ISSN 2385-1031 [Testo stampato]
ISSN 2385-0671 [Online]

Housing Policies and Urban Economics

HoPUE

Vol. 2 N. 1 Maggio 2015

Editore: *Fondazione Panta Rei Alta Scuola di Scienza e Formazione*

Periodicità: semestrale

Stampato in maggio 2015 in Pescara

Autorizzazione n. 16 del 17/12/2013 del Tribunale di Pescara
ISSN: 2385-1031 (testo stampato)
ISSN: 2385-0671 (online)

FONDAZIONE
PANTA REI

Casa Editrice Telematica Multiversum

Housing Policies and Urban Economics – Vol. 2, n. 1 / 2015

ISSN: 2385-1031 (print)
ISSN: 2385-0671 (online)

***Invited paper**

Housing Policies and Urban Economics Vol. 2, No 1, (2015), pp. 49 - 64

An integrated process for buildings revitalization: the Teenergy Schools Project experience

Antonella Trombadore[1]

Sunto: Il coinvolgimento di diversi partner territoriali e scientifici presenti nell'area mediterranea, risulta essenziale per l'elaborazione di un approccio integrato interdisciplinare teso alla riqualificazione del patrimonio edilizio esistente. In particolare, TEENERGY Schools ha puntato al miglioramento dell'efficienza energetica delle scuole delineando buone pratiche, all'adozione di una strategia comune transnazionale a livello MED, un decalogo, benchmark e linee guida progettuali per colmare il divario esistente con le altre aree europee.

Parole Chiave: approccio integrato, riqualificazione energetica, efficienza energetica negli edifici, pianificazione strategica.

Abstract: The involvement of different Mediterranean territorial partners together with scientific institutions from different geographical areas has proved to be essential for the development of a multidisciplinary integrated approach for climate appropriate retrofitting scenarios in public school buildings retrofitting action. TEENERGY project aims to improve the energy efficiency process, demonstrating best practice, benchmark, common transnational strategy, closing the existing gap with other European areas.

Keyword: integrated approach, retrofitting energy action, building energy efficiency, action plan.

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1. The framework of an integrated process

The energy efficiency retrofitting action in the schools has to be set in the framework of a revitalization and regeneration process, as an intervention on both the physical environment and on the students it hosts, and the series of cultural, social and economic activities that define the 'social environment', with the main objective of improving the living/comfort conditions as well as the quality of the 'built' environment and at the same time guaranteeing its coherent adaptation to the needs of contemporary life.

The Mediterranean climate presents specific characteristics compared with Centre and North European countries; one of the most evident differences is that in North and Centre Europe heating represents the principle cause of energy consumption in public buildings while in the Med area, cooling represents the main cause.

The TEENERGY SCHOOLS project, financed by MED Programme for transnational programme of European territorial cooperation, has successfully implemented a Multi-Issues Platform as an interactive Network for the gathering of a common data base and the dissemination of best practices regarding energy efficient retrofitting and new building of secondary schools in the Mediterranean climate context http://teenergy.commpla.com.

The Project has operated from 2009 to 2011 in four countries of the Mediterranean (Italy, Spain, Cyprus and Greece) and has pointed out the lack of energy saving benchmarks targeted to south Europe climatic conditions and the low energy efficiency of existing school buildings taking into account not only heating but also cooling needs.

Based on the experimentation of energy saving techniques, integration of innovative materials and renewable energies, including passive cooling for reducing costs and consumption in the school buildings, a common Action Plan, Guidelines and 12 Pilot Projects have been developed in close collaboration between all territorial and scientific partners, the pupils of the schools throughout direct participation and the involvement of post graduate students during three international Workshops and a one week CAMPUS session.

Teenergy Schools strategy starts from these considerations and has been elaborated by Province of Lucca, with the support of 7 partners operating tin 4 MED countries.

The involvement of different Mediterranean territorial partners together with scientific institutions characterized as Province of Lucca by different geographical areas has proved to be essential for the development of a specific approach for climate appropriate retrofitting scenarios in public school buildings and particularly for:

- improving the energy efficiency in secondary existing schools buildings and demonstrate best practice benchmark for the new construction;
- adopting a common transnational Strategy at a MED level;
- closing the existing gap with other European areas.

The objectives of the TEENERGY Schools approach are to order and systematize the stages of the common process (from political will to carrying out and evaluation of the action), identify the tools and instruments to be used (technical, administrative and legal) for optimum management and development, and define the common criteria that will allow reflection on the problems and the strategies to be established in order to guarantee the success of the process.

The TEENERGY Schools projects focuses on all the actors (decision makers and technicians) involved in the design schools process and energy retrofitting actions, but particularly on the public authorities - who must set themselves up as promoters of the process - and the experts commissioned with coordinating and managing its application, aiming to contribute to the construction of an optimum framework and choice the Best Path for the rehabilitation of the existing buildings or plan and design the new ones, as well as to define the overall guidelines for action that are coherent with the specificities of each place in Mediterranean contest.

The TEENERGY project helps to improve the process, creating an ideal common framework and international network of reference that also accepts that its application will depend on the reality of each country, subject to very different, socio-cultural, political normative and technical conditioning factors.

The method can be developed partially or with differing intensities in each of its stages, but the starting point is always the need for an overall understanding of the process and the acceptance of its principles

2. Five Phases of the project

The approach of the TEENERGY Schools project is to formulate a response to the growing, trans-national demand of updating the policies and the methodologies for improving energy efficiency in school buildings in the Mediterranean Area. The aim is to close the existing gap with other European areas by focusing directly on appropriate, climate-specific criteria.

The TEENERGY approach is divided into five phases of action, according to which we can identify eight key stages or moments in the process.

	Focus	Phase	Action
1	**Political backing**	*Quality indicators of the project*	*(1.1)Definition of Quality indicators of the interventions and the performances to be reached for the Pilot Projects*
2	**Diagnosis**	*Collection of data and mapping*	*(2.1)Energy Audit* *(2.2)End user satisfaction questionnaire (qualitative)* *(2.3)Mapping of results and benchmarking)*
3	**Strategy**	*Action and evaluation methodology*	*(3.1)Action Plan* *(3.2)Target scenarios* *(3.3)Best Path*
4	**Action**	*Pilot project*	*(4.1) Concept design and architectural solution* *(4.2) Pilot project for retrofitting action and/or new building*
5	**Communication**	*Communication set and evaluation programme*	*(5.1) Communication for decision makers and end user involvement* *(5.2) Project phases and results monitoring*

Tab 1 Five Phases of the project and related actions

Focus 1 - Political backing

The process begins with the political will to act, which includes the making of the preliminary decisions required to appropriately organize and manage the rehabilitation of the existing buildings process (or plan and design the new ones): selection of building, decisions as to the nature of the actions to be carried out and the definition of the framework of governability that is, the organization of the intervention of the various agents involved in rehabilitation, and the participation of students.

Phase (1) *: Quality indicators of the project*

Action (1.1)*Definition of Quality indicators of the interventions and the performances to be reached for the Pilot Projects*:

- Energy efficiency for heating and cooling
- Efficient natural and artificial lighting
- High standard of natural ventilation in classrooms guaranteeing low CO_2 rate during the lessons
- Use of sustainable building material based on critical LCA analysis
- Bioclimatic Strategies for architectural quality and energetic efficiency in all seasons
- Correct Use and management of renewable resources: use of appropriate, cost-effective and energy-efficient technology
- Good acoustic quality inside the building
- High Outdoor Environmental Quality (microclimate)
- Good visibility and media communication to guarantee widespreading of results
- Didactical aspect of the intervention as added value of retrofitting / new construction

Focus 2 - Diagnosis

Before deciding on a strategy of intervention, it is necessary to recognize the existing conditions and establish the integrated analysis of the building, with a programme of multilevel approach.

The analysis is used as the basis for the integrated diagnosis quantitative as well as qualitative: an energy audit report on the current state of the building agreed by end users satisfaction questionnaire as social consensus with a detailed breakdown of its potentials and dysfunctions. The assessment of the energy performance of the building throughout data collection including bills, measurements and simulations.

Phase (2) *: Collection of data*

Action (2.1) *Energy Audit (quantitative analysis and evaluation)*

- Analysis of the functionality of the building
- Evaluation of the Security normative and issues related to maintenance
- Structural characteristics
- Sanitary equipment
- First definition of comfort quality

Action (2.2) *End user satisfaction questionnaire (qualitative)*

Analysis of the feedback of pupils and teachers thoughout a specific questionnaire in order to define the psico-physical aspects regarding the actual perception of indoor comfort.

Action (2.3) *Mapping of results and benchmarking*

- Benchmarking of the context
- Cost effectiveness evaluation

Focus 3 – Strategy

On the basis of the critical points of the field of action identified in the integrated diagnosis, and by means of strategic reflection that takes into consideration a series of strategic and sustainability-related issues, a series of hypotheses of action will be defined to evaluate its viability.

Once these feasible target scenario has been decided on, all actions to be carried out will be listed in order to define their strategic implementation.

Consequently a Best Path is outlined following the experiences made in the field of school building refurbishment of Prof. Mattheos Santamouris of NKUA/IASA, Prof Marco SALA of ABITA and Prof Despina Serghides of CUT.

It is designed to support the planning activities of decision makers in solving different problems using a multicriteria analysis, as a set of common evaluation criteria for Teenergy Schools. It will define a rating and weighting mechanism of all considered aspects.

The result shall be agreed on by scientific evaluation, social consensus and approved by the politicians; it will then, together with the proposed project solution and policies, implement the appropriate working instruments to undertake them.

Phase 3. *Action and evaluation methodology*

Action (3.1) *Action Plan*
Action (3.2) *Target scenarios*
Action (3.1) *Best Path*

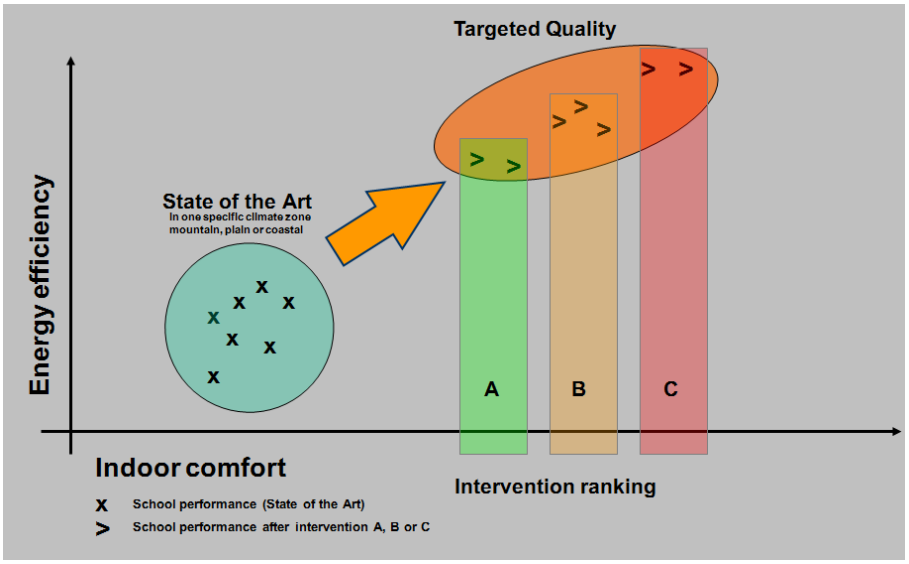

Fig1 Teenergy Schools Protocol – Quality Level of Retrofitting

Focus 4 – Action

This phase includes carrying out the actions foreseen in the action plan as specific projects scenarios for buildings, and complementary measures of a social, economic or environmental nature. TEENEGY Guide for High energy efficient schools in the Mediterranean will be applied.

Phase 4. *Pilot Project*

Action (4.1) *Concept design and architectural solution*
Action (4.2) *Pilot project for retrofitting action and/or new building design*

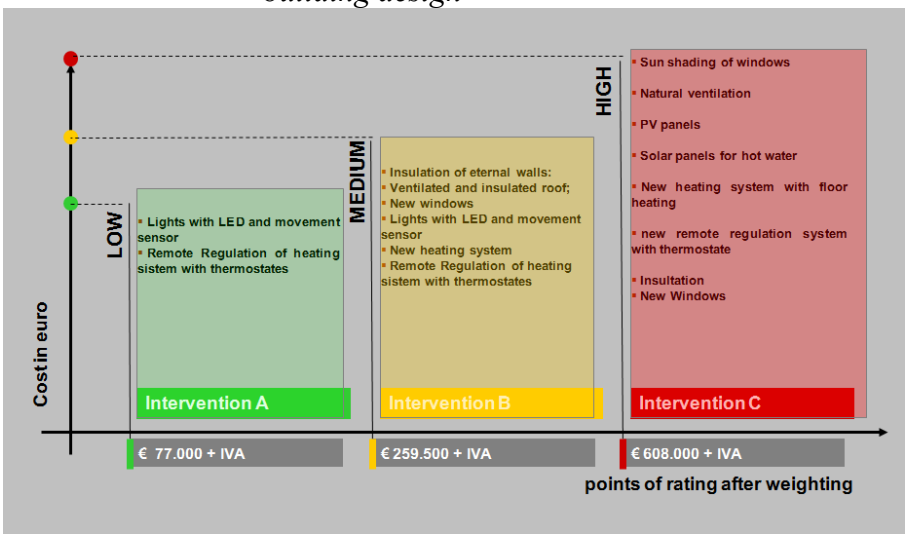

Fig2 Cost effectiveness examples of the three interventions

Focus 5 – Communication and Monitoring

The communication and promotion is mainly developed throughout the ICT Platform and media presence, itinerant exposition of the Pilot Projects as a result of the TEENERGY Schools Guidelines for Policy making.

The phase of continual evaluation of the actions will begin while they are carried out but will also continue once they are completed. It has to monitor the degree of compliance with the objectives established in the beginning. In the event of evidence that the actions do not produce the desired results or that the conditions of evolution are not as originally expected, it will be necessary to return to the strategic reflection phase or even, if the conditions of the building are seen to have evolved, to the diagnosis phase.

Phase 5 *Communication set and evaluation programme*

Action (5.1) *Communication for decision makers and end user involvement*

Action (5.2) *Project phases and results monitoring*

3. Teenergy Schools Decalogue for the Mediterranean Area

The added value of TEENERGY Schools lays within its implementation of the process and the constant exchange of the common results - from the definition of the quality indicators to the elaboration of an adequate Energy Audit for the Partnership, the evaluation of the data mapping and benchmarking towards the elaboration of 12 innovative Pilot Projects. In fact, the project aims at providing the local administrators with useful decision support instrument to suggest a Best Path to follow in the retrofitting action and revitalization of existing school building, or what design criteria should be considered when a new school building is to be planned, targeting low energy consumption approach and sustainability awareness.

There is a need for effective tools helping to decide by combining scientific, normative and quantitative aspects such as energy efficiency, with human perception and subjective, qualitative aspects such as indoor comfort and psycho-physical wellness as already mentioned. Above all, the Mediterranean context represents the reference point for a new interpretation of a climate-adapted standard for sustainable building.

TEENERGY Schools has developed a Decalogue to meet the needs for the providing a common Method of decisional support involving stakeholders to fulfill the challenge of improving the school environment of education for the next generation of pupils, by starting today. theTEENERGY Schools Decalogue aims at giving the basic indications for the implementation of existing schools retrofitting action a process. It is targeted toall the actors, but particularly to the public authorities—who must set themselves up as promoters of the process—and the scientific experts in charge with the coordination and the management of its application.

The Decalogue aims to illustrate the Best Path towards an appropriate energy efficient retrofitting of school buildings, going beyond the usual isolated interventions and taking into account new aspects such as bio-climatic technologies: solar architecture, passive cooling, intelligent windows for natural ventilation, cool or green roofs and the use of materials from natural local resources with positive LCA evaluation, energy efficient facades including sun shading.

Step 1 Setting the targets

Definition of the Quality objectives to be reached in the retrofitting of existing schools and for the construction of new school buildings aiming at energetic efficiency and good indoor climate in all seasons

- High Energy efficiency for heating and cooling
- Efficient natural and artificial lighting
- high standard of natural ventilation in classrooms guaranteeing low CO_2 rate during the lessons ensuring good studyconditions
- Use of sustainable building material based on critical LCA analysis
- Bioclimatic Strategies for energetic efficiency and good indoor climate in all seasons using Passive cooling (Ground cooling/Night cooling) Sun shading and Natural Ventilation systems against Summer overheating
- correct Use and management of renewable resources: use of appropriate, cost- and energy-efficient technology

- Acoustic quality inside the building for good audio comfort in the classrooms
- highoutdoor Environmental Quality (outside microclimate)
- Good visibility and media communication to guarantee wide spreading of results
- Didactical aspect of the intervention as added value of retrofitting / new construction for the active involvement of pupils(change of mindset/behavior)

Step 2 Energy Audit

Checking the State of Art of the building and the energy performance of the envelope and energy consumption on HVAC (heating, Ventilation and Air conditioning) systems throughout data collection including bills, measurements and software simulations:

- energetic behavior of the building taking into account the real consumption, the simulations (expressed in $kWh/y/m^3$)
- thermographicanaylis for the detection of heat losses for efficient problem solving
- Analysis of the functionality, occupancy ($pupils/m^2$), use and costs for the running of the building (euro/pupil/ year)
- Evaluation of the Security norms
- Evaluation of Level of maintenance
- Structural characteristics, anti-seismic aspects
- Sanitaryequipment

Step 3 End user feed back questionnaire

Involvement of the students and end user to improve their awareness

- Evaluation of indoor quality Analysis of the feedback of pupils and teachers throughout a specific (anonymous) Questionnaire in order to define the psycho-physical aspects regarding the actual perception of indoor comfort by the end users
- Comparison between assessed performances of the e school building, the monitored use and occupancy and the satisfaction of the end users of the building in order to obtain a critical view of the actual situation.

Step 4 Mapping and Evaluation

Analysis and mapping the results with the support of adequate tool for the homogenization of the data at an appropriated decision scale (Municipality context, Provincial/Regional/National/ International) and Analysis and graphical visualization of the collected datafrom the Energy Audit, the End User feedback Interpretation and graphical visualization of the collected data from the Energy Audit and the End User feedback

- Evaluation of the gap between State of Art and target,
- Analysis of the critical point where the data of energy performances of the school buildings are below the average
- Mapping and Positioning of the results in a larger context (regional, national, European) taking into account specific 3 climatic sub areas: coast, mountain and plain.

Step 5 Benchmarking in the context

Comparison of the monitored school buildings to obtain a performance- ranking for the definition of preferences: which school building need to be refurbished first

- Analysis throughout multi issue criteria: what are the main criteria?
- Definition of thresholds of energy performance, indoor quality level, available budget
- Definition of acceptablelimits
- the three main factors harmonizing with technical aspects factor will be given a critical weighting in order to elaborate a ranking of the interventions.

Step 6 BEST PATH Methodology

The Best Path Methodology aims at defining the most adapted solution in terms of economical technical and human aspects following the elaborated quality criteria as indicated above. on administrative and political level a critical weighting of the importance of each of the following four main objective must be considered:

a) *energy efficiency*
b) *indoor comfort*
c) *quality of communication of the project,*
d) *technical aspects (for instance obligatory issues such as anti-seismic norms, fire- security, sanitary aspects)*

Obviously each refurbishment or new construction of a school has an important communication value for the local administration, therefore the quality of the communication has to be considered an important issue. Building Sustainable Schools in the Mediterranean Area with bioclimatic principles in an energy efficient, socially and politically participated approach has a high value in terms of innovation. Each one of these aspects will have a weight expressed in % following the strategic decisions of each single administration.

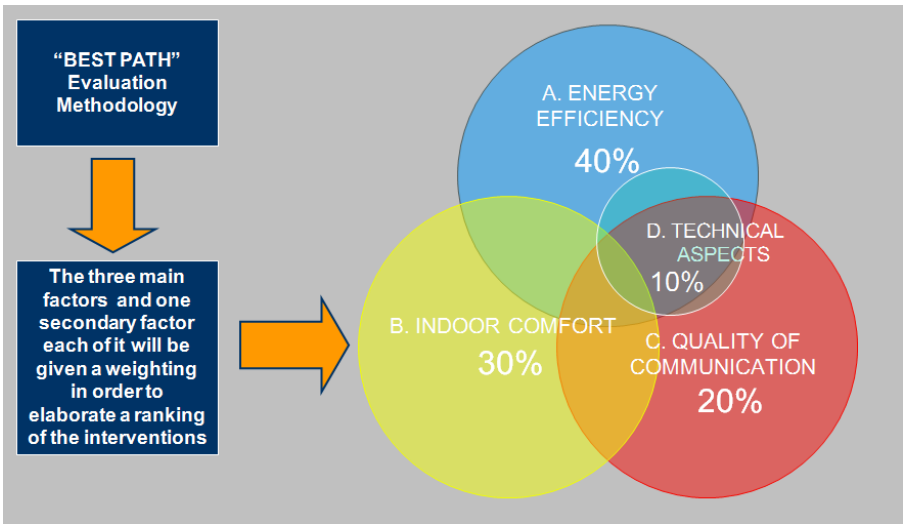

Fig3 Teenergy Schools Protocol - Best Path evaluation

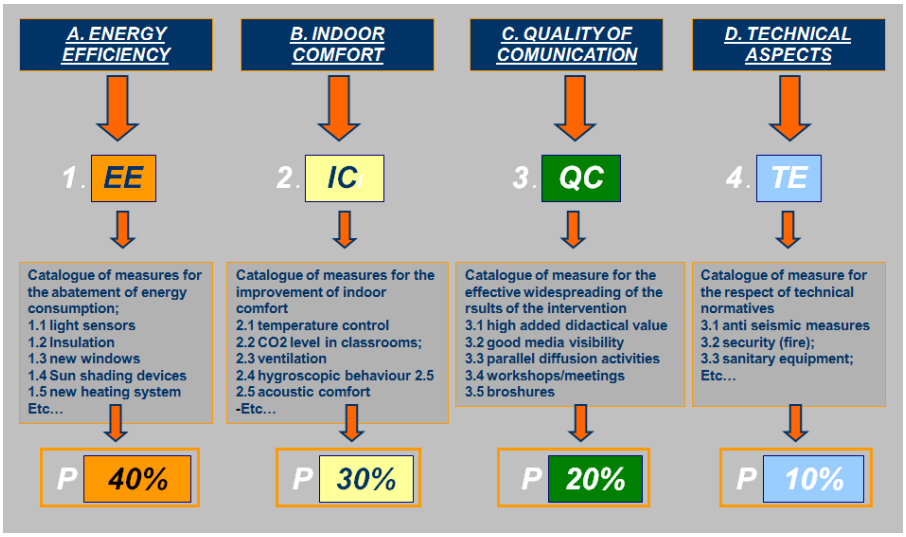

Fig4Teenergy Schools Protocol - Evaluation Criteria and Weighting

Step 7 **Interdisciplinary involvement in Planning Process**

Involving all the stakeholders of the school environment: pupils, parents and teachers, driven by the initiative of the administrational responsible engaged in a transparent, participatory round table with the help of qualified technicians: the project bases for new schools or the refurbishment strategies for existing schools has to be elaborated in an interactive and interdisciplinary process involving all parts, taking into account the above mentioned ranking of priorities following the Best Path integrating previous analysis such as Energy Audit and the End User Satisfaction.

Step 8 **Concept Design Implementation of Architectural Solutions /Retrofitting strategies**

The concept Design Solutions will be based on sustainable, energy efficient building technologies taking into account bio-climatical aspects in order to respond adequately in each single micro-climate area:

- high Indoor comfort is targeted by improving thermal, acoustic and visual comfort in the classrooms
- at least three scenarios with low medium and high outputs proportioned to the dedicated investment will be elaborated

Step 9 **Cost benefit evaluation**

Critical choice of the most suitable solution in terms of energy efficiency, satisfaction of the end users, economic context and communicational aspects for the local administrators political targets.

Step 10 **Diffusion and Communication of the results**

Constant monitoring of the feedback within the participated process:

- Promotion of the results within the context of a Pilot Project that has a didactical vocation
- Networking of similar experiences in order to promote wide speading of the initiatives and guarantee efficient research results in collaboration with scientific institutions and exponents of the building industry.

4. Concept Design Guidelines

A project for sustainable new school building or the retrofitting of schools in the Mediterranean Area must consider, as key element, the necessity of combining the research for a cost-effective insulation for the improvement of heating in the Winter period, with the Mediterranean climate –specific necessity of ensuring, during the Summer period passive cooling and a high ventilation rate to guarantee good indoor conditions. In fact, Secondary High schools are run until the end of June when temperatures have already risen substantially. Mediterranean buildings are traditionally built on a simple thermal mass concept, which helps to reduce the great temperature differences during day/night in the Summer time. Reintroduce thermal mass in the modern school building is to be reconsidered as a simple, but very effective, non energy intensive method to ensure comfort.

The experience of Teenergy Schools after having developed a Common Implementation Methodology, what pragmatic technical prescriptions can be given regarding energy efficiency in the

Mediterranean school context? In the following pages a short Guidelines are presented to implement the Decalogue approach as a pragmatic technical indications to allow higher energy efficiency in the Mediterranean schools buildings.

Analyzing the appropriated Architectural Solution elaborated during the Concept Design of the 12 innovative Pilot Projects we should take advice about developing an energy strategy, designing and specifying the fabric, services and controls systems, as tangible results and feasible propositions developed with the Partnerships local administrators.

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