# ZERO ENERGY CONSUMPTION BUILDINGS
# THE CASE OF THE GREEK BIOCLIMATIC SCHOOLS

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***Abstract***

*The present paper presents the big project for the construction of zero-energy buildings, as well as the effort of converting the old buildings (and traditional the most of the times) into nearly zero energy buildings.*

*In this effort EU is leading the way, as well as to all the effort of climate change. After the last UN Conference in Rio, Brazil in June 2012, also known as Rio+ 20, this ended without a binding agreement, followed by the 18th global UN Conference in Qatar in November 2012 that decided with the participation of 200 countries to extend the Kyoto agreement until 2020. Unfortunately, Russia, Japan and Canada have pulled out, while it is known that the U.S.A. does not participate in Kyoto. The EU is pledged since March 2007 for reducing greenhouse gas emissions by 20% by 2020. The EU's aim is to curb the warming to $2^0$ C until the end of the century even if it is recorded today an increase to carbon dioxide emissions by 50% since 1990.*

*Within an uncertain environmental and energy environment the building sector, which consumes the 41% of energy in the EU, it is obvious, that can contribute to reducing energy consumption and correspondingly to reduce greenhouse gases emissions. EU commitments for construction of new buildings by 2020 with zero energy consumption, and gradually upgrade old buildings into buildings with almost zero energy consumption by 2050, are optimistic prospects not only for the course of climate change but mainly for strengthening of traditional buildings in energy level.*

***Key words:*** *Europe 2021, zero building energy consumption, greenhouse gases.*

## Introduction

Failure of epic proportions//was characterized by the majority of environmental organizations the Declaration of Rio+ 20 titled the future that we want [(1)] while similar was the assessments of a large part of the participants.

At the end of the Conference, which was held in Brazil's Rio in June 2012, the Ministers of the 190 countries adopted a decision text, which provides for adoption of the green economy on a more sustainable social and economic development model.

The Summit, 40 years after the original Stockholm Conference in 1972 and 20 years after the meeting in the same place in 1992 found.

- The increase in greenhouse gas emissions by 48%
- The continued destruction of the forests
- The upward trend of world population
- Malnutrition of 16.5% of the world's population

The adopted vague proclamation of the Congress defines 2015 as the time limit to receipt and accept specific objectives.

One realizes, that substantive commitments and solutions were not decided. There could be for example more concrete decisions taken for

- dealing with the effects of climate change
- fighting against poverty
- The worsening of social inequalities
- The increase in world population

The World Summit that followed the November 2012 in Qatar resulted in the decision to extend the Kyoto Protocol until 2020, with a corresponding withdrawal of Russia, Japan and Canada.

Unfortunately the current global reality, with the unprecedented financial crisis that has erupted on the one hand and the requested protection of the environment on the other hand, is a real challenge for the political and scientific leaders globally.

It is obvious that under these circumstances very careful planning and implementation of appropriate policies is required to achieve development, not only with no serious effects on the environment, but that if possible to create environmental discharge.

In this direction the building sector, which consumes 40% of the total energy produced, is a top priority for energy saving, pollutant reduction emitted, but also for educational development of environmental consciousness in foreshadowing citizens of the world, with an emphasis on younger generations.

**Present Environmental Reality**

The revised Lisbon strategy in 2010, with the goal of 2020, has a focus on energy and climate change and moves to implement the doctrine "20-20-20", which means, that by 2020 emissions of gaseous pollutants in the EU-27 should be reduced by 20% compared with 1990, the involvement of RES should reach 20% of energy consumption and the consumption of fossil energy sources to be decrease by 20%with an increased energy efficiency. (European Commission, 2009) (2)

From the pre-industrial levels of 1750 until now, carbon dioxide emissions [CO2] in the atmosphere are 375 billion tons, which is an increase of 140%. (3)

Nowadays the levels of $CO_2$ is 391 parts per million [ppm]. Half of this huge amount is absorbed by forests and oceans. But our planet begins to lose its absorbent capacity, because all these billions of tons of coal will remain in the atmosphere for centuries.

This fact that apparently worsens the temperature of our planet, is affecting all aspects of life on Earth.

The second most important greenhouse gas is methane [$CH^4$], with the participation of 8% in greenhouse gases, which is 30 times more potent than carbon dioxide as a greenhouse gas.

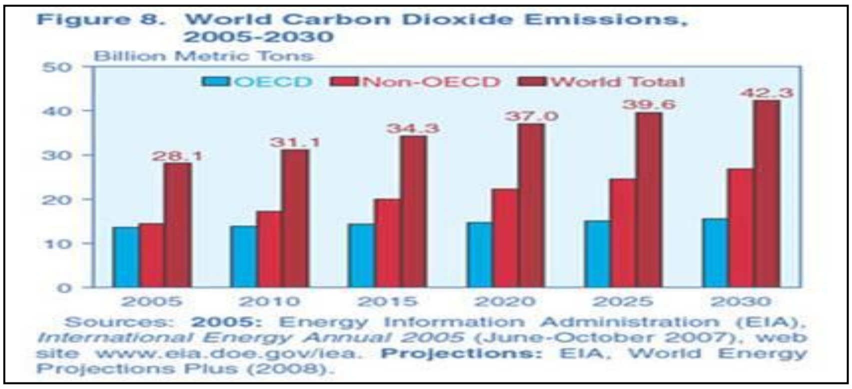
Methane is produced mainly from farm animals, rice cultivations and decomposition of waste in landfills. Its concentration today is 1813 ppm, corresponding to an increase 259% of pre-industrial levels.

Finally an increase is presented in nitric oxide [$N_2O$], derived from human sources and is 300 times more drastic than carbon dioxide. Its concentration today is 324 ppm.

Under these circumstances and without taking immediate action, there is a risk that the temperature of our planet will raise up to 4 $C^0$ by 2100, and sea levels will rise by a meter. Anyone can realize the disastrous consequences for mankind and especially to the poorest of this world, as Jim Yong Kim, President of the World Bank (4) is warning.

The only commitment made by the delegates to the Rio+ 20 was to reach an agreement with binding measures until 2015, aiming to curb the warming of our planet to $2^0$ C. The effort started in November of 2012 in Qatar, with the extension of the Kyoto Protocol until 2020. The threatened countries with devastating consequences is, Bangladesh, India, Indonesia, Madagascar, Mexico, Mozambique, the Philippines, Venezuela, Vietnam [(5)]

Table 1. Global carbon emissions




At this point it should be emphasized, that there is a rift between the global scientific community and society of certain developed countries, whether climate change is derived exclusively from the people.

Specifically, the study recorded the views of 10,000 scientists around the world showing that 97.1% agrees that climate change is entirely man-made. In contrast the society in the USA 43% does not accept anthropogenic source of climate change, while a 12% is sceptical. [(6)] Table 1[(6A)] captures the projected emissions of $CO_{2,}$ by 2030.

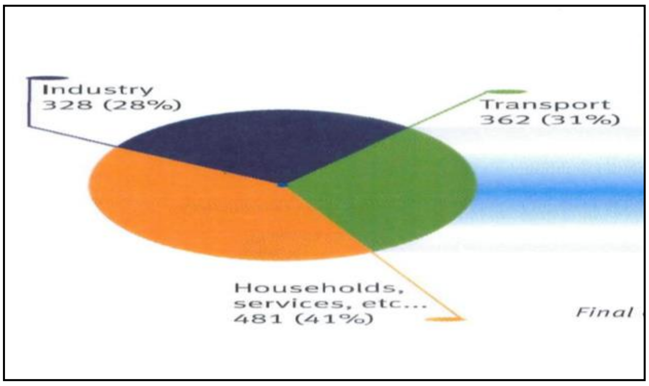
Under these data the building sector, which consumes 41% of energy and is responsible for the emission of toy15% of greenhouse gases, it is invited to contribute decisively to air improvement, **table 2**. This can be done.

- by reducing energy consumption
- emphasizing in bioclimatic building design
- With energy retrofit of existing buildings
- Using RES for the required functional action.

**Towards Buildings with null energy consumption**

It is obvious that the implementation of building shells with almost zero energy consumption, aims to reduce energy consumption and reduce greenhouse gas emitted. Nowadays the building sector consumes 42% of world energy production, transport 33% 26% the industries. 80% of the energy is consumed by buildings with size less than 1000m$^2$, while 66% of the energy consumed by each building is absorbed by energy-cooling.

Table 2. Energy consumption per sector



We define as net zero energy building that building that has very high energy efficiency, with almost zero energy consumption, and this is ensured by RES.

The European directive circumscribes the 2020 aims to implement these buildings [7]. Custom Greek legislation provides that all buildings being built by 2021 should have zero energy consumption [8] this obligation for public buildings will be put in place by 2019. Finally the recent EU directive[9] provides that each Member State should by1-1-2014 renovate each year 3% of the total surface of the heated or cooled public buildings in order to meet minimum energy performance requirements, pursuant to article 4 of the directive EU/31/2019. Incentives for implementation of above-mentioned legislation provides the law 6367/2012[10] with an increase of the coefficient of 5-10% at minimum energy consumption of buildings.

Zero energy buildings are to be based on the following.

- Design with utilization of microclimate – bioclimatic design
- Passive heating-cooling systems
- Production of hot water by solar systems
- Use of small photovoltaic systems the other RES
- Use devices with low energy consumption

**Bioclimatic design – microclimate – passive energy systems**

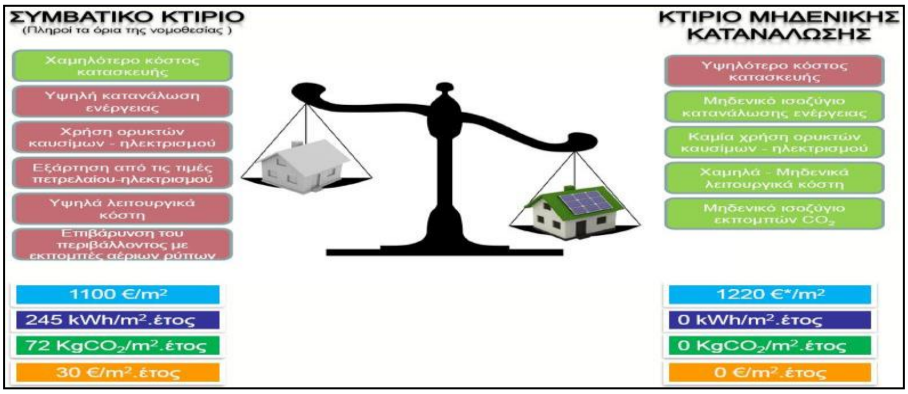
Bioclimatic design leverages the local climate and aims to ensure thermal and visual comfort. Essentially it harnesses solar energy for the application of passive systems, which are integrated in buildings, utilizing various environmental resources, such as the Sun, wind, soil, vegetation, water, etc.

Basic passive energy systems can be considered

- Climate-location-orientation
- sun shading — shading
- natural lighting
- Natural ventilation
- Planting-planted roofs
- Organic materials

The correct orientation of the building the South with some deviation up to 30 to East-West, is making a substantial contribution to better energy performance of the building. By placing large exposures in the South and scarce in the North, solar radiation is used for heating of the southern spaces and respectively reduce the heat losses from the North. With this design better conditions are created through ventilation and lower requirements for air conditioning.

Table 3. Comparison conventional-energy financial building



The correct orientation of the building the South with some deviation up to 30 to East-West, is making a substantial contribution to better energy performance of the building. By placing large exposures in the South and scarce in the North, solar radiation is used for heating of the southern spaces and respectively reduce the heat losses from the North. With this design created better conditions through ventilation and lower requirements for air conditioning.

Important factors of the energy behaviour of the building are

- Insulations
- The tightness of the frames
- The use of double glazing thermal insulation

With passive energy systems we shield the building shell. **Table 3**[10a] is typical of the advantages of building zero consumption.

The right shadings have a lot of great importance for thermal and visual comfort of spaces. Exterior sunshades, like e.g. Overhang, external blinds, which should be placed horizontally in the southern exposures and sharply to the East and West even exterior canvas and interior blinds, offering important precaution.

Finally, the use of household appliances with the lowest energy consumption offer significant energy benefits. Please note, that all appliances are characterized in terms of their consumption on a scale of a-F, [minimum-maximum, and consumption]. **Table 4**[10a] shows very low consumptions in some European States, which implement zero-energy buildings.

Table 4. Building low-power consumption Indicator at kwh/ $m^2$year

| Τύπος κτιρίου |  |  |  |  |  |
|---|---|---|---|---|---|
| Κατοικία | 45 | 40-65 | 42 | 50-65 | 50 |
| Διαμέρισμα | 37 | 40-60 | 42 | 50 | n/a |
| Μη οικιακό κτίριο (εξαιρουμένων νοσοκομείων) | 37-50 | 30-75 | 42 | 60-158 | 95-151 |

**Active energy systems**

Passive energy systems are called those systems, which collect sunlight and utilize thermal, either directly, or indirectly (e.g. wind, geothermal). The basically passive energy systems that can be used are as follows.

- photovoltaic systems
- Small wind turbines
- Thermal solar systems
- Geothermal pumps

***- Photovoltaic systems***

Photovoltaic systems (PV) are a highly prevalent R.E.S. both in Europe and in Greece.

Divided into two types, interconnected with the main electricity network and standalone network using batteries for storing the energy produced.

The material is lumpy or single-crystalline or polycrystalline silicon.

Their placement requires special specifications as to the orientation, the flair and the avoidance of shading of PV panels

Using photovoltaic systems we aim to:

- reduction of the energy produced at national level by fossil fuels
- significant environmental benefits, through the reduction of pollutant gases
- economical energy production

The advantages of using PV systems are numerous. We briefly focus on the following:

- Environmentally-friendly technology, if not caused pollutants from energy production
- Solar energy is decentralized fuel, available everywhere and it costs
- Silent mode
- Almost zero maintenance requirements
- Long life (25 years)
- Possibility of future expansion to meet the growing needs of users
- Can be installed in already existing structures
- Flexibility in applications, where they work out, both as standalone systems and hybrid systems, when combined with other sources of energy (conventional or renewable) and batteries for storing the energy produced.

It is estimated that the cost of construction of a photovoltaic system, has depreciation in 10 years, when the total lifespan of 25 years.

***- Thermal solar systems***

The use of solar thermal systems is so widespread across the EU, and in Greece. [11]

Solar water heaters are the most common hot water production technology.

Divided into open and closed circuit, with the latter being the most widespread, because they withstand and at low temperatures.

Combo systems used for simultaneous production of hot water and heating or cooling, even with main application, underflow heating and operation at 40 ~ 50 $^{o}$c.

***- Biomass***

Biomass is not very widespread but is Renewable material, both for heating and hot water production.

Consists of materials of plant and animal origin, such as forestry, industrial, agricultural, waste, energy crops, products of municipal waste.

Biomass combustion is used either directly through heat, or electricity production, either through thermo chemical or biochemical conversion is converted into bio fuel, gas or liquid or solid form, which is then used to produce electricity or heat, and transportation fuel.

***- Geothermal pumps***

Geothermal energy is a form of mild renewable energy. Energy is stored in form of heat beneath the surface of the Earth.

The subsoil temperature in depth 2, 00 m is roughly constant throughout the year and ranges from 14-18$^{o}$C for our country.

Holding temperature difference between subsoil and surface, using geothermal pumps and piping within the subsoil network so as to heat spaces in winter and cool them in summer.

Geothermal energy is available year-round, is not dependent on the weather conditions of the atmosphere.

The exploitation of this action is done with two systems:

- Geothermal systems closed circuit
- Open loop geothermal systems.

Geothermal systems closed circuit are based on construction of a heat exchanger in the subsoil (geothermal heat pump), which is constructed from a number of piping, in which water circulates.

Winter powered geothermal heat pump with water temperature around the $16^0$C by geothermal heat pump, which takes 4-$5^o$C before its return to Earth.

So with little power consumption, hot water 35 – $45^o$C is produced suitable for heating (underflow heating systems)

The geothermal heat exchanger can be placed in horizontal or vertical layout. Horizontal layout, is used when the surface of the land is adequate.

Open loop geothermal systems draw water from underground reservoir using drilling and using an intermediate water exchanger, inserted between the heat pump and geothermal open loop, impart or absorb energy in our system before the water is returned to the reservoir. This system is suitable in areas with shallow aquifer.

The dimensioning of pipes in geothermal systems must be done underground, to avoid energy losses when entering the building.

***- Small wind turbines***

Wind turbines are probably the most prevalent R.E.S., both throughout Europe and our country.

Wind farms supplying directly the main electrical grid, while the underpowered wind turbines (s/c) small-scale applications recommended for domestic applications.

Produce voltage DC 12 ~ 24 V, which with use of appropriate voltage inverter converts the host network.

The combination of small a/c with photovoltaic systems creates a very good combination household use R.E.S.

**Conversion of existing buildings into buildings with zero energy consumption**

In accordance with EU directive from 2009, all existing buildings must have by 2050 net zero energy buildings to enhance consumption. It is obvious, that an old building mainly will need to modernize its energy building shell, with low u-value. Also the mechanical installations, illuminative energy saving and the use of economic energy devices is the next stage of energy saving. Finally, add a small f/s will be required to approach the building zero energy consumption.

This EU effort is obvious, that if realized at a satisfactory rate, will save huge amounts of energy, limiting at the same time accordingly and greenhouse gas emissions. The implementation of this major European project requires a number of conditions, the most important of which are as follows.

- Development of appropriate technologies.
- Update of the responsible scientific groups.
- Develop financial support programmes.
- Update all the affected public and municipal authorities.
- Development of relevant industries.
- Participation of universities in the development and dissemination of know-how.
- Inform society of users, for both economic and environmental benefits.

In Greece we can achieve today up to 70% energy savings in old buildings, by applying passive systems in the shell more specifically we can achieve the following reductions [(12)]

- Insulation exterior walls 29-42%
- Insulation floors 8-19%
- Roof insulation 3-19%

- Double glazing 8-10%
- Reduce air infiltration 7-20%

Similarly we can achieve energy savings in the heating system at significant rates, since 60% of energy consumed by a building spent on heating. More specifically [(13)]

- New boiler 18%
- Pipe Insulation 2%
- Thermostatic valves 20%

Finally illuminative energy saving should be persuade, which is 14% of the total energy. With the use of efficient control systems and components, natural lighting, it is possible to save 30-50% rate [(12)]

**The case of Greek bioclimatic schools**

The gradual improvement of education was the main objective in both the original Lisbon Strategy 2000 (Commission staff working document, 2011[(14)] and in the final amendment of objectives at the beginning of 2010.

This fact is not a coincidence. Europeans have fully embraced the doctrine that economic progress and social cohesion depends decisively on education.

School infrastructure and the necessary digital equipment, play a major role in the quality of education provided to younger generations in every country.

Only a reformed learning and working environment, such as school, can better develop a teaching reform and create an impact on those who is addressed.

EU leads the way in this effort in seeking to limit the rate of pupils who drop out of school from 15% to 10%, while trying to increase the proportion of the population aged 25 ~ 34 years old who have university education from 31% to 40% in 2020. It is noted that in America the corresponding higher education rate is 40% and 50% in Japan.

Greece currently has 14,000 Schools at all levels. The mountain and island character of the country requires the operation of large number of small schools, covering the needs of remote regions.

**Oldness - Seismic adequate schools**

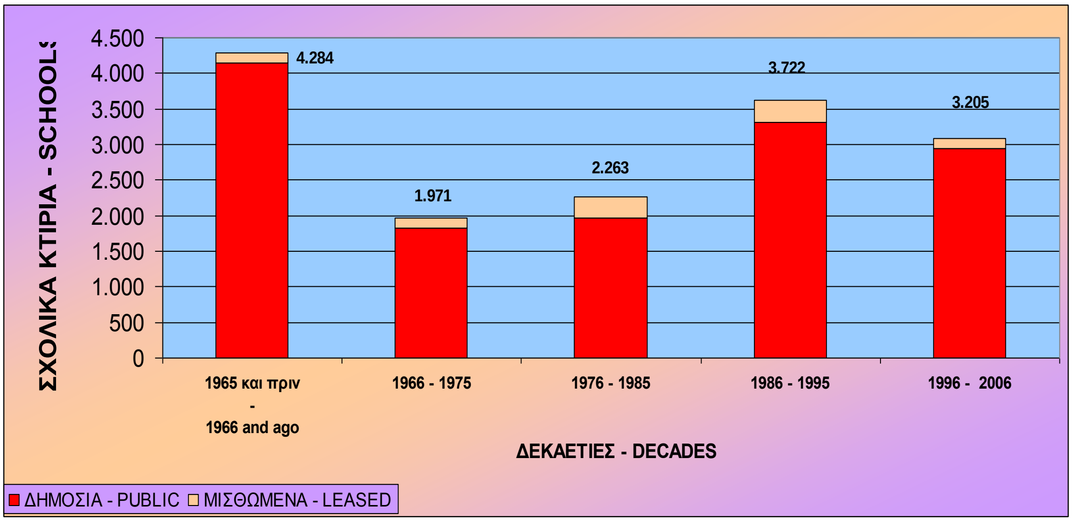
The age of Greek schools at a rate of around 55%, is considered up scaled since they have been built before 1985.

Table 5 [(15)] presents per decade their seniority.

Another important point is that only schools built after 1985, i.e. 45% with enhanced anti-seismic regulation have significant static-seismic adequacy in a country such as Greece, with very large seismic action.

It is therefore obvious that our country requires establishing a major project, not only for functional and sustainable new structure of the Greek schools, but also for the static and seismic adequacy. Obviously this can be designed only with the Horizon 2020.

Table 5. Age of Greek schools




Of the total 15,445 Greek schools, which had then the country since 2005 5,900 schools have been tested for the static and seismic adequacy. With pro- seismic controls 4.700, i.e. all that had been built before 1959, without any earthquake safety regulations, while the aftershock controls (after the onset of seismic events) 1,200 Schools have been checked. These checks were made at very high level under the responsibility of the teachers of 5 Universities of our country.

The results of the checks indicated 3.5%, percentage of schools of which required a smaller or larger static interference.

These inspections resulted in the upgrade of some cases and the static restoration in other, 410 schools total cost of 90.000.000, 00 €.

This effort must obviously continue for schools which were constructed in the period 1959 ~ 1985 based on the first anti-seismic regulation of Greece. The checking of the schools this time requires special attention, since they have been constructed with reinforced concrete mediocre standards and is expected to require special attention to their control.

## The Bioclimatic schools in Greece

The first bioclimatic data in schools in Greece have begun to apply since 1930, with main element the orientation of buildings, although the concept of bioclimatic was not yet known.
Later, in the 1960s-70s and after the establishment of the Agency school buildings in 1963, other items were also used and special importance in orientation, the lighting and ventilation of premises was given.

The first cooperation in scientific level in Greece is that which is done by the K.A.P.E. in collaboration with O.S.K., within the framework of the program SAVE of the 17th the Directorate-General of the Commission of the European Union, which began in 1993 and was completed in 1995, with the release of extremely useful guide for "thermal visual comfort and energy savings in public schools".

The first bioclimatic school in our country (table 6[16] -organization of school buildings) started to be manufactured in October 2004 and ended in June 2005. This is a Kindergarten in Old Faliro, which implemented the following Bioclimatic actions (Centre for renewable energy sources, 2003):

- Utilization of the orientation of the building.
- The natural ventilation and cooling of the building.

- Optimal utilization of natural lighting.
- Installation of photovoltaic systems to cover part of the solar energy needs.
- Application of double improved panes, which lead to energy savings in comparison with the "ordinary" double during the heating season.
- Sun protection system with fixed positioning sunshades (external), which led to improved thermal comfort conditions (reducing the internal temperature of adjacent zones).
- Properties of roof mounting in that part of the building.
- Annexation special solar space (Conservatory) in n-W side of the building.

Table 6. Bioclimatic School Of Old Faliro

Since 2004 in the field of Greek schools the bioclimatic Measures occupy a key priority and targeting. The Organization of school buildings, in cooperation with many universities and special distinguished scientists, develop pilot projects (in theory and application) and progresses to full implementation of positive results, where these have positive results.

Nowadays more than 150 schools have been constructed with Greek bioclimatic applications.

**Towards schools with almost zero energy consumption**

The school buildings are in the whole world the greatest alike category public buildings. So obvious is their choice for energy upgrade priority. EU policy encourages its Member States to implement and if possible surpass the target of 3% for annual energy retrofit public buildings.

The Mediterranean countries are focused as pioneers of this effort. Four Mediterranean countries, Italy, Greece, Spain and France have 87,000 schools and for this reason a large European project ZEMEDS [Promoting renovation of schools in a Mediterranean climate up to nearly zero energy buildings [(17)], with the participation of nine players from the four countries is underway. Greece admitted the national and Kapodistrian University of Athens with the Physics Department and the municipality of Peristeri. Two main objectives that the program focuses on are

1. Developing know-how to upgrade its Mediterranean schools
2. Ensure public sector resources for the implementation of the energy upgrade of their schools.

As to the first axis briefly we can mention the following key actions.

- Strong thermal insulation of shell
- Modernization and insulation of the heating system
- Economic lighting equipment
- External shading
- Small interventions in the shell for embedding passive heating-cooling systems

- Development environment green exterior
- Use small RES

As for the second axis we can extract the following.

- Creation of small flexible units of study and implementation of the project
- Securing financial sources [European programmes, national resources, public-private partnerships, sponsorships, equal resources]
- Promotion of the economic and environmental benefits for the local community

**Conclusions**

At a crucial period for humanity, where it is crucial whether the climate changes will get uncontrollable dimensions or not, at the risk of triggering a possible warming of our planet at 40 C, resulting in the rise of sea level by 1 meter, all environmental factors should be focused on reducing greenhouse gas emissions through reduction of energy consumption.

The building sector is a key pillar in this endeavour. The construction of buildings with zero energy consumption by 2020 and the gradual conversion of old buildings into buildings with almost zero consumption is an action of great environmental importance.

Absolute priority should be given to schools and other public buildings, for which the EU provides by 2014 at 3% a year upgrading them according to the new energy framework. Of course, the construction cost of a building energy consumption to zero is increased by 10%, when there's grant, compared to a conventional building, or by 20% without a grant, but the end is achieved in 7 years.

Of great importance is to guarantee all those parameters which are necessary for the implementation of the programme. Key factors can be considered the followings:

- Developing the necessary know-how.
- Update operators and users.
- Establish an adequate financial support programs
- Update users and society for economic and environmental benefits.
- Priority in public buildings starting from school units.

It is clear, that this great effort that has just started can and should contribute significantly to halting the worsening climate change and extreme climatic phenomena that this entails.

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