Energy Performance Development of Non-regulated Retrofit Mass Housing Estates in Northern Cyprus

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Abstract: This research project was undertaken in the Turkish Republic of Northern Cyprus (T.R.N.C). The objective of the research is to investigate the occupants' behaviour and role in the refurbishment activity; to explore how and why occupants decide to change building components and to understand why and how occupants consider using energy-efficient materials. The study is conducted through semi-structured interviews to identify occupants' behaviour as it is associated with refurbishment activity. This research paper presents the results of semi-structured interviews with 70 homeowners in a selected group of 16 housing estates in four different regions of the T.R.N.C. The expected solutions should be effective, environmentally acceptable and feasible given the type of housing projects under review, with due regard for their location, the climatic conditions within which they were undertaken, the socio-economic standing of the house owners and their attitudes, local resources and legislative constraints. Furthermore, the study goes on to insist on the practical and long-term economic benefits of refurbishment under the proper conditions and why this should be fully understood by the householders.

Keywords: Construction Process, Energy-Efficiency, Housing, Refurbishment Activity, Retrofit Strategies.

1. Introduction

This research project was undertaken in the Turkish Republic of Northern Cyprus (T.R.N.C). In the T.R.N.C, most current house owners are not aware of the benefits that changing their building components taking into consideration building or planning regulations can generate in terms of improving the energy performance of buildings. However, they do not seem to be understand the cost-benefits of energy efficiency, as usually the refurbishment action focuses mainly on the improving the quality of living conditions including the over-use of air conditioning units during summer time.

At the same time, a change in vision in the construction process after major political event in the region 'The Annan Plan phenomenon' meant a shift from focusing on construction activity and its impacts on the environment. For this reason, refurbishment action by way of intervention on the physical quality of buildings and how they relate to energy, is essential. Naturally, these energy efficient implementations are to be considered jointly as they produce benefits in terms of improving indoor comfort standards and the quality of life itself. Consequently, even if all these actions for reducing energy consumption in the housing sector are full understood the greatest priority is to establish and implement effective and feasible adaptation solutions.

Starting from 2003, all the construction activity has been increasingly oriented towards the identification of those key elements that grew from the influence brought to bear by the expectations of the Annan Plan, which saw a rapid increase in demand within the property market and the creation of major environmental problems (Yorucu and Keles, 2007. In the T.R.N.C., the most crucial factor when looking at the housing sector is that it is dominated by privately owned construction companies (see fig.1). This means that during the decision making process, the companies targets can be included in plans to introduce the implementation of energy-efficient technologies. Another important fact is the role of the house owners' requirements in the design process and how these may impact the construction process. So the great challenge is to create collaborative mechanisms whereby both the privately owned construction companies and the house owners may contribute and co-ordinate efforts in solving the energy problem.

Figure 1. Invasive and destructive en mass housing development of the untouched natural habitat by privately owned construction companies in the T.R.N.C.

Nowadays, the role of privately owned construction companies and their targets in the field of building housing estates in both urban and suburban areas, have changed because of current economic conditions, the increasing demand on properties and also because the geopolitical context within which building is taking place has undergone important changes. Climate change too has altered the situation in which the building industry finds itself. Based on the pseudo-effect of major political event that of the 'Annan Plan' has had on these matters, the construction process and its impact on the environment are outlined and the high demand on construction activity is assumed as the preferential area of interest. Considering that the recently-built housing stock in the T.R.N.C. does not meet acceptable energy efficiency standards in terms of its predominance in high amount percentage out of the whole residential sector.

So, in order to obtain reliable and effective results in terms of energy efficient improvements, it is important that the interventions are articulated by occupants in the housing sector, as they represent now the common problems of the new-built housing stock. In this research context, the selected housing projects are composed of heterogeneous buildings with different typologies and dimensions, and consequently with different built purposes applied. The State Planning Organisation-T.R.N.C. (Devlet Planlama Orgutu-K.K.T.C. in Turkish) (2008) statistics show that the largest part (64%) of the housing stock was built by privately owned construction companies between 2003 and 2008. This means that households rely on buying properties from privately owned construction companies. However, it is important to note that the new-built housing stock is totally inadequate in terms of meeting current European Union level standards in regard to reducing over-heating risk of buildings, energy efficiency and the quality of indoor comfort temperatures.

Despite a lack of a database to record interventions and non-undertaken related polices, it is considered a challenge to reach the goals of reducing the negative effects of the construction activity and bringing in refurbishment activities under the same control mechanisms. The most interesting aspect concerning the adoption of retrofit packages is to be able to identify which effective strategy has been best suited to counteract common problems and how successfully they have been implemented in the housing sector. Therefore, this study focuses on the identification and analysis of the refurbishment activities as they are articulated by occupants that have caused an increase in energy consumption.

The aim of this research will:

- (to) investigate the potential impacts and effects of refurbishment activities in terms of the implementation of energy-efficient materials and their practicality concerning the issue of energy reduction.
- (to) identify the initial energy performance diagnosis of the building.
- (to) address the problem of energy savings for cooling through the identification of know-how on cooling systems that are energy efficient (where possible to implement cost-effective retrofit packages)

2. Literature Review

The International Panel on Climate Change (IPCC) (2007) identifies the reduction of energy consumption and carbon-dioxide emissions from the housing sector has one of the highest benefit-cost levels, among many possible mitigation measures across different sectors. This is probably due to the fact that most housing projects in the construction sector have suffered from a non-use of energy efficient technologies both during the construction and design process, mainly derived from the current market conditions, in addition to having to face the challenge of ever rising refurbishment activities articulated by occupants in terms of quality, level of building performance and reduction in environmental impact while trying to achieve significant energy savings and realise buildings capable of adapting to climate change impact that rely on the implementation of retrofit strategies.

Kwok and Rajkovich (2010) suggest that both carbon-dioxide emission and climate change adaptation should be added to building energy codes and thermal comfort standards, through cost-effective integrated strategies. In the T.R.N.C. space cooling in summer time especially in August plays a major role in the determination and timing of peak electricity demand (see fig. 2). It is also to be noted that in recent times, global climate change warming trends are shifting the T.R.N.C'S mild Mediterranean climate to bringing in a significantly warmer climate conditions and a particularly

large impact on buildings' cooling energy usage is anticipated (IPCC-Report of Cyprus, 2012). What seems to be clear is that there is an urgent need for an understanding the major role that climate change has on building energy use because this information may help the construction activity to respond to concerns about the impact that changing climatic conditions has on construction activity and on energy consumption in the housing sector.
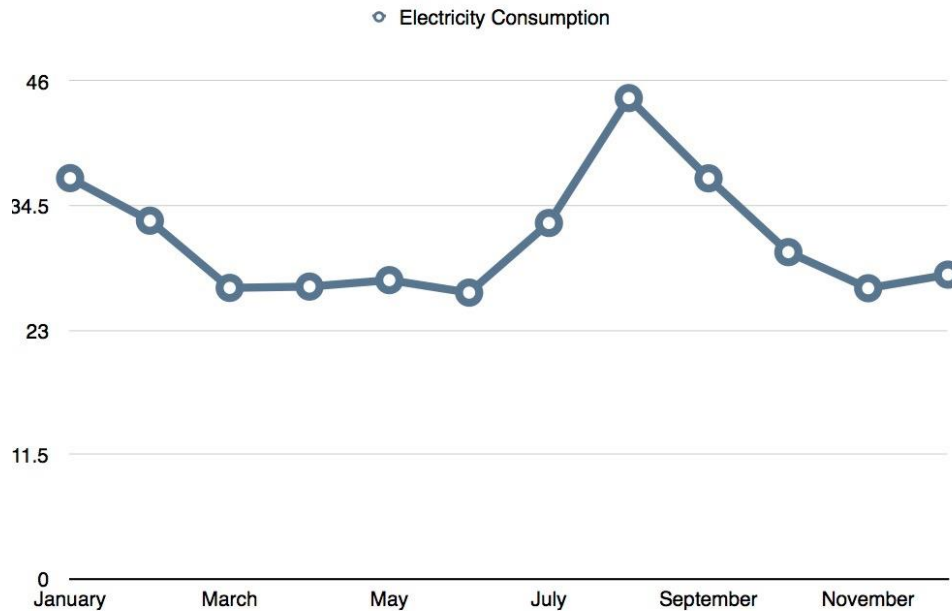

Figure 2. The electricity consumption by residential sector in 2014.

Meier and Rehdanz (2009) state that energy use by the housing sector is dependent on many variables such as climate, building forms, socio-economic factors, the efficiency of heating and cooling systems and occupant behaviours, all of which are part of the challenge to undertake this research. Steemers and Yun (2009) claim that implementation of energy efficient technologies through the construction process is a significant indicator determining the energy use within the housing sector, followed by occupant behaviour and the physical characteristics of the buildings within the planning of land use.

The adaptation of retrofit strategies in identifying necessary the scope to respond to growing energy demand by households is of the utmost importance. Janda (2009) explains that occupant behaviour in energy demand plays a key role. This fact is often stated that it households, rather than buildings that consume energy. Rittel and Webber (1973) argue that reducing the energy use of households and the reduction of the negative effects of construction activity in the housing sector is characterised by radically different implementations from occupants, continuously changing building components that are resilient to climate change and that will improve the living conditions of the occupants. However, within the confines of this research there are no variable policy scenarios and inadequate experience to deal with the problem because it cannot be completely identified by the governmental bodies.

As mentioned above, the level of awareness and understanding of refurbishment activity needs to be raised in the current construction process and in terms of the demand on property market conditions are concerned, in addition to the environmental impact and energy saving ones. Furthermore, Dineen and Gallachoir (2011) claim that the main opportunities for energy efficiency and carbon-

dioxide emission reduction come from the retrofitting of poorly-built housing stock. On the other hand, Bradley and Kohler (2007) and Balars et. al (2007) insist that there has been a shift in targeted actions from increasing the level of energy efficiency of recently-built housing projects to efficiency procedures that are applicable during the refurbishment process.

Mahdavi (2009) stresses that the implementation of energy efficient technologies increases the environmental socio-economic value. At the same time, Quartermaine (2009) claims that in the UK, the most effective refurbishment activities rely on payback periods after the completion of refurbishment process. It varies on shortest to longest payback turns of the building. These are achieved as follows; variable speed heating pumps, energy-efficient lighting, DC fan coil units, heat recovery systems, high-efficiency boilers. CABA (2008) reported that in most studies on refurbishment, it is observed that the greatest financial benefit comes from upgrading the fabric, such as improved insulation, glazing, airtightness or installation of central A/C units. The CABA Report (2008) also shows that these upgrading packages provide payback periods of 25 years after the completion of the project. It is commonly known that this financial return is normally beyond the targeted budget of building developers in the construction industry.

As a matter of fact, the main incentive for the adaptation of retrofit packages targeted today is represented by the cost benefits produced by a reduction in energy consumption costs, resulting from an implementation of energy efficiency technologies without taking into consideration of occupants' needs if this reduction is a result of an effective refurbishment activity on the physical characteristics of the building or from bringing control mechanisms to the housing sector. Table 1 and Table 2 describe work which show how energy efficient buildings can reduce capital and running costs, energy consumption, and carbon emission but at the same time can also increase indoor thermal comfort, rental value and occupancy satisfaction. Reflected on the terminology deployed by Hirigoyen and Newell (2009), it is evident that the construction phase of the building, factoring in the get financial return of the overall life cost of the building is part of the process. The running costs of the building is also included in the process (ibid). More evidence which supports this argument is that showing that energy efficient buildings reduce the overheating risk of buildings, decrease energy running costs and increase society's awareness of implementing effective adaptation packages during the refurbishment process. This becomes particularly clear if we summarise the potential benefits of the greater energy efficiency and the value of the built asset increases in various studies (Thompson and Jonas, 2008; Newell, 2009; Clements-Croome, 2004a).

Table 1. Typical examples of advantages of energy efficient buildings.

Typical examples of advantages of energy efficient buildings	
Economic	Reduction of 24% capital cost (Bowen, 2005) Return on Investment (ROI) OF 10 years (Kelly, 2008) Command more rent (Burr, 2008)
Efficient	Reduction of 36% in running costs (Bowen, 2005) Energy bills reduced by 20% (Johnson, 2007) Lighting control reductions of some 30-40% (Ratcliff, 2008) Identity and Access Management strategy paid for out of efficiency gains (Tizard and Mockford, 2008) Energy cost savings between 10% and 50% (Shapiro, 2009)

Effective	Small productivity gain (0.1-2.0%) large effect (Woods, 1989; Clements-Croome, 2000b, 2005)
	Reducing temperature - higher productivity - 1.8% for every 1Celcius (Niemela et al., 2001, 2002; Wargocki et al., 2006)
	Increase in quality of learning as a result of higher productivity (Everett, 2009; Bako Biro et al., 2007, 2008; Clements-Crome et al., 2008; Wargocki and Wyon, 2007)
	0.5% productivity increase pays back within 1.6 years (Wyon, 1996)
	17% improvement in productivity - RAE (McDougall et al., 2002)
	Increased rents by 2-6% (Eichholtz, Kok and Quigley, 2009)
	Occupancy rates 4.1% higher (Burr, 2008)
	Higher income growth over 10 years (Baue, 2006)
Efficacious	Sustainable environmental approach (Edwards, 2002)
	Carbon saving strategies (Carbon Trust, 2002)
	15% reduction in global carbon emissions (Thomas, 2009)
	Focusing on quality of learning (Everett, 2009)

Table 2. The views of all the interested parties in the traditional design and construction process need to be appreciated if mutual understanding is to be developed.

In this research context, 'culture' will certainly be an important element with specifically designed prototype retrofit scenario. This will enable the privately owned construction companies and house owners to take on the role of knowledge participants. This research concept will finally lead to assessing and generating new pathways of research and innovative design tools in the management of the mass housing renewal and urban development but at the same time involving the notion of a socio-cultural paradox. The aspect of this research is to understand how its best possible to integrate the application of energy efficiency technologies to the adaptability of the prototype retrofit scenario.

The views of all the interested parties in the traditional design and construction process need to be appreciated if mutual understanding is to be developed		
Practitioners	Viewpoints	Objectives
Users	Social	Usability; natural light, space and fresh air, with some degree of personal control of thermal conditions; amenities; improve the quality of living conditions
Clients	Economic	Reliability, quality; economic operating costs; after care
Designers (e.g. architect, engineer/consultant)	Technical	Overall quality and reliability
Developers/planners /surveyors	Business/economic	Conformance to requirements; costs
Contractors	Technical	Quality; profit; workmanship; delivery times
Project managers	Operational	Integration; facilitating resources; coordination; time constraints
Facilities managers	Operational	Operation and maintenance; POE; green issues
Financiers	Economic cost	Successful completion of project on time within budget

3. Methodology

3.1 Geography and Climatic Characteristics

Cyprus is the third largest island after Sicily and Sardinia. It is located in the Eastern Mediterranean part. Its closest neighbours are Turkey to the north and Lebanon, Syria, Israel, Egypt and Greece to the south and south-west. It sits on latitude 35 North and longitude 33 East. The island is divided in four different physical regions (see fig.3). According to the Cyprus Meteorological Service data (2013) the main geomorphological characteristics of the island are as follows: semi-mountainous climatic zone, coastal climatic zone, mountainous climatic zone and inland climatic zone.
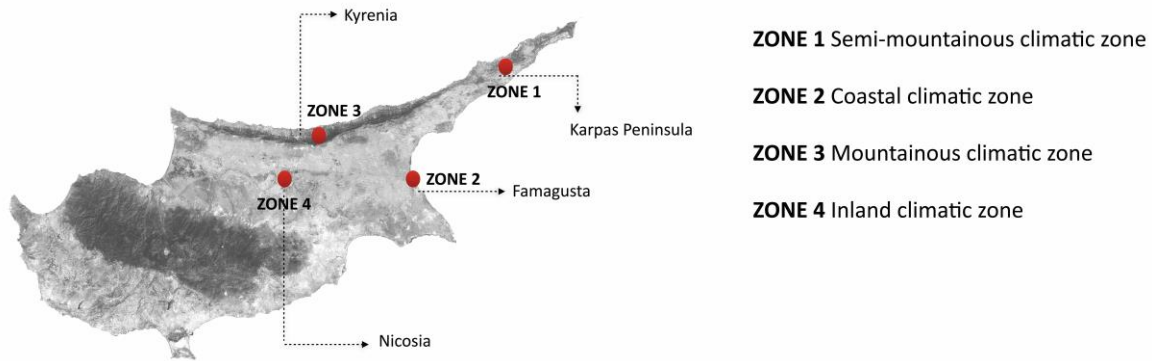
Figure 3. Map of selected case studies.

According to the Koppen climate classification, Cyprus has climate characteristics that are typical Mediterranean. The Koppen climate data shows that the overall climate of Cyprus is a Subtropical (Csa) type climate and partly Semi-Arid (Bsh) type climate in the north eastern part of the island (Kottek, 2006). That is to say, the climate characteristics of Cyprus' are the hot and dry during summertime.

The Cyprus Meteorological Service (2013) data indicates that generally, in July and August, the mean daily temperature rises by approximately 30 Celsius on the central plain. According to the same report, the mean daily temperature is recorded at 23 Celsius. It is also noted that the average maximum temperatures are between 37 Celsius and 28 Celsius respectively. It is important to say that these temperature levels are not so bad for summertime. It is, however, in July and August that there are a few days where temperatures can reach up to 45 Celsius inland and 40 Celsius on the coastline. Temperatures, in the mountainous regions are much cooler than other regions during summertime.

Temperatures in winter in Cyprus are 3 and 10 Celsius on the central plain and 0 and 5 Celsius on the higher parts of mountainous regions. Naturally enough, temperatures on lower ground and the coastline are significantly lower, ranging between 8 and 12.5 Celsius. In general, and using the available data, Cyprus has got the relatively mild winter conditions. However, there are occasions during the winter period when temperatures may drop below zero Celsius especially at higher altitudes in the mountains regions and sometimes inland. Very low temperatures are unusual near the coast where they tend to go no further down the temperature scale that 2 to 3 degrees Celsius, even on the coldest of winter nights.

3.2 Local construction techniques and materials

The vernacular houses of Cyprus resemble those in the rest of Mediterranean islands: solid volumes, thick masonry walls with small openings, the whitewashed plaster skin covering almost everything with an integrative power, the creation of composition through continuous repetition of the traditional building layout. All these elements have produced organic building forms, evolving through a long response to the climatic conditions using the locally available resources. In this research context, nature is taken a decisive role of that architectural idiom, imposing its whims on the local builders, i.e. the dwellers themselves in most cases. Climate, earthquakes, scarcity of materials and topography had been the primary design parameters, and were respected with admirable integrity to the built environment. Furthermore, the main building materials are hard limestone rock and sand stone ('yellow stone' as they are known in the Cypriot dialect), used with or without mortar and covered with plaster that protects joints from the decay caused by wind and rain.

A more elaborate and permanent form of vernacular architecture, found in four different regions, was the arcaded rectangular house. This is the simplest type of flat-roofed dwelling typology across the island. The windows of the rectangular house were defined by the masonry walls, 50-100cm thick, which includes carved niches and storage areas, and were limited in number and size according to the climatic characteristics of the region. Lintels were local 'yellow stone' blocks or wooden elements. It is also worth mentioning that no protrusions were evident, and smaller openings located above these windows (below the roof) served as ventilators (closed during winter). At the same time, overhangs were later introduced as shading devices and to keep rainwater away from walls and windows. For this reason, the thick sometimes, tapered walls were carefully designed to shade the opening in summer but not block sunlight in winter. To avoid excessive sun light luminosity through the indoor living spaces, the wooden shutters was also used as a shading device. The orientation of these windows followed the contextual features since site integration and minimum excavation ruled the positioning and form of the house.

3.3 Current construction practice

The T.R.N.C needed a labour force to complete their rapid construction projects. During the 'property boom' period, the skills and construction materials were supplied from mainland Turkey. The influx of labour from Turkey to work on on-going construction projects meant that incoming workers were ready to work on a temporary or extended basis at the prevailing wage rates and fill in the labour demand in the T.R.N.C. However, these labourers were unskilled as workers in the construction industry. The result was that the houses built were of a very inferior standard.

The rapid process of construction in many cases led to low occupancy and utilisation owing to the scarcity or inadequacy of complementary infrastructural features to support project sites. In many cases, for example, there were massive shortcomings in electricity, water supplies, sewers and local government services. These problems were arisen from the design continued to the construction process itself. At a very basic level, this explosion in housing demand was not matched within the construction industry for using passive solar design systems to reduce energy use of buildings. The end result of this rapid growth and the use of unskilled labour force led to inefficiency, poor quality in workmanship, low productivity and a reckless neglect of any building regulations.

3.4 Research Design

This study focuses on selected en-mass housing projects by privately owned construction companies in four regions (coastal, inland, semi-mountainous and mountainous climatic zones) of the T.R.N.C. It examines the design and construction process of the housing estates and looks at interventions, which have been carried out by occupants after the completion of the projects. The study uses 'the bottom-up' method to elucidate the energy performance of the selected buildings. This is done by using a repetitive transverse survey to examine the entire housing sector. This approach combines regular site visits to the same households for two seasons (summer and winter) for a report on the environmental impact of the built environment over a period of one year in different climatic locations and in different locations.

With such a case study approach, this research aims to provide an adaptation of retrofit packages that can be applied during the refurbishment process in general in most regions in the T.R.N.C. For this purpose, this study combines data collection and the identification of refurbishment activities on 16 selected case studies from four different en-mass housing estates locations. The proposed methodology consists of working with privately owned construction companies and their projects with the support of the local contractors, stakeholders, non-governmental organisations and house

owners, in engaging with the design and construction process, conducting interviews, taking inventory, making diagnoses and putting in place a post occupancy evaluation.

The analysis of field data has come from the identification of privately owned construction companies' projects, their policies, their targets and the problems they encountered in both the design and construction process. This goes some way in providing information on the current condition of the development of en-mass housing projects in a particular centre or region.

For this purpose, 15 small and medium size architectural companies are identified in terms of their willingness to participate in the research process. These companies are key players, which have responded to the growing demand in the property market. Their structures and target groups show variations within the location of the construction company and its projects. It is also noted that the construction practice of the companies plays a significant role. The reason is that all medium size companies started to play an active role the pre-1974 construction sector while there was an increase in the number of small scale firms beginning in the early 2000s. However, a common factor applying to all these companies is the change in construction vision as a consequence of the Annan Plan. For the first time they began to look to the construction of en-mass housing estates as a new practice in the industry. At the same time, the interviews were conducted with the privately-owned construction company owners, contractors and stakeholders. It is essential to the study to discover how to what degree these target groups would be willing to implement the retrofit strategies in the future.

Within this general framework, this research looks into the 'retrofit strategies' through a set of questionnaires given to construction companies, house owners and stakeholders in need of energy consumption reduction via setting control mechanisms to the retrofit agenda. The questionnaire survey aims to address what the architects and construction company owners' vision and understanding of energy-efficiency in the design process of buildings. The previous survey data for implementing energy efficiency in the design process had focused primarily on individual implementations and did not take account the necessity for households to know the how best to bring energy efficient supply systems to each household. This survey approach makes use of the housing projects to gain an insight into the key parameters related to adaptation of the retrofit strategies.

In the discipline of undertaking the survey with architects and the construction company owners, energy efficiency is addressed as a major concern in the design process with issues starting from the modelling based on the physical parameters of the building form, materials and systems. General assumptions are made about the designer's role in the process to respond to the occupants' patterns and internal gains. It is clear that adaptation of the retrofit strategies in the housing sector through a conducted survey addresses the extent to which building energy performance, often assumed to relate primarily to physical building characteristics is determined by architects' decisions, as well as building and climate characteristics.

As mentioned above, this research includes some case studies, which can be considered different indicators of the buildings as each of them contains general information about the estate - its location, characteristics, the demographic structure of the households and also information on construction companies. Although there is an effort towards the post occupancy evaluation with occupants in order to understand and assess the impact of changes carried out by house owners, there seems to be a gap in this research context analysis.

Before starting to work on post-occupancy evaluation, a pre-visit questionnaire is needed. This data collection method looks at selected housing projects in terms of understanding typical energy

consumption values and the effect of refurbishment activities. The display sheets are prepared to identify key indicators through the field study. It consists of the background data on a building; typology, size, construction period, supply system type, already implemented refurbishment activities, construction details, the number of occupants and hours of use.

This approach emphasis on understanding that the occupants' energy use is dependent on complex social parameters and consists of undertaking qualitative research within in-depth interviews with selected housing projects in addition to conducting a post-occupancy survey. The post occupancy evaluation method consists of the distribution of questionnaires to residents, reported conditions of the site survey, a walk-through evaluation through site visits and the collection of historical data such as electricity bills. It is also noted that the electricity consumption data of the selected buildings will be collected from the KIB-TEK (Cyprus Turkish Electricity Authority - Kibris Turk Elektrik Kurumu - in Turkish) with of the house owner' s permission. It is to be also noted that the post occupancy evaluation of buildings is conducted on certain selected buildings. However, the findings are only applicable for this study. Data collected through a variation of methods in this research can be used to inform on guidelines about the method 'adaptation of the retrofit strategies' in the mass housing sector.

4. Analysis and Results

In the selected case studies, geographic and climatic indicators account for the many differences recorded, as well as the demographic structure of the occupants related to some of the housing estates identified. However, today's construction standards for these buildings, which include a strict control of overheating risk and more specific use of indoor thermal quality of spaces are far from being energy efficient. Consequently, this case study approach is utilising reliable sources from a quantitative point of view, in order to better understand the gap between current housing stock conditions and the ones the privately owned construction companies' targets have to be able to offer. This is a key element in establishing the control mechanisms in the construction industry for implementing energy efficiency requirements to be satisfied by the refurbishment activities and to improve the quality of the housing stock (see fig. 4).
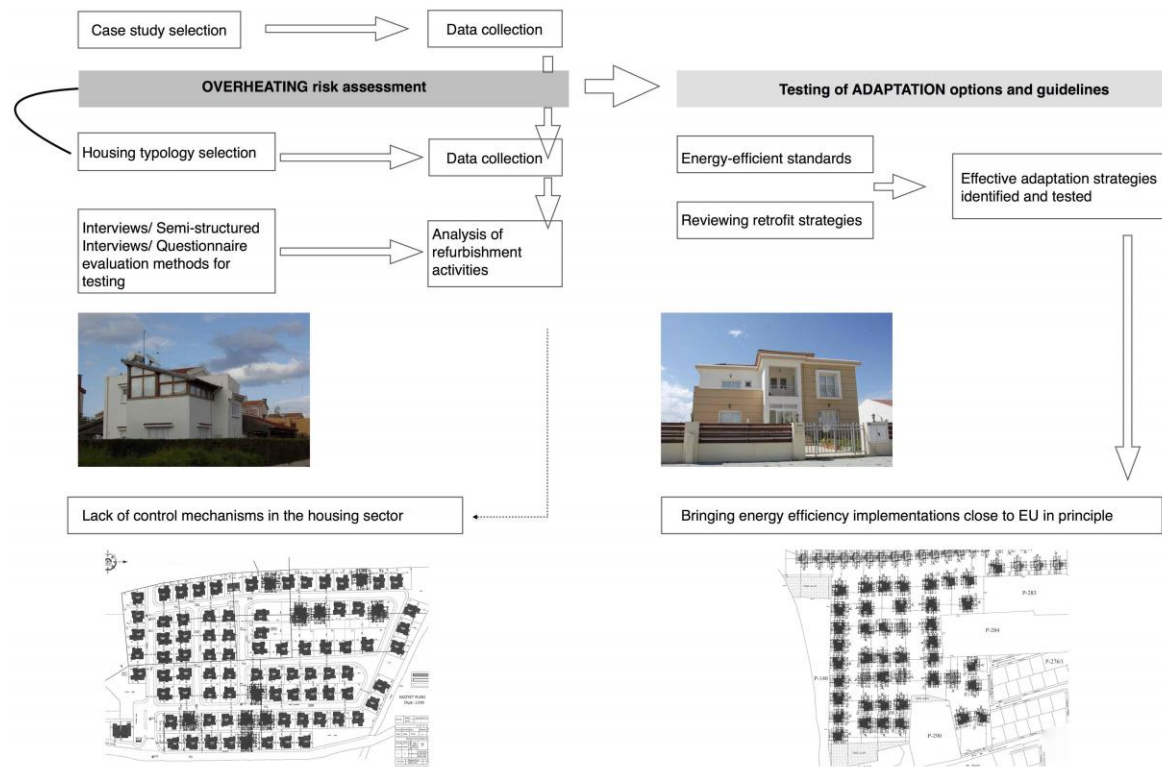
Figure 4: Overheating risk assessment of buildings.

- The first phase is dedicated to a typological analysis of the housing estates and refurbishment, and to the reasons for refurbishment activities, common refurbishment trends and their processes, as well as physical quality of buildings, using technical, financial and social diagnostic tools.
- The second phase is focused on the influence of EU energy efficiency objectives, from an energy saving point of view, on the housing estate projects, retrofitting, and the identification and classification of adaptation of retrofit packages.
- The third phase concerns the detailed description of adaptation of retrofit packages and thermal comfort, the implementation of energy efficiency materials, the environmental characteristics of building materials and materials potentially adopted for the selected buildings. Other issues that are considered are the management of the implementation of retrofit projects, the maintenance of buildings and the control of the process.
- The last phase is dedicated to planning the refurbishment activity, starting from the diagnosis of the building, to the financial planning stage and implementation of the works.

Taking into account the limits in data collection, information on housing projects are identified according to common indicators such as climatic and geographic conditions, building typology, construction companies targets and the demographic structure of occupants. Alongside the construction process and its impact on the environment, the preliminary research points out the need for control mechanisms in the housing sector to promote and support the adoption of retrofit strategies and minimise non-controlled refurbishment activities, in line with a diagnostic information of the selected buildings.

Although there is an effort towards the post occupancy evaluation within occupants to understand how to assess the impact of changes by house owners, there seems to be a gap in this research context analysis where the main goal accelerates for issues concerning occupants' necessities. The contribution to the field is that concerning both construction industry's design tools and planning strategies and understanding occupants on-going changes after the completion of projects to analyse how rapid construction process caused an increase in energy use and is certainly the evaluation carried out in the case of the T.R.N.C. This method can also be utilised in how the occupants can play a key role in identifying retrofitting strategies. Another contribution to the field is the evaluation carried out on understanding energy consumption of recently built housing stock in the T.R.N.C. As this study points out, there has been no academic research, which has not been undertaken that targets 'retrofit strategies'.

The result of this work tries to offer an adaptation of retrofit packages in the context of the refurbishment activities being developed. The renovation processes' main drivers are collected in the selected case studies and examined within the scope of the energy efficient objectives at European level, focusing on the potential benefits to the housing sector in terms of demand and energy savings. Understanding the process used by construction companies, their vision in the adoption of energy-efficiency technologies, the methods adopted for data collection, the refurbishment activities are articulated by occupants and the negative impact on energy consumption through selected housing estates are taken into account with an analysis of the current housing sector and how it works within current climate conditions across different geographical regions are carried out.

4. Discussions

As the common nominators emerging from these selected case studies show, what is required is an understanding of the benefits of energy efficient technologies. A pattern emerges which draws a sketch where a number of drivers belonging to different indicators such as energy consumption patterns of buildings, climate, environment etc. seem to be working without much concern for effective solutions in terms of controlling and regulating the renovation process.

This research's key concept is not only to adopt the retrofit strategies, but also to select an approach - whose standards can be measured in terms of how best to implement energy efficient technologies both in the design and the construction process. At the same time, it aims to look at possible further development, which would allow us to identify key drivers in relation to the effectiveness of new retrofitting strategies for the mass housing sector.

The current economic conditions in the T.R.N.C. and the political pressures, which affect the construction companies in administering energy efficient standards are discussed. However, at the same time, EU objectives offer an opportunity for highlighting the improvement of building components and the economic benefits that such changes bring about. Primary among those the main expected benefits from energy efficient technologies is a reduction in energy consumption and a reduction in maintenance and management costs of the buildings after their completion.

To reach this goal, the demographic structure of occupants and their behaviour is required. Each single household has to be convinced and assured of the reasonableness and the economic advantages that will accrue from investing in the improvement of building components concerning energy efficiency in and on their property.

The objectives are achieved through actions related to:
- the development of construction activity and its effects on the built environment

- the integration of energy efficiency standards (under the influence of EU objectives)
- the adaptation of retrofit strategies
- the management of refurbishment activity and its cost-effectiveness
- the combined production of heating and cooling of buildings (through thermal insulation)

In should be underlined that the energy efficiency standards and interventions actually targeted are oriented in considering the occupants' behaviour, controlling refurbishment actions on a wide scale that also include a reduction in the negative effects of the construction activity with the aim to recognise the diagnosis of the energy performance of buildings and maximise the potentialities of energy saving in terms of management and maintenance of the buildings.

With the purpose of reaching an adaptation of retrofit packages that would lead to realising the standards of energy efficiency, the case study approach on housing estates is integrated with a much a more in-depth study of the problems and related diagnosis at building level. At the same time the occupants' behaviour evolves in conjunction with a better understanding of the reasons for the refurbishment activity. Furthermore, the range of action of construction companies' targets, involving house owners needs that are broader and oriented towards an investigation of the problems on these housing estates, while trying to identify effective solutions that can be adapted to different regions.

4. Conclusions

The main objective is to propose concrete solutions to bringing in control mechanisms in the housing sector aimed to counter the effects of current construction activity, refurbishment trends, climate changes and strengthen the energy efficiency standards. Beside these, it tries to meet specific needs of occupants: improving the occupant's quality of life, promoting the energy efficient methods, applying retrofit strategies for an improvement in the physical conditions of buildings, creating a collaborative framework between construction companies, house owners, local contractors, stakeholders, non-governmental organisations and governmental initiatives for a retrofitting, and increasing the level of comfort and reducing the demand on energy consumption.

The role of an architect and the influence of architects are crucial for such energy efficiency retrofitting in buildings. The decisive role of architects is to enable households to identify and implement innovative technical solutions in order to improve thermal comfort levels in their properties. At the same time, taking into account of collaborative communication between architects and households, the well-integrated decision making process could allow to design and optimise an economically viable deep retrofitting strategies. It could also investigate ways to motivate clients to do an integral holistic retrofit. In general, the motivation and reasons for installation of cost-effective energy efficient construction materials are related to comfort improvement, quality of living and the necessity of certain replacements and improvements, and is less about energy savings.

As already stated above, in most cases in the situation currently in operation and with particular regard to the poorly-built housing stock, the indoor comfort standards needs are considered primary. However, these needs still do not meet basic energy efficiency standards and the expectations of occupants still focus on improving indoor living conditions. The future is challenging, much attention must be given to the quality of construction material, the perceived indoor comfort level and on the energy efficient materials rather than the level of obsolescence achieved by the un-controlled refurbishment activity. Therefore, this study offers significant added value to internal effort towards achieving energy savings within the recently built en-mass housing stock.

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