CERtuS

Grant Agreement N. IEE/13/906/SI2.675068

Co-funded by the Intelligent Energy Europe
Programme of the European Union

# Cost Efficient Options and Financing Mechanisms for nearly Zero Energy Renovation of existing Buildings Stock

## *A step-change for nZEB renovations of public building*

# CERtuS

The Promotion /Dissemination Project on Integrated Initiatives of the Executive Agency for Small and Medium-sized Enterprises (EASME) CERtuS - Cost Efficient Options and Financing Mechanisms for nearly Zero Energy Renovation of existing Buildings Stock - has received funding from the EU – IEE EASME under the Grant Agreement number IEE/13/906/SI2.675068

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# PREFACE - THE CONTEXT

*The latest European Energy Efficiency Directive demands strict energy efficiency measures for the public sector. Many of the municipal buildings in Southern Europe require deep renovations to become nearly Zero Energy Buildings (nZEB).*

*Compliance with this directive is difficult for the public sector because the required investments to renovate public buildings and achieve nearly zero energy consumption are capital intensive and some interventions have long payback times. Therefore, the interest of financing entities and ESCOs is small, especially when banks have limited resources.*

*CERtuS is an action aiming to help stakeholder gain confidence in such investments and initiate the growth of this energy service sector. Representative projects that could act as models for replication are needed.*

*To this end CERtuS has prepared twelve nZEB renovation designs of public buildings in four Municipalities in Italy, Greece, Portugal and Spain with detailed technical and economic assessment regarding their sustainability. For these twelve renovation schemes the CERtuS partners have adapted energy service models and procedures and they have identified financing schemes suitable to both the building project and municipalities' specific needs.*

*CERtuS results are highly replicable and replication is ensured by guidelines, training materials and courses for capacity building of municipality staff, flyers, brochures and web available tools developed to this end.*

## Overview of the EU energy policy in the building sector

The energy efficiency of buildings is one of the most relevant and strategic issues that are debated in recent years in European and global level, considering that buildings are responsible for more than 40% of world global energy use and as much as 30% of global greenhouse gas emissions [1] .

The European Union has become the promoter of programs, guidelines and Directives, such as the 2002/91/EC and 2010/31/EU on the energy performance of buildings, 2006/32/EC on energy end-use efficiency and energy services and, the 2012/27/EU on energy efficiency, in order to put in place instruments, criteria and harmonized and shared solutions on the specific issue of the increase of energy efficiency of buildings, existing and new.

All the mentioned Directives represent cornerstones of the Energy Efficiency. Since 2010, the recast of 2010/31/EU (EPBD) introduced the concept of nZEB at European level: *'nearly zero-energy building' means a building that has a very high energy performance. The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby.* The EPBD requires the final national detailed definition under the responsibility of each European Member State.

According to the recast of the EU Directive on EPBD by the end of 2020 all new buildings should be nearly Zero Energy; the deadline is even sooner - by the end of 2018 - for the existing buildings occupied and/or owned by public authorities. It is obvious that new buildings have limited impact on the overall energy reduction as they represent just a small part of the building stock. From the other hand, existing buildings can often be improved at far lower cost than would be required to demolish and erect new buildings. If energy consumption is high in the existing buildings, the potential for savings is proportional and this constitutes a great opportunity for energy efficiency improvements. It is equally true that is more difficult to apply the concept of nZEB in existing buildings with respect to the new buildings. The performance of building is a sum of the following factors, which in the existing buildings are already defined: (i) building envelope characteristics; (ii) HVAC-and BAS-systems, if exist; (iii) the building use and users behavior; (iv) the building type; (v) location and climate conditions; (vi) maintenance and management. The key issue is how the individual factors perform and how well they are integrated to perform together. As mentioned above there are several parameters to consider when working with existing buildings.

In existing buildings all or some of these factors can be improved, but there are limitations and obstacles, caused by the technical reasons, (e.g. lack of proper information, such as consumption figures or deficiencies on measurements) economic reasons and/or organisational / management reasons.

More difficulties arise when the renovation options interfere with preservation requirements of historic buildings as apposite authorities set limitations. For that motive, energy efficiency and application of nZEB on historic buildings is a special case and it can be very difficult, but with the implementation of energy efficiency measures adapted to their specific characteristics it is not impossible.

## Where we stand: the nZEB in Europe and specifically in the four CERtuS countries

According to the more recent report of national applications of the nZEB definition [2] there is not a common and homogeneous national progress within the Members States. Furthermore, the progress in developing and setting the national application of the nZEB definition in most countries, as Southern European countries has been a slow process. As claimed by the report above about 40% of the Member States did not have, at that date, a detailed definition of the nZEB, while 60% of them had laid out their detailed nZEB description, although in different level of definition. The report shows also that the Central and Northern Member States are more advanced in implementing the articles within the Directive. There is a gap between Southern European countries and Central and Northern Member States in order to catch up their progress toward nZEB.

The current status of national nZEB definitions of the four CERtuS countries is the following:

In Italy, the Ministerial Decree of 26 June 2015 completes the transposition of the European Directive EPBD 2002/91/CE, defines the requirements of nZEB and set the new minimum requirements, to be in force since October 2015. Existing and new buildings are characterized by very high energy performance and very low energy requirements covered to a significant extent by energy from renewable sources, produced within the pertinent areas of the building (on-site and not nearby).

In this legislative measure it is also introduced a new calculation method for the energy performance, based on the comparison with a reference building having the characteristics set in the decree. All energy use needed to comply with the standard use of the building is included in computation of the energy performance of the building, which is referred to different classes. The format for technical project reports is also defined, relative to new and nZEB relevant retrofitting and technical installations [3].

In Greece, the recently published law, N.4342/15 transposes the Energy Efficiency Directive 2012/27/EU in the national legislation. The levels of nZEB and the expected contribution of RES is under development.

In Portugal, the national legislation (Decree-Law 118/2013) defines nearly Zero Energy Buildings as buildings with high energy performance and where the energy needs are mainly ensure by energy from renewable sources, produced on site or nearby.

In such Decree-Law it is also determined that a nZEB must have: Efficient component compliant with the most demanding limit levels of economic viability that may be obtained by applying the methodology of optimal cost, differentiated for new and existing buildings and for different types; Local ways of capturing renewable energy covering a large part of the remainder of the predicted energy requirements, preferably in the same building or in the same plot of land of the building or in addition, in common use infrastructures as close as possible to the place where it is not possible to meet the needs of renewable energy resource.

The Decree-Law 118/2013 determines that a methodology of optimal cost and the levels of minimum energy performance must be defined in the national plan for rehabilitation of buildings and be approved by the government members in charge of the areas of energy, regional planning and finances. However, such plan was not yet defined, and therefore there are not yet any levels of energy performance defined.

Spain has not yet formulated the definition of nZEBs. The detailed definition is expected between 2016 and 2018 and, even though implementation will not become compulsory until December 2020, it may be applied on a voluntary basis and will serve as a benchmark for incentives.

A revision of the Spanish technical building code, foreseen to 2018, will update technical regulations on energy performance and will introduce the definition of nZEBs. It will establish the obligation to comply with corresponding requirements in all buildings constructed from 31/12/2018 for buildings owned by public authorities and from 31/12/2020 for all other buildings.

## The energy renovation and its relevance in public buildings

In the EPBD recast it is requested that "the public sector in each Member State should lead the way in the field of energy performance of buildings" and "buildings occupied by public authorities and buildings frequently visited by the public should set an example".

Energy efficient renovation of public buildings and other options, as the nZEBs, for high energy performance show that energy innovation through the deep envelope refurbishment and contribution of RES is possible; public buildings can be forerunners and "shining examples" in it. The impact of the innovative technologies and systems, as the indoor comfort can be visualized to every day users and visitors of public buildings and they can be repeated also in the private sector. In addition, it is also question how taxpayer's money has been used.

The energy renovation of the public building stock opens the way for ambitious large-scale renovation of the entire existing building stock. Its role can be symbolic, but it can generate a spillover effect.

## Financing the Energy renovation of public buildings

The investments on the existing buildings tend to focus on measures with short and medium payback period (less than 10 years) which usually generate less than 30% energy savings. However, according to Bullier and Milin [4] ambitious energy and climate policies require saving up to 80% energy in buildings, which is only possible with structural interventions such as insulation of facades, or replacement of windows. These deep renovations have a payback time between fifteen and forty years in the EU, at current energy prices. This varies across countries and types of buildings. The payback refers to energy investment costs (without general refurbishment measures), with stable energy prices.

# THE CERTUS PROJECT

Southern European countries undergo a severe economic crisis. This has a profound negative effect on energy savings and the progress towards achieving 20-20-20 goals. Energy saving investments have been impeded in the public sector because the priorities are now different.

More specifically, the crisis hinders the compliance to the latest Energy Efficiency Directive, demanding strict energy efficiency measures for the public sector. Investments required to renovate public buildings and achieve nearly zero energy consumption have long payback times. Simultaneously the EPBD recast sets out that member states shall draw up national plans for increasing the number of nearly zero-energy buildings and the public sector must be a leading example.

The Energy Efficiency Directive 27/2012 further requests that the member states shall encourage public bodies at regional and local level governed by public law to adopt an energy efficiency plan with specific energy saving and efficiency objectives regarding existing buildings. Thus, the 20-20-20 commitment of the member states and the obligation to implement the aforementioned Directives call for intensified actions in energy efficiency in public buildings which become extremely difficult under the current economic austerity. Moreover, banks have limited resources and ESCOs and third parties hesitate to be involved in financing in the public sector because of disincentives such as the complex administrative procedures and current budget management of public buildings which need reform.

**IMPLEMENTATION OF nZEB PUBLIC BUILDINGS OF SOUTHERN EUROPEAN COUNTRIES**
**THE EXPERIENCE OF CERtuS PROJECT**

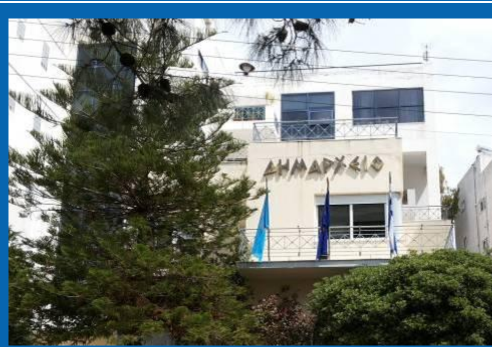
**Messina, ITALY**

**Zanca Palace – City Hall**

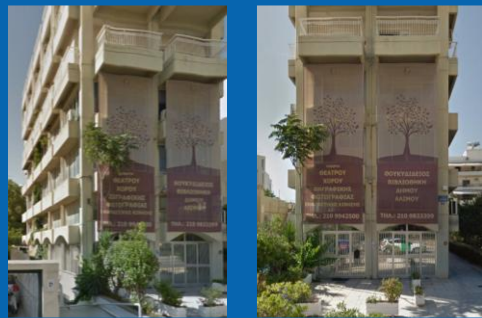
**Palace of Culture “Antonello da Messina”**

**Satellite Palace**

**Alimos, GREECE**




**City Hall**



**Municipal Library**

**Municipal Offices**

The objective of the proposed action is to help stakeholders gain confidence in such investments and initiate the growth of this energy service sector. Municipalities, energy service companies and financing entities from Italy, Greece, Portugal and Spain are involved in this project.

CERtuS is a project aiming to producing representative deep renovation projects that will act as models for replication. Twelve buildings in four municipalities of each targeted country were selected. The partners adapted existing energy service models and procedures and developed financing schemes suitable for the 12 projects. Currently, CERtuS partners are investigating opportunities and instruments such as combination of funds coming from different sources, both private and public ones. Such a combination will alleviate the burden from the public resources due to the inflow of private funds whilst simultaneously will leverage private capitals by reducing risks, payback times and thus making the overall investment more attractive. Nevertheless, the aim of the proposed project is to maximize the inflow of private funds.

Another key issue is the energy service market, which is not as developed in the southern member states as is in other parts of EU, especially regarding the ESCOs. Additionally, most energy service providers as for example the ESCOs, operate on well-tried contracts such as EPC (Energy Performance Contracting) or EEO (Energy Efficiency Obligation). These contracts, however, have not been used up to now for nZEB deep renovations.

**IMPLEMENTATION OF nZEB PUBLIC BUILDINGS OF SOUTHERN EUROPEAN COUNTRIES**

**THE EXPERIENCE OF CERtuS PROJECT**

**Coimbra, PORTUGAL**

**City Hall**

**Municipal House of Culture**

**Elementary School of Solum**

**Errenteria, SPAIN**

**Town Hall**

**Kapitain Etxea**

**Lekuona**

In order to provide the financing and energy service options to be implemented and replicable obstacles related with the municipal infrastructure and mainly with the administration, accounting and budget management will be addressed and proposals will be made to the competent bodies of Central Government.

A very important issue to deal with in CERtuS is the capacity building in Municipalities - not only for the participating ones but in a very large target group – which will facilitate replication of the renovation examples to be produced and especially it will support local and regional Governments to prepare plans for energy efficiency and energy savings and facilitate the implementation of EED (article 5.7(a)).

CERtuS is working with representative Municipalities in size, population and building stock. In Mediterranean member states as for example in Italy, the majority of public buildings has a historic value but is not monumental. For these buildings there are legislation requirements that any renovation activity needs to comply with. It is important for CERTUS project to take in consideration these buildings and work out nZEB renovation schemes and financing mechanisms. The results on this issue are already very important because a large pool of existing buildings will not be exempted from the Energy Efficiency Plans of the member state. Nowadays, the successful implementation of Directive 2010/31/EU concerning the transformation of public buildings in nZEB, largely depends on whether or not Mediterranean members states take in consideration the refurbishment of the historical buildings. Considering that the EU Mediterranean countries have a building stock of 70% built before the laws on energy efficiency and it is often obsolete and needs urgent and necessary energy efficiency interventions and that, big part of this public building stock is historic, with law restrictions, it is obvious that if we exclude this public building stock, which is historic, the Directive may not reach the expected results.

CERtuS partners are creating materials suitable to support the intensive communication plan of the Project. The plan includes four workshops with B2B sessions targeted to municipalities, ESCOs and financing entities. These actions shall be complemented by four training activities targeting municipal employs and the participation in international events targeting all 3 stakeholders. We are confident and we expect that our action will have a significant impact by triggering investments in innovation to achieve nZEB and to uptake the ESCO market in Southern European member states.

# THE PILOTS OF THE CERtuS PROJECT

## MESSINA, ITALY

### ZANCA PALACE

| | |
|---|---|
| **Building Type** | **City hall/ multiple purpose use** |
| **Year of Construction** | **1914** |
| **Area / Volume** | **13.500 $m^2$ (about 7.000 $m^2$ to floor) / 95.000 $m^3$ .** |
| **Responsible Project Partner** | **ENEA** |

### BUILDING DESCRIPTION

Palazzo Zanca is located on the seafront, at the same place of the historic town hall, which was destroyed twice before by earthquakes in 1783 and then definitively in 1908. It had been restored using the original architectural materials after the earthquake of 1908 and its restoration belongs to the reconstruction plans of the city. The works of the ruined building began in December 1914 and were completed in 1924. The building's style is neoclassical and consists of two floors above ground. Its dimensions are the same for each floor.

All rooms are in municipal office use. The building is usually in use between 0h:00 and 24h:00 from Monday to Sunday, but the services are available and employees present only between 7h:30 and 19:h30. The building hosts about 750 employees and it is visited by an large number of visitors.

### BUILDING CURRENT CONDITION - TECHNICAL AND OTHER PROBLEMS DETECTED

Palazzo Zanca is a courtyard-detached building, developed in an articulated platform through five pavilions. The building structure was built according to the “Hennebique” system in reinforced concrete (Portland cement). Three out of five pavilions have a continuous system of masonry in reinforced concrete, conversely, two other pavilions have a frame system with bricks, as infill wall. The external part of the envelope is in “fake stone”.

All the windows are single glazed with wood frames. The structure of doors is equal to the windows, except 3 doors on the ground floor are glass and metal doors. All the windows do not have rolling shutters but simple shutters. Almost all rooms have opaque dark color cloth curtains. The building is shaded by other building to the North and by ever green trees to the South. The main façade oriented to the East is not subject to any shading.

A thermal survey made in the building shows that walls present, generally, good thermal performance. Conversely, the windows, with single glazing and wood frames, present insulation problems, aggravated by aging. Some characteristics of the building contribute to poor thermal performance: The orientation is not the optimum, requiring additional energy consumption with heating during the winter (mainly in the north areas) and with cooling during the summer (mainly in the west areas without any direct protection from the direct radiation). The walls with high thermal inertia and large ceiling height provide advantages during the summer, but disadvantages during winter, since the building does not have users in the night period and weekends which leads to a high temperature decrease. The windows have a low level of airtightness, enabling a high level of air infiltration, which is not controllable and undesirable, mainly during the winter. The doors are old and have a high thermal transmittance. The building presents many pathologies, such as condensation and mould growth.

The HVAC is ensured with several heat pumps, which were installed gradually Therefore, there are several different types of equipment with different characteristics and performance. In total, there is at least one split in every room and the total number exceeds 150 units. Almost all the areas of permanent use have HVAC, being the control ensured locally with individual control. The split units have more than fifteen years now, and their efficiency is reduced.

The air circulation and renewal is ensured naturally, there are not systems of forced ventilation.

Lighting is mainly supplied by incandescent and fluorescent lamps. There is no mechanism to control lighting and plants are dated.

## ECONOMIC, FINANCIAL AND LEGISLATIVE CONSTRAINS

### *Economic/Financial Risks*

The energy related interventions of public buildings require high overall investment and the Municipality has not specific financing to invest on the building stock. Furthermore, the interventions of deep renovation are still considered too risky and they do not attract the local market players. There are therefore objective difficulties for the insertion of energy improvements. Administration is trying to raise funds from national and regional funding programs.

### *Legislative Obstacles*

Renovating the historic buildings to today's standards through the use of renewable energy technologies and deep renovation is a difficult issue. This issue become impossible when the renovation options interfere with preservation requirements of historic buildings, as the apposite authorities - properly - set limitations. The main objective, in these cases, is to find intelligent ways of approaching the historic building conservation and energy efficiency, without cause any visual impact or modify integrity of historical fabrics. Considering that each historic building is a special case, addressing the conflict between energy efficiency - conservation and providing guidance regarding solutions and best practices becomes an important step toward resolving or eliminating barriers.

## RENOVATION SCHEME

### *Building Envelope*

Opaque Envelope: Currently, the building envelope is insulated according to the standards prevailing at the period of construction. Following a sensitivity analysis based on the results from the Design Builder simulations of the renovation design, it is expected inserting a high performance plaster that improves slightly envelope performance. Glazing:The existing glazing and frames with total U-value of 5,80 W/m$^2$K will be replaced by selective glazing and thermal break with total U- value 1,6 W/m2K, total solar transmissions 42,1 %, light transmission 0,682.

### *HVAC*

The proposed HVAC systems are VRV (Ceiling-Mounted Cassette) with COP of 3.91 and EER of 3.46, according the instructions of the relevant regulations.

### *Lighting*

All lamps of the building will be replaced with new LED lamps, after a better zoning of the fixtures. In addition, day lighting sensors will be installed on the luminaires that provides on/off switching. Also, an occupancy sensor can be connected to the daylighting sensor so that the lights can be turned ON or OFF based on light levels and occupancy detection.

### *RES*

A PV system of 126 kWp will be installed on the roof of the building. This value ensures just over 25% of post renovation consumption of electricity.

### *Energy management system*

A Building Automation Control System (BACS) to optimise the building's mechanical and electrical equipment will be installed. The BACS will integrate different kinds of disciplines (HVAC control, lighting and blind control, sub-systems…), will be coordinated through a Building Management and will guarantee the maximum comfort for the users and a correct functionality at minimum cost.

### *Passive solar gains*

Appropriate ventilation openings are located both at monumental stair windows and at the main atrium, so to ensure an appropriate exchange of the air and a constant ventilation.

### *Equipments*

Consumptions were evaluated separately for office's equipment and CED. The envisaged interventions are divided into three types: (i). staff's training to a rational use of office equipment; (ii). purchases regulated by Green Public Procurement (GPP model), by providing clear environmental criteria for products and services and giving a favourable evaluation to the products with better energy class; (iii) control systems which manage, command and regulate the behaviour of other devices or systems.

## RENOVATION SCHEME EVALUATION

| | |
|---|---|
| **Costs** | 2,309,752 € |
| **Energy Savings** | 774,308 kWh/year<br>139,375 €/ year |
| **$CO_2$ Savings** | 277,098 tons /year |
| **Maintenance Savings** | 77,620 €/ year |
| **Potential Savings (energy + maintenance)** | 216,995 €/year |
| **Simple Payback** | 11 years |

*Energy Savings*

The energy consumption before renovation is equal to 1,306,563 kWh/year and the energy consumption on square meter is equal to 97 kWh/m$^2$. The energy consumption savings are equal to 774,308 kWh/year, that means an energy expenditure saving of 139,375 Euro/year.

*$CO_2$ Savings*

The $CO_2$ savings are 277,098 tons/year, with respect to the mix for electricity production (base year for calibration 2015).

*RES Integration*

The installation of a 126kWp PV system for energy generation is expected to produce about 176,400 kWh/y.

### Economic Evaluation

*Renovations cost*

The total investment cost is equal to 2,309,752 Euro that means an investment cost per square meter of 171.09 Euro/m$^2$.

| INVESTMENTS | € |
|---|---|
| **HVAC** | 700,000 |
| **Cooling Pumps** | 244,352 |
| **Lighting system (internal+external)** | 321,000 |
| **Renewable energy (PV)** | 226,800 |
| **Windows – Low-e /thermal break** | 817,600 |
| **Investment for Renovation** | 2,309,752 |

*Economic Savings*

The energy expenditure saving is 139,375 Euro/year. The maintenance expenditure post renovation is lower than before by 77,620 Euro/year. This situation affects positively, at economic level, on the total savings achievable by the intervention, in fact the economic saving both energy and maintenance is about 216,995 Euro/year.

*Project Payback Period*

The Project Payback period is 11 years considering the maintenance savings but the cash flows are not sufficient to implement a financial structure at market condition.

### Financing Scheme

*Energy Performance Contract*

The strategy of Messina's Municipality is to promote the nZEB concept, despite its inability to financing the needed renovation options under the current tight economic conditions. Dealing with the expensive renovation of Zanca Palace, the most suitable operational financial scheme corresponds to a solution which combines the use of three types of public/private partnerships EPC contracts, with provision of specific conditions, in order to make the project attractive for the ESCo market.

To make it palatable to the market projects and allow a contract term not exceeding nine years is necessary:

a) reduce the investment value postponing interventions that bring lower energy benefits (see. Table);

b) a contribution from the Municipality on investment of 30%;

c) recourse to financing with concessional funds or use of incentives of the Energy Bill.

| SEPARATED INVESTMENTS | COST € | SAVING € |
|---|---|---|
| **Windows– Low-e /thermal break** | 817.600 | 5.980 |

In this way, the investment is reduced by about € 800,000, the pay-back of the project for the ESCO is greatly reduced.

*Duration of EPC*

In accordance with the measure of separated investments, the contract duration is of 9 years con un IRR per la ESCO del 5,5.

*Financial Sources*

The Municipality can directly finance part of the renovation measures through the National Operational Programme on Italian Metropolitan Cities for an amount of 450 k€ that corresponds to approximately 30% of the total investment of the building renovations. The remaining cost will be funded by an ESCO through the 'Conto Termico 2' and own resources as well by subsidized and dedicated funds (national and European).

*Other considerations*

The total investment of the municipality for the three projects would amount to about 2,000 k € which would be fully covered by the National Operational Programme on Italian Metropolitan Cities, any other remaining funds would allow to directly realize the deferred works.

### PALACE OF CULTURE "ANTONELLO DA MESSINA"

| | |
|---|---|
| **Building Type** | **Multifunctional center** |
| **Year of Construction** | **1975 / 2009** |
| **Area / Volume** | **10,300 m²** |
| **Responsible Project Partner** | **ENEA** |

### BUILDING DESCRIPTION

Palacultura is an imposive building of Messina, lying nearly the marina of the city. It consists of three areas for cultural activities and has several equipment, as: a public library, a measeum, a theater of 850 seats, an outdoor amphitheatre, among the largest and most modern in Italy and even an exhibition area located on the terrace.

The inverted pyramid structure has been obtained by exploiting the considerable flexibility offered by materials such as cement and steel and taking into account that Messina is an earthquake risk zone.

The building designed in 1975 and after various events, was completed only at the end of 2000. It comprises six floors above ground. The dimensions in height and shape are very different for each floor. Cultural activities are hosted in the first three levels, while the other three (those with the opaque envelope) are occupied by offices. The building is, usually, in municipal office use and, on the occasion, on the museum exhibitions or theater performances. The municipal services are available and employees present between 7h30 and 19h30, five days weekly. The building hosts about 200 employees and visitor numbers change according to the activities taking place at the palace.

### BUILDING CURRENT CONDITION - TECHNICAL AND OTHER PROBLEMS DETECTED

Palacultura is a detached building. The shape of the building, very articulated both in plan and in elevation, is a parallelepiped on a retangular base on which is erected the inverted pyramid structure. Only the west side is relatevely close to neibouring properties. The main axe of the building is elongated along the noth-south axis.

Building's envelope is made of wide range of materials, mainly steel and concrete. The north glazed continuous façade is made from vertical pillars and horizontal structural components of aluminum alloy with a double layer of laminated glass. The eastern glazed continuous facade is made of aluminum alloy profiles with double-layered crystal glass.

The facade of the inverted pyramid structure of the three upper floors, in municipal office use, is made from sandwich panels in concrete reinforced and glass fiber of 12.5 mm. It is finished with pilaster strips in EPS, with plaster wire mesh panels placed over the sandwich panels.

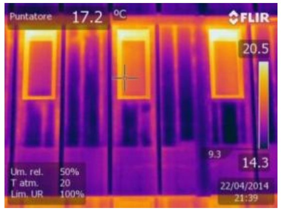
The glazed surface area of the inverted pyramid structure covers a considerable part of the building, around 40%.. All windows have singe glazing with alluminium frames and simply shutters. Only few rooms of the building have opaque dark cloth curtains. Facades are not subject to any shading.

The building as a whole has a low energy performance. The opaque envelope has a low thermal inertia and many thermal bridges due to the type of wall construction. In addition, windows have low air-tightness, enabling a high level of air infiltration, which is not controllable, mainly during winter. The doors present significant heat losses. The indoor conditions are not optimal neither in winter nor in summer.

The HVAC is ensured with several ceiling mounted split, for the forced ventilation and air conditioning. Therefore, all split units are connected to a single hydronic heat pump. The ventilation is ensured both naturaly through the doors and windows as well as through the mechanical system. There is forced ventilation in every room.

Lighting is mainly supplied by fluorescent lamps. There is no mechanism to control lighting and installations are dated.

The main energy needs of the building are covered by electricity, but there are also present small plants using natural gas for heating.




## ECONOMIC, FINANCIAL AND LEGISLATIVE CONSTRAINS

### *Economic/Financial Risks*

The main economic barrier to the implementation of the renovation plan is the limited budget of the municipality to cover part of the high overal investment. The Municipality is trying to raise funds from national and regional funding programs. Additional limit is the undeveloped ESCo market in Sicily and the lack of adequate, long-term financial instruments, for the hight overall investment requested. Existing financial mechanisms are insufficient to implement such type of renovation actions without the national energy targets.

### *Legislative Obstacles*

There were not specific regulatory obstacles identified in the renovation design. However must be pointed out that the Regional Landscape Plan of the Province of Messina imposes constraints on the entire city center. However, for the specific building was possible foreseen the change of existing glazing or, in alternative, the affixing of photovoltaic films.

## RENOVATION SCHEME

### *Building Envelope*

Opaque Envelope: The approach of the building renovation includes extra internal insulation on the three upper floors. The internal coat it will be possible with a new layer with high insulation value. The insertion of an internal insulation decreases the floor area of the building but it is the only possible solution in the case of a prospectus with the external geometry as difficult as that of the Palace of Culture. Will be using the panels of cork and plasterboard thickness up to 4 cm. Glazing: also, the existing glazing and frames will be replaced by selective glazing and thermal break frame in PVC. Regarding the frames, they were chosen to include window frames with thermal break.

### *HVAC*

The use of more environmental friendly HVAC systems was investigated but VRV appeared to be the most suitable choice. The Variable Refrigerant Volume (VRV) systems offer high levels of energy efficiency, as well as flexibility. They operate quietly and provide the user full control of the environmental temperatures. It will be isolated for use diversification depending on the intended use of the different areas.

### *Lighting*

It is expected to replace the existing lighting with the introduction of LED lamps and, where it is possible, to insert intelligent system.

### *RES*

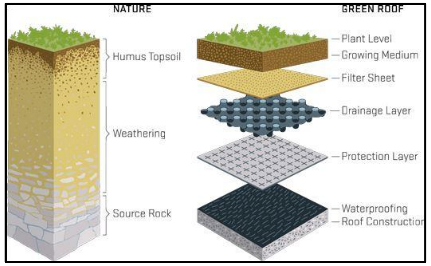
On the roof of the building will be installed a photovoltaic system of 28 kWp: this size ensures about 18% of post renovation consumption of electricity.

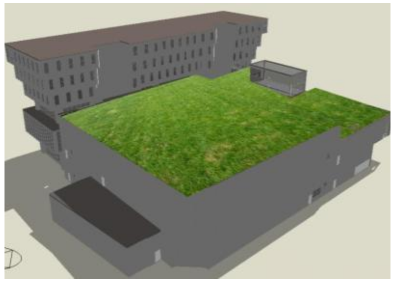
### *Passive solar gains / insulation*

A green roof is suggested to give two great advantages: at first it will decrease heat losses during winter season, working as thermal insulation and then, it will hinder heat input, during summer season, working as a reflecting system for sunlight.

### *Equipments*

The envisaged interventions are divided into three types: (i). staff's training to a rational use of office equipment; (ii). purchases regulated by Green Public Procurement (GPP model), by providing clear environmental criteria for products and services and giving a favourable evaluation to the products with better energy class; (iii) control systems which manage, command and regulate the behaviour of other devices or systems.



### Renovation Scheme Evaluation

| | |
|---|---|
| **Costs** | 1,114,175 € |
| **Energy Savings** | 228,860 kWh/year<br>41,195 €/ year |
| **$CO_2$ Savings** | 76,213 tons/year |
| **Maintenance Savings** | 839 €/year |
| **Potential Savings (energy + maintenance)** | 42,034 €/year |
| **Simple Payback** | 27 years |

*Energy Savings*

The energy consumption before renovation is equal to 408,733 kWh/year and the energy consumption on square meter is equal to 40 kWh/m$^2$. The energy consumption savings are equal to 228,860 kWh/year, that means an energy expenditure saving of 41,195 Euro/year.

*$CO_2$ Savings:*

The $CO_2$ savings are 76,213 tons/year.

*RES Integration*

On the roof of the building will be installed a photovoltaic system of 28 kWp: this size ensures about 18% of post renovation consumption of electricity.

### Economic Evaluation

*Renovations cost*

| INVESTMENTS | € |
|---|---|
| **Lighting system (internal)** | 252,150 |
| **Renewable energy (PV)** | 50,400 |
| **Building envelope** | 500,000 |
| **Windows - Low-e /thermal break** | 261,625 |
| **BACS** | 50,000 |
| **Investment for Renovation** | 1,114,175 |

The total investment cost is equal to 1,114,175 Euro, that means an investment cost per square meter of 108 Euro/m$^2$.

*Economic Savings*

The maintenance expenditure post renovation is lower than before by 839 Euro/year. This situation affects positively, at the economic level, on the total savings achievable by the intervention. In fact the economic saving both for energy and maintenance is about 42,034 Euro/year.

*Project Payback Period*

The Project Payback period is very long, 26.5 years considering maintenance, and the project cash flows are very low. This situation has a very negative impact on the sustainability of the project and consequentially on the attractiveness for an ESCo.

### Financing Scheme

*Energy Performance Contract*

The strategy of Messina's Municipality is to promote the nZEB concept, despite its inability to financing the needed renovation options under the current tight economic conditions. Dealing with the expensive renovation of Palace of Culture, the most suitable operational financial scheme corresponds to a solution which combines the use of three types of public/private partnerships EPC contracts, with provision of specific conditions, in order to make the project attractive for the ESCo market. To make it palatable to the market projects and allow a contract term not exceeding nine years is necessary: a) reduce the investment value postponing interventions that bring lower energy benefits (see. Table); b) a contribution from the Municipality on investment of 30%; c) recourse to financing with concessional funds or use of incentives of the Energy Bill.

| SEPARATED INVESTMENTS | COST (€) | SAVING (€) |
|---|---|---|
| **Building envelope** | 603.625 | 4.258 |

In this way, the investment is reduced by about € 600,000, the pay-back of the project for the ESCO is greatly reduced. The project is still not sustainable for an ESCO.

*Duration of EPC :*

In order to allow the sustainability of the contract in the market is necessary to extend the contract duration at least 15 years

*Financial Sources:* The Municipality can directly finance part of the renovation measures through the National Operational Programme on Italian Metropolitan Cities for an amount of 153 k€ that corresponds to approximately 30% of the total investment of the building renovations. The remaining cost will be funded by an ESCO through the 'Conto Termico 2' and own resources as well by subsidized and dedicated funds (national and European).

*Other considerations:* To allow for a greater financial commitment to ESCOs could be included in the contract also management of other outside maintenance services. As the municipality may entrust to third parties, including services for the public and the management of certain cultural activities increasing revenues and margins for further investment.

## SATELLITE PALACE

| | |
|---|---|
| **Building Type** | **Municipal Office** |
| **Year of Construction** | **1970** |
| **Area / Volume** | **6,870 m$^2$ (about 1,350 m$^2$ to floor) / 18,550 m$^3$** |
| **Responsible Project Partner** | **ENEA** |

## BUILDING DESCRIPTION

Palazzo Satellite is a municipal building of Messina. The building is located in the historic centre of the city, near the central station. The building includes many functions of municipal government, including the Local Health Unit, the municipal Police management and several Municipal Departments.

Building style is modern; it is an example of a frame structure made of reinforced concrete. The walls are made of masonry and the floors are in slab and masonry. The building is constituted of 5 floors above ground. The dimensions are the same for each floor.

The building is usually in use between 0h00 and 24h00 from Monday to Sunday only for the municipal police management. The public activities of employees are carried out only between 7h30 and 19h30. The building hosts about 200 employees and it is visited by an indeterminate number of public.

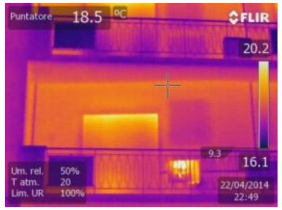
## BUILDING CURRENT CONDITION - TECHNICAL AND OTHER PROBLEMS DETECTED

The building was built for residential use and each floor hosts several residential units / apartments. This residential building typology has been converted in office and public space without any planning or adaptation. Furthermore, the building even if it is owned and managed by one entity (the municipality), is subdivided into individual office suites (originally residential units) and is in use by organisations of different size, needs and business types. This results in areas with favourable, less favourable and poor indoor environment and further complicates the physics and the overall performance of the building.

Besides, some characteristics and technical standards of the building contribute to its poor thermal performance.

The orientation is not favourable demanding high heating energy consumption during the winter (supplementary in the north exposition) and high cooling energy consumption during the summer. In addition the facades do not have any protection from solar radiation.

The external walls have a medium thermal inertia with over-media ceiling height, this aspect increases the envelope energy thermal response during the summer, but causes disadvantages during the winter. Still, the windows are the old type with a single glazing and aluminium frames and present insulation problems and limited air tightness. Indeed, the building investigation by IR shows thermal losses due to thermal bridges. The doors are old and don't retain heat. The building presents many pathologies, such as condensation and mould.




## ECONOMIC, FINANCIAL AND LEGISLATIVE CONSTRAINS

*Economic/Financial Risks*

The municipality has no specific financing to improve public buildings. There are therefore serious difficulties to undertake energy improvements. The Administration is trying to raise funds from national and regional funding programs.

*Legislative Obstacles*

There are no legislative obstacles to the renovation of this building.

## Renovation Scheme

*Building Envelope*

Opaque Envelope: among the actions planned, there is the facades renovation, it is planned to ensure the safety of unsafe parts and, where necessary, to do an important refurbishment. Another change concerns the reconstruction of the plaster of the facades, using a thermal insulation plaster. Among other interventions there is waterproofing of the roof, so it is expected to enter under the floor of a fiber-reinforced bituminous membrane.

Glazing: also, the existing glazing and frames will be replaced selective glazing and thermal break frame in PVC. Regarding the frames is chosen to include window frames with thermal break. It is chosen to use windows with PVC frames. Glasses chosen are selective double glazing with air chamber 6/13 mm.

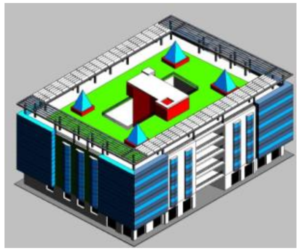
*HVAC*

Almost all working rooms, have air conditioning systems. It is expected to insert a false ceiling in all circulation areas and, where possible in all rooms of the building. The result is a decrease in the net height of the rooms to be heated and creation of a channel for heating and lighting installations.

*Lighting*

It is expected to replace the existing lighting with the introduction of LED lamps and, where possible, to insert intelligent dimmerable systems.

*RES*



The choice is the installation of a PV system with120 kWp. This ensures about 84% of post renovation consumption of electricity.

*Passive solar gains / insulation*

it is hypothesized the inclusion of a green roof that will give two great advantages: at first it will decrease heat loss during winter season working as thermal insulation, and then it will hinder heat input during summer season working as a reflecting system for sunlight.

*Energy management system*

A centralised Building Automation Control System (BACS) is foreseen to control the building's heating, cooling and ventilation, lighting and other systems through a Building Management. This distributed system includes networked computers, all electronic devices useful to control security, lighting in general and emergency lights as well rooms' humidity and temperature.

*Equipments*

The envisaged interventions are divided into three types: (i). staff's training to a rational use of office equipment; (ii). purchases regulated by Green Public Procurement (GPP model), by providing clear environmental criteria for products and services and giving a favourable evaluation to the products with better energy class; (iii) control systems which manage, command and regulate the behaviour of other devices or systems.

## Renovation Scheme Evaluation

| | |
|---|---|
| **Costs** | 1,629,738 € |
| **Energy Savings** | 308,557 kWh/ year<br>55,540 €/ year |
| **$CO_2$ Savings** | 98,545 tons/year |
| **Maintenance Savings** | - 598 €/year |
| **Potential Savings (energy + maintenance)** | 54,942 €/year |
| **Simple Payback** | 2'9 years |

*Energy Savings*

The energy consumption before renovation is equal to 340,626 kWh/year and the energy consumption on square meter is equal to 50 kWh/m$^2$ yearly.

The energy consumption savings are equal to 308,557 kWh/year, that means an energy expenditure saving of 55,540 Euro/year.

*CO2 Savings*

The $CO_2$ savings are 98,545 tons/year.

*RES Integration*

The potential integration of RES was investigated and several options were considered. The optimum choice regards the installation of photovoltaic systems on the roof and on the walls of the building. The installed capacity will be 120 kWp with an estimated PV total saving 168,000 kWh.

## Economic Evaluation

*Renovations cost*

| INVESTMENTS | € |
|---|---|
| HVAC | 500,000 |
| Lighting system (internal) | 101,000 |
| Renewable energy (PV) | 216,000 |
| Building Envelope | 792,538 |
| Control system (BACS) | 20.000 |
| Investment for Renovation | 1,629,738 |

The refurbishment investment cost is equal to 1,629,738 Euro (excluded VAT), that means an investment cost per square meter of 237.2 Euro/m$^2$.

*Economic Savings*

The energy expenditure saving is 55,540 Euro/year. The maintenance expenditure post renovation is higher than before by 598 Euro/year. This affects negatively, at economic level, on the total savings achievable by the intervention and also on the payback period. In facts, the economic saving both for energy and maintenance is 54,942 Euro/year.

*Project Payback Period*

The Project Payback period is very long, 29 years considering the maintenance, and the project cash flows are very low. This situation has a very negative impact on the sustainability of the project and consequentially on the attractiveness for an ESCo.

## Financing Scheme

*Energy Performance Contract*

The strategy of Messina's Municipality is to promote the nZEB concept, despite its inability to financing the needed renovation options under the current tight economic conditions. Dealing with the expensive renovation of Satellite Palace, the most suitable operational financial scheme corresponds to a solution which combines the use of three types of public/private partnerships EPC contracts, with provision of specific conditions, in order to make the project attractive for the ESCo market.

To make it palatable to the market projects and allow a contract term not exceeding nine years is necessary:

a) reduce the investment value postponing interventions that bring lower energy benefits (see. Table); b) a contribution from the Municipality on investment; c) recourse to financing with concessional funds or use of incentives of the Energy Bill; d) the project is still not sustainable for an investment of an ESCO.

| SEPARATED INVESTMENTS | COST (€) | SAVING €) |
|---|---|---|
| Waterproofing foundations | 237.168 | 3,205 |

*Duration of EPC*

In order to allow the sustainability of the contract in the market is necessary to extend the contract duration at least 15 years.

*Financial Sources*

The Municipality can directly finance the renovation measures through the National Operational Programme on Italian Metropolitan Cities for an amount of 1.400 k€ that corresponds to approximately 100% of the total investment of the building renovations. The Municipality will recover part of the investment incentives through the 'Conto Termico 2'.

*Other considerations*

The total investment of the municipality for the three projects would amount to about 2,000 k € which would be fully covered by the National Operational Programme on Italian Metropolitan Cities.

# ALIMOS, GREECE

## CITY HALL

| Building Type | City Hall |
|---|---|
| Year of Construction | 1986 |
| Area / Volume | 1,302 m$^2$ / 3,612 m$^3$ |
| Responsible Project Partner | EUDITI-Energy & Environmental Design |


### BUILDING DESCRIPTION

The City Hall of Alimos is located close to the coast and enjoys a good sea view from the upper floors. It comprises five floors and a basement. The first two levels and the basement were constructed in 1986 whilst the other 3 were added in 1996. The shape of the initial two-floor building is elongated along the N-S axis. The 5-storey addition, at the back side, has a rectangular shape and consists of two adjacent building blocks. The orientation of the whole complex deviates 30$^o$ from south due west.

The occupation profile of all floors is from 07:30 to 15:30 on week days apart from 4$^{th}$ floor (Mayor's office) which is occupied from 07:30 to 17:30. There are 78 employees in the City hall and around 130 visitors daily.

### BUILDING CURRENT CONDITION - TECHNICAL AND OTHER PROBLEMS DETECTED

The building is detached and only the northwest side of the stairwell is in contact with heated areas of the neighbouring building. Each floor is divided into two areas; the office space and the entrance hall. They are separated with insulated walls as the latter is a non-heated area.

The walls are insulated with 4 cm of extruded polystyrene placed in between two brick layers and the windows have double glazing in an aluminium frame.

The envelope has thermal bridges resulting from the type of wall construction. In several windows there is moisture in between the two glass panes.

Regarding the HVAC there are two types of air conditioning systems used: a) small split systems b) ceiling mounted and floor standing units with inlet and outlet vents, which supply heating and cooling by using electricity.

Lighting is mainly supplied by fluorescent T8 lamps with magnetic ballast.

### ECONOMIC, FINANCIAL AND LEGISLATIVE CONSTRAINS

*Economic/Financial Risks*

This building hosts numerous services and employees but the current situation can change depending on the needs of the municipality. A potential increasing of the number of the services or the employees of the City Hall will increase the energy consumption (i.e. cooling, ventilation) and consequently the payback period of the investment.

The required investment for simultaneous implementation of all the foreseen energy efficiency measures is quite high and this presents a serious difficulty for the Municipality. Thus, to proceed with the proposed renovation plan, inflow of capital from third parties is required.

*Legislative Obstacles*

There were not regulatory obstacles identified in the renovation design. However, the major difficulty is the integration of renewable energy systems when the building is located in a densely built area. This is due to the lack of space availability, the reduced solar potential due to shadowing, the reduced wind potential etc. In Greece the legislation defining the levels of nZEB and the expected contribution of RES is under development. So, it is important the "nearby areas", as indicated by the Energy Performance of Buildings Directive, EPBD, to be defined as flexibly as possible in order to facilitate the integration of RES and make nZEB levels achievable.

## RENOVATION SCHEME

### *Building Envelope*

Opaque Envelope: The thermal insulation of the walls and roof will be enhanced with additional 5cm polystyrene, having 0.032 W/mK that will be placed externally. The thickness was selected following a sensitivity analysis. It is interesting to note that due to building operation, concentrating during daytime up to 17:00 daily, and, the mild weather conditions prevailing in the area, a greater thickness does not contribute in further reduction of heat losses.

Glazing: Similar to the thermal insulation, a sensitivity analysis was carried out for the window U-value. Following a sensitivity analysis for different U-values, it was concluded that the optimum choice will be a window with U-value 1.80 $W/m^2K$. A low–e coating is foreseen on the internal side of the external glass pane to reduce the incoming heat. The glazing has 42% Solar Factor and 66% Light Transmission.

Shading: To enhance the thermal performance of the transparent envelope and reduce the cooling demand during summer, shading devices will be installed. External retractable louvers are selected for all the facades except the north one. The louvers are sized according to the orientation of the openings to provide full shading during summer.

Natural/Night ventilation: To further reduce the energy demand for cooling natural/night-time ventilation is foreseen. Air vents equipped with dampers will be installed on the north and south façade of the building so as to achieve cross ventilation on each floor. The ventilation openings will automatically operate only when the external temperature is sufficiently lower than the internal.

Passive solar system: During wither time, in order to avoid any potential overheating of the offices on the south part of the building, appropriate openings will be integrated into the internal walls which separate the south and north spaces on the second and third floor. This intervention will allow the circulation of the heat generated by solar radiation incoming through the south facing glazed wall.

### *HVAC*

The new HVAC system will be a multi-zone VRV system consisting of three external and forty four internal units. The internal units, ceiling mounted cassettes, will be installed in every office and will be controlled by individual controllers so that every office has the desired internal air temperature. In addition, the Heat Recovery Ventilation System (HRV), will modulate the temperature and humidity of incoming fresh air to match indoor conditions.

### *Lighting*

All lamps of the building will be replaced with new LED lamps. Additionally, the wiring of fixtures will be replaced to allow for better zoning of the room lighting. Also, daylight sensors will be installed on the luminaires located close to the windows of the 3 upper floors so that artificial lighting can be turned off automatically when the desired lighting levels are reached.

### *RES*

The building is located in a densely built area that offers limited opportunities for use of renewable energy sources. The potential integration of RES was investigated but only a small photovoltaic (PV) system can be integrated on the roof of the building. The installed capacity will be 15.26 kWp with an estimated annual production of 20,900 kWh.

### *Building Energy Management System*

To optimize the performance of the mechanical and electrical equipment such as, lighting, ventilation and HVAC system, an energy management system (BEMS) will be installed. The BEMS will control, monitor and record data such as (i) air temperatures, hours of operation and energy consumption of each VRV cassette separately, (ii) the lighting energy consumption of each floor.

In all windows will be placed an on/off touch connected to VRV cassette so as to stop operation of the corresponding cassette when the window opens. The opening and closing events will be recorded by the BEMS.

## RENOVATION SCHEME EVALUATION

Three alternative renovation options were carried out with the aim to achieve lower payback time for the renovation investment and increase the potential to attract private funding. Option A excludes only the external insulation, Option B excludes only the replacement of the glazing and Option C excludes both interventions. The most financially attractive was the Option C.

| | ALL INTERVENTIONS | OPTION C |
|---|---|---|
| **Energy Savings kWh/year** | 104,537 | 103,170 |
| **Costs €** | 310,943 | 172,088 |
| **Savings €/year** | 17,988 | 17,790 |
| **Simple Payback** | 17.2 | 9.7 |
| **$CO_2$ Savings tons/year** | 103.37 | 102.02 |

As can be seen the savings are comparable between the two options but the cost and the simple payback period are varying substantially. For this reason Option C was selected for implementation.

### *Energy Savings*

The energy consumption (for heating, cooling, and lighting) before renovation is equal to 111,965 kWh/year and the energy consumption per square meter is equal to 102 kWh/m$^2$. After renovation (Option C) the consumption is reduced to 8,795 kWh/year or 8 kWh/ m$^2$.

Specifically, the energy efficiency interventions, excluding the electricity generated by the PV system, reduce the energy consumption to 27 kWh/m$^2$ by generating savings equal to 82,270 kWh/year. These savings represent 73% of the energy consumption before renovation. The remaining demand is covered up to 70% by the PV system which produces 20,900 kWh/year.

### *$CO_2$ Savings*

The $CO_2$ savings resulting from Option C are 102.02 tons/year.

## Economic Evaluation

### *Renovations cost*

| INVESTMENTS | € |
|---|---|
| **HVAC** | 80,336 |
| **Lighting system** | **18,905** |
| **Renewable energy** | 25,707 |
| **Shading** | **25,000** |
| **Cross Solar Heat** | 1,230 |
| **Control system** | 20,910 |
| **Total Investment** | **172,088** |
| ***The costs reported above include 23% VAT.*** | |

The cost of the interventions which are excluded is 83,505 € for the external insulation and 55,350 € for the windows.

### *Economic Savings*

The total annual economic savings are equal to 17,790 € and consist of the energy and maintenance expenditure savings that are 14,354€ and 3,436 € respectively.

## Financing Scheme

Under the current challenging economic conditions, municipality of Alimos has limited financial resources for implementing the energy retrofit. The most suitable financing model is to assign the project to an Energy Service Company (ESCo). The ESCo is responsible to secure the total investment cost, the implementation of the project, the maintenance during the contract period and, guarantee the energy performance of the agreed solutions. The money savings, corresponding to the energy savings, will be shared between the ESCo and the Municipality, according to the "Shared Savings" model contract.

### *Financial Structure of Project*

The most market efficient financing source for implementing the project is market money (private equity, bank loan), followed by Subsidised Loan. The least favourable one is Grants since they have zero revolving effect. Even so, in many nZEB renovations Grants are necessary for turning a project market attractive and marketable. The optimum financial structure should involve the provision of sufficient subsidised loans as the latter improve the attractiveness of the project and make it marketable.

The optimum financial structure consists of:

- Equity investment by the ESCo - 24%
- Subsidized Loan - 65%
- VAT Facilities - 11%

The expected project payback period is approximately 10 years, while the duration of the EPC is 15 years which is still market acceptable.

### *Other considerations*

The EPC takes into provision that the relevant money savings are allocated to the repayment of the investment, allowing 5% annual money saving to be enjoyed by the Municipality who has zero contribution to the capital cost. Once the EPC is concluded all money savings will be enjoyed by the Municipality.

## MUNICIPAL LIBRARY

| | |
|---|---|
| **Building Type** | **Library** |
| **Year of Construction** | **1984** |
| **Area / Volume** | **611 $m^2$ / 2,185 $m^3$** |
| **Responsible Project Partner** | **EUDITI- Energy & Environmental Design** |


## BUILDING DESCRIPTION

The Municipal Library building was constructed in 1984. It comprises five floors and a basement. The Municipality uses the first three storeys and the basement to house the Municipal Library, offices, school activities and dancing courses. The rest of the building is residential.

The building is elongated along the N-S axis and its orientation deviates 53° from south due west.

The occupation profile is from 07:30 to 20:30 on week days. There are 13 employees and about 70 visitors per day.

## BUILDING CURRENT CONDITION - TECHNICAL AND OTHER PROBLEMS DETECTED

It is a detached building and the construction is typical of the period and region.

The walls consist of double brick and reinforced concrete for the load bearing structure. The walls are insulated with 5 cm of extruded polystyrene placed in between the two brick layers. The roof slab is insulated with 8 cm extruded polystyrene. The windows have double glazing in an aluminium frame.

The envelope has thermal bridges resulting from the type of wall construction.

Split and floor standing air conditioning systems are used for heating and cooling the building via electricity. The ground and the first floor use extra oil radiators for heating. There is also central heating system which is currently out of use.

Lighting is mainly supplied by fluorescent T8 lamps with magnetic ballast.

## ECONOMIC, FINANCIAL AND LEGISLATIVE CONSTRAINS

### *Economic/Financial Risks*

The fact that the municipality rents this building gives rise to risks as the relocation of the library might take place before the end of the payback period. However, this is considered a medium to low level risk.

The total cost of the energy consumption is low and this fact affects the final payback period of the investment which is quite long for certain interventions. This happens because the daily operation is short and the energy demand of the services/activities taking place in this building is modest.

### *Legislative Obstacles*

In a building which has central heating system it is not always easy to abolish this system and/or replace it with more flexible ones. This obstacle appears when there are more than one owner and not all of them agree with this change. In this case the regulation regarding multi – owner buildings applies and requires either a unanimous vote or a majority vote. For this reason the most feasible choice is to improve the existing central heating system. Likewise, the installation of PVs on the roof has to be approved by all owners of the building.

## RENOVATION SCHEME

### *Building Envelope*

Opaque Envelope: The thermal insulation of the walls and roof will be enhanced with additional 5cm polystyrene, having 0.032 W/mK, that will be placed externally. The thickness was selected following a sensitivity analysis. It is interesting to note that due to building operation, concentrating mainly during daytime, and, the mild weather conditions prevailing in the area, a greater thickness does not contribute in further reduction of heat losses.

Glazing: Similar to the thermal insulation, a sensitivity analysis was carried out for the window U-value. Following a sensitivity analysis for different U-values, it was concluded that the optimum choice will be a window with U-value 1.80 $W/m^2K$. A low–e coating is foreseen on the internal side of the external glass pane to reduce the incoming heat. The glazing has 42% Solar Factor and 66% Light Transmission.

Natural/Night ventilation: In order to reduce further the energy demand for cooling natural/night-time ventilation is foreseen. Air vents equipped with dampers will be installed on opposite façades of the building so as to achieve cross ventilation on each floor. The ventilation openings will automatically operate only when the external temperature is sufficiently lower than the internal.

### *HVAC*

The existing cooling systems will be replaced with new, more efficient A/C systems.

Regarding the heating of the building it was considered that the optimum choice is the conversion of the old boiler to a new Pellet boiler. The renovation is simply a matter of removing the existing oil burner and replacing it with a new automatic feeding wood pellet burner. The old heating system will be transformed to a more environment friendly one. Additionally, the pipes of the central heating system will be insulated with 9 mm insulation to reduce losses and the central heating water pump will be replaced with a new one, equipped with inverter technology to further reduce self - consumption.

### *Lighting*

All lamps of the building will be replaced with new LED lamps. Additionally, the wiring of fixtures will be replaced to allow for better zoning of the room lighting. Also, daylight sensors will be installed on the luminaires located close to the windows of the 3 upper floors. The aforementioned interventions give the opportunity to take advantage of the daylight as the artificial lighting can be turned off automatically when the desired lighting levels are reached.

### *RES*

In addition to biomass burning central heating, a photovoltaic system of 5.73 kWp will be installed on the building's roof and the annual energy production will be 8,040 kWh.

### *Thermostats and power meter*

The use of a thermostat in every room of the building will ensure that the desired internal air temperature will be stable at the desired level and will prevent the excess use of energy. Additionally, in order to record the energy consumption of the A/C systems and lighting, power meters will be installed on the electrical board of each floor.

## RENOVATION SCHEME EVALUATION

Three alternative renovation options were carried out without the building envelope improvement with the aim to achieve lower payback time for the renovation investment and increase the potential to attract private funding. Option A excludes only the external insulation, Option B excludes only the replacement of the glazing and Option C excludes both interventions. Among all the options only the initial one satisfies the CERtuS targets but the most financially attractive was the Option C.

| | ALL INTERVENTIONS | OPTION C |
|---|---|---|
| **Primary Energy Savings kWh/year** | 108,614 | 107,047 |
| **Costs €** | 127,994 | 39,988 |
| **Savings €/year** | 4,764 | 4,667 |
| **Simple Payback** | 26.9 | 8.6 |
| **$CO_2$ Savings tons/year** | 40.31 | 39.73 |

As can be seen the savings are comparable between the two options but the cost and the simple payback period are varying substantially. For this reason Option C was selected for implementation.

### *Energy Savings*

The primary energy consumption (for heating, cooling and lighting) before renovation 122,195 kWh/year and the primary energy consumption per square meter is equal to 241 $kWh/m^2$. After renovation (Option C) the consumption is reduced to 15,148 kWh/year or 29.9 $kWh/m^2$.

Specifically, the energy efficiency interventions, excluding the electricity generated by the PV system, reduce the consumption of the primary energy to 75.8 kWh/m$^2$ by generating savings equal to 83,728 kWh/year. These savings represent 68.5% of the energy consumption before renovation. The remaining demand for electricity is covered up to 63% by the PV system which produces 8,041 kWh/year. Additionally, the energy consumption for heating is covered by biomass which means that in total 90% of the building's energy demand is covered by renewable energy sources

### *$CO_2$ Savings*

The $CO_2$ savings resulting from Option C are 39.73 tons/year.

## ECONOMIC EVALUATION

### *Renovations cost*

| INVESTMENTS | € |
|---|---|
| **HVAC** | **18,881** |
| **Lighting system** | **2,645** |
| **Renewable energy** | **9,840** |
| **Night Ventilation** | **4,920** |
| **Control system** | **3,702** |
| **Total Investment** | **39,988** |
| ***The costs reported above include 23% VAT.*** | |

The cost of the interventions which are excluded is 38,007 € for the external insulation and 50,000 € for the windows.

### *Economic Savings*

The total annual economic savings are equal to 4,667 €. The energy expenditure savings are 6,167 but post renovation maintenance is higher than before by 1,500 €/year.

## FINANCING SCHEME

Under the current challenging economic conditions, municipality of Alimos has limited financial resources for implementing the energy retrofit of the selected buildings. The most suitable financing model is to assign the project to an Energy Service Company (ESCo). The ESCo is responsible to secure the total investment cost, the implementation of the project, the maintenance during the contract period and, guarantee the energy performance of the agreed solutions. The money savings, corresponding to the energy savings, will be shared between the ESCo and the municipality of Alimos, according to the "Shared Savings" model contract.

### *Financial Structure of Project*

The most market efficient financing source for implementing the project is market money (private equity, bank loan), followed by Subsidised Loan. The least favourable one is Grants since they have zero revolving effect; Grants' money once used, they never come back to the market. Even so, in many nZEB renovations Grants are necessary for turning a project market attractive and marketable. The optimum financial structure should involve the provision of sufficient subsidised loans as the latter improve the attractiveness of the project and make it marketable.

According to the study the optimum financial structure consists of:

- Equity investment by the ESCo - 24%
- Subsidized Loan - 65%
- VAT Facilities - 11%

The expected project payback period is approximately 15 years, while the duration of the EPC is 15 years which is not favourable but still market acceptable.

### *Other considerations*

The EPC takes into provision that the relevant money savings are allocated to the repayment of the investment, allowing 10% annual money saving to be enjoyed by the Municipality who has zero contribution to the capital cost. Once the EPC is concluded all money savings will be enjoyed by the Municipality.

## Municipal Environmental Office

| | |
|---|---|
| Building Type | Office |
| Year of Construction | 1986 |
| Area / Volume | 446 m$^2$ / 1,518 m$^3$ |
| Responsible Project Partner | EUDITI-Energy & Environmental Design |

### Building description

The building houses the environmental and hygiene services of the Municipality. It is one-floor building surrounded by a large open area with a parking lot and a vehicle repairing facility. The construction was completed in 1986.

The neighbouring buildings are in sufficient distance so that there is no important shadowing and the building enjoys full sunshine.

The building has an orthogonal shape and is elongated along the E-W axis and oriented 33° from North due East.

The occupation profile is from 07:30 to 15:30 on week days. There are 20 employees and about 10 visitors per day.

### Building current condition - technical and other problems detected

This is a detached building with a construction system typical for the period and region.

The walls are insulated with 5 cm of extruded polystyrene placed in between the two brick layers. The roof slab is insulated with 6 cm extruded polystyrene while there is a mineral fibre suspended ceiling in the office space. The windows have double glazing in an aluminium frame.

The envelope has thermal bridges resulting from the type of wall construction.

Regarding HVAC, split air conditioning systems are used for both heating and cooling.

The lighting system is mainly constituted by fluorescent T8 lamps with magnetic ballast.

### Economic, financial and legislative constrains

*Economic/Financial Risks*

As the building operates during the daytime only, the energy consumption is low compared to buildings with 24h operation. This fact affects the final payback period of the investment which is quite long, reaching 23 years for certain interventions such as thermal insulation and replacement of windows.

The cost of more innovative systems (solar cooling, geothermal, etc.) is considerably high and so their integration in the building is not a feasible solution unless they are eligible for subsidies by state or other sources.

*Legislative Obstacles*

There is a restriction regarding the total power of the PVs which can be installed in buildings. For public buildings the installed capacity can be 100% of the maximum capacity agreed with the Utility. This limits the size of the proposed PV system even though there is space for a larger one.

### Renovation Scheme

*Building Envelope*

Opaque Envelope: Similarly with the other two buildings, namely, the City Hall and the Municipal Library, the thermal insulation of the walls and roof will be enhanced with additional 5cm polystyrene, having 0.032 W/mK, that will be placed externally. The thickness was selected following a sensitivity analysis. It is interesting to note that due to building operation, concentrating mainly during daytime, and, the mild weather conditions prevailing in the area, a greater thickness does not contribute in further reduction of heat losses.

Glazing: Similar to the thermal insulation, a sensitivity analysis was carried out for the window U-value. Following an investigation on different U-values, it was concluded that the optimum choice will be a window with U-value 1.80 W/m$^2$K. A low–e coating is foreseen on the internal side of the external glass pane to reduce the incoming heat. The glazing has 42% Solar Factor and 66% Light Transmission.

Natural/Night ventilation: In order to reduce further the energy demand for cooling natural/night-time ventilation is foreseen. Air vents equipped with dampers will be installed on opposite façades of the building so as to achieve cross ventilation on each floor. The ventilation openings will automatically operate only when the external temperature is lower than the internal.

### *HVAC*

The new HVAC system will be a multi-zone VRV system and it includes one external and fourteen internal units. The internal units, ceiling mounted cassettes, will be installed in every office and will be controlled by their individual controllers so that every office has the desired internal air temperature. In addition the Heat Recovery Ventilation System (HRV), will modulate the temperature and humidity of incoming fresh air to match indoor conditions.

### *Lighting*

All lamps of the building will be replaced with new LED lamps. Additionally, the wiring of fixtures will be replaced to allow for better zoning of the room lighting. Also, daylight sensors will be installed in offices in the northeast side. The aforementioned interventions give the opportunity to take advantage of the daylight as the artificial lighting can be turned off automatically when the desired lighting levels are reached.

### *RES*

A photovoltaic system of 26.7 kWp will be installed on the roof and the annual energy production will be 37,300 kWh. The proposed PVs system is oversized in order to cover not only the electricity demand (for heating, cooling and lighting) but other uses too, such as the equipment of the building PC, printers, etc. and, the water pump.

### *Building Energy Management System*

To optimize the performance of the building's mechanical and electrical equipment such as, lighting, ventilation and HVAC system, an energy management system (BEMS) will be installed.

The BEMS will control, monitor and record data such as air temperatures, hours of operation and power consumption of each VRV cassette separately. Also it will control, monitor and record the lighting energy consumption.

In all windows will be placed an on/off touch connected to VRV cassette so as to stop the operation of the corresponding cassette if a window opens. The opening and closing events will be recorded by the BEMS.

## Renovation Scheme Evaluation

Three alternative renovation options were carried out without the building envelope improvement with the aim to achieve lower payback time for the renovation investment and increase the potential to attract private funding. Option A excludes only the external insulation, Option B excludes only the replacement of the glazing and Option C excludes both interventions. The most financially attractive was the Option C.

| | ALL INTERVENTIONS | OPTION C |
|---|---|---|
| **Energy Savings kWh/year** | 59,543 | 58,578 |
| **Costs €** | 124,396 | 86,266 |
| **Savings €/year** | 7,454 | 7,205 |
| **Simple Payback** | 16.7 | 12.0 |
| **$CO_2$ Savings tons/year** | 58.9 | 57.9 |

As can be seen the savings are comparable between the two options but the cost and the simple payback period are varying substantially. For this reason Option C was selected for implementation.

### *Energy Savings*

The energy consumption (for heating, cooling and lighting) before renovation is equal to 30,160 kWh/year and the energy consumption per square meter is equal to 97 kWh/m$^2$. After renovation (Option C) the consumption is reduced to 0 kWh/year.

Specifically, the energy efficiency interventions, excluding the electricity generated by the PV system, reduce the energy consumption to 25 kWh/m$^2$ by generating savings equal to 21,278 kWh/year. These savings represent 71% of the energy consumption before renovation. The remaining demand is covered up to 100% by the

PV system which produces 37,300 kWh/year. The surplus energy of 28,428 kWh/year will be used on the other uses as it is mentioned above.

### *$CO_2$ Savings*

The $CO_2$ savings resulting from Option C are 57.9 tons/year.

## Economic Evaluation

### *Renovations cost*

| INVESTMENTS | € |
|---|---|
| **HVAC** | **21,550** |
| **Lighting system** | **4,041** |
| **Renewable energy** | **45,977** |
| **Night Ventilation** | **3,874** |
| **Control system** | **10,824** |
| **Total Investment** | **86,266** |
| ***The costs reported above include 23% VAT.*** | |

The cost of the interventions which are excluded is 25,830 € for the external insulation and 12,300 € for the windows.

### *Economic Savings*

The total annual economic savings are equal to 7,205 €. More specific the energy expenditure savings are 4,031 but post renovation maintenance is higher than before by 970 €/year so economic saving from both energy and maintenance is 3,061 €/year. Additionally, the energy expenditures of the building reduced due to the use of the surplus energy from PVs by 4,144 €/year.

## Financing Scheme

Under the current challenging economic conditions, municipality of Alimos has limited financial resources for implementing the energy retrofit of the selected buildings. The most suitable financing model is to assign the project to an Energy Service Company (ESCo). The ESCo is responsible to secure the total investment cost, the implementation of the project, the maintenance during the contract period and, guarantee the energy performance of the agreed solutions. The money savings, corresponding to the energy savings, will be shared between the ESCo and the municipality of Alimos, according to the "Shared Savings" model contract.

### *Financial Structure of Project*

The most market efficient financing source for implementing the project is market money (private equity, bank loan), followed by Subsidised Loan. The least favourable one is Grants since they have zero revolving effect; Grants' money once used, they never come back to the market. Even so, in many nZEB renovations Grants are necessary for turning a project market attractive and marketable. The optimum financial structure should involve the provision of sufficient subsidised loans as the latter improve the attractiveness of the project and make it marketable.

According to the study the optimum financial structure consists of:

- Equity investment by the ESCo - 14%
- Subsidized Loan - 75%
- VAT Facilities - 11%

The expected project payback period is approximately 13 years, while the duration of the EPC is 15 years which is not favourable but still market acceptable.

### *Other considerations*

The EPC takes into provision that the relevant money savings are allocated to the repayment of the investment, allowing 5% annual money saving to be enjoyed by the Municipality who has zero contribution to the capital cost. Once the EPC is concluded all money savings will be enjoyed by the Municipality.

## COIMBRA, PORTUGAL

### TOWN HALL

| | |
|---|---|
| **Building Type** | **City Hall / Multiple functions of public utility** |
| **Year of Construction** | **1876-1879** |
| **Area / Volume** | **5,880 m$^2$ / 40,575 m$^3$** |
| **Responsible Project Partner** | **ISR- University of Coimbra** |

### BUILDING DESCRIPTION

The building is located in the downtown of Coimbra and it was built after the demolition of part of the old Monastery of Santa Cruz. The demolition work and construction was carried out mainly between 1876 and 1879, but some construction works were developed gradually until the beginning of the 20th century. The building is used as the town hall of the Municipality of Coimbra, being mainly constituted by offices and storage areas.

The building usually has occupation between 7h30 and 19h30 (Monday to Friday). However, the public only have access between 9h00 and 17h00. The building has 220 employees and is visited by more than 25,000 users/year.

### BUILDING CURRENT CONDITION - TECHNICAL AND OTHER PROBLEMS DETECTED

The building consists of three floors and two intermediate floors, with the main façade is oriented to West.

The external walls are made of stone masonry and have a thickness of 90 to 145 cm. All the windows and balcony doors are of single glazing with wood frames. A thermal survey made in the building showed that walls present a good thermal performance but the windows, with single glazing with wood frames, present insulation problems, aggravated by aging, contributing to high heat losses during winter.

Some characteristics of the building contribute to a bad thermal performance. The orientation is not ideal, requiring additional energy consumption with heating during the winter (mainly in the north areas) and with cooling during the summer (mainly in the west areas without any direct protection from the direct radiation).

The walls with high thermal inertia and large ceiling height provide advantages during the summer, but disadvantages during winter, since the building does not have users in the night period and weekends which leads to a significant decrease in temperature. The windows have a low level of air-tightness, resulting in a high level of air infiltration, which is not controllable and undesirable especially during the winter.

The building does not present major pathologies, such as condensations or mould growth.

The existing lighting is ensured by several different types of lamps and luminaires, including fluorescent linear T8 and T5 lamps, several types of compact fluorescent lamps, incandescent lamps, halogen spots and projectors and metal halide lamps.

The HVAC is ensured with several heat pumps, which were being installed gradually. Therefore, there are several equipment with different characteristics and performance. In total, there are 8 multi-split units and 21 mono-split units. Almost all the areas of permanent use have HVAC systems. The control of the HVAC systems is ensured locally with units of individual control.

### ECONOMIC, FINANCIAL AND LEGISLATIVE CONSTRAINS

*Economic/Financial Risks*

The main economic barrier to the implementation of the renovation plan is the high overall investment, which is aggravated by the lack of public budget and the low availability of financial schemes (mainly due to the economic crises and the transition period between the Community Support Frameworks).

The main economic risk is the reliability of the value considered to the total investment needed to the implementation, because the prices of the technologies present variations over time, and in some technologies such as photovoltaic the oscillations of prices can be high. Other uncertainty is the percentage of price reduction obtained in the public procurement process.

### *Legislative Obstacles*

Coimbra - part of the historic city center, older University buildings and other urban structures - is since June 22th 2013 inscribed on the World Heritage List of UNESCO. The Property inscribed is called University of Coimbra — Alta and Sofia (http://worldheritage.uc.pt/). It is composed of a set of buildings whose history has been associated to the academic institution, either through participation in the process of knowledge production and dissemination, or through contribution to the creation of unique cultural and identitarian traditions. The Coimbra Town Hall is included in this area and therefore strong restrictions are applied in the renovation of such building due to the protection rules. Therefore, it is not possible to implement any change in the building envelope able to cause any visual impact.

## Renovation Scheme

### *Building Envelope*

The walls present a good thermal performance. The roof is to undergo an already planned renovation. Therefore, the improvement of the opaque envelope was not considered in the renovation plan.

The windows present high thermal losses. However, since the building is part of the property "University of Coimbra — Alta and Sofia" inscribed on the World Heritage List of UNESCO it is not possible to replace the windows by double glazed windows using standard solutions, since the original frame must be maintained (the usual solution is to implement other window in the interior). Since these frames have to be specifically designed to this building, this cannot be ensured with standard solutions available in the market, and would have a high cost. Therefore, the improvement of openings was not considered in the renovation plan.

### *HVAC*

The HVAC system is constituted by 8 multi-split units and 21 mono-split units with a total cooling power of 273.02 kW. Most of the systems are old and have low levels of efficiency. The replacement of mono-split systems by multi-split systems and the concentration of multi-split systems in less units was not considered, since the impact of the installation process on the building operation would be much higher. Therefore, it was always considered the replacement by systems of the same type, but with higher efficiency, keeping the same total power.

### *Lighting*

The actual lighting system is constituted by several different types of lamps and luminaires, including fluorescent linear T8 and T5 lamps, several types of compact fluorescent lamps, incandescent lamps, halogen spots and projectors and metal halide lamps. The planned action is to replace all lamps by LEDs.

### *RES*

Since the building is part of the property "University of Coimbra — Alta and Sofia" inscribed on the World Heritage List of UNESCO and it is not possible to achieve a Zero Energy Building without generation and since there are no other available options, the use of PV power must be considered. Due to the protection rules, the use of traditional PV panels was not considered due to its high visual impact. Therefore, it was considered the use of solar tiles, to replace the actual roof. It was considered the installation of 2,102 $m^2$ (with the different directions of the roof) of thin film PV panels, ensuring an installed power of 126.1 kWp. This will ensure a generation of 143.3 MWh/year.

### *Other*

ICT and other appliances (mainly PCs, monitors and printers, large UPS systems and a small data centre) do not represent individually a large share of energy consumption and therefore the achieved savings with such appliances would not have a major impact on the total energy consumption. The replacement of such appliances by new devices is not cost-effective just from the energy savings point of view and therefore this is not considered in the renovation plan. However, in the regular replacement of ICT appliances it is recommended to install just ICT appliances with lower energy consumption.

## Renovation Scheme Evaluation

| | |
|---|---|
| **Energy Savings** | 249,599 kWh |
| **Costs** | 723,949 € |
| **Savings** | 42,739 €/year |
| **Simple Payback** | 16.94 years |
| **$CO_2$ Savings** | 34.92 tons/year |

### *Energy Savings*

The energy consumption before the renovation, considered as baseline, is equal to 305,107 kWh/year (electricity) and the energy consumption by square meter is about 51.9 kWh/m$^2$. After the renovation the energy consumption drops to 55,508 kWh/year (electricity only) and the energy consumption by square meter is equal to 9.4 kWh/m$^2$. Which means 42,739 Euro/year of savings. The renovation will lead to 72.1% savings in the building.

### *$CO_2$ Savings*

The $CO_2$ savings are 34.92 tons/year

### *RES Integration*

In the evaluation of the PV generation it was considered the self-consumption of 90% of the energy. RES will ensure 72.1% of the total energy consumption.

## Economic Evaluation

### *Renovations cost*

The totall investment cost is equal to 632.068 Euro, which means the investment cost per square meter is 107.5 Euro/m$^2$.

| INVESTMENTS | € |
|---|---|
| **HVAC** | 80,209 |
| **Lighting system (internal)** | 16,917 |
| **Renewable energy** | 534,942 |
| **Building Envelope** | 0 |
| **Control system** | 0 |
| **Investment for Renovation** | **632,068** |

### *Economic Savings*

The energy expenditure saving is 34,880 Euro/year.

### *Project Payback Period*

The project payback period is close to 17 years

## Financing Scheme

### *Energy Performance Contract*

On the basis of Deliverable D3.5 the implementation of the “shared savings” EPC contract (considered to be the most widespread among the four CERtuS countries) was chosen. The ESCo is supposed to invest through a Special Purpose Vehicle (SPV).

### *Duration of EPC*

Duration of EPC: 25 years

### *Financial Sources*

Given the Renovation Scheme selected and the characteristic of the project, ESCo involvement is possible at current market conditions but it needs a mix of source of finance, in particular the use of Subsides Funds:

- Equity is about 26% of the whole financial source
- Senior Debt is about 61% of the whole financial source
- VAT Facilities is about 13%

### *Equity Pay Back Period*

The project equity payback period is 18 years

### *Other considerations*

In this case, the project generates enough cash flows to pay the debt but it is not able to remunerate sufficiently the capital invested by the ESCo. As a consequence, an ESCo intervention at market conditions should be considered sustainable but not profitable enough.

## Municipal House of Culture

| | |
|---|---|
| **Building Type** | **Library, auditorium and art gallery.** |
| **Year of Construction** | **1991-1993** |
| **Area / Volume** | **13,225 $m^2$ / 39,944 $m^3$** |
| **Responsible Project Partner** | **ISR-University of Coimbra** |

### Building Description

The building was built in 1991-1993 and opened on October, 26th 1993. It is located near the city center and near to the University. It is used as Municipal House of Culture and has several cultural equipment, such as library, auditorium and art gallery, as well as several offices used by Municipality. The building has 8 floors, with 3 floors below and 4 floors above the ground floor.

The building has 80 employees and is visited by 17,500 users/year.

The building is usually used in the following schedule:

- July 15th to September 15th - Monday to Friday 9h00 – 18h30
- September 16th to July 14th - Monday to Friday 9h00 – 19h30 and Saturday: 11h00 – 13h00 and 14h00 and 19h00.

The users have access to the rooms of public use only after 10h00.

There are two areas of the building loaned to other entities:

- Part of floor -2 is one refectory used by the University of Coimbra;
- Part of floor -3 is used by the CAPC - Círculo de Artes Plásticas de Coimbra (cultural association of contemporary art).

These spaces are managed by such entities, but they receive electricity from the main board of the building, being the electricity paid by the Municipality.

### Building current condition - technical and other problems detected

The building external walls are made of breeze blocks and bricks and have a thickness of 20 to 55 cm. The windows are of single glazing with aluminium frames. Almost all windows have interior shutters. The exception is the front floor where darkened windows are used. The doors have the same characteristics of the windows.

The back façade presents signs of condensations, mainly in areas covered with vegetation.

The lighting is usually ensured by fluorescent lamps. Most of the rooms have a false roof in wood with small square holes, being the luminaries installed above the false roof.

The lighting fixtures are open luminaires with double reflector and have 2 or 3 lamps. The installation of the lamps above the false roof causes a high loss of luminosity, which is aggravated by the difficulty of maintenance of such luminaries, being very common to find faulty lamps. These situations lead to a low visibility in some areas. The planned action is to replaced all lamps by LEDs.

Almost all working rooms, as well as all the rooms receiving public have acclimatization. The circulation areas do not have acclimatization. The total acclimatized area is about 6,900 $m^2$.

The building does not have a centralized HVAC system. It has several mono-split units, which were gradually installed. The exception to it, are the silos and the storage areas which have systems (one in each silo) of temperature and humidity control with pipelines to protect the publications.

### Economic, financial and legislative constrains

*Economic/Financial Risks*

The main economic barrier to the implementation of the renovation plan is the high overall investment, which is aggravated by the lack of public budget and the low availability of financial schemes (mainly due to the economic crises and the transition period between the Community Support Frameworks).

The main economic risk is the reliability of the value considered to the total investment needed to the implementation, because the prices of the technologies present variations over time, and in some technologies such as photovoltaic the oscillations of prices can be high. Other uncertainty is the percentage of price reduction obtained in the public procurement process.

### *Legislative Obstacles*

There are no major legislative obstacles to the renovation of this building.

## Renovation Scheme

### *Building Envelope*

The roof has been renovated (replacement of the asbestos-cement slabs by a sandwich panel constituted by two thermolacquered metal sheets with 80 mm of polyurethane insulation).

Other renovation options, requiring construction works in the façades were considered. However, the renovation options requiring major construction works, incompatible with the normal activities of the building, should be avoided due to the incompatibility between use and renovation works.

All the windows used in the building are of single glazing with aluminium frames. The replacement of windows by double glazing windows was not considered in this plan since the option to replace the HVAC system present higher cost-effectiveness and is more easily assessed and monitored. However, such replacement should be considered in future renovations of the building.

### *HVAC*

The HVAC in most of the building is ensured by mono-split systems with heat pumps installed in the wall or roof with a total power of 239.27 kW. The replacement of the several mono-split systems by multi-split systems was not considered, since despite the potential lower purchase cost of multi-split systems the costs of installation would be higher and mainly the impact of the installation process on the building operation would be much higher. Therefore, it was considered the replacement by other mono-split systems with higher efficiency, keeping the same total power. In the renovation plan the replacement of such systems by new systems with higher efficiency was considered, being selected a system with EER of 5.2 and COP of 5.74.

### *Lighting*

The actual lighting system is mainly constituted by fluorescent linear T8 lamps with electromagnetic ballast. The planned action is to replace all lamps by LEDs.

### *RES*

In the renovation plan it was considered the installation of PV panels oriented to south, but keeping the orientation of the building (azimuth of 20º) in order to minimize the visual impact of the PV panels. Therefore, it was considered the installation of 770 PV panels, ensuring an installed power of 181 kWp. This will ensure a generation of 254.2 MWh/year.

### *Other*

ICT and other appliances (mainly PCs, monitors and printers) do not represent individually a large share of energy consumption and therefore the achieved savings with such appliances would not have a major impact on the total energy consumption. The replacement of such appliances by new devices is not cost-effective just from the energy savings point of view and therefore this is not considered in the renovation plan. However, in the regular replacement of ICT appliances it is recommended to install just ICT appliances with lower energy consumption.

## Renovation Scheme Evaluation

| | |
|---|---|
| **Energy Savings** | 473,750 kWh |
| **Costs** | 396,656 € |
| **Savings** | 65,742 €/year |
| **Simple Payback** | 6.03 years |
| **$CO_2$ Savings** | 66.27 tons/year |

*Energy Savings*

The energy consumption before the renovation, considered as baseline, is equal to 487,229 kWh/year (electricity) and the energy consumption by square meter is about 49.4 kWh/m$^2$. After the renovation the energy consumption drops to 13,479 kWh/year (electricity only) and the energy consumption by square meter is equal to 1.4 kWh/m$^2$. Which means 65,742 Euro/year of savings. The renovation will lead to 97.2% savings in the building.

*$CO_2$ Savings*

The $CO_2$ savings are 66.27 tons/year

*RES Integration*

In the evaluation of the PV generation it was considered the self-consumption of 90% of the energy. RES will ensure 95.1% of the total energy consumption.

**ECONOMIC EVALUATION**

*Renovations cost*

| INVESTMENTS | € |
|---|---|
| HVAC | 126,945 |
| Lighting system (internal) | 17,121 |
| Renewable energy | 194,208 |
| Building Envelope | 0 |
| Control system | 0 |
| **Investment for Renovation** | **338,274** |

The total investment cost is equal to 338.274 Euro, which means the investment cost per square meter is 26.6 Euro/m$^2$.

*Economic Savings*

The energy expenditure saving is 53,081 Euro/year.

*Project Payback Period*

The project payback period is close to 6 years.

**FINANCING SCHEME**

*Energy Performance Contract*

On the basis of Deliverable D3.5 the implementation of the “shared savings” EPC contract (considered to be the most widespread among the four CERtuS countries) was chosen. The ESCo is supposed to invest through a Special Purpose Vehicle (SPV).

*Duration of EPC*

Duration of EPC: 15 years

*Financial Sources*

Given the Renovation Scheme selected and the characteristic of the project, ESCo involvement is possible at current market conditions because the project is able to generate enough cash flows to pay back the loan and to remunerate the capital invested by the ESCo.

- Equity is about 26% of the whole financial source
- Senior Debt is about 60% of the whole financial source
- VAT Facilities is about 14%

*Equity Pay Back Period*

The project equity payback period is 13 years.

*Other considerations*

With this financial structure, an ESCo intervention is possible and the remuneration of the invested capital, in terms of IRR, should be considered adequate for this kind of projects.

## ELEMENTARY SCHOOL OF SOLUM

| | |
|---|---|
| **Building Type** | **Elementary School** |
| **Year of Construction** | **In the 1950s** |
| **Area / Volume** | **1,655 m$^2$ / 6,269.21 m$^3$** |
| **Responsible Project Partner** | **ISR-University of Coimbra** |

### BUILDING DESCRIPTION

The Elementary School of Solum (Escola Básica do 1º Ciclo da Solum) is located in the East side of the city, near to the Stadium and a commercial area.

The school was built in the 1950s but until the 1970s it was an annex school to the teacher training colleges dedicated to pedagogical training. In the 1990s it was converted into an Elementary School. The construction of refectory and a partial renovation of the building was done 10 years ago.

The school has about 300 students. The schedule of the daily activities (Monday to Friday) is:

- Classes – 9h00 to 12h30 and 14h00 to 16h00
- Lunch – 12h30 to 14h00
- Extra-curricular activities – 16h30 to 17h30
- Family support – 7h30 to 9h00 and 17h30 to 19h00

### BUILDING CURRENT CONDITION - TECHNICAL AND OTHER PROBLEMS DETECTED

The school is constituted by 2 buildings with 39.8 x 9.5m each and 1 building (refectory) with 2 areas of 9.73 x 6.5 m and one of 7.15 x 2.15 m. The largest buildings have two floors and the refectory building only one floor.

The external walls are made of breeze blocks and bricks and have a thickness of 55 to 60 cm in the 2 blocks and of 35 to 55 cm in the refectory.

All the window frames are aluminium with the exception of 2 windows, which have a wooden frame. These windows are located in the hall of floor 1 of each block. All the windows are double glazed with the exception of 4 windows. These windows are located in the hall of floor 1 of each block and in the lateral of the refectory building.

The lighting system is mainly constituted by fluorescent linear T8 lamps with electromagnetic ballast.

The 2 main blocks have old wall radiators with circulation of hot water. However, the system is no longer operational and therefore these buildings do not have any source of central heating. To ensure the heating during the coldest days the classrooms have one oil-filled radiator.

### ECONOMIC, FINANCIAL AND LEGISLATIVE CONSTRAINS

*Economic/Financial Risks*

The main economic barrier to the implementation of the renovation plan is the high overall investment, which is aggravated by the lack of public budget and the low availability of financial schemes (mainly due to the economic crises and the transition period between the Community Support Frameworks).

The main economic risk is the reliability of the value considered to the total investment needed to the implementation, because the prices of the technologies present variations over time, and in some technologies such as photovoltaic the oscillations of prices can be high. Other uncertainty is the percentage of price reduction obtained in the public procurement process.

*Legislative Obstacles*

There are no major legislative obstacles to the renovation of this building.

### RENOVATION SCHEME

*Building Envelope*

The building was recently renovated and therefore the opaque envelope does not present major problems. Additionally, since the building does not have any centralized HVAC system the improvement of the envelope would not lead to a major reduction of energy consumption in heating and cooling. Therefore, the improvement of the opaque envelope was not considered in the renovation plan.

The main entrance doors of the 2 blocks are not airtight and present unintentional infiltration of air into the building. However, the circulation areas do not have any HVAC source and its replacement is not traduced in any energy saving. Therefore, the improvement of openings was not considered in the renovation plan.

### *HVAC*

The main opportunity of renovation in the HVAC is the replacement of the gas boiler used in the central heating of the refectory. It is possible to replace this boiler directly by a heat pump without the need of a total refurbishment of the system.

The other areas of the building do not have central heating, being the heating in the classrooms during the coldest days ensured by one oil-filled radiator. The building does not have cooling, but this is not a major problem since in the months with higher temperatures the building is not used (there are no classes). However, the option to replace such oil-filled radiators by heat pumps, which can also be used for cooling, would create new energy consumption. This renovation could increase the comfort in the building. However, it cannot be considered as an option to increase the energy efficiency, since the total energy consumption would increase and therefore it is not included in the renovation plan.

### *Lighting*

The actual lighting system is mainly constituted by fluorescent linear T8 lamps with electromagnetic ballast. The planned action is to replace all lamps by T5 lamps with electronic ballast.

### *RES*

The building already has a small PV system (18 panels with a total power of 4,23 kW) and also a 200 l solar thermal system.

In the renovation plan it was considered the installation of PV panels oriented to south, but keeping the orientation of the building (azimuth of -15º) in order to minimize the visual impact of the PV panels. Therefore, it was considered the installation of 72 PV panels, ensuring an installed power of 16.92 kWp. This will ensure a generation of 23,316 kWh/year.

### *Other*

ICT and other appliances (mainly PCs, monitors and printers, large UPS systems and a small data centre) do not represent individually a large share of energy consumption and therefore the achieved savings with such appliances would not have a major impact on the total energy consumption. The replacement of such appliances by new devices is not cost-effective just from the energy savings point of view and therefore this is not considered in the renovation plan. However, in the regular replacement of ICT appliances it is recommended to install just ICT appliances with lower energy consumption.

## Renovation Scheme Evaluation

| | |
|---|---|
| **Energy Savings** | 32,191 kWh |
| **Costs** | 31,469 € |
| **Savings** | 5,082 €/year |
| **Simple Payback** | 6.19 years |
| **$CO_2$ Savings** | 5.54 tons/year |

### *Energy Savings*

The energy consumption before the renovation is equal to 39,291 kWh/year (electricity and natural gas) and the energy consumption by square meter is equal to 23.74 kWh/m$^2$.

After the renovation the energy consumption drops to 928 kWh/year (electricity only, gas is not used after the renovation) and the energy consumption by square meter is equal to 0.56 kWh/m$^2$. Which means an energy expenditure saving of 5,082 Euro/year. The renovation will lead to 97.6% savings in the building.

### *$CO_2$ Savings*

The $CO_2$ savings are 5.54 tons/year

### *RES Integration*

In the evaluation of the PV generation it was considered the self-consumption of 90% of the energy. RES will ensure 96.2% of the total energy consumption.

## ECONOMIC EVALUATION

### *Renovations cost*

The total investment cost is equal to 31,469 Euro, which means the investment cost per square meter is 19.12 Euro/m$^2$.

| INVESTMENTS | € |
|---|---|
| **HVAC** | 6,556 |
| **Lighting system (internal)** | 2,920 |
| **Renewable energy** | 21,993 |
| **Building Envelope** | 0 |
| **Control system** | 0 |
| **Investment for Renovation** | **31,649** |

### *Economic Savings*

The energy expenditure saving is 5,082 Euro/year.

### *Project Payback Period*

The project payback period is 6.19 years.

## FINANCING SCHEME

### *Energy Performance Contract*

On the basis of Deliverable D3.5 the implementation of the "shared savings" EPC contract (considered to be the most widespread among the four CERtuS countries) was chosen. The ESCo is supposed to invest through a Special Purpose Vehicle (SPV).

### *Duration of EPC*

Duration of the EPC: 15 year.

### *Financial Sources*

Given the Renovation Scheme selected and the characteristic of the project, ESCo involvement is possible at current market conditions but it needs a mix of source of finance, in particular the use of Subsides Funds:

- Equity is about 33% of the whole financial source
- Senior Debt is about 22% of the whole financial source
- Subsided Funds 31%
- VAT Facilities is about 14%

### *Equity Pay Back Period*

The project equity payback period is 14 years.

### *Other considerations*

With this financial structure, an ESCo intervention is possible and the remuneration of the invested capital, in terms of IRR, should be considered adequate for this kind of projects.

## ERRENTERIA, SPAIN

### TOWN HALL

| Building Type | Town Hall |
|---|---|
| Year of Construction | 1603-2000 |
| Area / Volume | 2,961 $m^2$ / 11,418 $m^3$ |
| Responsible Project Partner | TECNALIA |

### BUILDING DESCRIPTION

Errenteria City Hall has an appreciable square ground plan, which defines one side of the Herriko Plaza, the meeting point for five of the seven streets of the medieval town. The construction of the building started in 1603 and it was inaugurated in 1607. The City Hall suffered important damages, as Errenteria was burned in 1638 by the French troops. Looting and destruction were so extensive that, in a first attempt, it was decided to construct a new building. Nevertheless, in 1654 it was agreed to start with the reconstruction, which lasted till 1666. The City Hall corresponds to the typical Basque structure, made in sandstone ashlars. The building has a ground floor and two storeys, with a retracted raised part added at a later date. Each floor has four rooms distributed symmetrically. In 2000 an extension project started, which resulted in the merger of three existing buildings: the original building of the 17th century and other two buildings with less relevance, but contributing to the practical use and the overall streetscape.

The project was undertaken to improve efficiency of the local government, facilitate circulation, structural stability and guarantee the unitary use of a single building. This entailed the erection of a new structure behind the original façades of the two less significant buildings, retaining their scale, materials and openings. The historic City Hall was also renovated. The existing interior courtyard was kept as a key element of the plan yet covered with a skylight. The courtyard provides daylight to the interior office spaces. A circulation and utility core was also erected in the place of a small single story building of minor relevance. This new portion of the structure was necessary to make the three existing buildings function together.

### BUILDING CURRENT CONDITION - TECHNICAL AND OTHER PROBLEMS DETECTED

The building was extensively renovated in 2000, hindering the task of encountering a balance between investment and energetic improvements. The building envelope (walls, roof and windows) presents acceptable thermal transmittance and existing systems (lighting and HVAC) are relatively modern. The building does not present significant airflow infiltrations from outside and it is regularly maintained. Nevertheless improvements in energy efficiency are still possible. Concerning Renewable Energy Systems (RES), the geometry and location of the building represent major constrains for their installation. The building is located in the Old Town, characterised by narrow streets and urban density, which reduce the sun incidence on roofs. Furthermore the original building is listed and its historic value cannot be extensively altered. Additional equipment cannot be installed inside the building as each room has a well-defined use, limiting the selection of new systems to be installed.

### ECONOMIC, FINANCIAL AND LEGISLATIVE CONSTRAINS

*Economic/Financial Risks*

The lack of public budget and the low availability of financial schemes can reduce the possibilities to implement the proposed renovation scheme. The equipment installed in the City Hall can be considered as modern and with a considerable remaining life time. Its efficiency might be improved by raising awareness of users, which can be as effective as the replacement of expensive equipment. However, the effect of this kind of measures cannot be easily quantified in advance. Furthermore, in Spain PV system up to 100 kW may not sell electricity and are required to donate this electricity without compensation, thus extending the payback periods.

*Legislative Obstacles*

The City Hall was declared "Municipal ensemble" according to the Basque Government Decree 101/1996 of May 7th, which means that it has special protection and restrictions are applied for its renovation. Solutions with high visual impact or which might harm the building's integrity cannot be applied.

## Renovation Scheme

### *Building Envelope*

As the building was refurbished in 2000, walls, roof and windows present thermal transmittance values that do not justify high investments, since the real impact in the energy demand reduction would be low. The improvement of the thermal transmittance would require extensive works, entailing the temporary reallocation of functions and employees. The achievements in energy demand reduction will not be worth the investment.

### *HVAC*

The heating system is a centralised system which can be independently regulated in different areas of the building. It is formed by radiators which are warmed by hot water produced by a gas boiler, which is activated by exterior temperature sensors. The existing boiler is supplying hot water to two buildings: Kapitain Etxea and the City Hall. As the first building will have an independent system, the total power is currently oversized leading to a reduction in the efficiency of the current equipment. Efficiency of the heating system will be improved by means of a high Coefficient of Performance (COP) condensing boiler. The boiler proposed in the renovation scheme has a COP of 1.1 and a total power of 130 kW. The cooling system is divided in independent phases. The first phase is used to cool the administrative are of the third floor, a double-flow air to air system, with one condenser coil in the roof and the evaporator coil placed in the ceiling. The second phase is a varied refrigerant volume (VRV) solution formed by 8 condenser units placed in the roof. Each condenser unit can be connected to 7 evaporator units. Each evaporator unit is independent within the set linked to the condenser unit and it is controlled manually by means of a remote control. Additionally, the eight condenser units are controlled by timers that limit their working period to the timetable of the City Hall. The VRV system offers acceptable levels of energy efficiency and meets users flexibility, so no interventions are foreseen.

### *Lighting*

In the renovation scheme proposed, fluorescent lamps will be substituted by LED lamps. Where possible (e.g. crossing areas with enough natural lighting), automatic controllers will be installed.

### *RES*

The renovation scheme includes the installation of Photovoltaic (PV) panels on the roof of the building. Considering the useful surface, panels will be installed on the sloped roofs. The plant, of 40.2 kWp, will be made of standard monocrystalline panels and will occupy a surface of 332 m$^2$.

## Renovation Scheme Evaluation

| | |
|---|---|
| **Primary Energy Savings** | 231,045 kWh |
| **Costs** | 169,684 € |
| **Energy Savings**<br>**Manteinance + energy** | 12,374 €/year<br>21,478 €/year |
| **Simple Payback** | 5.6 years |
| **$CO_2$ Savings** | 57.36 tons/year |

### *Energy Savings*

Currently, the building has a final energy consumption of 131,630 kWh in gas and 147,530 in electricity and a total primary energy consumption of 517,999 kWh. The renovation scheme proposed will reduce final energy consumption to 127,040 kWh in gas and to 60,783 kWh in electricity and to 286,954 kWh in primary energy. Primary energy savings will therefore be 231,045 kWh. Considering electricity and gas prices of 2015 in Spain, expenditure savings will be 12,374 € per year.

### *$CO_2$ Savings*

The $CO_2$ savings are estimated in 57.36 tons per year.

### *RES Integration*

39% of energy will be supplied by renewable energy systems. PV will provide a generation of 38,757 kWh.

## Economic Evaluation

### *Renovations cost*

The total investment cost is 169,683 Euro, which represents an investment cost per square meter of 57.30 Euro/m$^2$.

| INVESTMENTS | € |
|---|---|
| **HVAC** | 9,760 |
| **Lighting system (internal)** | 10,493 |
| **Renewable energy** | 149,430 |

### *Economic Savings*

The energy expenditure is 11.698 Euro/year.

The expenditure for maintenance after renovation is lower than before of 9.781 Euro/year. This situation affects positively, at economic level, on the total savings achievable by the intervention: the economic saving, energy and maintenance, is about 21.478 Euro/year.

### *Project Payback Period*

The Project payback period is 9 years. From an ESCo point of view, some extra investment is considered in order to provide the project with sufficient liquidity to pay interests, banking fees and to finance initial working capital.

## FINANCING SCHEME

### *Energy Performance Contract*

Although the project has an adequate payback time, the cash flows does not create an attractive contract to the ESCo to market conditions. In order to make the project desirable for an ESCo, an important financial support should be given to the project and the duration of the EPC contract should be extended. In this case, a specific financial structure was implemented assuming:

- Equity investment by the ESCo 9%;
- Subsided Funds for 40%;
- Grant for 40%;

The implementation of this EPC contract leads to a reduction of expenditure for the Municipality of around 10.365 Euro/year, resulting from the 5% shared energy savings of 585 Euro less the reduction in maintenance costs of 9.781 Euro.

Three types of contracts are best placed to meet the needs of the Municipality: First In, First Out and Shared Savings. All three contracts transfer more than 70% of the risk to the ESCO thereby ensuring the Municipality which has declared to have not experience in managing of EPC contracts. The contract that offer greater guarantees to the City is the first out with 78% of the risks allocated to ESCO.

The analysis of the differences among the three risk arrays corresponding to the three EPC contracts applicable (FIRST IN, FIRST OUT and SHARED SAVINGS) shows:

- FIRST IN = a greater transfer to the ESCO of counterparty risk and a lower transfer of the technology risk
- FIRST OUT = a greater transfer to the ESCO of the market risks and a lower transfer of technological risk
- SHARED SAVING = a lower transfer to the ESCO of market risks

### *Duration of EPC*

The duration of the EPC contract is of about 20 years.

### *Financial Sources*

The optimal solution could be the Shared Saving contract in which:

- The energy savings is shared between ESCO and the Municipality (for only 5%) in order to reduce the duration of the contract that in this way would be around in 20 years;
- All of the interventions will be performed by the ESCO who assumes the technical risk and guarantees the savings;
- The Municipality finances directly part of the interventions through the funds of the SEAP and by using loan funds.

### *Other considerations*

In order to make the investment more sustainable for the ESCo the project could consider alternative ways to the standard EPC contract, for example to implement other kind of contract or a global service or a direct procurement by the Municipality. In addition, given the small dimension of the project, it could be a good option to aggregate more than one initiative. This aggregation could be useful to obtain cost efficiency, incremental revenues and synergies.

## Kapitain Etxea

| | |
|---|---|
| **Building Type** | **Municipal archive** |
| **Year of Construction** | **1650 (aprox.)** |
| **Area / Volume** | **395 $m^2$ / 1,362 $m^3$** |
| **Responsible Project Partner** | **TECNALIA** |


### Building description

After the catastrophic fire in 1638, Errenteria started rebuilding the city. The most outstanding houses of the historic centre date back to this period. One of these ancestral houses is nowadays known as the Captain's House (Kapitain Etxea in Basque), due to the name of Martín de Rentería y Uranzu, known as "the captain of Errenteria". It is a terraced building of rectangular ground plan with a gable roof perpendicular to the principal facade made of sandstone ashlar. Although it initially had a ground floor and two stories separated by flat roofs, the upper part has suffered alteration: the floors are no longer at their original height and the openings interrupt the flat roofs. In 1925 the original building was divided in two and nowadays it is possible to distinguish the differences only between the roofs. There is one single row of openings on the ground floor and projecting balconies with forged iron railings on the first and second floors. While the right-hand side is residential, the left-hand side has been used for cultural activities, as a result of which the facade has been cleaned and the interior has been transformed in 1984.

Currently the building is used as part of the municipal archive, as it presents poor accessibility conditions and entrance has been restricted to municipal employees. The Municipality decided to refurbish the building to host the Center of the Basque Costume. The new use of the building will therefore require interventions aimed at improving accessibility and comfort conditions.

### Building current condition - technical and other problems detected

The Municipality has already defined a project for the inclusion of an elevator and a new staircase, while improvements on the energetic behaviour of the buildings are addressed in the CERtuS project. Due to the change of use of the building and the systems currently installed, it is difficult to estimate values before and after interventions. Real consumption of the building is not useful, as the archive is sporadically used and is not comparable with the Centre that will be open to the public from 10 am to 8 pm every day. The energy performance has therefore been calculated simulating the new use of the building, both for current and future conditions. Nevertheless, lighting and HVAC system installed in the building are not sufficient to guarantee the use and enjoyment of the Centre by people. In order to meet higher comfort conditions, HVAC system should be resized and proper lighting should be guaranteed. This will result in an increase in the energy demand. However, the continuous use of the building will guarantee appropriate maintenance, thus avoiding costs associated to abandonment and will permit citizens benefitting from their heritage, thus preserving cultural identity.

### Economic, financial and legislative constrains

#### *Economic/Financial Risks*

Also if the building has limited dimensions and there is no need of major investment, the lack of public budget and the low availability of financial schemes still remain a constrain. While the building's envelope retrofitting will significantly improve the energy efficiency and provide monetary saving, performances and benefits of PV panels in this specific location (small surface and low sun exposure) are limited. Furthermore, in Spain PV system up to 100 kW may not sell electricity and are required to donate it without compensation.

### *Legislative Obstacles*

The Old Town of Errenteria has been listed due to its historical and aesthetical values. In the case of Kapitain Etxea this entails that the external walls have to be preserved with no alterations, while windows do not have any restriction. Solutions with high visual impact or which might harm the building's integrity cannot be applied.

## RENOVATION SCHEME

### *Building Envelope*

The energy demand analysis of the current situation shows that windows and walls are the main weak elements, as they have poor thermal performances. Additionally, roof and the ground contribute significantly to thermal loses through the building envelope.

Opaque Envelope: Front and rear walls are constructed in sandstone ashlar; the rear façade is facing a courtyard and has a thin layer of render, with a U-value of 2.60 W/m$^2$K. As the building is listed, interventions are possible only in the inner surface of the walls and, due to the limited dimensions of the building, should guarantee the minimum floor area reduction. Insulation will use mineral wool and mortar render to achieve a U-value of 0.35 W/m$^2$K. The roof is a timber structure in a bad state of conservation, which will be replaced. The new construction will be similar but with improved insulation and waterproof materials, including a breathable sheet, PUR and a vapour barrier. The intervention will reduce the U-value from 2.42 to 0.24 W/m$^2$K. Slab on ground will also be improved, as it is currently made of cast concrete in direct contact with the soil and is affected by the presence of a ground water table. Gravel, air gap and PUR will be included. This will reduce U-value from 2.42 to 0.22 W/m$^2$K.

Glazing: Existing glazing and frames will be replaced by low e coated, air filled windows and wooden frames in order not to modify the aesthetic of the building. The existing skylight will be eliminated to include PV panels.

### *HVAC*

HVAC systems will be completely renovated. As one of the criteria was to avoid heat radiators and underfloor heating, the most feasible option was a Air Handled Unit (AHU) that combines ventilation, heating and cooling. Also if air ducts will be larger, there will be a unique system, overcoming the problem of lack of space. In order to enhance efficiency, the AHU will be provided with a heat recovery system and will be located in the loft.

### *Lighting*

Current lighting system presents different types of luminaries and lamps, which are irregularly distributed and with high visual impact. The whole system will be replaced and designed according to the standard values established for a museum. Also if a more efficient system will be proposed, actual values are below the recommended power per area, thus installed power will increase to meet comfort conditions.

### *RES*

The renovation scheme includes the installation of Photo Voltaic (PV) panels. Due to the small dimensions of the building, power supplied will not be high, being 3.4 kWp. Monocrystalline panels will be placed instead of the skylight. Despite it is not the best orientation, is the area which is less affected by shading and will reduce visual impact.

### *Other*

No other interventions are foreseen.

## RENOVATION SCHEME EVALUATION

| | |
|---|---|
| **Energy Savings** | 44,919 kWh |
| **Costs** | 111,636 € |
| **Savings** | 4,971 €/year |
| **Simple Payback** | 22 years |
| **$CO_2$ Savings** | 4.95 tons/year |

### *Energy Savings*

Currently, the building has a final energy consumption of 54,383 kWh in gas and 14,602 in electricity and a total primary energy consumption of 93,039 kWh. According to the renovation scheme proposed there will be no gas consumptions but the final energy consumption in electricity will increase in 9,464 kWh. Primary energy savings will be 44,919 kWh. Considering electricity and gas prices of 2015 in Spain, expenditure savings will be 4,971 € per year.

### *$CO_2$ Savings*

The $CO_2$ savings are estimated in 4.95 tons per year.

*RES Integration*

12% of energy will be supplied by renewable energy systems. PV will provide a generation of 3,389 kWh.

## ECONOMIC EVALUATION

*Renovations cost*



The total investment cost is 111,636 Euro, which represents an investment cost per square meter of 295 Euro/m$^2$.

| INVESTMENTS | € |
|---|---|
| HVAC | 21,540 |
| Lighting system | 26,624 |
| Renewable energy | 12,602 |
| Building Envelope | 50,870 |

*Economic Savings*

The energy expenditure is 1.528 Euro/year.

The expenditure for maintenance after renovation is lower than before of 3.455 Euro/year. So, the economic saving, energy and maintenance, is about 4.971 Euro/year.

*Project Payback Period*

The project payback is 22 years considering the maintenance savings.

## FINANCING SCHEME

*Energy Performance Contract*

The project involves a change of use of the building: from archive to Centre of the Basque Costume. For this reason, a comparison with the previous situation as regards energy consumption and savings obtainable is not possible.

The project is not able to pay-back the investment in 15 years by itself because economic savings are minimal compared to investment costs. As a consequence, the implementation of an EPC contract is very difficult . Despite all, a possible way of implementation of a theoretical EPC contract should have the following features:

- Equity investment by the ESCo 10%;
- Grant for 88%;

The analysis shows that only two types of contracts, are best placed to meet the needs of the City of Errenteria: Guaranteed Saving and Shared Saving. The Shared Savings transfers more than 70% of the risk to the ESCO thereby ensuring the Municipality, while the Guaranteed Savings contract moved to ESCO about 60% of the risks

*Duration of EPC*

The duration of the EPC contract is about 25 years, higher than the normal market condition.

*Financial structure*

The optimal solution could be to build based on a mix of the two types in which:

- all of the interventions are performed by the ESCO, who assumes the technical risk and guarantees the savings;
- most of the work is funded by the City which assumes the financial risk while a small portion is funded directly by the ESCO
- the ESCO performs maintenance and shares the savings achieved for the part that is measurable; In fact, as said previously, in these two cases is not possible to define the basic situation being different situations of use of the raw properties and after renovation.

The municipality shoul consider a public / private partnerships by the involvement of the ESCO also in activities related to the provision of other services linked to the new use of the buildings, such as management and maintenance services. This scenario would lead to a greater involvement of ESCOs in the operation of the building, to an increase in revenues by allowing the ESCo to be able to undertake more investment reducing the financing for the Municipality.

*Other considerations*

In order to make the investment more sustainable for the ESCo the project could consider alternative ways to the standard EPC contract, for example to implement other kind of contract or a global service or a direct procurement by the Municipality. In addition, given the small dimension of the project, it could be a good option to aggregate more than one initiative. This aggregation could be useful to obtain cost efficiency, incremental revenues and synergies.

## LEKUONA

| Building Type | Industrial |
|---|---|
| Year of Construction | 1963 |
| Area / Volume | 4,406m$^2$ / 20,328 m$^3$ |
| Responsible Project Partner | TECNALIA |

### BUILDING DESCRIPTION

Lekuona is a family name associated to a long tradition of bakers, who opened their first small shop in Errenteria in 1858 and still continue their activity. As time goes by, the small shop became an industrial bakery. The need of adapting the business to a changing environment required a technological development. For this reason, the company decided to move, at the end of the 60's, to an industrial building located nearby the river, known as the "Lekuona building". The bakery continued its activity in the building till 2005, when the family decided to move to a bigger plant. Lekuona building, which is currently abandoned, is owned by the Municipality of Errenteria, in charge of preserving, rehabilitating and reusing it. The building is partially protected by the Coastal Law and its industrial character should be preserved. The Municipality is carrying out an ambitious project to transform the building into a dance school and cultural centre that will be known as "Dantzagune – Arteleku", as part of the Strategic Plan of the city, aiming to become a cultural and creative centre.

The Lekuona building is located next to the Oiartzun estuary, formed by a large central structure with two adjacent buildings for a total area of around 2000 m$^2$. The building has three floors and a basement. It has a rectangular shape with an adjacent trapezoid. The ground floor and first floor have similar shapes, but the second floor is a later extension of the building. The renovation project, which has been already approved by the Municipality, will have a larger area, as a new part will be constructed. The design proposed is in line with energy efficiency standards and will be qualified as "A class" according to the Technical Building Code of Spain (CTE).

### BUILDING CURRENT CONDITION - TECHNICAL AND OTHER PROBLEMS DETECTED

The Municipality of Errenteria has undertaken an ambitious project to transform a former industrial building into a modern cultural centre. The policy of the local government is clearly focused on an energy efficient solution. Hence, this renovation project will be a reference benchmark for the region. The building is labelled as Energy Category A and has been designed to present very low energy consumption and $CO_2$ emissions compared to a standard building. Suitable envelope typologies and materials, use of RES or efficient systems were considered from the beginning of the project. As the deep renovation designed has been already approved through a participative approach with citizens, few improvements can be achieved. However, some actions have been detected, especially related to the use of RES that will be used to achieve better results. Moreover, considering the willingness of the Municipality to improve the efficiency of its municipal buildings, the measures that are proposed in the frame of CERTus project will be considered in the near future.

### ECONOMIC, FINANCIAL AND LEGISLATIVE CONSTRAINS

*Economic/Financial Risks*

The Municipality and the provincial Government of Gipuzkoa have already invested an important budget for the renovation of the building, being the total amount of the project around 6,5 million €. The risk of implementing new measures in the project should not be underestimated. This is mainly due to the uncertainty of the legal framework on the use of PV. The use of PV panels is drastically limited by a series of fees that penalize the cost effectiveness of the installed system, e.g. a toll for each kWh produced. Additionally, the produced electricity that is not consumed must be dropped in the net without compensation.

*Legislative Obstacles*

Part of the building is subjected to the Spanish Coastal Law 22/88 (1988), which protects the area up to 20 meters from the estuary's shore. The portion of the building included in this area will therefore be maintained and restored, while a new structure will be added on the rear side.

## Renovation Scheme

### *Building Envelope*

The new constructive typologies of the envelope elements are in compliance with the aim of nZEB buildings. As these elements have already been well designed and possibilities to significantly reduce the energy demand are restricted. The project presents a good balance between retaining elements of the existing building and meeting energy conservation parameters.

Opaque envelope: Original walls, constructed of two layers of masonry with an air gap and no insulation, will be insulated internally by means of mineral wool and plasterboard, in order to protect the aesthetic of the fabric. The new walls will be new masonry with a similar insulation treatment. The existing roof, made of reinforced concrete will be augmented by corrugated sandwich panels of high density mineral wool. The basement floor is formed by a concrete finish over the structural concrete slab-on-ground. The renovation foresees the use of a wood structure located over the concrete slab with insulation.

Glazing: All the windows will be replaced with double-glazing with an air gap.

### *HVAC*

Heating Ventilation and Air Conditioning (HVAC) system of the building will be centralized and will use water-to-air Air Handling Units (AHUs). These elements will gather all the HVAC functions together: ventilation, heating and cooling. Various AHUs will be installed strategically on the roof to properly distribute the conditioned air to the assigned rooms or areas. Domestic Hot Water (DHW) necessary to supply the heating part of the system will be provided by a pellet biomass boiler placed in the basement. All requirements for the selection of efficient equipment and comfort have been fulfilled and no modifications have been proposed.

### *Lighting*

Lighting has been designed according to the Spanish and European Normal standards CTE – DB HE and UNE – EN 12464.1. Also in this case, energy efficiency and comfort parameters are met.

### *RES*

The heating system will be supplied by a biomass fired boiler. Considering that approximately 50% of the building will be used at a given time, a pellet-fired biomass boiler of 201 kW of nominal power was selected. Biomass is considered a renewable energy source and a carbon-neutral renewable energy. Thus, all the energy consumption related to the heating system will come from a renewable source.

450 PV panels will be installed, for a solar surface of 281 m$^2$. Panels will be installed keeping the orientation of the building in order to minimize the visual impact. PV ensures a generation of 35.75 MWh/year, with a specific production of 1050 kWh/kWp/year.

### *Other*

No other interventions are foreseen.

## Renovation Scheme Evaluation

| | |
|---|---|
| **Energy Savings** | 35,745 kWh |
| **Costs** | 126,587 € |
| **Savings** | 5,004 €/year |
| **Simple Payback** | 25 years |
| **$CO_2$ Savings** | 23.19 tons/year |

### *Energy Savings*

The installation of PV panels will permit achieving 35,745 kWh savings.

### *$CO_2$ Savings*

The $CO_2$ savings are estimated in 23.19 tons per year.

### *RES Integration*

59% of energy will be supplied by renewable energy systems, by the combined used of PV panels and biomass boiler, estimated in 194,568 kWh.

## Economic Evaluation

### *Renovations cost*

The total investment cost is 126,587 Euro, which represents an investment cost per square meter of 29 Euro/m$^2$.

These costs consider only the installation costs of photovoltaic system, not originaly planned in the renovation project.

| INVESTMENTS | € |
|---|---|
| **Renewable energy** | 126,587 |

### *Economic Savings*

Considering that the building is originally abandoned, the savings are represented by the lower cost of electricity purchase. This failure cost is calculated in € 3,704 / year.

### *Project Payback Period*

The payback period is more than 30 years.

## FINANCING SCHEME

### *Energy Performance Contract*

The project has borned to redevelop a derelict site and not used by the population in order to turn it into a cultural center. This project, already approved by the Municipality, is being expanded through the introduction of photovoltaic system with the aim of making the nZEB building.

These conditions do not allow a comparison with the previous situation as regards energy consumption and the relative savings obtainable after renovation scheme but we can say that the variation to the project will produce energy and economic savings compared to initial conditions.

For this project, an ESCo intervention is not possible at market conditions because cash needed to serve the debt service is much more than cash generated by the project.

In order to make the project desirable for an ESCo, an important financial support should be given to the project and the duration of the EPC contract should be extended. In this case, a specific financial structure was implemented assuming:

- Equity investment by the ESCo 9%;
- Grant for 59%;
- subsided Funds 25%

The analysis shows that only two types of contracts, are best placed to meet the needs of the City of Errenteria: Guaranteed Saving and Shared Saving. The Shared Savings transfers more than 70% of the risk to the ESCO thereby ensuring the Municipality, while the Guaranteed Savings contract moved to ESCO about 60% of the risks.

### *Duration of EPC*

The duration of the EPC contract is of about 25 years, higher than the normal market condition.

### *Financial structure*

The optimal solution could be to build based on a mix of the two types in which:

- all of the interventions are performed by the ESCO, who assumes the technical risk and guarantees the savings;
- most of the work is funded by the City which assumes the financial risk while a small portion is funded directly by the ESCO
- the ESCO performs maintenance and shares the savings achieved for the part that is measurable; In fact, as said previously, in these two cases is not possible to define the basic situation being different situations of use of the raw properties and after renovation.

The municipality should consider a public / private partnerships by the involvement of the ESCO also in activities related to the provision of other services linked to the new use. The ESCO could be involved not only for the construction of the photovoltaic but also, for example, for the assignment of the maintenance of the entire post-restructuring structure and for the management of a part of the services inside it. This scenario could allow more investments from the ESCO with a reduction of those from the Municipality.

### *Other considerations*

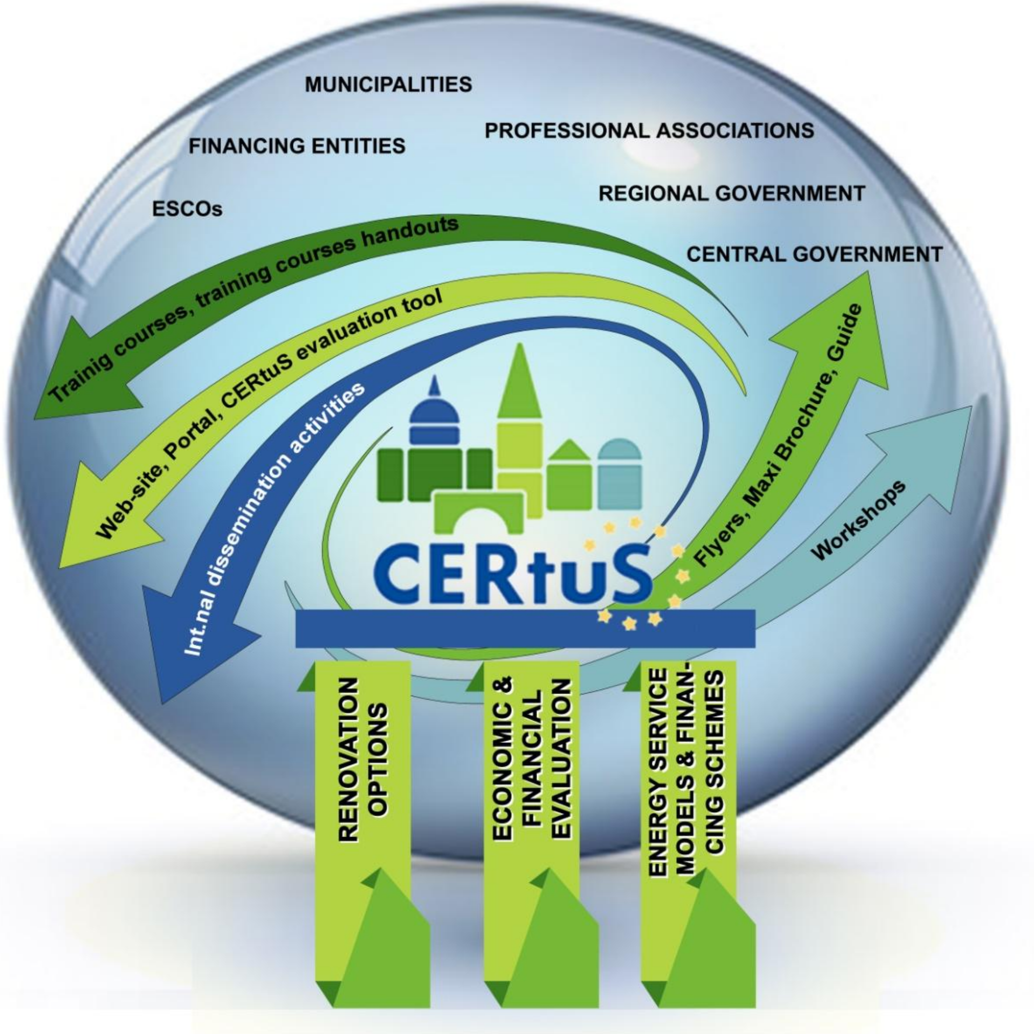
In order to make the investment more sustainable for the ESCo the project could consider alternative ways to the standard EPC contract, for example to implement other kind of contract or a global service or a direct procurement by the Municipality. In addition, given the small dimension of the project, it could be a good option to aggregate more than one initiative. This aggregation could be useful to obtain cost efficiency, incremental revenues and synergies.


ΔΗΜΑΡΧΕΙΟ

# PRESENTATION OF OTHER PROJECT RESULTS

The outcomes produced in the project are composed of different deliverables / project documents. Thirty one out of thirty five deliverables produced or under production by the CERtuS consortium have a public nature and are made available to any interested through the project web-site page: www.certus-project.eu.

The four confidential deliverables of the CERtuS project concern with the design of the web portal and its implementation, as well with the updated IEE CPI and specific objectives, key outputs, impacts and performance indicators within the duration of the action.



**Deliverable D2.1:** *Report presenting the 12 nZEB renovation schemes fully documented with technical and economic evaluation.*

Presents in detail the 12 nZEB renovation schemes and covers all technical aspects of renovation options of each building of the involved municipalities

**Deliverable 2.2:** *Report presenting the risks, difficulties and constraints envisaged by the stakeholders regarding nZEB renovations.*

Presents the results and conclusions which aim at establishing a framework for a useful renovation process of existing public buildings with high energy efficiency goals. Available in English and translated in IT, HE, PT, ES.

**Deliverable 2.3:** *Four documents, one per Municipality, summarizing the obstacles, risks and difficulties for the renovation schemes*

Comprises 4 specific papers, one of each involved municipality. The four reports are structured in the same manner and are available in English and translated in IT, HE, PT, ES.

**Deliverable 2.4:** *Catalogues of materials equipment and technologies pertinent to all municipal buildings.*

Summaries the analysis of potential materials, equipment and solutions considered in the project case studies to achieve nZEB.

**Deliverable 2.5:** *Twelve economic evaluation reports.*

Defines a common economic evaluation methodology for the renovation schemes which considers several aspects and analyses 12 renovation options in order to understand if they are market sustainable, partial market sustainable or no sustainable at market conditions.

**Deliverable 2.6:** *A report with proposals for regulation improvement.*

Summaries an overview of the legislation pertinent to energy efficiency and integration of RES, and documents proposals to regulators on needed regulation improvement to facilitate nZEB renovations, considering also the historic buildings. Available in English and translated in IT, HE, PT, ES.

**Deliverables 3.1 - 3.2 – 3.3 – 3.4:** *Report of analysis of current conditions for Messina / Alimos / Coimbra / Errenteria*

Outlines the economic, legal and policy conditions prevailing in the four Municipalities, relevant to renovation project financing. Available in English and translated in IT, HE, PT, ES.

**Deliverable 3.5:** *Report of existing performance contracting examples and energy service models*

Reviews the existing energy performance examples and energy service models through: (i) an analysis of the projects funded by IEE,; (ii) a survey among partners on the existing EPC and energy service models; (iii) an analysis of energy efficiency building projects realized by ESCo.

**Deliverable 3.6:** *Report on suitable energy service options for the four municipalities.*

Reports on the most suitable energy service options and describes the adapted energy service schemes with suggestions for each municipality. Available in English and translated in IT, HE, PT, ES.

**Deliverable 3.7:** *Report on financing mechanisms suitable for each Municipality*

Identifies, analyses and classifies the existing financing schemes for energy efficiency retrofits in public buildings, with a special focus on those available in the 4 involved Southern countries. Available in English and translated in IT, HE, PT, ES.

**Deliverable 4.1 & 4.2:** *Reports: requirements and goals of the web-based information portal & design specifications and blueprint of the portal. (Confidential)*

Presents the requirements and goals of the web-based information portal.and the design specifications and blueprint of the web-based information portal

**Deliverable 4.3:** *Open service-oriented integrated web-based portal in English, IT, HE, PT, ES.*

Communicates the objectives, results and deliverables of the project to the public and it presents the modifications of the Web portal contents and the new sitemap of CERtuS website.

**Deliverable 4.4:** *Portal with information entered in English, IT, HE, PT, ES.*

Introduces the CERtuS project outputs and other informations on nZEB projects. The Portal is available in English and translated in IT, HE, PT, ES.

**Deliverable 5.1:** *Training courses handouts*

Collects the materials and other outputs developed within the CERtuS project in different modules for the municipality technicians and employees training.

**Deliverable 5.2:** *Translation and adaptation of training courses handouts in IT, HE, PT, ES.*

Presents the translation of the materials and other outputs developed within the CERtuS project in different modules for a municipality employees training and adapts them to the local needs.

**Deliverable 5.3 - 5.4 -5.5 – 5.6:** *Training courses for municipalities in Greece, Portugal, Spain, Italy.*

Develops the training courses realization in the 4 countries by the local partners involved in the project

**Deliverable 5.7:** *Report on training courses evaluation*

Reports on the results of the evaluation of each training course.

**Deliverable 6.1:** *CErtuS website, logo and project flyer*

Introduces and describes the different communication tools of the project. All tools are available in English and translated in IT, HE, PT, ES.

**Deliverable 6.2:** *Guide*

Details the technical options and financial schemes for the Municipalities. The Guide is available in English and translated in IT, HE, PT, ES.

**Deliverable 6.3:** *Maxi Brochure*

Informs and describes the Project and its activities focusing on the model renovation schemes of the twelve pilot buildings. The Maxi Brochure is available in English and translated in IT, HE, PT, ES.

**Deliverable 6.4 – 6.5 – 6.6 – 6.7:** *Workshop on nZEB energy services and financing in municipalities in Greece, Portugal, Spain ans Italy*

Presents the examples projects of nZEB renovation and the identified financing schemes with the aim to facilitate better understanding of how results can be used in the CERtuS Municipalities.

**Deliverable 6.8:** *CERtuS stand at 'Energy Week' or equivalent international event*

Communicates to the targeted groups via direct personal contacts the existing opportunities for ESCOs and financing Entities in Southern European countries under the current difficult economic conditions.

nZEB
solutions
ENERGY USE
public buildings
PALACE Alimos
ERRENTERIA plan
Municipalities
training materials
EU
RES
EPC
Italy
FACTOR
definition
Messina
maintenance
public sector
EXISTING BUILDING
Options
investments
Coimbra
renovation
STRATEGIC
energy service
PARTNERS
SCHEMES
Cost
envelope
Zero
RENOVATIONS
CITY HALL
MUNICIPAL
TOOL
COIMBRA
consumption
economic assessment
capacity building
Spain measures
sustainability RES
Efficient
ITALY payback times
ESCOs
results
MODELS
nZEB
ALIMOS
procedures
HVAC
impact
technical
Directives
public sector
Errenteria
Financing Mechanisms
PERFORMARNCE
parameters
EFFECTS
LED
HVAC
economic
GREECE
concept
SPAIN
glass
RES
State
PROCEDURES
EPBD
PROJECTS
Stock
ESCOs
REFORM
courses
improvements
Energy Efficiency
renovation schemes
municipality
Coimbra
European Union
MESSINA ESCOs
Buildings
STAFF
objectives
PORTUGAL
stakeholder
Renovation
authorities
LIMITATIONS
designs RES
Greece CO2
characteristics
GUIDELINES
management
Southern Europe

# LESSONS LEARNT AND RECOMMENDATIONS

*The purpose of this section is to bring together any experience and knowledge gained by the implementation of CERtuS activities.*

## DESIGN, CONSUMPTION AND PERFORMANCE ASSUMPTIONS LESSONS

**The renovation options for existing buildings should be implemented by group of measures, based on preliminary studies and evaluations and on analyses of their final impact, instead of in-advance defined and fixed single measures. These renovation options should include technical and financial actions.**

For example, the replacement of windows produces post-required actions (e.g painting) which affects the building envelope and is related to the additional wall insulation. Moreover, the technical aim of such interventions is the reduction of the heat losses and the improvement of the indoor conditions. So the additional wall insulation without the replacement of the windows (in some cases):

- it is not as efficient for the reduction of heat losses;
- makes the replacement of the windows a non-financiable solution as they would be installed later. In this case the potential energy reduction will also be estimated on a lower base case scenario (it is refered to the estimated energy consumption after the additional insulation).

Thus, the renovation measures must be based on a carefully determined design and evaluation approach. The total effect of planned measures must defined on systematic approach.

**A renovation option should be totally profitable. Otherwise it could be never implemented, excluding the projects in which other benefits could be reached.**

The payback time of energy related renovation is the controlling factor but in some cases the longer pay-back time can be accepted if this prevents risks or material damages and/or obvious structural defects, which could cause bigger investments in the future. Obviously, the value of energy savings of one particular measure with reasonable payback time can also be combined with a measure of longer payback time if the mixture is technically and economically viable and attractive.

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**The deep renovation is complex and expensive. Thus, the implementation of energy performance design studies must be addressed through some tasks, giving priority, to:**

- The measures which must be carried out because of risks and obvious damages found during the design stage (can be very expensive later);
- Energy saving measures with zero and low-cost investments and short payback time (e.g. tightening of windows, door, adjusting running time of HVAC and lighting);
- Energy saving measures with reasonable payback time;
- Improvement of the energy efficiency by long-term effective installations, such as RES and hybrid or/and passive systems replacing fossil fuels.

This approach and procedure requires a short- and long-term maintenance plan and also allocation of resources in a way that life-cycle curve of a building will be opitimized.

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**It is very difficult to reach the nZEB threshold by developing projects in public-private partnership at market conditions involving an ESCo.**

The investments on the existing buildings tend to focus on measures with short and medium payback period which usually generate around 30%-40% energy savings. This is the current obtainable threshold in the market and varies across the involved countries and building types. Further energy savings are therefore achievable only by increasing investments, that are not always cost-efficient at market conditions and that usually need to be financed with specific ad-hoc financial instruments and/or public grant.

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**In order to make investments which are more sustainable for ESCos, the renovation projects, when possible, could consider alternative ways compared with the standard EPC contract.**

For example, to implement other types of contracts, a global service or a direct procurement by the Municipality.

**Small size energy efficiency projects are not rare in the public sector of Southern European countries. Whereas energy efficiency projects - generally tend to be larger both in investment and in reduction effects - could be a good option to aggregate more than one initiative.**

This aggregation could be useful to obtain cost efficiency, incremental revenues and synergies.

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**Financial barriers are considered by the stakeholders as the main barriers for nZEB renovations.**

This fact is worsened, in some cases, by the decreased interest, political decision-making and the shortage of public funds. The promulgation of ambitious energy plans accompanied by suitable tax policy, as well by incentives, is seen necessary to boost energy renovation not only in the majority of the involved countries, but probably also in other South and East European countries.

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**The lack of knowledge of retrofitting technologies, especially the innovative ones, and the unclear energy policies has been identified as the main barrier from the technical point of view.**

Moreover, this lack of knowledge also depends on the absence of credible energy savings data, uncertainty of maintenance costs and complexity of the installations.

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**When the renovation options are not financially sustainable, is due generally to several factors, as:**

- Technological solutions which are currently available in the market are quite expensive if compared with the obtained savings costs. This has a negative impact on the economic and financial feasibility of the projects;
- The medium and long payback-time of some specific measures;
- The additional costs caused by special constructions or systems, required for listed buildings, compared with conventional ones,
- Energy efficiency interventions may improve the ability of public authorities to identify the significance of proper maintenance frequency, compared with the conditions before renovation. Usually this will come up when annual maintenance costs increase, (entirely sustained by the ESCO). This aspect - although it initially increases public expenses - is fundamental for the proper maintenance of the new systems.

## RECOMMENDATIONS

In order to encourage nZEB interventions and financing them at market conditions some actions should be considered. Those do not necessary derive from the investigations and other analysis done within the CERtuS project. They are proposed, as stimulus for thinking, concerning the feasibility and sustainability of the nZEB interventions:

- Increase the use of public buildings during the daytime by additional activities, when it is possible (e.g. sport and social activities during the evening/night, office activities during the day). If the use of a building can be extended from a normal/conventional use, it will bring benefits, as the optimisation of the building usability and profitability.
- Increase ESCo services, which, in addition to hard facility management (e.g. mechanical, fire and electrical services), could offer them the possibility to carry out auxiliary services such as soft facility management, (e.g. cleaning services, green care, reception). This would provide additional revenues to the ESCOs, and would make it more attractive.
- At the end of the implementation of the renovation works and when the building has reached the defined requirements and standards and / or when it comes fully operational, a further opportunity to increase energy efficiency interventions could be possible. This deals with the participation of financial institutions (e.g. institutional investors, funds, etc.) investing money into the ESCO.

  Consequently, the ESCo could bring more resources to carry out extra projects. This scheme may solve ESCO's undercapitalization or decrease their need of financial resources.

**CERtuS project promotes the implementation of Energy Efficiency and encourages stakeholders creating business frameworks that are favorable to investments.**

CERtuS has adapted existing energy service models and procedures and has identified financing schemes that are suitable for the building projects and the specific requirements of each municipality.

- CERtuS renovation design has succeeded to show that energy consumption for heating, cooling, ventilation and lighting can be significantly reduced with the share of renewable energy. The same principle is in force and achievable in the many cases of the historic buildings, when an interdisciplinary approach, both theoretical and technological, ensure the implementation of quality interventions in accordance with the specific characteristics of the historic buildings.
- CERtuS renovation design, even if innovative, purposefully is not at the forefront. This choice better reflects market conditions, has less risk and is closer to investors requirements for safe investment options.
- CERtuS has developed a methodology and a Simplified Economic Evaluation Tool, aiming to provide support to municipalities to prepare and evaluate the potential of energy efficiency and deep renovation retrofitting to be financed with an energy service contract.
- CERtuS has developed a methodology which assesses the risk and evaluate the specific requirements for each municipality to identify existing energy service models and procedures and the most suited mix of market money, subsidy funds and grants needed to finance nZEB renovation and energy efficiency interventions.

CERtuS results' replication is facilitated by the development of guidelines and training material, capacity building in municipalities, workshops and web tools.

# THE CERtuS PROJECT TEAM

## CERTUS TEAM

## CERTUS PROJECT PARTNERS

ENEA - Italy

EUDITI- Greece

Tecnalia - Spain

U. of Coimbra - Portugal

U. of Aalborg - Denmark

Messina - Italy

Alimos - Greece

Errenteria - Spain

Coimbra - Portugal

SINLOC - Italy

ETVA VI.PE. - Greece

INNOVA BIC - Italy

ASSISTAL- Italy


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CERtuS

ENEA
Italian National Agency for New Technologies, Energy and Sustainable Economic Development

Municipality of Messina

Municipality of Errenteria

Municipality of Coimbra

Municipality of Alimos

ISR UNIVERSITY OF COIMBRA

SINLOC
Sistema Iniziative Locali

ETBA
ΕΠΙΧΕΙΡΗΜΑΤΙΚΑ & ΒΙΟΜΗΧΑΝΙΚΑ ΠΑΡΚΑ
ΜΕΛΟΣ ΤΟΥ ΟΜΙΛΟΥ ΤΡΑΠΕΖΑΣ ΠΕΙΡΑΙΩΣ

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ASSISTAL