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POLICY OPTIONS FOR THE THERMAL UPGRADE OF EXISTING MALTESE HOUSING STOCK: AN ENVIRONMENTAL AND ECONOMIC APPROACH.

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ABSTRACT: This study formulates and evaluates policy options to identify the most economically viable means to accomplish the thermal upgrade of the existing residential buildings stock in Malta. In a first step, policies adopted in various EU countries have been reviewed to determine their benefits, success, and adaptability to Maltese settings. The UK and Germany were found to have progressed significantly in this area, and their policies were consequently reviewed in greater detail. While climatic differences are less important in the policy context, it is imperative to understand the processes that allowed such countries to arrive at their present state of policy adoption. Sudden introduction of hefty measures and policies that took years to be implemented and accepted in other countries may be counterproductive. In a second step, it was surveyed how Maltese stakeholders are viewing different policy options in terms of technological, social, environmental, and economic impact. In a third step, a detailed techno-economic analysis was performed to compare the energy saving effect of various energy efficiency measures with their cost in relation to heating/cooling expenditures of Maltese households. Based on this analysis, investment into roof insulation is the prime measure to be recommended.

Keywords: *Retrofitting, buildings, policy, economic, thermal.*

1 INTRODUCTION

Dwellings account for 16% of Malta's final energy consumption [1] and 27% of the total electricity consumed [2]. The thermal upgrade of existing residential building stock would thus be expected to result in significant energy savings while improving the quality-of-life of residents. It is also in line with energy efficiency requirements as laid out in European directives. The objective of this study was to assist the formulation of a sound policy framework to thermally upgrade the existing residential building stock.

2 APPROACH

Research included a literature review and a series of one-on-one stakeholder interviews to obtain relevant information. The participants were selected to represent experts in the field and representatives of the main bodies within the building industry. Questions in the interview schedules were adjusted, from one interviewee to another, to account for the different roles they represent. Technical and economic data used for the analysis was based on these interviews, scientific literature, and practical experience.

3 MAIN RESULTS

Findings resulting from interviews can be grouped under four main headings.

3.1 The status quo of thermal retrofitting in Malta:

Technical Guidance F, which constitutes construction requirements for all new buildings since January 2007, and the Environmental Performance Certificate (EPC) system were key topics of argument, with a clear consensus by all parties that there would be less need to retrofit dwellings built in the last six years if Guide F had been respected.

To help this situation, there have been a number of grants during the last years, including those that promoted double glazing and roof insulation. Various EU Projects also promoted such retrofitting. The eeWise project, for instance, targets the present faulty transfer of knowledge within the retrofitting sector system while Build Up Skills is a programme set out by the EU specifically to boost the skills needed to achieve the EU's targets in renewable energy and energy conservation.

3.2 The present situation with regard to adherence to EU directives and policies;

Two EU directives refer to thermal retrofitting of existing dwellings; Directive 2010/31/EU and the Energy Efficiency Directive 2012/27/EU. The former has been transposed into local legislation through the Buildings regulation Act L.N. 376/2012: Energy Performance of Buildings Regulations.

The first version of the EPDB Directive established the current EPC system through L.N. 261/08. There was a general consensus among the interviewees that the current procedure governing EPC certification is not functioning properly. Hopefully the situation will improve with the new LN 376/12. This enforces the display of EPC on advertisement of properties as well as demands that the EPC is provided with the promise of sale of property instead at contract stage. The aim is to allow the EPC to have better influence on the property market and therefore push contractors/ estate agents/ architects to give it its due importance.

3.3 The building elements that deserve most attention during retrofitting;

To yield best results, retrofitting policies should target primarily those aspects, which cause the greatest energy loss in dwellings.

One important element, which accounts for a good share of energy loss from Maltese houses, is the external walls constructed with one skin, mostly back facade and internal yard walls.

Prof. Buhagiar and Dr. Fsadni during interviews identified the following building elements as those requiring most attention during thermal retrofitting:

1. Roofs which are exposed all year, all day long;
2. Exposed walls, especially single skin yard and exposed party walls; and
3. Glazing.

Perit Degiorgio identified the wall (exposed) as the element requiring the most upgrade of its U-value stated in Guide F [3]. This is followed by the windows and a new element, specified as 'Floor over unconditioned space', referring mostly to ground floor residential units overlying basement or semi-basement garages.

3.4 Proposals for future policies.

The interviewees proposed a number of noteworthy policies that may be adopted by the Maltese government. They highlighted the need for an education campaign. They felt that people do not fully appreciate the value of energy services provided, and that this includes non-monetized aspects. Without such appreciation, the EPC will have no effect, and if the certificate is to influence the general trend of market prices of dwellings, it will have to be well enforced.

Extensive education programmes are necessary to change the behaviour of people. Until now the construction industry feels hindered by the EPC and the public views it as an additional cost. A mixture of policies, guidelines and regulations should be used to instil confidence in people with regard to thermal retrofitting measures.

4 DISCUSSION OF FINDINGS

Based on an NSO study, Malta in 2005 had a total of 194,000 dwellings [4], out of which 72.6% are occupied dwellings. One would assume that occupied dwellings are the ones which consume energy, and whose upgrading will improve the living conditions of the Maltese population. On the other hand, unoccupied dwellings would be assumed to represent a waste of resources, and any upgrading measure would be a further waste. However, 25% of so-called unoccupied dwellings are in fact used as vacation homes in summer and a percentage of the remaining unoccupied dwellings may be rented out unofficially. Due to the uncertainties with respect to the utilization level of so-called unoccupied dwellings, this study relates to dwellings officially categorized as occupied.

Different studies about thermal performance in local construction may help in providing guidelines with respect to different indoor temperatures and also energy loss in our dwellings. Studying a theoretical model building, S.P. Borg, N.J. Kelly and K. Rizzo found that the unconditioned indoor temperature for an examined top-floor, low-efficiency apartment in July was close to 31^{o}C in the living room and 1^{o}C less in the bedroom area, while the temperature in a ground-floor apartment of the same building stabilises at a little less than 26^{o}C [5]. In winter, however, the living room unconditioned temperature of the low-efficiency ground-floor apartment was only around 12^{o}C. These figures are well outside the BRO (Building Regulation Office) thermostat set points for the EPRDM (energy performance for residential dwellings in Malta) of 23.0^{o}C in winter to 25.0^{o}C in summer in occupied areas. In contrast, ASHRAE 55-1992 indicates that people can be comfortable in a wider temperature range, between 19.5^{o}C and 27.0^{o}C. It is this temperature range given by ASHRAE (American Society of Heating, Refrigerating and Air Conditioning Engineers.) that is targeted through thermal retrofitting measures within this study. This range is considered narrow enough to allow for an adequate quality-of-life, especially if the local behavioural adaptation to experienced temperature conditions is taken into account. Such behaviour may be intended to influence indoor temperatures or to better cope with them. It includes choice of indoor clothing, use of fans, use of heavy rugs and heavy curtains in winter, and light ones in summer, not using hottest areas in the house in summer, installing sunshades over windows in summer, use of thick bedding in winter, and seasonal behavioural patterns such as resting whenever at home in the summer afternoon. All such measures would influence the level of comfort experienced in households.

Table 1 shows the number and type of existing dwellings according to year in which they were built. Installing energy efficiency measures during construction is far more cost-effective than to retrofit existing building stock. It is therefore evident that the policies proposed here should be implemented in a scenario that already covers adequate measures for new buildings.

Table 1: Dwellings built in Malta until 2005 [4]

	Two – Storey Dwelling	**One-Storey Dwelling**	**Total**
1918 or earlier	10,220	5,340	15,560
1919 - 1945	8,540	5,860	14,400
1946 - 1960	7,540	10,190	17,730
1961 - 1970	5,940	8,580	14,520
1971 - 1980	10,250	11,590	21,840
1981 - 1990	15,180	9,370	24,550
1991 - 2000	8,270	15,120	23,390
2000- 2005	1,950	5,110	7,060
Total	**67,890**	**71,160**	**139,050**

Given that a number of existing buildings will be demolished every year, only those dwellings which have enough lifetime left to render the thermal measures effective should be considered. In the absence of precise data, assumptions were taken with regard to the remaining lifetime of the existing dwellings that were categorised according to the date of construction.

Dwellings erected after 1960 are assumed to be subject to a demolition rate increasing by 5% every decade. Those built during the construction boom between 1960 and 1990 will suffer the largest percentage of demolition. Recent buildings have still a long service life ahead and it is assumed that the demolition rate is negligible for the first 30 years of service.

As a key element of this study, a costing exercise has been carried out for three energy efficiency measures. This was based on a standard area of 100sqm floor space, and the measures included roof insulation, single skin exposed wall insulation and double glazing. This allowed for a quantification of resources required and comparison between the different measures with regard to cost-effectiveness.

In 2008, the average Maltese household spent €535 annually on electricity and gas. [6] This figure could not be used for this study, since besides the increase in the price of energy which can be calculated, one has to appreciate both the current trend of locals to seek greater comfort and the long term effects of such retrofit policies. Thus, the total heating and cooling cost required to keep local dwellings within the ASHRAE comfort temperature range was estimated at €1,102 per year. These calculations were based on a cooling/heating load of $150W/m^2$ in the bedrooms and $250W/m^2$ in the living room.

These figures take into account the energy load resulting from infiltration/ventilation, power equipment, U-value of room envelope, lighting and occupiers. As is typical of a Maltese household, it was assumed that gas is used to heat the living room for just 3 hours a day during the winter months, while air conditioning is used for heating two bedrooms in winter and cooling both living room and bedrooms in summer. It was assumed that no heating/cooling was required during the shoulder months and that only the mentioned three rooms are heated/cooled.

One important assumption in the presented analysis is that only 60% of the heating/cooling load is associated with the building envelope. The remaining 40% are attributed to air exchange necessary for supply of fresh air and internal heat sources. Thus, having a fully insulated building envelope can only save a maximum of 60% of the total space conditioning costs, i.e. € 661.51 p.a.

With respect to the proposed retrofitting measures, the savings of €661.51 p.a. are distributed between the investigated measures according to the ratios derived from UA-value (U-Value x Area of each element) calculations of a single and two storey dwelling. For a two-storey unit, the roof element is responsible for 39% of the energy loss. Therefore the retrofitted roof may save a maximum of 39% of €661.51 or €257.99. These ratios correspond to the energy losses associated with the building elements as indicated by the local studies mentioned beforehand. Following the retrofit intervention, the roof U-value improved by 88.2% and is still allowing some energy loss. So the €257.99 in possible savings are further factored by 88.2%, to €227.54. The payback period for each measure was calculated over the 40 years lifetime of these measures and the table below summarises the results.

Table 2: NPV (net present value) for various retrofitting measures. The NPV shown here was calculated using a discount rate of 6%, reflecting low risk associated with thermal retrofit measures.
* only relevant for flats on top of a garage. Not considered for recommendations below.

<table>
<tr><th>Measure</th><th>Cost
€</th><th>U-value before $W/m^2 K$</th><th>U-value after $W/m^2 K$</th><th>NPV of savings €</th></tr>
<tr><td>Roof Insul. One-Storey</td><td rowspan="2">2,676</td><td rowspan="2">2.252</td><td rowspan="2">0.265</td><td>2,328</td></tr>
<tr><td>Roof Insul. Two-Storey</td><td>748</td></tr>
<tr><td>Exposed floor insul.</td><td>1,239</td><td>1.980</td><td>0.399</td><td>--*</td></tr>
<tr><td>Dbl Glazing One-Storey</td><td rowspan="2">2,900</td><td rowspan="2">5.700</td><td rowspan="2">3.300</td><td>- 2,355</td></tr>
<tr><td>Dbl Glazing Two-Storey</td><td>- 2,241</td></tr>
<tr><td>Exposed Wall One storey</td><td>1,701</td><td rowspan="2">1.660</td><td rowspan="2">0.585</td><td>- 731</td></tr>
<tr><td>Exposed Wall Two-Storey</td><td>3,024</td><td>- 1,601</td></tr>
</table>

The results showed that investment into roof insulation is most cost-effective and indeed the only viable measure according to the NPV analysis.

The level of behavioural adaptation allows the Maltese people to use much less energy in their homes than would otherwise be required according to calculations. In fact, we know from the studies referred to above that although indoor temperatures in Malta are far outside those recommended by the BRO, only 14% of the people stated that they could not heat their homes properly in winter. As the thermal conditions revealed in the studies are not specific to low-income but to general households and all types of dwellings in Malta, it can be concluded that 86% of the households do not heat/cool their homes enough even though they could apparently afford it. This suggests that people are used to non-ideal indoor conditions, accept the situation, and find ways to adapt to such temperatures.

Acceptance of the present thermal situation in dwellings may stem from lack of knowledge that appropriate solutions exist. However, proposed policies should arguably not interfere with present adaptation levels if residents are truly comfortable under current indoor conditions. For instance, if 27°C instead of the recommended 25°C in summer are perceived as tolerable, a change in such perception would be counterproductive to energy saving measures. Indeed, air-conditioning is generally used only in extreme weather, and only by a small percentage of households.

In the last decade, double glazing has gained in popularity, and people understand that it adds value to the property. This may be partly due to it being the most 'visible' measure of the three. Furthermore, a grant administered by the Malta Resources Authority (MRA) helped promoting this measure. In addition, apertures have a shorter lifetime than walls and roofs, and are more likely to be replaced during the lifetime of a building.. A good education campaign combined with the present level of government aid should suffice. Besides, the existing grant for double glazing does not burden public funds all that much, as it is being provided as refund of VAT charged on work. Nevertheless, policy-makers should focus on supporting roof insulation, the one truly cost-effective measure for existing housing stock according to this study. Following a sensitivity test discount rates of 4% and 8%, and a reduction of 25% on the present Enemalta tariffs, retrofitting the roof with insulation results in a positive NPV in all combination except for two-storey dwellings when using a discount rate of 8% with a 25% reduction on present Enemalta tariffs.

4.1 Financial and Fiscal Instruments

Financial and fiscal instruments play a crucial role for the reduction of the economic barriers, especially with regard to large upfront investments and long payback periods associated with building refurbishment. The main grant should focus on roof insulation, however other secondary grants may be offered for benefits stated later.

Based on the calculated energy savings resulting from these measures and a discounted payback period of 5 years at micro level for the individual investor, the grants should be:

- 50% rebate on roof insulation capped at a maximum of €1,300 for all types of dwellings;
- 50% rebate on exposed single skin wall insulation capped at a maximum of €1,600 for two-storey dwellings;
- 20% rebate on exposed single skin wall insulation capped at a maximum of €300 for one-storey dwellings;
- 15.25% rebate on double glazing capped at a maximum of €1,000 for all types of dwellings;
- 15.25% rebate on exposed floor insulation capped at a maximum of €1,000 for all types of dwellings.

These suggested grants could be offered for a 7-year period, assisting towards Malta's 2020 targets and supporting the "green" construction sector while allowing adequate time for households to take up the measures.

4.2 Regulations & Enforcement

Technical Guidance F does not include any requirements for existing buildings. It needs upgrading to at least include minimum U-values of building elements forming part of existing dwellings which undergo retrofitting. These values should be in line with those in the NEEAP [7] and should be confirmed by a tailor-made study to ensure their cost-effectiveness. Retrofit measures shall only be eligible for grants if they respect the new guidance.

The U-value for elements in existing buildings should be different from those of new buildings. Germany's grant system is criticized for requiring the same standard for retrofit and new buildings. Retrofitting insulation usually necessitates additional works and is more expensive than application during initial construction.

The present energy performance certificate (EPC) system demands that in certain occasions an EPC is issued for existing buildings but fails to determine a minimum grade. To be eligible for grants, dwellings undergoing retrofit work need to achieve a minimum level of improvement. At the elapse of the seven year retrofit program, dwellings being offered for sale, rent or applying for a full planning permit and failing to obtain a minimum EPC grade will have to finance investment by themselves or face a number of penalties. Penalties may include higher property transfer tax, disqualification for ECO Reduction and higher application fees when applying for a planning permission.

Regulations are difficult to enforce within existing buildings. However, enforcement is a vital aspect of the proposed policies. Grants should not be released unless a professional auditor assesses the dwelling and confirms that the retrofit measures have been correctly installed and will result in the desired benefits. Benefits are not confined to the individual household, but each retrofit will contribute a gain to the general environment, economy and society.

4.3 Informational and educational measures

A national public education campaign would naturally aim to reach and appeal to a wide audience, spanning various age groups, income and education levels. This may include traditional advertising channels from billboards to leaflets, printed mass media to local television and radio stations. Expert discussions and adverts would explain the benefits for the individual, the environment and the larger community. The initial aim would be to create public awareness of, and interest in, thermal retrofitting. Grants can be expected to create demand for adequate products, and in response suppliers would react by introducing such products to meet demand. A 7 year grant provided by the government would give some security to suppliers/businesses to invest in this sector.

4.4 Financing of the proposed policies

The 57,000 interventions being projected for roof insulation will generate a total of €152.5Million in the local construction industry. The proposed programme could be jointly financed by the Maltese government, the private sector and EU funds.

4.4.1 State Contribution

The government's total contribution could be €72.44million (excluding VAT). Spreading the programme over 7 years, the average yearly state contribution stands at €10.35 million. In addition, it is suggested that secondary grants are offered. Apart from the grants themselves, these schemes need administration, implementation, processing and auditing. The funds required for these grants should be in line with the scheme offered in 2012 for roof insulation and double glazing, which cost €400,000. [8]

Upgrading the building minimum requirements and their enforcement, in particular, will also represent a cost to the state. For BRO to be able to take up the work load associated with these policies, its organisation and workforce has to be increased.

An extensive public educational and information campaign which calls for mobilisation of mass media, individual household audits and an intense programme at schools, would bear a considerable expense on the state.

It would be difficult to quantify all the expenses associated with these policies, but past national campaigns may shed some light on the costs involved. A very successful scheme was the 2007 rebate on energy efficient domestic appliances. The scheme enabled consumers to claim a 20% rebate - up to €116.46 - on energy-efficient domestic appliances. The original budget for the scheme was €1.8million, €1.3million of which was provided by EU funds. However, the scheme was so successful that it was oversubscribed by a further €80,000. This brought the total amount handed out to consumers to €1.88 million.[9]

Setting up an Energy Efficiency Fund would have the advantage of spreading the cost on the largest base possible, although the final consumer would in most cases carry the cost indirectly. Energy efficiency funds offer more flexibility in promoting innovative technologies and solutions than other financing mechanisms. They are also slightly more independent from state budgets which can dry up in times of economic downturns.

4.4.2 EU Funding

A total of €776 million worth of EU funds has been allocated to Cohesion Policy 2014-2020 for Malta. [10] In more developed and transitional regions, at least 80 % of ERDF resources at national level have to be allocated to energy efficiency and renewables, innovation and SME support, of which at least 20 % should be allocated to energy efficiency and renewables. [11] In the field of environment, the Cohesion Fund will support investment in climate change adaptation and risk prevention as well as investment in the water and waste sectors, and the urban environment.

4.4.3 Private sector

The private sector's annual share of investment towards the proposed retrofit programme would be €9.6million for roof and a further €2.6million for secondary measures. The construction industry had a gross value added of €218.7million in 2011 (Central bank 2012 annual report) [12] and so the total €12.2million required is just 5.5% of the total value of construction. One is also encouraged by the investment households are expected to do in 2013/2014 in the renewable energy sector of €21 million for photovoltaic panels and €1.5million in solar water heaters. As investment in thermal retrofitting will be competing with RES investments for disposable household income, policies promoting the one or the other need to be orchestrated to avoid a scenario where one scheme flourishes at the expense of the other.

4.5 Benefits of implementing energy saving measures

4.5.1. Contribution towards EU Targets and Directives Obligations

Retrofitting dwellings will help Malta to achieve the targets set out in the following three EC directives: -

- Energy Efficiency Directive 2006/32/EC;
- Renewable Energy Directive (2009/28/EC);
- Energy Performance of Buildings Directive (EPBD) of 2002 (2002/91/EC) and the EPBD recast of 2010 (2010/31/EC);

4.5.2 Reduction in CO_2 Emissions & Pollution in an effort to combat Climate change

Electricity generation accounts for about 64% of all of Malta's greenhouse gas emissions in terms of CO_2 equivalent. Using the (latest revised) 2011 figure of 1.94 million tonnes of carbon dioxide emissions to produce 2.18 TWh of electricity at Enemalta's Delimara and Marsa power stations, results in a factor of 0.889 $kgCO_2$ emitted for every kWh generated. As explained in a previous publication [13], this figure needs to be adjusted for self-consumption of power stations (5.7% of generated electricity in 2011) and distribution losses in order to get the more relevant figure for CO_2 emitted at the power stations per kWh of electricity used at the consumer end. Though Eurostat data shows "distribution losses" as 11.7% of total net electricity production for 2011, much of this is attributed to non-technical "losses" (including theft), and an estimated 4.6% of technical transmission and distribution losses has been used to calculate a factor of 0.989 $kgCO_2$ emitted for every kWh of electricity used by final consumers. This will be slashed once gas-fueled electricity generation will commence at Delimara, and the remaining parts of the Marsa power plant retire. An emissions factor of 0.344kg CO_2/kWh may be assumed for the modern ElectroGas plant as well as the gas-converted Delimara extension that would combined account for a generation capacity of 359 MW and would dominate generation in Malta. Ignoring further generation emissions by assuming that the remainder of electricity demand will be served by imports through the new interconnector to Sicily, and assuming that power plant self-consumption and distribution losses will remain the same, we would get a figure of 0.383 $kgCO_2$/kWh as a rough estimate of CO_2 emitted in Malta per kWh of electricity used by consumers by the end of 2015.

Taking into account ODYSSEE/MURE project's estimate that 10% of the energy consumed by Maltese households is used for space conditioning [14], we can state that 57,125MWh were consumed in 2010 for space conditioning. The same ODYSSEE/MURE project also states that in 2005, the average Maltese dwelling consumed 550 kWh for air conditioning. Therefore 76,548MWh were needed for air-conditioning. Taking a conservative position, the figure of 60,000MWh is taken as being used for air conditioning. The possible savings from retrofitting our dwellings, by roof insulation is 45.5% of 60GWh, i.e. 27.3GWh, Taking the possible saving of 27,300 MWh of electricity used for space conditioning, the maximum CO_2 emissions that could be avoided was 27.0 kilotons with the former power plants, or 10.5 kilotons with the new Delimara gas power plants.

Retrofitting would decrease emissions even further, since it also affects the amount of LPG gas used for heating purposes. The LPG in the heat generation in the domestic sector stood at around 16,000 toe in 2010, and was projected to increase to ca. 20,000 toe by 2020 [15]. With one toe being equivalent to $1.163x10^4$ kWh, and a factor of 0.2147 $kgCO_2$ per kWh for LPG, 39.95 kilotons of CO_2 would have been emitted for heat generation in households in 2010.

Compared to total national greenhouse gas emissions of 3.0212 million tonnes of CO_2 equivalent (2011) [16], retrofitting can save up to 1.2%. This is made up from 0.89% reduction in emissions from electricity and 0.32% from LPG consumption.

4.5.3. Reduction in Energy Bills

According to NEEAP, roof insulation alone will save 260kWh for a dwelling with a 55sqm of roof, i.e. 4.7 kWh per sqm. On the other hand, the pilot study at Triq il-Ftieh, B'kara projected a saving of 11,000 kWh for a roof of approx. 500sqm, i.e. 22kWh per sqm [17]. For a 100sqm typical roof, the saved energy would range from 470kWh to 2,200kWh and money wise at 17.3c/kWh: from €81.31 to €380.6 p.a.

Referring to the calculation of normal space conditioning required for our dwellings, a saving of €264.87 is estimated. This is based on the average household saving of 45.5% of electricity consumption for space conditioning. Thermal retrofitting of Maltese homes will also counteract a possible future trend of seeking greater comfort through increased energy use.

4.5.4. Higher Property Value

It would be difficult to estimate how much thermal retrofitting would add to the property market value. An annual investment of some €24 million would represent no more than 0.084% of the net value of €28.65 billion of Malta's entire housing stock in 2004 [18]. However, buildings are a main asset to both individuals and the nation. Should an investment in retrofitting, perhaps with some degree of associated refurbishment, increase the combined net monetary housing value even slightly, it would render such investment worthwhile judging by this criteria on its own.

4.5.5 Employment and local industry

In 2011, the construction industry in Malta employed 12,051 people or 8.1% of the total employed population [12]. An additional annual investment of €24 million would reflect an investment increase of 11.0%, and if employment would increase proportionally, an additional 1,326 jobs would be created.

According to a 2005 report compiled by ECOFYS for EURIMA, every additional €35,000 in turnover results in one additional job. Based on this figure, the thermal retrofit investment discussed will generate 686 new jobs, which still means an increase of 5.7% over the 2011 workforce in the construction industry. [19]

4.5.6 Social impact of policy measures for the building sector

Rising energy prices impact lowest-income households the most. Various EU Member States have attempted to counterbalance this effect through targeted subsidies, but this is not considered a sustainable option in the long run and on a larger scale. Energy efficiency improvements, on the other hand, would serve as a better means to combat fuel poverty. However, mobilising the upfront-investments has strong distributional aspects and may not be possible for low-income households. Energy efficiency policies therefore have to be designed in a way that allows low-income households to undertake the necessary investments or put the burden on stronger investors.

4.5.7. Health and Thermal Comfort Improvement

Our dwellings offer little protection from outdoor temperatures. Limited use of space conditioning, while keeping our utility bills low, deters our living conditions. A thermal retrofit programme will definitely achieve more in comfort than in financial savings.

Health benefits is an ''externality' offered by better insulation, and provides spill-over benefits to the wider community in the same way that an effective public health system generates social benefits. To the extent that insulation also lowers energy use, it generates environmental benefits (less air and water pollution, lower greenhouse gas emissions) and again, such benefits accrue to the wider community.

5 CONCLUSION

It has been demonstrated that a simultaneous introduction of all investigated retrofitting measures would render the investment non cost-effective. In fact, roof insulation has been identified as the only cost effective measure in the context of this study using a NPV ranking method. It is imperative to state that this measure by itself will not create the same thermal performance results as an approach targeting a building as a whole, or the passive house design, for instance. However, roof insulation will nevertheless create a significantly more comfortable and healthy indoor environment. Given that over half of the Maltese households do not have an air conditioner installed, the proposed measure will make a great difference by bringing the indoor temperatures closer to the acceptable comfort range.

Retrofitting roof insulation is considered financially viable and has a payback period of 17 years in single storey dwellings and 24 years in two-storey dwellings. Based on the data available, for such payback periods and taking into consideration the remaining lifetime of existing dwellings, the number of possible interventions adds up to 57,000, and will generate a total revenue of almost €152.5 million for the local construction industry.

This investment may be funded through a combination of private financing, national public contributions and EU funds. It is suggested that an Energy Efficiency Fund is set up for this purpose. A policy mix of fiscal instruments, regulations, training programmes and educational campaigns shall be needed to achieve the desired results.

Proper government incentives may not only induce environmental benefits by reducing CO_2 emissions, but will also create jobs in the construction industry. Retrofitting will contribute towards the achievement of EU targets and the fulfilment of directives' obligations. In addition, a successful policy will create healthier indoor living conditions for Maltese families with a subsequent reduction of public health spending. Encouraging people to invest in thermal upgrading of their homes will also help reducing the burden of electricity bills and thus help especially low-income households, while the property value is increased.

Policies advocating the thermal upgrade of existing Maltese housing stock will put the country in a strong position in the face of future challenges of sustainability.

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