, as well as the experience and competence of designers, contractors, and control of the refurbishment implementation.

3. ENERGY REFURBISHMENT OF PUBLIC BUILDINGS

STEP BY STEP - OUR EXPERIENCES WITH REFURBISHMENT OF BUILDINGS

The energy refurbishment includes 87 buildings of various public purposes:

- 39 kindergartens
- 15 primary schools
- 6 secondary schools
- 4 home for the elderly and disabled
- 3 health centres
- 3 city administration buildings
- 17 local government buildings
3.1. Building registry

One of the first activities for the successful implementation of planned investments in energy refurbishment of buildings was the preparation of a comprehensive registry and buildings database with all the information and data collected from previously conducted energy audits, as well as the regular collection of data on energy characteristics and consumption of buildings in the City of Zagreb. The registry and database enabled making decisions on the final selection of buildings with an overview of measures that may be applied, and planned energy savings that may be achieved.

3.2. Technical documentation

Selection of energy, environmentally and economically optimal energy system of the building, along with considering the physics of the building and the energy processes that take place in the building, as well as energy sources used, has a key role in the subsequent exploitation of the building, both in terms of cost and impact on the environment. It was therefore crucial to create high-quality technical documentation in the framework that gives the technical solution of energy refurbishment with which energy savings of an average of 49% are achieved, taking into account other aspects that have a significant impact on the final result, such as functional, environmental, and financial aspects. Energy refurbishment of buildings requires a multidisciplinary approach; therefore, all relevant experts were involved in the development of technical documentation and all professions such as architect, mechanical engineer, electrical engineer, and economist were represented.

TECHNICAL DOCUMENTATION FOR EACH BUILDING CONTAINS THE FOLLOWING ELEMENTS:

— Survey of the existing situation

Survey of the current state of the building gives an exact insight into the current state of the building, current consumption, method and duration of use, restrictions in applying energy refurbishment, and other essential elements that influence the selection of energy efficiency measures.

— Preliminary Design

The designer creates a preliminary design of energy refurbishment for each building with calculated savings and payback period, which is optimal with regard to the targeted achievement of energy savings and the necessary financial investments.

The subject solution shall be presented through a...
calculation of energy savings and the necessary investment.

— Main project
The Main project of energy refurbishment provides for all measures that are necessary to obtain a high-quality and optimum energy efficient building with the required impact in reducing energy consumption.

The solutions were chosen according to the basic principles:
- analysis of location, orientation, and shape of the building,
- application of a high level of thermal insulation of the entire outer shell and avoiding thermal bridges,
- utilizing heat gains from the sun and protection from overexposure to sunlight,
- use of energy-efficient heating, cooling, ventilation, and lighting, and combining it with renewable energy sources,
- implementation of advanced consumption metering with a continuous monitoring system.

— Feasibility study
The feasibility study gives a clear indication of the justification for implementing energy refurbishment of the building with a payback period calculation. The study produced economic and financial analyses that prove the economic feasibility of investment for each individual planned measure. On the basis of the created study, the justification and reality of implementing planned energy refurbishment measures of the building is considered.

— Tender documentation for the performance of works
For the purposes of implementing public tenders for works concerning energy refurbishment of buildings, which are subject to the project assignment, it is necessary to draw up tender documentation for the building, in accordance with legal regulations.

Part of the tender documentation which shall be drawn up by the designer consists of:
— a technical description of all relevant data essential for the high-quality formation of the bid price per items in the list of expenses,
— a list of expenses for the works.

**STEPS IN THE IMPLEMENTATION:**
- creation of project task and tender documents
- implementation of public procurement for the production of project documentation
- service contracting
- coordination and control of the technical documentation production
- obtaining necessary permissions and approvals in accordance with the law
3.3. Works on energy refurbishment

ENERGY REFURBISHMENT OF BUILDINGS WITHIN THE ZAGEE PROJECT INCLUDED THE APPLICATION OF THE FOLLOWING MEASURES:

- preparing tender documentation
- implementation of public procurement for works
- contracting
- construction site registration and introduction to business
- coordination and control of the works
- acceptance of works - handover

The works of building energy refurbishment are a very complex procedure that requires knowledge and skill of the contractor who needs to be aware of the consequences of negligent or bad construction on the final functionality of the building from an energy aspect. A high energy standard and the planned reduction of energy consumption in line with projected measures may only be achieved by consistent performance of all designed interventions. It therefore follows that it is crucial to develop cri-
1. thermal insulation of external walls with the ETICS system of mineral wool slabs with 14 - 20 cm thickness,
2. thermal insulation of the base of the walls with XPS panels - extruded polystyrene with a 12 cm thickness,
3. thermal insulation of the impassable pitched and flat roof with mineral wool slab with a 20-25 cm thickness,
4. replacement of existing locks, windows and doors with energy efficient wood, PVC windows and doors and/or Al locks with a heat conduction coefficient of U≤1,00 W/m²K,
5. replacement of lighting fixtures with energy-efficient lighting,
6. replacing fuel oil with ecologically acceptable fuel,
7. modernization of the boiler room and balancing the heating system,
8. installation of thermostatic radiator valves,
9. setup of solar collectors for preparation of expendable hot water,
10. setup of photovoltaic systems,
11. remote reading system of energy and water consumption.

Criteria in the tender documentation for the works to demonstrate the ability of the contractors. Furthermore, technical and design supervision over the implementation of the refurbishment works is necessary, which, along with the implementation of the available measurements, may ensure the quality of performance, or quality of energy refurbishment of the building as a whole.

Coordination, effective communication, and information of all participants in the construction are basis for achieving the quality and deadlines of implementation. Considering that the works are carried out while the building is in use and the building user must be provided with normal conditions for work, it is important to respect the set framework in which the contractor is able to perform works. The role of the coordinator is to ensure the high motivation of all the participants and achieve the investment of additional effort from all sides to allow for the realization of energy refurbishment.
3.4. Professional supervision

Professional supervision of energy refurbishment is an instrument of ensuring the designed measures quality of execution. In addition to controlling the work dynamics and billing situations, it is particularly important to verify the performance of details, because it determines whether the performance is high-quality or will serious problems appear during building use (e.g. condensation in the room). In energy refurbishment, control of technical specifications/features of installed materials, products, and equipment is especially important, and it must be consistent with the project characteristics. Control is based on the prescribed tests and documents and adequate records and reports are maintained on completed controls. In coordination with the designer, the supervision points out and participates in the resolution of technical details that are not clearly defined by the project, as well as the necessary changes of project solutions due to the technology of the work itself.

For the purposes of carrying out the supervision, it is necessary to have a team of experts that oversees the entire process of completing the works, from the introduction of the job to the handover.

3.5. Building management after energy refurbishment

Energy refurbishment actually results in a completely new building, and information and features that were valid for the building before the refurbishment are now no longer relevant. Therefore, on completion of refurbishment, it is important to change the method of building management and consider the following steps:

— **An energy audit and energy certificates**

After completing the energy refurbishment, it is necessary to perform an energy audit and accordingly create an energy certificate under the new energy characteristics of the building.

— **The handover**

Project documentation which was the basis on which energy refurbishment was performed, as well as all approvals for installed materials and equipment with the corresponding guarantees, is submitted to the competent city office for maintenance of the building and the director of the building. In addition, with regard to capital investment in the building, added value on the building must be recorded in the accounting books.
— **User training**

The implementation of energy refurbishment of buildings ensures the energy and financial savings on the restored buildings, but in order to achieve optimum cost savings, it is important to take into account the human factor. User education is an important and essential factor in the implementation of energy refurbishment, given that each person directly affects the level of the achieved energy efficiency of buildings by their behaviour. The ZagEE project also included training for building managers in order to help them become familiar with the proper use of the building after energy refurbishment. In doing so, the importance of responsible behaviour towards energy consumption of each user of the building was particularly emphasized, as well as the role of the building manager in achieving such relationship of users towards energy. A Guide for building managers, containing rules and guidelines for the rational and efficient use and maintenance of the area of the building, was produced in the project. On the basis of the Guide, the manager can easily inform each building user which guidelines should be followed in order to rationally and effectively use building elements, devices, areas, and equipment.

— **Monitoring energy consumption and analysis of the state after refurbishment**

In order to obtain accurate data on savings realized on the energy plan, it is important to continue to monitor energy consumption after energy refurbishment of buildings. Analysis of the new state of the building is carried out using a remote reading system (Energy Information System of the City of Zagreb - EIS ZG), monitoring the consumption of gas, water, electricity, and heating energy. Using the remote energy consumption reading and reports that the system generates greatly facilitates the continuous control of energy consumption and analysis of consumption per individual building or group of buildings, which is the basis of systematic energy management. Comparing individual indicators obtained during the analysis provides an insight into energy consumption and, consequently, a very quick and effective reaction is possible if the power consumption is higher than expected.

— **Continuous communication with users**

Energy savings that are enabled by the energy refurbishment of the building may only be achieved by all users contributing. Monitoring consumption using EIS ZG at any time allows an insight into the real state of energy consumption in the building. If control of data shows that there were deviations from the planned savings, the analysis must determine the cause and make sure to continue the education of users until the set goal is reached.
4. MODERNISATION OF PUBLIC LIGHTING SYSTEM

STEP BY STEP - OUR EXPERIENCE WITH MODERNISATION OF PUBLIC LIGHTING SYSTEM

Modernizing the part of public lighting system involves replacing more than 3,000 obsolete, energy-inefficient, spherical lamps with a sodium light source with lamps with the latest LED (SSL) technology, in primarily pedestrian areas. Modernization of the public lighting contributes to a significant reduction of light pollution and, alongside reducing electrical energy consumption, a significant reduction of emissions of CO₂ is also expected. LED lighting includes the regulation that reduces the intensity of the lighting late at night, further reducing power consumption.

4.1. City of Zagreb Lighting Masterplan

One of the first activities for the successful modernization of a part of the public lighting system was the development of the Lighting Masterplan for the intended scope of the project. A technical analysis of the existing public lighting system was created within the Masterplan, which included an overview of the existing state of the system and the potential scope of the modernization of public lighting. Locations with spherical lamps were identified and suitable sites for modernization were selected.

WHEN CHOOSING A LOCATION, SEVERAL FACTORS WERE TAKEN INTO ACCOUNT, SUCH AS:

- coverage of the whole City area,
- related units were not separated,
- savings potential,
- population density,
- evaluation of the positive effects of the population.

Expected energy and financial savings were determined through the Masterplan. In addition, the Masterplan is the basic document which defines guidelines for drafting the project task for the technical documentation of the public lighting system modernization.
4.2. Technical documentation

The technical documentation of the public lighting system modernization contains the following elements:

— Survey of the existing situation
Survey of the existing situation includes a geodesic survey of the existing condition, analysis of the initial state of public lighting elements and an energy analysis involving energy measurements.

— The main street lighting project which includes:
  • the creation of several new solutions (3-5) with various types of LED light sources for each location, in accordance with the set objectives and the proposal of measures to comply with the standardized light-values. The subject measures may not include an addition of lighting places;
  • in accordance with the principles of energy efficiency, creation of new lighting-technical budgets and proposals (3-5 kinds of LED lamps) for the modernization of existing lighting,
  • development of a method of managing the public lighting system, including a method of turning the public lighting on and off,
  • development of methods and criteria of decreasing in the luminance intensity (regulation),
  • calculation of savings in energy consumption and maintenance costs of the projected solution in relation to the existing situation,
  • analysis of savings in electricity consumption which will be achieved by implementing the project,
  • analysis of savings on greenhouse gas emissions.

— Tender documentation for the performance of works
For the purposes of implementing public tenders for the modernization of street lighting, it is necessary to prepare the tender documentation, in accordance with legal regulations. Part of the tender documentation which shall be drawn up by the designer consists of:
  • a technical description of all relevant data essential for the high-quality formation of the bid price per items in the list of expenses,
  • a list of expenses for the works

STEPS IN THE IMPLEMENTATION:

- preparation of a project task
- implementation of public procurement for the production of project documentation
- contracting
- coordination and control of the production of technical documentation
4.3. Works on the modernization of the public lighting system

Modernization of the public lighting system included the replacement of spherical lamps with new, energy-efficient lamps with LED technology and replacing wiring and splitters in a public lighting post. The works were carried out at a number of locations so that communication of people and vehicles in those areas was not disturbed. The functional control of all works was performed.

4.4. Professional supervision

Professional supervision of works on the modernization of the public lighting system is an instrument to ensure the quality of the designed measures execution. Control is based on the prescribed tests and documents and adequate records and reports are maintained on completed controls. In coordination with the designer, the supervision points out and participates in the resolution of technical details that are not clearly defined by the project, as well as the necessary changes of project solutions due to the technology of the work itself.
4.5. Management of the street lighting system after modernization

The modernization of the public lighting system was carried out so that in the next 15-20 years, it will not require significant intervention on behalf of the competent services. Periodically, it shall be necessary to monitor the functionality of lighting and maintain the cleanliness of the optical system for maximum light output efficiency. Turning the system on and off shall be centralized, or equal for the entire lighting system of the City of Zagreb.
5. FINANCING ENERGY REFURBISHMENT

5.1. Investment Plan – ZagEE programme

In order to enable the launch of the investment for energy refurbishment and modernization of the public lighting system in the framework of the ZagEE project, it was first of all essential to develop an investment plan - The programme of energy refurbishment of buildings and public lighting systems (ZagEE - Zagreb Energy Efficient City).

The ZagEE programme is implemented in the period from 2013. to 2017, as the first phase of implementation of a comprehensive program of energy refurbishment of buildings and public lighting owned by the City of Zagreb, and refers to the complete energy refurbishment of high-priority, selected, energy inefficient public buildings owned by the City of Zagreb and the modernization of parts of the public lighting system and the use of renewable energy sources.

The ZagEE programme was adopted by the Zagreb City Assembly on 28th November 2013 and is a key document for planning the necessary financial resources for energy refurbishment works within the City of Zagreb budget. The Programme is therefore an important basis, not only for planning the city’s budget, but also serves as a means of communication with other financial institutions and funds that have open opportunities for co-financing this kind of program. An estimate of the necessary financial and human resources for the implementation of planned investments for the period 2013 - 2017 was given in the ZagEE programme. Indicators of investment profitability, expected results, as well as possible risks that may arise in the implementation of the Programme were presented in the ZagEE programme.

THE ZAGEE PROGRAMME INCLUDES THE FOLLOWING TOPICS:

— strategic and legal framework,
— description of activities,
— expected results and effects, risk assessment,
— buildings involved in the Programme and steps in implementation,
— means for realization of the programme with an indication of financing sources,
— timeframe (planned dynamics of spending on buildings),
— project management (coordination and dissemination),
— monitoring the implementation and achieved results,
— final provisions (defining responsibilities for implementing the Programme).

### STEPS IN THE IMPLEMENTATION:

- market research related to the price of energy refurbishment
- calculation of planned costs of energy refurbishment for each building
- setting the dynamics of investment for each building
- creation of the ZagEE programme
- implementation of the procedures of accepting the ZagEE programme by the competent authority (the Zagreb City Assembly)
- inclusion of the ZagEE programme in the City budget
5.2. Financing sources

The ZagEE programme is co-financed from multiple sources, and its implementation was complex in that regard. It was necessary to carry out additional activities, such as preparing the application documents for tenders for co-financing, planning the income/expense in the City budget, preparing the documents for withdrawing funds in accordance with the requirements of the institution which finances the works and other activities necessary for the completion of the investment. All in all, it could be said that this is demanding administrative work involving all stakeholders in the implementation of the energy refurbishment - the contractor, supervision, accounting, and the coordinator of energy refurbishment must ensure that the implementation take place in accordance with the legal rules and regulations of the City.

For the realization of works on energy refurbishment, in addition to budgetary funds, the following sources of funding were used:

5.2.1. Environmental Protection and Energy Efficiency Fund

The Environmental Protection and Energy Efficiency Fund (FZOEU) provides a central location for collecting and investing the extra-budgetary funds in programmes and projects to protect the environment and nature, energy efficiency and renewable energy use.

In July 2014, the City of Zagreb signed the "Agreement on cooperation in the implementation of the ZagEE - Zagreb Energy Efficient City programme" with the Fund. The signed Agreement expressed a common interest in cooperation for achieving the objective of applying the environmental protection and energy efficiency principles in public buildings of the City of Zagreb and it determined that the Fund take part in co-financing the costs of the ZagEE project in the amount of 40% of the overall investment for the works on the energy refurbishment of buildings involved in the ZagEE programme.

5.2.2. Croatian Bank for Reconstruction and Development (HBOR)

Since 2007, the Croatian Bank for Reconstruction and Development has earmarked a special line of credit for local and regional government, named the Loan programme for environmental projects, energy efficiency and renewable energy. Through this line, it is possible to finance investments in fixed assets that do not include preparation of project documentation. The HBOR programme encourages a comprehensive energy refurbishment of altering the physical (energy) characteristics of the building and optimization of the energy supply and energy production system for the building from renewable energy sources, in order to achieve a maximum impact of energy savings.

HBOR, in cooperation with the European Investment Bank (EIB), allows the use of grant funds from the Programme of the European Commission for loans intended for the financing of fixed assets in the context of investments that contribute to saving energy and reducing CO₂ emissions.

The City of Zagreb and HBOR concluded a Financing agreement that includes the grant by the EIB and, within the framework of this Agreement, an energy refurbishment was conducted on 8 buildings from the ZagEE programme.

5.2.3. European structural and investment funds

Within the framework of the Operational Programme Competitiveness and Cohesion, the Ministry of Construction and Physical Planning is implementing the Programme of energy refurbishment of buildings, financed by the European...
Regional Development Fund. Based on this, the Ministry announces calls for delivery of project proposals for “Energy refurbishment of buildings and the use of renewable energy sources in public institutions that perform activities of education”. The purpose of the Call is the implementation of energy refurbishment and the use of renewable energy in public buildings in which public institutions perform activities of education, which will result in a reduction of energy consumption for heating/cooling through an integrated approach, for a minimum of 50%.

The City of Zagreb applied several buildings to the respective calls and an award of grants from that call is expected in the coming period for further energy refurbishment for the registered buildings. Also, given the readiness of the technical documentation that is appropriate for such kinds of tenders, the City of Zagreb will continue to apply for open calls of the relevant Ministry.

5.2.4. Financing the investment through the ESCO model and Energy performance contracting (EPC)

The ESCO financing model should be considered for measures in which financial savings are sufficiently high that the investment to an ESCO company may be paid off in a given period (usually up to eight years). The European Commission particularly stressed the importance of the ESCO/EPC models in achieving the strategy Europe 2020.

In Croatia, the Agency for Transactions and Mediation in Immovable Properties (APN) implemented a programme of energy refurbishment of public buildings following the model of energy performance contracting (EPC). The program anticipated that the FZOEU, through the APN, and pursuant to the Agreement on co-financing the implementation of the Programme, shall co-finance 40% of eligible costs without refunds in accordance with the rules of the FZOEU.

BASIC SETTINGS AND CHARACTERISTICS OF THE PROGRAMME:

- The Energy service contractor (ESC) orders, and the energy service provider (ESP) provides the energy services, in order to improve the energy characteristics;
- The ESP is obliged to achieve demonstrable cost savings of energy and water by imple-
menting energy efficiency measures;
— Energy efficiency measures include the following:
  • the production of project documentation - the main project,
  • energy refurbishment of the building (performance of works, installation of equipment and materials),
  • monitoring and investment maintenance of all elements of the building and installed equipment that were the subject of energy refurbishment;
— The ESP invests and takes over the technical, economic, and commercial risk of the work so that there are no additional expenses for the ESC;
— The ESC is obliged to ensure payment of the fee for energy services to the provider for a stipulated period of time;
— The payment of the service is based on verifiable savings (service fee must be less than the savings);
— Arranging energy services pursuant to the Agreement on energy performance is not a budgetary loan of the ESC;
— The savings are proven by the project. The difference of the annual projected energy needs of the building before and after the refurbishment presents the projected savings. The ratio of the projected annual savings and the projected annual energy needs of the building before refurbishment shows the percentage of savings. The projection of the percentage of savings to the reference consumption gives the absolute savings in natural units (kWh m3). The multiple of the absolute savings with unit prices of energy-generating products gives the financial annual amount of savings (HRK).

As part of the ZagEE project and based on the analyses conducted, two buildings that would be appropriate for the refurbishment through the ESCO model were selected, but there appeared administrative barriers in the initial stages of application. For this reason, this financing model was not used until now.
5.3. Monitoring financial savings

In order to assess the project success, the achieved financial savings that follow as a result of reduced energy consumption should be monitored as well.

Through the information system EIS ZG, the City Office for Energy, Environment and Sustainable Development continuously monitors the actual costs of energy consumption for each building as well, through an invoice for particular energy-generating products. On the basis of the conducted analyses, a clearer picture will be given on the actually achieved financial savings, the cost-effectiveness of investments in energy refurbishment, the causes why they are lower/higher than planned, a reference pattern for buildings per purpose, as well as other data that may be used to effectively manage energy in the subject buildings.
6. EXAMPLES OF EXCELLENCE
**CONDITION BEFORE REFURBISHMENT:**

**Exterior walls:** the composition of the wall from the inside out: 5 cm autoclaved aerated concrete, vapour barrier, thermal insulation 3 cm, 20 cm reinforced-concrete wall

**Roof:** lists of layers from top to bottom
- **passable flat roof:** K1 - roof tiles in cement mortar 4.0 cm, sand 2.0 cm, water proofing, inclined foam concrete 5.0 - 10.0 cm, HDPE film, coated Okipor 5.0 cm, vapour barrier, cold coating with Bitizol, reinforced-concrete slab 14.0 cm
- **impassable level roof:** K2 - granular gravel 4.0 cm, water proofing, inclined foam concrete 5.0 - 15.0 cm, HDPE film, coated Okipor 5.0 cm, vapour barrier, cold coating with Bitizol, reinforced-concrete slab 14.0 cm

**Windows and doors:** wood frame, single glazing

**Heating system:** fuel oil

**Preparation of consumable warm water:** electric water heaters used

**Energy class** according to the building physics: F

**The annual need for thermal energy** according to the building physics: 159 MWh/a

---

**6.1.1. Energy refurbishment of the kindergarten Vrapče, Kerestinečkih žrtava Street 13**

**BASIC INFORMATION ABOUT THE BUILDING:**

<table>
<thead>
<tr>
<th>Purpose of the building:</th>
<th>kindergarten</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shape of the building:</td>
<td>non-compact, two floors</td>
</tr>
<tr>
<td>Year of construction:</td>
<td>1981</td>
</tr>
<tr>
<td>Area (useful area):</td>
<td>1,292.00 m²</td>
</tr>
<tr>
<td>The annual need for thermal energy according to the building physics:</td>
<td>159 MWh/a</td>
</tr>
<tr>
<td>Number of users:</td>
<td>253</td>
</tr>
</tbody>
</table>

**Windows and doors:** wood frame, single glazing

**Heating system:** fuel oil

**Preparation of consumable warm water:** electric water heaters used

**Energy class** according to the building physics: F

**The annual need for thermal energy** according to the building physics: 159 MWh/a
IMPLEMENTED ENERGY REFURBISHMENT MEASURES:
— thermal insulation of external walls using ETICS system of mineral wool slabs 14 - 20 cm thick
— thermal insulation of flat passable roof using rock wool slabs 8 - 13 cm thick and of flat impassable roof 20 cm thick
— replacement of the existing windows and doors with energy efficient AL locks and triple-glazed PVC windows and doors, heat transfer coefficient of 1.10 W/m²K
— replacement of fuel oil with natural gas as energy source
— construction of a new boiler room
— replacement of lighting fixtures with energy-efficient lighting
— installation of solar panels for DHW
— installation of thermostatic radiator valves
— implementation of the new electrical wiring of the boiler room
— system of remote read-out of energy and water consumption

EXPECTED RESULTS:
— energy consumption reduced by **121.81 MWh/a (77%)**
— CO₂ emissions reduced by **35.14 t/a**
— energy produced from **renewable energy sources** amounts to **11.44 MWh/a**
— total financial savings on energy consumption of **9,017 EUR/a**
— energy class **B**
— **increased quality** of service
6.1.2. Energy refurbishment of the Lovro pl. Matačić Elementary School, Jozo Laurenčić St. 1

CONDITION BEFORE REFURBISHMENT:

**Exterior walls:** lime-cement render 2.5 cm, full brick 25.0 cm, lime-cement render 2.5 cm and cement render 1.0 cm

**Roof:** list of layers from top to bottom

- **impassable flat roof:** sand and gravel 5.0 cm, bituminous waterproofing membrane 1.0 cm, mineral wool 10.0 cm, bituminous strip with Al foil of 0.4 cm, reinforced concrete 5.0 cm, a layer of air between RC ribs 25.0 cm, gypsum plaster on cane 3.5 cm

- **sloping roof - undeveloped attic:** AC corrugated tiles 1.0 cm, air layer of the attic, reinforced concrete 5.0 cm, a layer of air between RC ribs 25.0 cm, gypsum plaster on cane 3.5 cm

**Windows and doors:** wood frame, single glazing

**Heating:** heating plant

---

**BASIC INFORMATION ABOUT THE BUILDING:**

<table>
<thead>
<tr>
<th>Purpose of the building:</th>
<th>elementary school</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shape of the building:</td>
<td>non-compact, three floors</td>
</tr>
<tr>
<td>Year of construction:</td>
<td>1963</td>
</tr>
<tr>
<td>Area (useful area):</td>
<td>2,921,00 m² (school)</td>
</tr>
<tr>
<td>Area (useful area):</td>
<td>475 (375+51)</td>
</tr>
</tbody>
</table>

**DHW:** heating plant

**Energy class** according to the building physics: F

**The annual need for thermal energy** according to the building physics: 625.56 MWh / a (school)

**IMPLEMENTED ENERGY REFURBISHMENT MEASURES:**

- thermal insulation of external walls by ETICS, expanded polystyrene panels 18 cm thick
- thermal insulation of socles and parts of foun-
dation by ETICS, expanded polystyrene panels 10 cm thick

— thermal insulation of ceilings towards the low impassable attic using mineral wool slab 32 cm thick
— replacement of the roof covering of the sloping roof with corrugated coloured metal sheets
— replacement of the existing windows and doors with energy-efficient AL locks and PVC windows and doors, double-glazed, heat transfer coefficient 1.3 W/m²K
— system of remote read-out of energy and water consumption

EXPECTED RESULTS:

— energy consumption decreased by 487.63 MWh/a (77.95% per year)
— CO₂ emissions reduced by of around 146.29 t/a
— total financial savings on energy consumption of around 51,847 EUR/a
— energy class B
— increased quality of service
6.1.3. Energy refurbishment of the home for the elderly  Park, Ivanićgradska Street 52

CONDITION BEFORE REFURBISHMENT:

**Exterior walls:** lime-cement render 2.5 cm, full brick of clay 38.00 cm, lime-cement render 3.5 cm

**Roof:** list of layers from top to bottom
- **flat impassable roof:** sand and gravel, 5.0 cm, bituminous waterproofing membrane 1.0 cm, RC plate 15.0 cm and lime-cement render 1.5 cm
- **passable flat roof:** exposed aggregate concrete in cement mortar 5.0 cm, bituminous waterproofing membrane 1.0 cm, reinforced concrete 15.0 cm, lime-cement render 1.5 cm

**Windows and doors:** wood frame, single glazing

**Heating:** heating plant

**DHW:** heating plant

**Energy class** according to the building physics: F

**The annual need for thermal energy** according to the building physics: 578 MWh / a

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**BASIC INFORMATION ABOUT THE BUILDING:**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Purpose of the building:</strong></td>
<td>a home for the elderly and frail persons</td>
</tr>
<tr>
<td><strong>Shape of the building:</strong></td>
<td>compact (seven floors, ground floor + 6)</td>
</tr>
<tr>
<td><strong>Year of construction:</strong></td>
<td>1981</td>
</tr>
<tr>
<td><strong>Area (useful area):</strong></td>
<td>3,587.5 m²</td>
</tr>
<tr>
<td><strong>Number of beneficiaries:</strong></td>
<td>217</td>
</tr>
</tbody>
</table>

**IMPLEMENTED ENERGY REFURBISHMENT MEASURES:**

- thermal insulation of external walls using the ETI-CS system of mineral wool slabs 14 - 20 cm thick,
- thermal insulation of the roof using mineral wool slabs 24 cm thick
- replacement of the existing wood windows and doors by argon-filled double-glazed PVC windows and doors, heat transfer coefficient
of 1.24 W/m²K
— replacement of the existing glazing in PVC windows on the ground floor by argon-filled thermally insulating glass (low-E glass) with maximum heat transfer coefficient of 1.3 W/m²K
— installation of thermostatic radiator valves
— system of remote read-out of energy and water consumption

Since the energy refurbishment of buildings has only recently been completed, accurate savings still need to be determined, but after the first winter there has been a significant reduction in heat consumption, the quality of service has been raised and customer satisfaction has improved. In order to achieve the planned energy savings and in order for the buildings to maintain the designed energy performance, after the refurbishment, the users were educated on the rational and efficient use of elements, devices, premises, and equipment of buildings.

EXPECTED RESULTS:
— energy consumption decreased by 441 MWh/a (76%)
— CO₂ emissions decreased by 88.64 t/a
— total financial savings on energy consumption of 30,852 EUR/a
— energy class B
— increased quality of service
**6.1.4. Energy refurbishment of the kindergarten Jabuka, Resnički put 88**

**CONDITION BEFORE REFURBISHMENT:**

**Exterior walls:** composition of the wall from the inside to the outside: 2 cm plaster, full brick 20 cm, wood panel 5 cm, full brick 6.5 cm, plaster 12 cm (old part of the building)

**Roof:** list of layers from top to bottom
- **ceiling towards the attic** – 2 cm plaster, AB panel 20 cm, PE foil 0.02 cm, hardboard 6 cm polystyrene, 0.3 cm polyester felt and reinforced cement screed 6 cm
- **passable flat roof** – 2 cm plaster, AB panel 20 cm, lightweight concrete for 5-1 cm fall, pressure equalization layer, steam damper, expanded polystyrene 10.0 cm, PVC foil 0.2 cm, reinforced cement screed 6 cm, ceramic tiles 1 cm
- **flat impassable roof** – 2 cm plaster, AB panel 20 cm, lightweight concrete 5-1 cm thick, aluminium bitumen strips 0.3 cm, hydrophobic membrane 0.02 cm, expanded polystyrene 10 cm, UV protective coating and layer of gravel 6 cm

**Windows and doors:** wood joinery glazed with double IZO-glass

**Heating:** The facility has central heating from its own boiler room. Energy source is fuel oil used for heating and hot water preparation.

**DHW:** in boiler room, energy source - fuel oil

**Energy class** according to the building physics: E

**Annual need for thermal energy** according to the building physics: 352 MWh/a

---

**BASIC INFORMATION ABOUT THE BUILDING:**

<table>
<thead>
<tr>
<th>Purpose of the building:</th>
<th>kindergarten</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shape of the building:</td>
<td>non-compact, two floors</td>
</tr>
<tr>
<td>Year of construction:</td>
<td>1979, upgraded in 2001</td>
</tr>
<tr>
<td>Area (useful area):</td>
<td>2,425.00 m²</td>
</tr>
<tr>
<td>Number of users:</td>
<td>255</td>
</tr>
</tbody>
</table>
IMPLEMENTED ENERGY REFURBISHMENT MEASURES:

- thermal insulation of external walls using the ETICS system of stone wool slabs 16 cm thick
- thermal insulation of impassable, slantwise and flat roof with stone wool slabs 25 cm thick
- replacement of existing wood windows and doors with energy-efficient PVC joinery and Al-locksmith with coefficient of thermal conductivity U≤1.00 W/m²K
- replacement of existing lighting with energy-efficient lighting
- replacing fuel oil with natural gas
- modernization of boiler room
- replacement of thermostatic radiator valves
- setup of solar collectors on the roof for preparation of expendable hot water
- remote reading system for energy and water consumption

EXPECTED RESULTS:

- energy consumption decreased by 273.84 MWh/a (78%)
- CO₂ emissions decreased by 77.23 t/a
- energy produced from renewable energy sources 21.52 MWh/a
- total financial savings for energy consumption of 27,856 EUR/a
- energy class B
- increased quality of service
6.1.5. Energy refurbishment of the kindergarten Kustošija, Stjepana Pasanca Street 5

CONDITION BEFORE REFURBISHMENT:
Exterior walls: composition of the wall from the inside to the outside: lime-cement plaster 2 cm, reinforced concrete 20 cm, brick 19 cm, facade plaster 2 cm
Roof: list of layers from top to bottom
- flat passable roof – sand and gravel 5.0 cm, bituminous waterproofing membrane 1.0 cm, mineral wool 10.0 cm, bituminous strip with Al foil of 0.4 cm, reinforced concrete 5.0 cm, a layer of air between RC ribs 25, 0 cm, gypsum plaster on cane 3.5 cm
Windows and doors: wood frame, single glazing
Heating: fuel oil
DHW: heating plant
Energy class according to the building physics: F
The annual need for thermal energy according to the building physics: 357 MWh/a

BASIC INFORMATION ABOUT THE BUILDING:

<table>
<thead>
<tr>
<th>Purpose of the building:</th>
<th>kindergarten</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shape of the building:</td>
<td>non-compact, three floors</td>
</tr>
<tr>
<td>Year of construction:</td>
<td>1972</td>
</tr>
<tr>
<td>Area (useful area):</td>
<td>2,934,00 m²</td>
</tr>
<tr>
<td>Number of users:</td>
<td>745</td>
</tr>
</tbody>
</table>
IMPLEMENTED ENERGY REFURBISHMENT MEASURES:

- thermal insulation of external walls using the ETICS system of stone wool slabs 16 cm thick
- thermal insulation of the base of the walls and part of the foundation with extruded polystyrene panels 12 cm thick
- thermal insulation of basement walls with extruded polystyrene panels 16 cm thick
- thermal insulation of flat roofs with extruded polystyrene panels 25 cm thick
- replacement of existing wood windows and doors with energy-efficient PVC joinery and Al-locksmith with triple glazed IZO-glass, coefficient of thermal conductivity 1.10 W/m²K
- replacement of existing lighting and chokes with energy-efficient lighting
- setup of photovoltaic system
- remote reading system for energy and water consumption

EXPECTED RESULTS:

- energy consumption decreased by 241.55 MWh/a (68%)
- CO₂ emissions reduced by 63.77 t/a
- produced energy from renewable energy sources 35 MWh/a
- total financial savings on energy consumption of 23,407 EUR/a
- energy class C
- increased quality of service
6.2. Modernization of the public lighting system

Pedestrian path in Kolareva Street

CONDITION BEFORE RENOVATION:
- number of lamp-posts 5
- width of the pedestrian path 4.1 m
- distance between posts 30 m
- height of lamp-post 4 m
- distance of the lamp-post from the edge of the pedestrian path 0.7 m
- mean illuminance 3.8 lux, minimum 1 lux (lighting class P5)
- total lamp power 656 W

CONDITION AFTER RENOVATION:
- number of lamp-posts 5
- width of the pedestrian path 4.1 m
- distance between lamp-posts 30 m
- height of lamp-post 4 m
- distance of the lamp-post from the edge of the pedestrian path 0.7 m
- mean illuminance 10.1 lux; minimum 2.3 lux (lighting class P2)
- total lamp power 195 W

EXPECTED RESULTS:
- energy savings of over 76%
- reduction of CO₂ by 0.71 tCO₂/year
- annual electricity savings 1890.1 kWh
- increased lighting quality - from the lighting class P5 into lighting class P2
- reduced light pollution
COMMUNICATION AND STRENGTHENING THE CAPACITY OF PROJECT STAKEHOLDERS