Towards low carbon homes through energy renovations

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***Abstract*--In this paper a description of the ERACOBUILD "Countdown to Low Carbon Homes" project along with the current progress to date in Cyprus is presented. This project began in 2012 and involves partners from three EU countries: Cyprus Energy Agency (Cyprus), Aristotle University of Thessaloniki (Greece), and Severn Wye Energy Agency (United Kingdom). Cyprus Energy Agency is undertaking this project in order to develop a one stop service for the sustainable energy retrofit of homes in Cyprus. This service aims to support anyone wishing to improve the energy efficiency of their home, by showing them low cost methods to maximise their return on investment, with long term benefits for the environment and their own family budget. In Cyprus twenty-one case studies of domestic sustainable energy retrofit have been selected while also two support groups have been created: the Regional Advisory Group and the Local Installers Group. Both groups meet on a regular basis to exchange information and opinions on the progress, implementation and outcomes of the project.**

***Index Terms*—Energy behavior, Financial, Low Carbon, Quantitative results, Retrofit, Smart meter, SMEs**

I. Introduction

Building upon workable local solutions provides the ideal basis for scaling up and cutting costs. Working within geographical communities in 3 member states (UK, Greece and Cyprus), the Countdown project aims to research, develop and communicate an integrated practical delivery approach to community scale retrofit of buildings, with a particular focus on homes and delivery by SMEs, and with the potential to contribute substantially to challenging carbon and energy saving targets within the EU. The project involves partners from three EU countries: Severn Wye Energy Agency-lead partner (United Kingdom), Aristotle University of Thessaloniki (Greece), and Cyprus Energy Agency, CEA (Cyprus).

Attention will be given to the whole 'retrofit journey', encompassing both demand and supply side action, including awareness-raising, bespoke advice, local installer groups and financing mechanisms, with a new financing programme established and trialled in one of the partner regions, to form the basis for an exchange of knowledge and experience with the other partners.

Following the sustainable development framework of 'engage, encourage, enable and exemplify', innovative aspects of the project include action research to draw lessons from the retrofit experience of both installers and households, engaging all key actors (home owners, installers, suppliers, advisers, and building and planning control) in co-learning, and engaging households themselves in post retrofit monitoring.

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II. State of the Art

Current thinking on cost reduction and scaling up retrofit tends to focus on area-based approaches (limited area street by street) as the solution, to secure logistical benefits and scale economies, which depend on being able to carry out substantial works within a relatively short time. This may work for social housing, but application to private sector requires leverage of investment by property owners, as well as willingness to accept the disruption of building works which is common to all tenures. For high deprivation areas there may be enough subsidy and benefits in improvement in living conditions to overcome these barriers, but not elsewhere.

Our direct experience of working with owner occupiers and installers indicates growing concern about energy costs and climate change, and interest in improving energy efficiency, but many reasons in practice for a step by step approach to making improvements. There are also many barriers and opportunities, practical, financial, aesthetic, regulatory.

These details will be explored through researching knowledge and experience of key actors: home owners and the retrofit supply chain, in particular (mainly SME) builders and installers, planning/ building control, and local building suppliers. Little research has been done to engage this crucial sector (focussing rather on larger commercial and public sector market actors),or to document the real experience of home-owners in getting retrofit work done, making user adjustments post retrofit, and barriers and solutions to ensuring full benefits are realised.

Finally, the issue of how to finance deep carbon reduction retrofit (as opposed to quick return measures only) is highlighted in current debate, but only partly addressed, due to lack of detailed knowledge of real practical issues, costs and savings.

The high proportion of owner occupied homes in the EU makes this a significant issue to understand better in terms of scaling up retrofit, and reducing costs.

III. Proposed Solutions

Policy work is being done in UK to develop a 'Green Deal' retrofit framework, and many programmes here and in other countries support roll-out of single measures, but practical delivery of deep carbon cuts through retrofit is complex, and primarily delivered on a bespoke level by the local/regional supply chain.

Scaling up can be achieved by starting at this level and building on it, overcoming practical barriers step by step. This also has the benefit of supporting the local economy and increasing capacity, as opposed to 'cherry-picking' profitable measures by larger companies with no long term local presence.

Finance can be a major barrier for the private owner. Studies by SWEA and FEDARENE have reviewed existing finance products and note heavy reliance on public sector funding, with funds available diminishing. A knowledge exchange programme between partner regions will explore different approaches in use, such as the CERT/ECO in the UK, 'Exikonomo katikon – Saving energy at home' in Greece, and observe development in UK of a Revolving Loan Guarantee Fund, following the successful approach used in Hungary and Estonia.

The project will deliver:

- Valuable insights into barriers and solutions to retrofit of private housing, from perspective of key actors directly involved
- Quantitative results in terms of potential and actual savings, and evidence of user behaviour issues encountered
- Trialling, evaluation, documentation, communication of integrated local delivery model, including advice, supply, installation and behaviour support
- Knowledge exchange on retrofit finance between regions, including application of revolving loan guarantee fund to private housing in a western European country for the first time

This will provide a core delivery model which can be replicated to achieve retrofit on a large scale, building up from practical success at community level. Outputs will be disseminated at regional, national and EU level.

IV. Description of the Project

A. Research and Development Actions

The research and development part of the project aims to develop and trial a local delivery model and draw in knowledge and experience from key market actors and is separated in the following actions:

- Establishment of the Local Installers Group (LIG) and Regional Advisory Group (RAG).
- Implementation and evaluation of a co-learning programme.
- Recruitment of a Post-retrofit household group.
- Recruitment of a Pre-retrofit household group.

(1): Establishment of the Local Installers Group and Regional Advisory Group

The establishment of LIG in Cyprus is very important step towards the successful implementation of the project. The reason of establishing such group is to cover all the main technologies and techniques required for sustainable energy retrofit of homes in Cyprus. It is expected that the LIG should include the following specialities: Boiler installers, Chillers installers, Heating and Air Conditioning (HVAC) installers, Lighting improvements (designers and installers), Specialists on the Building envelope modifications (including the insulation materials, plasters, paints etc), Renewable technologies installers, Electricity utility including the smart metering, Domestic appliances sellers, Sellers and installers of double glazing and shading devices.

The number of persons that will be included in the LIG is expected to be 2 from each category. Approximately the Group will be consisted of 20 members.

The CEA will support this group as an identifiable service, at the same time as working with them to evaluate the barriers and solutions to retrofit from their perspective. The barriers related with the retrofit are usually (a) market barriers: consumer (demand Site) barriers and contractors (supply site) barriers, (b) financial, (c) Technology and (d) policy.

The objective of establishing the LIG is a win-win situation as the aim is that installers group should benefit from being part of the group, but also the CEA and the project would benefit as well from their experiences. The indicative list below describes the benefits of the LIG:

- cross-transfer of information and knowledge between providers and installers of different technologies
- possibility of Joint marketing of retrofit services and products
- Information on grants, planning, new technologies
- Arranging information and/or short training sessions according to interest, such as with suppliers and planning control officers
- Presenting examples of installations and barriers overcome in the local area
- Joint visits to see installations, or to trade fairs etc
- Collaboration on opportunities for join procurement, to save time and bring down costs
- Reviewing opportunities for other cooperative activities, to enable them to engage in new markets – such as training and accreditation

The LIG will meet 2 times together with the RAG. These meetings will be arranged in such a way as to be both convenient and attractive, offering information and exchange of views.

All activities and the reactions to them will be fully documented. The action research approach of action and reflection in series will be applied.

In addition, in Cyprus, a RAG will also be established to engage the key experts on the retrofit. This Group will come also in contact with the Installers Group as in Cyprus rarely key experts meet together with the Installers. In Cyprus for example, the aim is that the RAG will consist of 10 members, for example: Social housing providers e.g Cyprus Land Development Organization, a representative of the Cyprus Association of the Renewable Energy Enterprises, a senior planning control officer (e.g. Town Planning Department), a senior building control officer (e.g. ESCOs), a building supplies company representative (Associations of Energy Saving Enterprises), a research academic (Private and Public Universities).

(2): A co-learning programme

A co-learning programme will be implemented and evaluated, using case study (or 'exemplar') homes as the basis for study by groups consisting of all key actors, home owners, installers, building suppliers, building and planning control personnel and advisers. This will be fully documented and form the basis of written case studies. In particular the description of the actions will be implemented in Cyprus are the following:

- Find a number of home owners (the target will be 20) who are willing to undertake an energy renovation on their homes to improve energy performance.
- Agree with them to be case studies
- Advise and help them through the process, including technical advice, estimated energy savings, cost etc
- Set up some 'action learning' sets to involve the different actors involved – will for example include reviewing barriers and solutions to getting sustainable energy retrofit done, practical issues arising, user behaviour issues etc
- Write up the case studies as examples to form part of the report (this will also be used for advice and dissemination actions)

(3): Post retrofit household group

A group of households (target of 5 in Cyprus) will be recruited to work with over a period of 2 years. This will focus upon the user experience and behaviour, and the performance of buildings after retrofit. It will include the establishment of an 'energy diary' approach to self monitoring which will encourage the householder in the habit of monitoring consumption and actions or external factors that impact upon it .

The project partner will provide a monthly energy adviser visit to each home, so as to:

- take meter readings
- discuss and record any changes to usage behaviour
- discuss and record any changes to the building, works done etc

(4): Pre retrofit household group

This will focus upon the household experience of retrofit. Home owners will be recruited for assistance with retrofit and to participate in detailed documentation of their experience.

The project partner will provide an onsite energy visit and advice, with a written report on the energy performance of the house and recommendations for energy improvements. They will also provide follow on 'hand holding' advice to help to get works done, including finance and installers, with recording of the experience by both householder and adviser.

Focus groups will be held to draw out experience of the group, as well as each individually keeping a diary of experience.

Incentives will be provided to ensure participation (given at the end of the programme), the precise nature of these will be decided by each partner, but it could for example be a cash payment or a voucher for an energy efficient appliance.

B. Financing retrofit

This part of the project will involve two main elements:

- Finance for retrofit knowledge exchange:
- Implementation of Revolving Loan Retrofit Guarantee Fund

(1): Implementation of Revolving Loan Retrofit Guarantee Fund

This will be implemented only in the UK, and will be the first time that this has been established in a western European country. The work will be coordinated by Severn Wye Energy Agency in partnership with Stroud District Council (together with the other neighbouring partner local authorities) with expert support from sub-contractor GESB.

(2): Finance for retrofit knowledge exchange:

A programme of knowledge exchange on finance for retrofit within the UK and the other partner regions. This will be achieved by engaging the project partners (and other key actors identified by them) as observers in development of the RRGF in the UK, as well as through exchange communications regarding the range of finance products for retrofit employed in each of the partner countries. This exchange will be extended to other countries, through relevant EU networks as part of the dissemination programme.

C. Local retrofit delivery model

The results and learning from the previous actions of this project will be captured and presented as a basis for a replicable local retrofit delivery model. The detail of the content toolkit will be clarified and developed from the experience of the research program, but is likely to include the following general areas:

- typology of buildings, retrofitting measures, energy, carbon and cost calculations
- advice, information and support for home owners, installers
- financing the measures
- barriers and solutions in different building types
- connecting the local supply chain, so that advice and information, supplies, finance, installation expertise, and building permissions are all part of a coherent customer journey

V. Benefit for the Society and the Business Sector

The retrofit challenge is a major one for all countries in Europe, as reflected in EU wide policy on reducing emissions from existing buildings. Climate change agreements highlight the need to reduce carbon emissions, and there is concern about security of energy supplies to meet rising demand in the next decades. Energy poverty is on the rise and is a phenomenon increasingly recognised in EU countries, with consequences for health and well-being.

With economic downturn the rate of replacement of buildings has reduced drastically, increasing further the significance of achieving deep carbon retrofit. Loss of work in the construction sector is both an additional socio-economic concern, and risks loss of valuable skills.

Good quality and appropriate retrofit is a win-win solution, but is complex to achieve in practice, especially in private housing, where it relies on significant levels of own investment by home owners, as well as disruption and purchase of potentially unfamiliar new technologies. Most repair and refurbishment is done by SMEs, and they also face challenges and barriers. Other key actors in the supply chain are building suppliers, and local planning and building control personnel.

This project will view the sector from the perspective of these actors for the first time, bringing them together in a co-learning program. It will research and develop real practical experience, and produce evidence-based research conclusions and a practical guide for a local delivery model. This has the potential to kick-start an EU wide exchange on local retrofit of lasting benefit socially, environmentally, and economically.

The guarantee fund enables the scheme to run continually in the event of temporary default on repayments (as high as 5% can be accommodated). The loans funds can be derived from a range of sources and can be scaled up or down. We aim in this case to source European (Recovery Fund) funding for the guarantee fund, against which to interest commercial banks in offering loans to home owners. The scheme has been proven to be able to offer the highest leverage ratio (as high as 1:20) compared to other currently known finance mechanisms.

The exchange of knowledge on finance mechanisms will enable sharing of this crucial area of knowledge to enable retrofit across the EU

VI. Progress to Date in Cyprus

Currently, in Cyprus the LIG (Table I), the RAG (Table II) and the pre-retrofit household group have been formed and work with them is underway. Working with these groups enables us to identify opportunities and barriers for encouraging widespread take up of domestic energy improvements.

TABLE I
LOCAL INSTALLERS GROUP PARTICIPANTS

Installers/SMEs	Number
Boiler installers	3
Chillers installers	2
Heating and Air Conditioning (HVAC)	4
Lighting improvements	3
Building shell	7
Renewable technologies	11
Electricity utility & smart metering	1
Domestic appliances	-
Double glazing	1

TABLE II
REGIONAL ADVISORY GROUP PARTICIPANTS

Participants	Number
Policy Makers	2
Local Authorities	1
Energy Agencies	CEA
RES Associations	1
Other Association	2
Housing providers	1
Finance	1
Academia	3

The 1st meeting of the LIG was held on the 20th of December 2012 where the homeowners and the members of the RAG also participated. The LIG representatives presented their products and services. The aim of the meeting was to identify possible problems and barriers but also to find opportunities and solutions during the discussions with owners. For this purpose a specific questionnaire was formulated which included 6 different questions. The results of the completed questionnaires are graphically presented in Figs. 1-6 below.

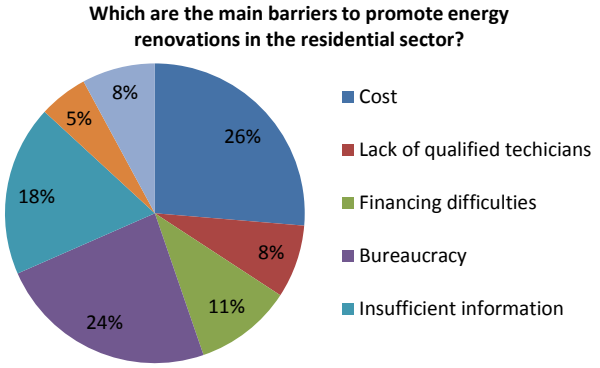

Fig. 1. The main barriers to promote energy renovations in the residential sector.

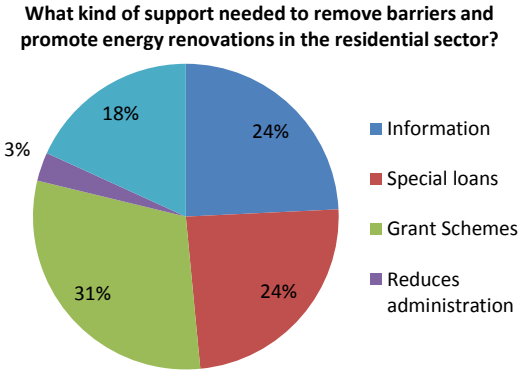

Fig. 2. The necessary kind of support required to remove barriers and promote energy renovations in the residential sector.

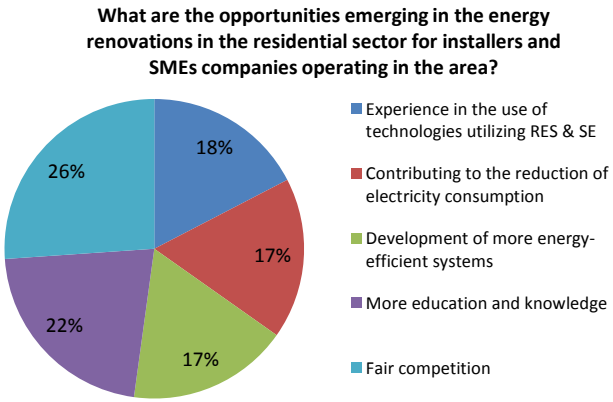

Fig. 3. The opportunities emerging in the energy renovations in the residential sector for installers and SMEs companies operating in the area.

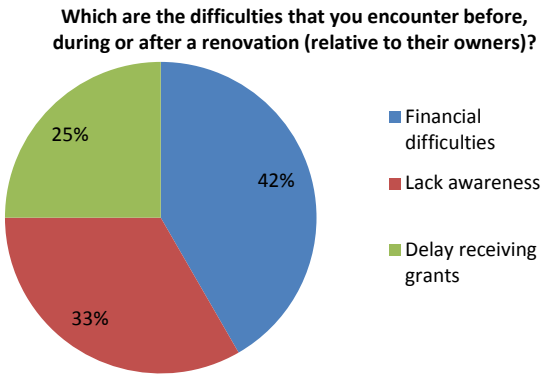

Fig. 4. The difficulties that the LIG encounter before, during or after a renovation (relative to their owners)

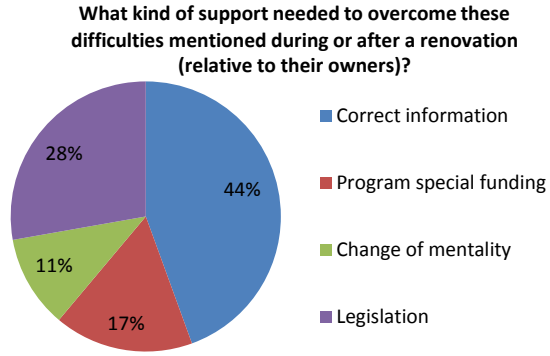

Fig. 5. The kind of support needed to overcome these difficulties mentioned during or after a renovation (relative to their owners).

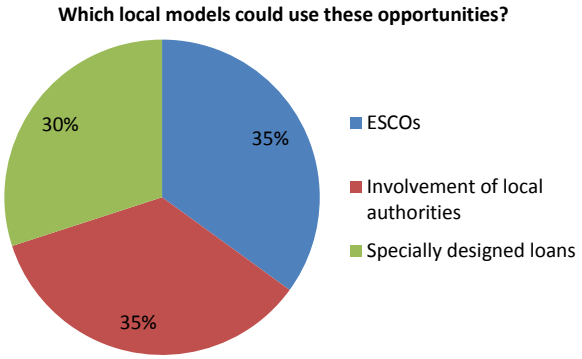

Fig. 6. The kind of local models to use these opportunities.

It is very interesting to notice that according to the LIG the main barrier to the promotion of energy renovations in the residential sector is their cost (26%) followed by bureaucracy (24%). The financial are also considered to be the main difficulties (42%) encountered before, during or after a renovation. Thus, the required support necessary to overcome these barriers and promote energy renovations in the residential sector in Cyprus are the deployment of new Grant Schemes (31%) and special loans by the banks (24%) and the correct information of the public (24%).

Twenty-one households, the location of which is shown in Fig. 7, have been selected to participate in the action research following a call for expressions of interest. The characteristics of the participating households are listed in Table III. The current energy status of these households will be evaluated through an onsite energy visit from energy experts in order to advise on possible measures and ways to reduce the current energy consumption and to calculate the Energy Performance Certificate (EPC). Additionally, in each household a smart meter has been installed (kind courtesy of CEA) in order both to log the energy consumption before and after the application of the proposed retrofit measures and also to assist the occupants of the house understand the main energy consuming devices and consequently help change their energy behaviour. The participating households have also been offered access to professionals, guidance for funding opportunities, as well as ongoing support both during and after their home energy improvements to ensure they reap the maximum benefits.

Fig. 7. Map of Cyprus showing the number of the selected households in each city of Cyprus.

TABLE III
CHARACTERISTICS OF THE PARTICIPATING HOUSEHOLDS

Year of construction

1965-1980	1981-1990	1991-2000	2001-2010	<2011
7	4	6	6	0

Area of the household

<100	101-150	151-200	201-250	251<
1	8	5	3	6

Type of the household

Flat	Single house	Duplex house	Semi-
3	10	9	1

Occupants

Single person	Couple	Family with	residents
2	1	15	5

Family annual income (thousand €)

0-20	20–30	30-40	40-55	55-70	<70
1	5	3	8	5	1

Between March-July 2013 the CEA team has completed the onsite energy visits and has collected qualitative and quantitative data concerning the energy consumption of each household. The purpose of the visits was twofold; to collect data from owners through a constructive questionnaire which was specifically formulated for the needs of this project and also technical information and data such as the U-values of the external walls, measurements of humidity, temperature and where possible, infrared thermal imaging of the house.

Currently, the collected data and information are being evaluated and it is expected that by the end of autumn of 2014 the results will be completed and sent to the

homeowners in the form of a report. Additionally these results will be disseminated by the CEA through web pages, scientific articles, participation in conferences, workshops and seminars through the media.

VII. Initial Results of the Energy Visits

The initial results of the analysis of the data acquired during the completed energy visits for 5 houses reveal some very interesting facts. The energy class of all 5 houses is calculated to be G while none of them has any kind of thermal insulation installed on their envelope. On the contrary 4 of the houses have double glazing and all 5 have solar water heating system (SWH) installed. As a result of the absence of thermal insulation several thermal bridges occur on the envelope of these houses. The existence of the thermal bridges was revealed by using infrared thermal imaging of the house as shown in Fig. 8.

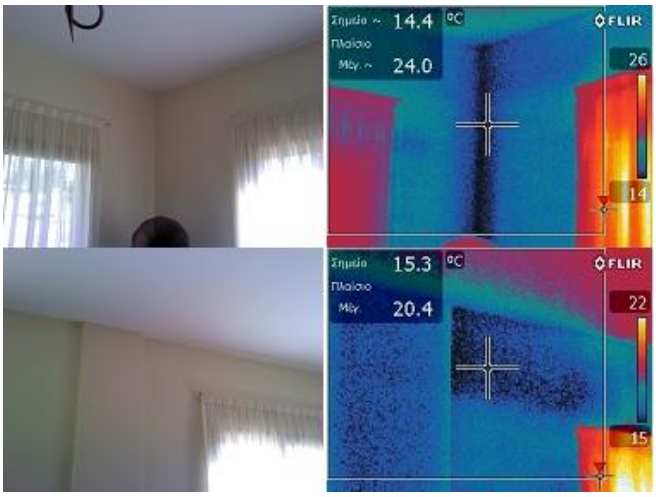

Fig. 8. Thermal images of the envelope of one of the selected households revealing the existence of thermal bridges.

The proposed measures included the following: replacement of tungsten lamps (1 case), installation of external insulation on the roof (2 cases), installation of internal insulation on top of the ceiling (1 case), replacement of old air conditioning units with new energy efficient (1 case) and replacement of single glazing with double glazing with thermal brakes in the aluminum frame (1 case).

The expected energy savings of each measure range between 8-40% while the consequent cost ranges between 150€ (replacement of the lamps) to 5,000€ (installation of external thermal insulation on the roof).

VIII. Conclusions

In this paper the ERACOBUILD "Countdown to Low Carbon Homes" project is presented along with its current progress to date in Cyprus. Cyprus Energy Agency is undertaking this project in order to develop a one stop service for the sustainable energy retrofit of homes in Cyprus.

In Cyprus twenty-one households have been selected to participate in the action research following a call for expressions of interest. An onsite energy visit from CEA energy experts has been carried out for all households in order to advise on possible measures and ways to reduce the current energy consumption and to calculate the energy performance certificate. Additionally, in each household a smart meter has been installed (kind courtesy of CEA) in order both to log the energy consumption before and after the application of the suggested retrofit measures and also to assist the occupants of the house understand the main energy consuming devices and consequently help change their energy behaviour.

The data collected during the energy visits are currently being evaluated and it is expected that by the end of autumn of 2014 the results will be completed and a report will be sent to the homeowners.

Additionally two support groups have been created: the Regional Advisory Group and the Local Installers Group. Both groups meet on a regular basis to exchange information and opinions on the progress, implementation and outcomes of the project.

During the 1st meeting of the LIG (20th of December 2012) a questionnaire was completed by the LIG members so as to identify the possible problems, barriers, opportunities and solutions concerning the energy renovations of the residential sector in Cyprus.

According to the results of the questionnaires the main barrier to the promotion of energy renovations in the residential sector is their cost 26% followed by the bureaucracy 24%. In the same manner the financial are considered to be the main difficulties by 42% encountered before, during or after a renovation. Thus, the required support necessary to overcome these barriers and promote the energy renovations in the residential sector are the development of new Grant Schemes 31%, the development of special loans by the banks 24% and the correct information of the public 24%.

IX. Biographies

Gregoris Panayiotou was born in Limassol, Cyprus on February 18, 1983. He graduated from the Technological Educational Institute of Athens first of his class as an Energy Technology Engineer in 2007. He had his MSc in Energy in Heriot-Watt University, Edinburgh where he graduated in 2008 with Distinction.

He is currently employed at Cyprus University of Technology as a Research Associate in a nationally funded project concerning the study and the deeper understanding of the thermosiphonic phenomenon that occurs in solar water heating systems that operate thermosiphonically.

In the past he had also worked in two research projects. The first project was funded by the Research Promotion Foundation of Cyprus and concerned the categorization of buildings in Cyprus according to their energy performance. The second project concerned the application and evaluation of advanced absorber coatings for parabolic trough collectors.

The main simulation tool he had used in most of his work is TRaNsient SYstem Simulation (TRNSYS) while he had also worked with HOMER and PVSyst.

He currently has 9 Journal publications and 12 Conference publications and his special fields of interest include wide range applications of Renewable Energy Sources systems and Energy Efficiency in buildings.

Anthi Charalambous was born in Paphos, Cyprus, on January 19, 1973. She is a Chemical Engineer by background, graduated from the National Technical University of Athens, and holds a MSc in Environmental Engineering, a Masters in Business Administration (MBA) and a MSc in Renewable Energy and Energy Management.

At the beginning of her career she worked abroad in environmental management, wastewater management and treatment and industrial pollution. From 2001 she began working in the field of Renewable Energy in Cyprus and Brussels. In 2007 she joined the European Commission Directorate General for Energy in the unit of renewable energy technologies. She is the Director of Cyprus Energy Agency since November 2008.

She participated in more than 60 conferences as invited speaker and she has released several publications and she is co-author of a number of papers.

Maria Ioannidou was born in Lefkosia in the Cyprus, on April 24, 1981. She holds an energy resources management degree graduated in 2005,

MBA and master on Environmental Education and Sustainable Development.

She is employed by the Cyprus Energy Agency since 2009. She is responsible for the development of educational material for primary and secondary education, and other target groups adults and public. She is entitled to visit schools in Cyprus (upon request) to present and demonstrate relevant materials including experiments for motivating and educating students on renewable energies, energy savings and sustainable transport as well to visit local communities to motivate and educate people on the field. Furthermore, she provides technical support in co-financed projects, she is an energy expert for buildings.