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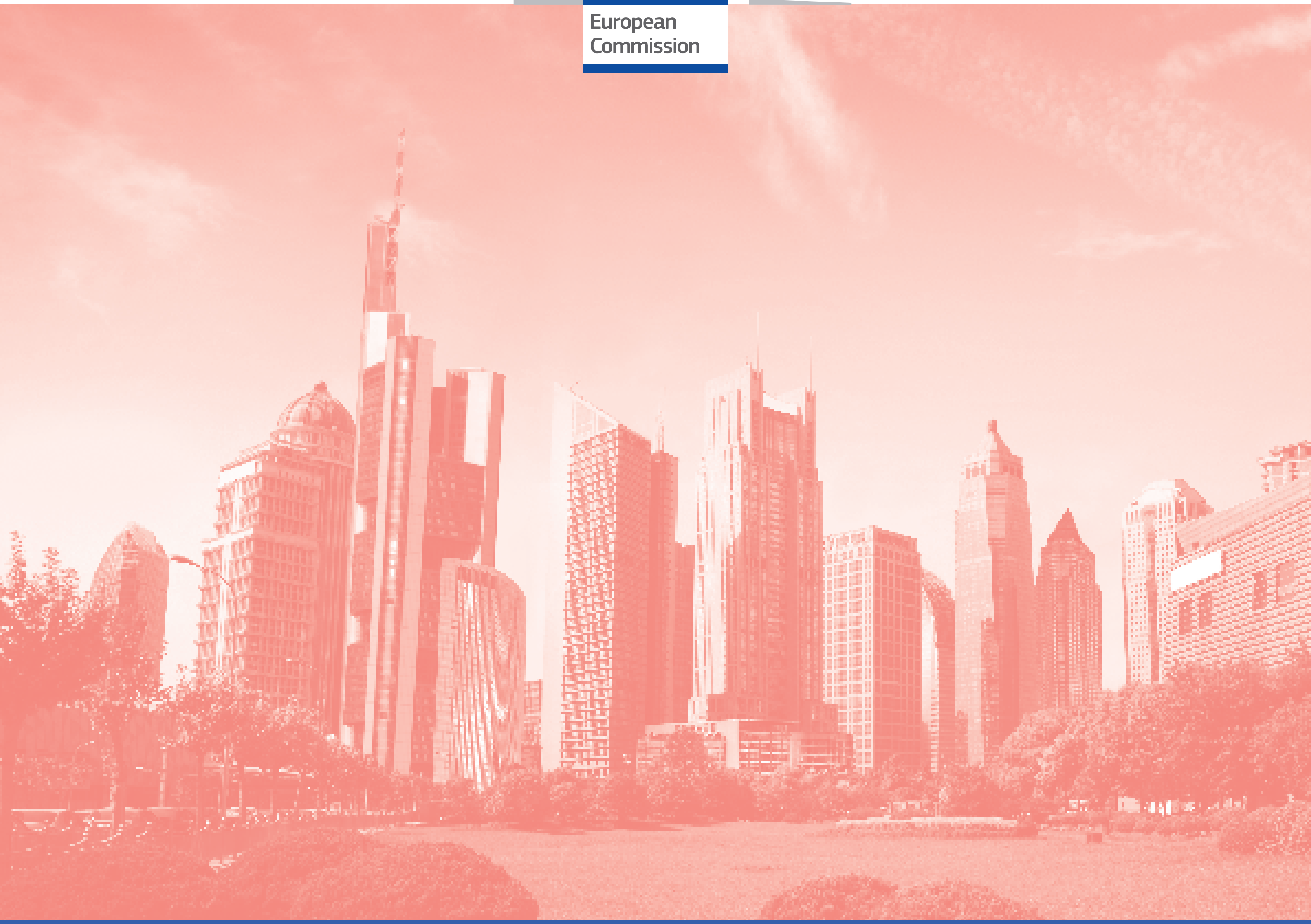

Smart Cities

Stakeholder Platform

Advanced Materials for Energy Efficient Buildings

SusChem
European Technology Platform For
SUSTAINABLE CHEMISTRY

Smart Cities
and Communities

Key to Innovation Integrated Solution

Innovative Chemistry
for Energy Efficiency of Buildings in Smart Cities

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TABLE OF CONTENTS

0. Introduction

Presently, cities are key to meet sustainability objectives in the European Union. Today, almost 75% of European habitants live in cities and this trend will continue growing in the following years. Cities actually are crucial for social, economical and entrepreneurial development of the European Union[01]. To succeed in creating sustainable and healthy cities, the Covenant of Mayors was launched in 2008 to support local authorities to implement sustainability policies. Currently, 4.418 cities have committed to meet the 20-20-20 objectives (20% reduction in emissions, 20% renewable energies and 20% improvement in energy efficiency) by 2020. Actually, the majority of cities have committed to increase energy efficiency by improving buildings, equipment and facilities' performance and by working with citizens and related stakeholders[02].

However, cities are facing several challenges to meet the 20-20-20 targets. The major challenge is the growing urban population and the foreseen increase of energy consumption per capita. Another challenge is the age of the European building stock in itself, which was built predominantly in the 60's - 80's when building insulation was not common and sustainable living was not a main concern.

In addition, most policy makers are not fully aware of all existing technologies and their real performance in energy efficiency in buildings. On the other hand, solution providers are developing green technologies that are not always fully fitted to the reality of today's cities. Modern and sustainable cities could be viewed as a large complex system in which both existing and new infrastructure and technologies are integrated into urban ecosystems (citizens, transport, buildings and green areas). For citizens, comfort and health may be even more important objectives than sustainability.

The Key Innovations (KIs) are a key output of the Smart Cities Stakeholder Platform. The Platform promotes innovation and is part of the Smart Cities and Communities European Innovation Partnership of the European Union. It aims to accelerate the development and market deployment of energy efficiency and low-carbon technology applications in the urban environment. The main focus: integrating technologies, financing and value chains to offer viable solutions to the challenges European cities face. The Platform brings together municipalities, technology providers, financiers and specialists in implementing smart city strategies at local level.

Within the EIP on SC&C, several expert Working Groups (on Energy Efficiency and Buildings, on Energy Supply and on Networks and Mobility and Transport) have selected from the spectrum of Solution Proposals (SPs) submitted by stakeholders[03] the most promising and fundamental solutions to accelerate the development of smart cities. The most promising solutions are referred to as the Key Innovations or KI. This particular document you are now reading presents one such KI, as

01 EU (2011): Cities of tomorrow. Challenges visions, ways forward.

02 www.convenantofmayors.eu

03 Solution proposals are published on the web site: www.eu-smartcities.eu/ solution-proposals

proposed by the European Technology Platform (ETP) on Sustainable Chemistry: Suschem.

Suschem represents all stakeholders from the chemical sector, which includes besides the well known large multinationals a large amount of SMEs, research centres and academia. Chemistry stands at the basis of many innovations and often has been a driver for change, even though its innovation accomplishments are often not highly visible, nor well recognized. Through this KI document, the chemical sector intends to draw attention to a selection of presently available chemistry-enabled products which can be applied in buildings today, especially when considering the refurbishment of existing buildings. The chemical sector strongly believes that it can help Smart Cities to achieve their objectives, collaborating closely with the entire value chain and of course with the cities themselves.

This document offers a first introduction to cities on the performance of the key innovation package proposed, its technical characteristics, as well as conditions for their optimal use such as the availability of, technical expertise, regulatory frameworks and financial costs involved. The document aims to help promote the adoption of the Key Innovations and to help identify and remove barriers to deployment. It is intended as a starting point for further dialogue between the demand side (cities) and the supply side (where chemical industry works together with the entire building value chain).

Key Innovations will be an integral part of the recommendations of the roadway being drafted by Smart Cities Stakeholder Platform. These include recommendations on necessary action at European level required to promote the adoption of key innovations, such as the removal of regulatory barriers as well as recommendations on the focus of the Horizon 2020 support.

It is important to stress that this document is not a technical proposal or full evaluation of the innovations presented - it has been developed to help cities identify potential solutions, allowing them to then take subsequent steps to detail the possibilities in their specific situation and outlook. It does not exempt or substitute a detailed cost/benefit analysis or implementation plan that would need to be developed for cities that wish to introduce the innovations proposed.

The present economic climate in Europe (and most of the rest of the world) does not make it easy to mobilize the needed investments. Exactly because of this, it will be important for Smart Cities to choose well which solutions they adopt, which investment recovery timeframes they can argue to investors and property owners. Suschem feels that its members have a portfolio of solutions that are ready for large scale market uptake, that offer financial feasibility and practical feasibility both in new buildings as well as in the top priority of existing building refurbishment.

Review of Europe's building stock

Europe contains some 160 million buildings, as estimated by experts of the ECTP (European Construction Technology Platform). Only some 65.000 are presently estimated to be so called Passive House buildings, this represents a mere 0,04% of the total stock. Only part of the Passive House[04] buildings actually incorporate one or more of the proposed technologies in this document. Which means, that the presently achieved impact is close to nothing compared to the impact we foresee in case these Suschem proposed solutions would be adopted on a large scale by European Smart Cities.

Today, annually about 1% of the existing building stock is built new (which represents 1,6 million buildings in the EU27 member states). At the same time, some 1,7% of the existing building stock is refurbished annually (including all kinds of refurbishments from 'light' to 'deep' interventions). Most policy supporting studies of recent years put the required (to reach EU objectives) refurbishment rate at 3% of building stock, which would mean doubling the present rate of 1,7%. Multiplying

04 Refers to a voluntary standard for energy efficiency in buildings.

refurbishment rates will not only require substantial regulatory streamlining but also selection of easy-to-implement technologies such as some of the ones proposed by Suschem here.

A recent study by Buildings Performance Institute Europe (BPEI)[05] (from which the graphs and tables below have been extracted) has made an inventory in terms of total m² of buildings, which leads to the following summarized numbers (**TABLE 1**).

Half of the total estimated European floor space is placed in the northern and western countries while 36% accounts for southern countries. The rest (14%) is located in central and east regions.

It is interesting to note that while energy consumption in residential buildings has dropped across Europe, the commercial buildings have actually increased by 74% their energy consumption over the last 20 years. The breakdown between residential and non-residential is shown in **GRAPH 1**.

With average energy consumption of 280 kWh per m² in non-residential buildings (with a floor space of 6,25 billion of m² in Europe) and residential buildings (with a 18,75 billion m² of floor space) consuming some 40% less (170 kWh/m²/y) one can easily calculate how much energy is consumed, and also how much would be saved if we could shave off 40% of that amount across Europe.

In general, buildings have improved over the years in terms of energy efficiency; which means that older buildings (if not renovated before) have more potential for improvement than newer buildings. BPEI has broken down the age of the buildings in Europe (**GRAPH 2**).

Conclusion here is that the vast majority of the building stock dates from before 1990, which is now 22 years ago. Some 40-50% of the building stock is pre-1960, and would benefit substantially from relatively feasible energy efficiency measures such as the ones proposed by this paper.

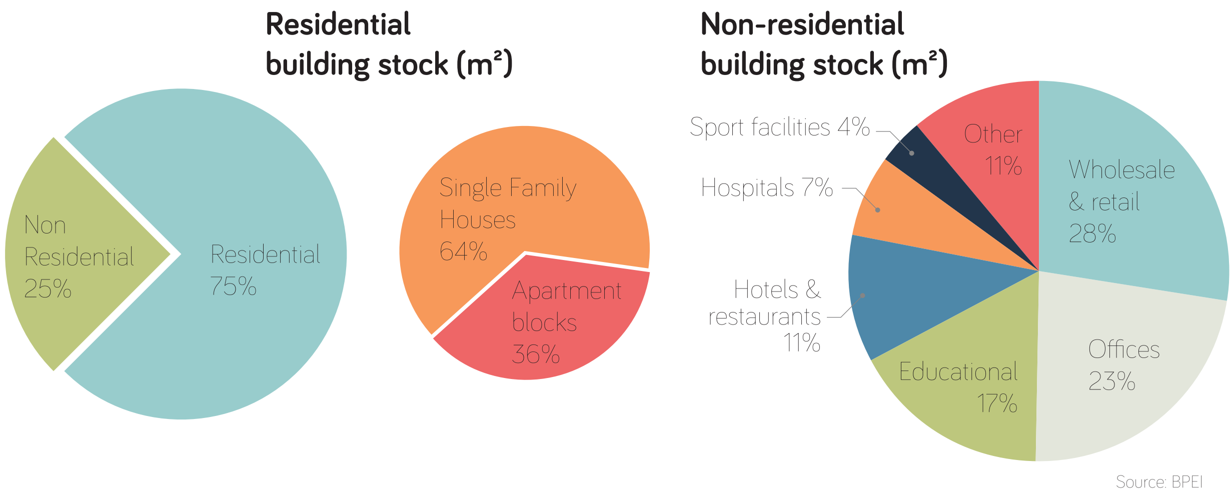
TABLE 1 - Global building floor space

	Population (2010)	Land area (km²)	Building Floor Space
EU27	501 million	4.324.782	24 billion m²
US	309 million	9.826.675	25 billion m²
China	1338 million	9.598.080	35 million m²

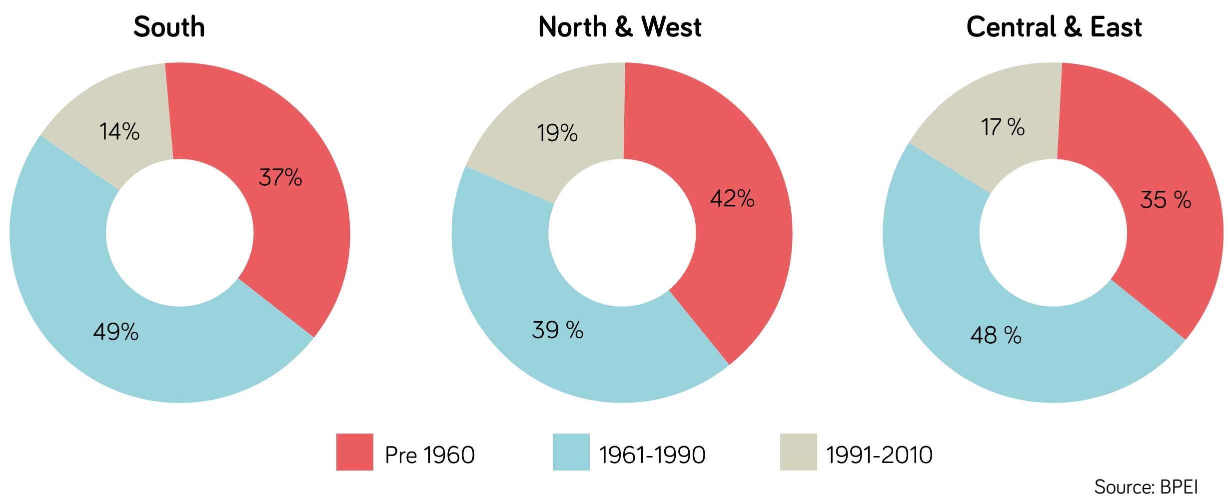
Source: BPEI

05 BPEI (2011): Europe'sbuildings under the microscope. A country-by-country review of the energy performance of buildings.

GRAPH 1 - European Buildings at a Glance



GRAPH 2 - Age Categorisation of Housing Stock in Europe into three regions



1. Presentation Of The Key Innovation

1.1 Description of the innovation and rationale for selection

When assessing the key challenges of cities to become Smart Cities, the area of energy efficiency in buildings should be addressed taking into account the fundamental differences between new buildings (the ones which are to be built now and in the future) and the existing building stock (all buildings that are found in cities today). For new buildings, many assessments and actual building projects exist that show that the added cost of reaching close to 'zero emission' buildings normally does not need to exceed the cost of 'normal' building by more than 8%. This very limited price penalty is in most markets compensated by the higher value that building buyers (or developers, or tenants) put on such a new building. For this reason, most experts agree that the market dynamics in combination with regulatory pressure on new buildings will drive the industry to predominantly produce near zero emission buildings from 2016 onwards. However, annually just about 1% of the existing building stock is added as new buildings.

If we do not wish to wait until the natural lifecycle of new buildings replacing old ones takes care of making all buildings 'near zero emission' (which would take 100 years at 1% being replaced per year), then we need to address also the refurbishment of buildings. It is however in the refurbishment of existing building stock that the business case often becomes more challenging. Costs of deep refurbishment of buildings including substantial energy efficiency measures can cost from a few hundred euros / m² up to close to €1.000 / m². The latter cost level (€1.000 / m²) is actually close (or beyond) the cost of building a new building from scratch in some parts of Europe (for example, in mid sized cities in Spain – in London the new build costs are closer to €2.000 / m²). Thus, in order to address the huge challenge of affordable building refurbishment to achieve substantial energy savings while investing a sensible amount of money, we need to very carefully select interventions in the building that are especially cost effective. It is exactly here that we feel that the chemical industry offers some very attractive solutions that when combined can really offer substantial energy savings at an acceptable investment (and minimal disruption of building use).

Concretely we propose to combine five solutions from the chemical industry that can bring significant energy savings:

1. Reflective indoor coatings
2. High reflectance and durable outdoor coating
3. Phase Change Materials (PCM)
4. New insulation foams
5. Other insulation modules

1. Reflective indoor coatings

By reflecting light better than normal paints, these coatings maximize the feeling of space and illumination. This in turn allows reducing the amount of energy used for artificial lighting and/or increases the perceived illumination by natural light.

These coatings optimize the use of natural and artificial lighting (increased perceived light up 20%, or 20% energy reduction for the same light perception) and can help keep sunshine radiation heat inside the building in wintertime. In recent tests, reflective indoor coatings have shown a life expectancy of 5-10 years without losing any performance. The cost of these coatings is only marginally higher than that of 'normal' good quality paints. The effect of using these coatings is highest in climate zones which suffer from limited daylight intensity and duration (North and middle Europe).

2. High reflectance and durable outdoor coatings

These coatings reflect sunlight radiation both in the visible and infrared parts of the spectrum. When applied to roofs and walls, the reflection of the sun's energy reduces roof and wall temperature and as a consequence also reduces the heating of spaces underneath the roof and inside the walls.

High reflectance and durable outdoor coatings applicable on building roofs and walls in hotter climate regions can save up to 15% of air conditioning energy consumption while also allowing for downscaling the size of the air conditioning system. Life expectancy of this technology is 12-15 years depending on the climate.

Costs of applying these coatings are affordable and offer reasonable payback times. In case a roof needs re-painting anyway for maintenance reasons, then choosing a high quality, low LCA solar reflecting paint is an obvious smart choice especially in sunny, Southern European cities.

3. Phase Change Materials

PCM are available on the market as an active ingredient of a range of semi-finished materials: plaster, cement, plasterboard and multifunctional wall and roof modules. When used in (interior) walls and/or ceilings, the PCM enables such walls and ceilings to absorb and store excessive heat during the day, in order to dissipate that excessive heat during the night when air temperatures have gone down. PCM basically increase the thermal inertia of the wall and ceilings, making them behave like the old-fashioned thick stone walls found in buildings of hundreds of years ago. As such, PCM containing walls and ceilings reduce fluctuations of the inside temperature (especially reducing the amount of hours that the inside temperature exceeds 26°C which is normally the threshold to initiate active cooling) and thus save energy (**GRAPH 3**).

In recent tests, PCM has demonstrated to have a life expectancy of 30 years without losing any performance. In concrete cases, it has been shown that up to 10% of cooling energy can be saved. In addition the PCM allows downsizing of the air conditioning (AC) system which reduces the investment required for this AC system.

4. Advanced insulation foams

Advanced insulation foams with high insulation performances allow significant energy savings and can be adapted to different building's configurations. It is estimated that these high performance foams can reduce the energy costs for heating by 30%-80%.

1. INSULATION IN WALL CAVITIES

Cavity wall insulation fills the space (cavity) between the two layers of the external wall of a building.

As illustrated in **Figure 1**, an existing building's wall cavity can be injected with foam as part of an energy efficiency refurbishment. In case of new construction, normally the cavity is filled up using rigid pre-foamed panels attached to the wall.

2. EXTERNAL INSULATION

In cases where no wall cavity is present, one can opt to insulate the external walls of the building from the outside. This approach maintains the thermal storage capacity (thermal inertia) of the building external walls, thus keeping temperature fluctuations at acceptable

GRAPH 3. PCM system make temperature more constant

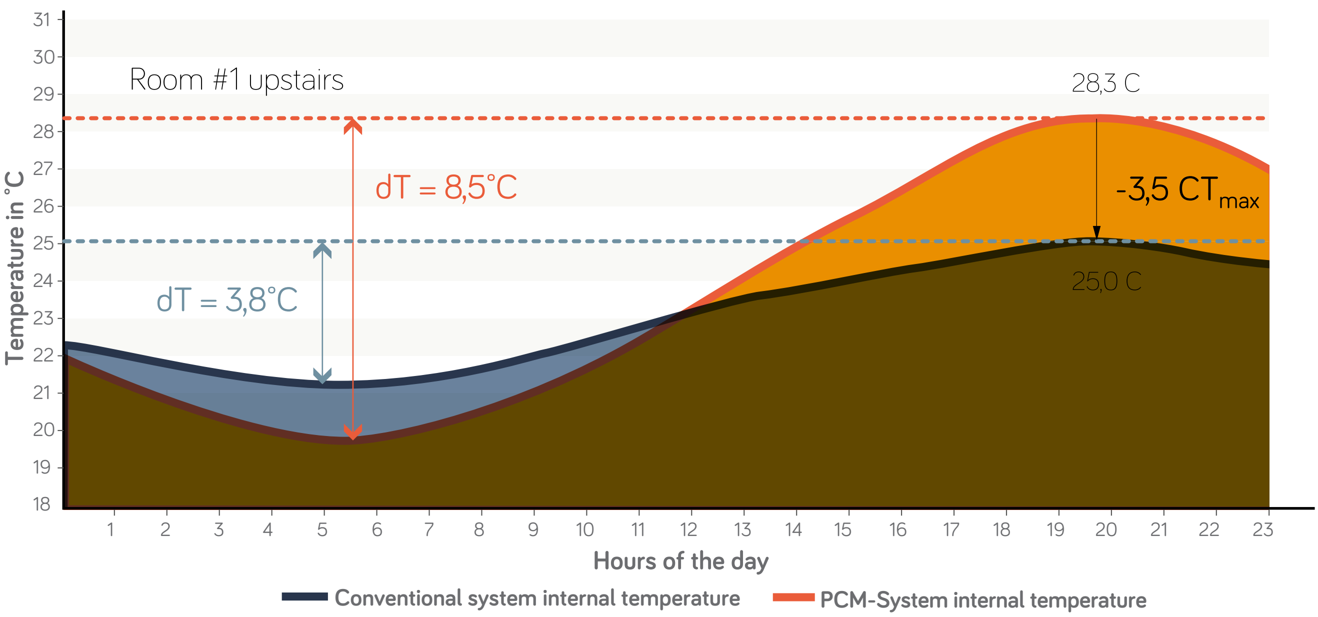
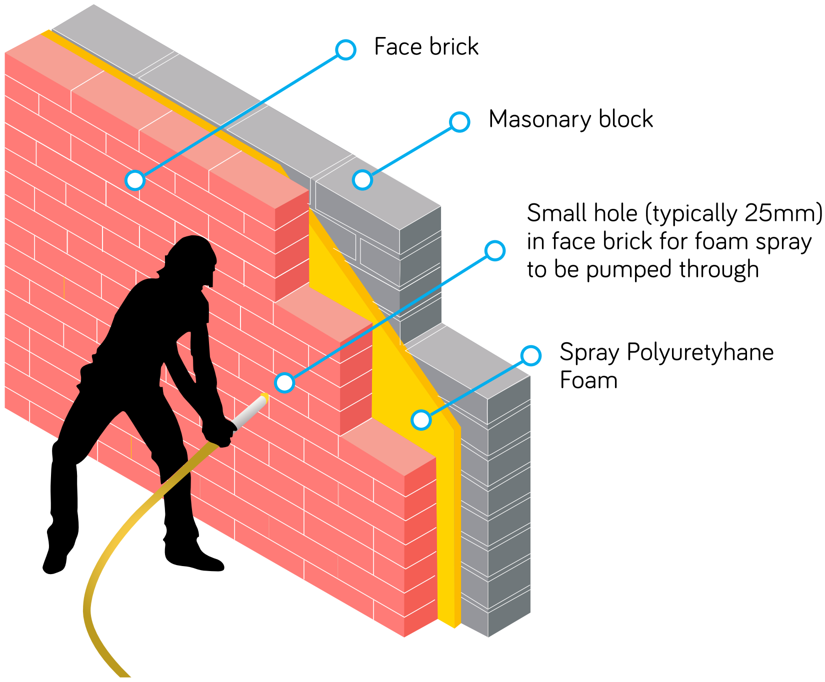
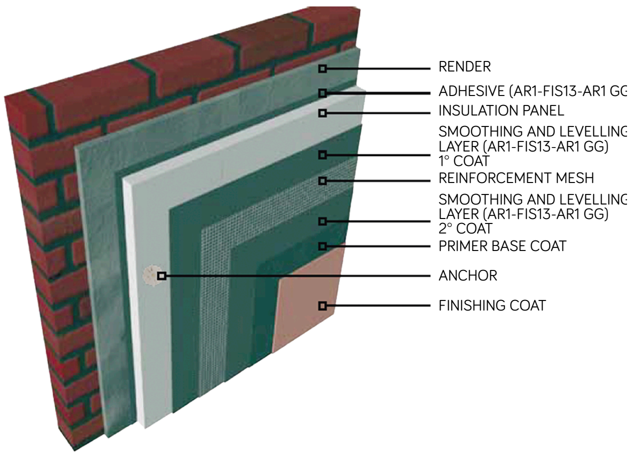


Figure 1. Cavity wall insulation



levels. Each insulation 'stack' is composed according to the specific wall characteristics, climate and orientation of the building. Apart from the thermal insulation performance level, other material selection criteria include fire resistance, mechanical strength, stability, water absorption, permeability and cost. For most applications, the lifetime expectancy of these insulation facade systems is up to 20 years [**Figure 2**].

Figure 2. External wall insulation



3. INTERNAL INSULATION

In case of historical façades as often found in Europe's older inner cities, buildings can also be insulated from the inside. By applying a layer of high performance insulation foam covered with for example plaster or plasterboard, this approach does not alter the external appearance of a building. Obvious disadvantages include a loss of net interior space (the thickness of the insulation layers) as well as an effect opposite to that of PCM: by insulating the interior space from the dampening effect of the stone walls, the thermal inertia of the interior is actually reduced, making the interior susceptible to stronger fluctuations under certain climate conditions.

5. Vacuum insulation panel (VIP) modules

Vacuum insulation panel (VIP) modules provide design freedom when refurbishing glass facade buildings. Their insulation performance is some three times higher than conventional insulation materials. Until recently, VIP were seldom used in buildings due to their fragility and the risk of damaging the vacuum by perforation. However recent products encapsulate the vacuum inside a double glazing package, allowing their use in glass-intensive building facades that need a strong improvement of their thermal insulation performance. VIP at the moment is still substantially more expensive than conventional insulation materials, among other reasons because they are still in the introduction phase. Therefore, with an increased market uptake the market price can be expected to come down[06].

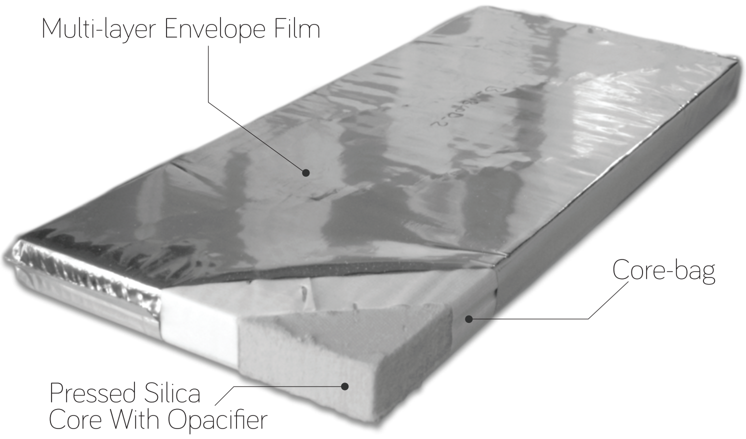
In the **Figure 3** the main components of a VIP can be seen:

VIP with fumed silica core has an average of 0,004 W/(m·K) in thermal conductivity. Thermal bridges created through panel edges with aluminized films increase the mean thermal conductivity of VIP. These technologies provide long-term insulation performance, with very limited loss of efficiency (20%) over the first 30 years of installed use.

The combination of these five technologies could on average result in overall energy savings for heating and air-conditioning of >40%. The exact amount of savings will depend very much on the type and location of the building.

NOTE: It is important that these technologies be integrated as part of the global (re)design of the building; for instance a building with issues of thermal bridging will only benefit fully of these high performance materials if such thermal bridges are addressed during refurbishment.

Figure 3. Vacuum Insulation Modules



06 Vacuum insulation in the building sector: Systems and Applications. Information can be found in: http://www.ecbcs.org/docs/Annex_39_Report_Subtask-B.pdf

1.2 Technical feasibility and viability

The five proposed solutions all have reached a stage of innovation maturity that proves their technical feasibility and maturity. They have reached reliable performance, robustness under normal operating conditions and also are sufficiently easy to handle to allow normal trained construction workers to apply them successfully.

Especially the application of thermal reflection coatings and / or light reflection coatings is a fairly straightforward process. The application of PCM usually involves using plaster, aerated cement or plasterboard that incorporates PCM particles, and thus the application process is equal to that of normal plaster application, fairly straightforward as a traditional discipline in the construction industry.

The explained insulation systems have been applied for decades in certain countries and efficient application methods are available for any existing building type.

The application of the VIP panels packaged in double pane glass modules is the least wide-spread technology; however also for this product category several success cases can be shown that demonstrate the technical feasibility and viability.

2. Impacts

2.1 Achieved Impacts

Level of deployment

Presently (2012-2013) these technologies have been deployed in some hundreds of buildings all over the world, both in new build as well as in refurbishment. For insulation foam solutions the numbers even run in the hundreds of thousands of buildings at least. For each of the solutions presented, substantial production capacity is in place to allow for larger scale adoption, but market uptake has been slow due to inertia of the traditional sectors involved and lack of awareness among decision makers. In addition, present limited market demand limits the production volumes, which results in less than ideal price levels in the marketplace, which leads to longer than necessary payback times for the additional investment related to the use of these advanced materials and coatings. As such, a typical chicken and egg situation exists: until market demand grows, prices will remain higher than what would be feasible if mass production was possible; until prices drop, market demand will be sluggish unless specific measures are taken to address this (temporary) market failure.

In **Figure 4**, an example is shown of a 1980's residential building being treated with wall cavity insulation injected into the cavity. This type of interventions has been applied for some decades now in Northern European countries, where the lower winter temperatures and longer heating season result in shorter payback times on the investment. However with present energy prices (and especially, those to be expected in the next decades) this intervention is becoming financially attractive also in the Southern parts of Europe. Chemical industry is promoting these measures using its own traditional communication channels with the market, but an active positive role of the local government could speed up adoption substantially.

With 'cool roof' coatings, again relentless R&D by the chemical industry has delivered today coatings that reflect solar radiation energy much better than normal roofs, and that keep on doing so for at least 2 decades after having been applied. It is especially this durability that has improved compared to earlier products that could not withstand the harsh climate conditions found on rooftops. **Figure 5** illustrates the typical before-after situation as well as the ease of implementation. Building inhabitants confirmed the very noticeable temperature

Figure 4. Advanced insulation foams real life example

reduction after the reflective coating had been applied.

Roof coatings have been used for the last 12 years in a wide number of buildings especially in US. The first well documented application in the South of Spain was installed in a warehouse 8 years ago.

Interior coatings are still in most cases primarily applied for esthetical reasons. Those that design interior spaces of offices and private homes alike seek freedom to select from a range of colours. Again, chemical industry has spent decades of substantial R&D efforts to come up with products that optimize the use of available light (either natural or artificial) while also delivering a freedom to choose the colour that fits best with the esthetical demands. The illustrations below (**Figure 6**) show both the natural light case (allowing for a 20% smaller window offering the same light perceived inside) as well as the artificial light case (where the coating allows to cut lighting energy consumption by 20%).

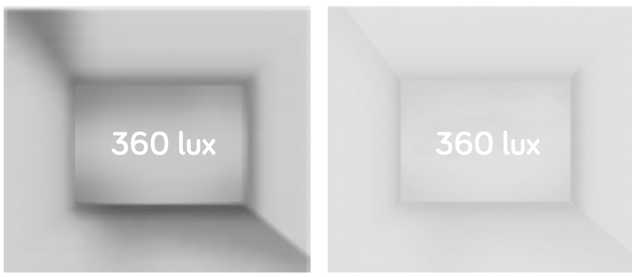
The more factual illustration **Figure 7** exemplifies the difference between a 'normal' white coating and the specific light reflective coating in a lighting research set-up. Both spaces are lit using 360 lux, but one is much brighter than the other.

Figure 6. Reflective indoor coating real life example

Perhaps the least mature solution proposed are the VIP modules. Vacuum Insulation panels were developed decades ago, but their actual market application has been limited to special high performance cases in high end professional refrigerators and deep-freezers. In the building sector VIP technology has been tried in some pilot projects, which proved that without special protection the VIP is too vulnerable to survive real life in real buildings that are inhabited by real people.

Figure 5. High reflectance and durable outdoor coatings real life example

Figure 7. Differences between Conventional coating and reflective indoor coating



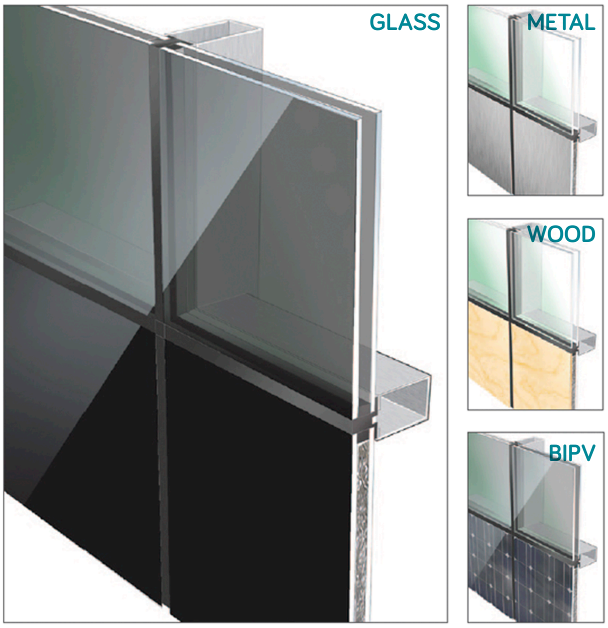
Conventional Master Palette Colors | LumiTec Technology Colors

The elegant solution of packaging such VIP into a double glazing module completely overcomes this weakness. Even though just launched into the market quite recently, already in this early stage more than 10 projects have been realized.

In **Figure 8** one can appreciate the complexity of the latest Architectural Insulation panels developed by chemical industry combining the necessary aesthetics for buildings and the energy savings benefits of VIP panels.

These examples illustrate just a few of the specific products that chemical industry suggests to Smart Cities as affordable, smart solutions to make buildings consume less energy while keeping investments levels affordable.

Figure 8. VIP innovative design



2.2 Energy savings expected

As with all technologies that reduce energy consumption of buildings, the savings to be expected are perhaps best expressed in a typical amount of kWh per year per m². Given the overall building stock energy consumption average of some 200 kWh/m² across Europe (residential and non-residential) and a possible heating/ cooling cost savings of 40%, this would amount to some 56[07] kWh/m². With electricity costing some 10-25 cents per kWh (EU median some €0,17) and gas ranging from 3 to 12 cents per kWh (EU median €0,06) one can calculate that a typical gas-heated 100 m² apartment would save 100 x 56 x €0,06 = €336 per year.

In terms of energy this would be some 5600 kWh per apartment saved per year. If we can refurbish some 180.000 apartments per year under the Smart Cities program and build also some 20.000 new ones using the proposed solutions then this would bring a total saving of 200.000 x 5600 = 1.120 million kWh.

For commercial buildings we take as an indicative example the possible target to refurbish some 10.000 office buildings of on average 5.000 m² per building, which would deliver at 40% energy reduction (40% x 0,7 x 280 kWh/m²) some 78 x 5.000 x 10.000 = 3,9 billion kWh saved annually. Assuming an average cost of €0,10 (offices pay less for their energy, but use electricity for substantial cooling) this would provide some 350 million euros of annual savings. More importantly though, if the energy efficiency measures are well integrated into a general deep refurbishment of the building, it would provide the future-proofing of these 10.000 office buildings, allowing to profitably renting them out for at least another 2 decades.

It cannot be highlighted enough that for many of these buildings (especially the commercial ones like offices) the alternative strategy to do nothing is increasingly not a realistic one. In many parts of Europe, the last decade of 2000-2010 has created an availability of office space that for years to come is expected to exceed demand. The tendencies of home working now really 'kicking in' and more and more mobility of the workforce leads to companies needing less space for their workforce, while at the same time these companies do seek increasingly sophisticated office space. Most large-scale office building owners know this and are adjusting their portfolios towards green and modern buildings; it is especially the local, smaller scale office space owner that needs to be supported in the development of an adequate strategy along similar lines. Again here municipalities can play a key role of raising awareness and supporting concrete measures that help to maintain

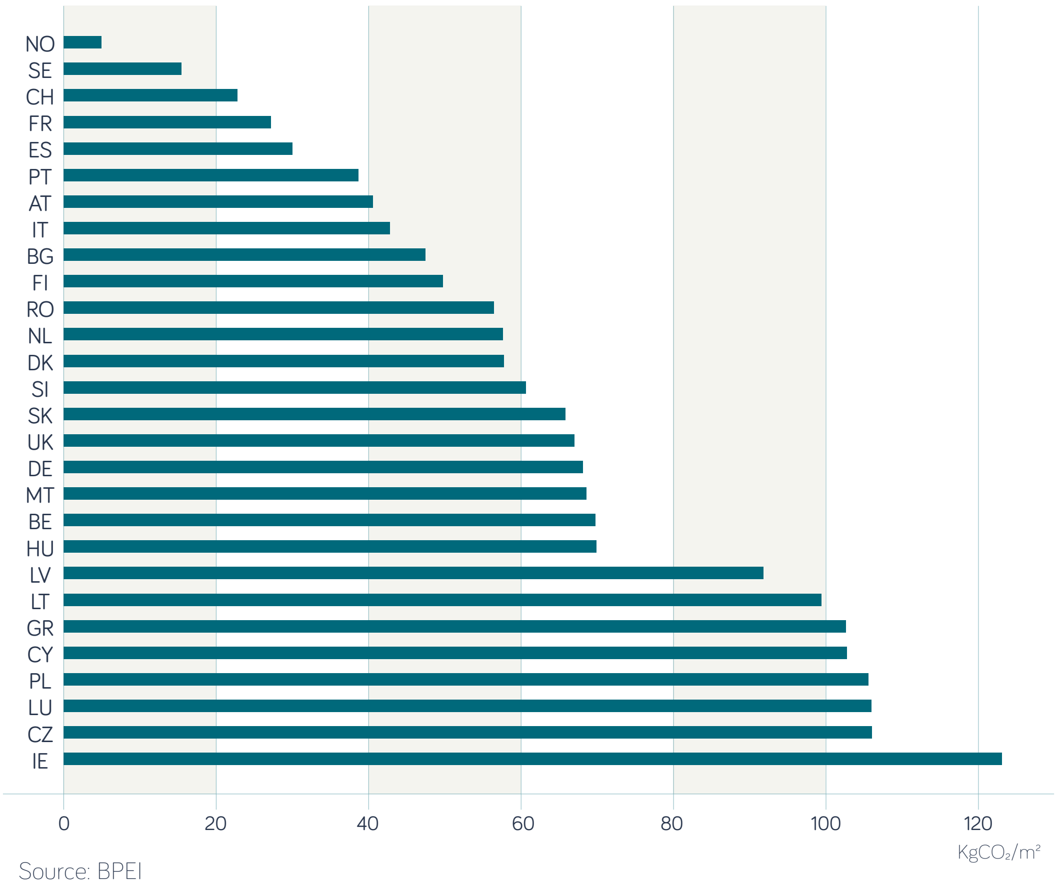
07 * Asuming 70% of overall energy consumption being used for space heating & cooling.

the available office space occupied and avoiding that empty buildings bring neighbourhoods into negative spirals of deterioration.

2.3 Expected impact on GHG emissions

GHG emission reduction associated with these energy savings depends on the energy source mix chosen. If we take the EU-27 average mix then the relationship is some 443g[08] of CO_2 per kWh saved. Thus the 180 thousand apartments impact of 1600 million KWh energy savings would deliver a reduction of CO_2 emissions of some 700 million kg (or 700.000 tons) of CO_2. Furthermore, there are some statistics available regarding how much CO_2 each country emits regarding its building stock[09]. The graph below indicates the CO_2 emissions per m² **GRAPH 4**.

GRAPH 4 CO_2 emissions per m²



Source: BPEI

08 Kg CO² /Kwh (average Europe): 443 kg CO2 (by European Commission).

09 BPIE (2011): Europe'sbuildings under the microscope. A country-by-country review of the energy performance of buildings.

As it can be seen in this graph, the richest economies tend to have the best performing buildings. We can also see the influence of climate; Mediterranean countries have lower CO_2 emissions per m² because their climate requires less heating energy. It can also be analysed that Scandinavian countries, where buildings are better insulated, have lower CO_2 pollution per m².

In average CO_2 emissions in Europe was 54 $kgCO_2$/m² per year, but actual levels vary strongly between countries.

Environmental impact of products does not only include in GHG emissions but also energy demand from non-renewable and renewable resources, acidification, eutrophication, abiotic resource depletion, photochemical oxidant formation, farm land use, ozone depletion and smog creation. In order to make a fully balanced judgment about the 'green' credentials of a certain refurbishment, data on each of these aspects needs to be taken into account. Chemical industry has worked hard to calculate this data and offer it to the value chain, allowing for well informed choices to be made.

To illustrate the complexity of the issues, we can compare the environmental impact of PUR foam, EPS foam, mineral wool and organic insulation products. Some Life Cycle Analysis (LCA) analyses were carried out (see two different articles[10]).

Based on these articles, insulation products can be ranked regarding only the non-renewable energy use, abiotic resource depletion, and global warming potential. The most appealing alternatives following the mentioned sources would be organic products, EPS Foam, PUR Foam and mineral wool. However, organic products have the highest eutrophication potential and the second highest acidification potential, and they involve the use of farm land. Mineral products score worst in land use related to mining. Mineral products need the highest density and thickness to reach the same thermal insulation as offered by chemical (foam) products. EPS foam has the lowest contribution to acidification and the highest contribution to photochemical oxidant formation. Nevertheless, PUR foam has the lowest contribution to photochemical oxidant formation. Disposal of organic and EPS foam products lead to a lower environmental impact than PUR foam and mineral products, which are primarily incinerated. As can be appreciated, simple answers are hard to give.

Other studies have performed a LCA of Vacuum Insulation Panels (VIP) comparing these to EPS foam and glass wool. The results show that VIP products have the same GWP as EPS but perform best in their use of fossil resources. In general, VIP have a more negative environmental impact in other categories such as acidification, photochemical oxidant formation, eutrophication and energy use. Most of the components of the VIP are produced in highly energy-consuming processes. However, the report concludes that environmental impact can be reduced with the increasing market uptake of Vacuum Insulation Panels[11].

2.4 Wider potential benefits for cities

The construction industry as a whole in Europe employed some 14,8 million people in 2007. Since then, the sector has destroyed employment at a fast pace. In little over one year (end of 2007-early 2009) some 8% of jobs (8 x 148.000 = 1,2 million jobs) disappeared. In some countries like Spain, more than 30% vanished over the same period. Since 2009, the economic crisis has hit even harder, especially in the construction sector, and by 2012 in Europe at least several millions of jobs have been lost. With an average added value per employee of between €30.000 and €75.000 per employee (EU 27 average around €38.000) one can easily calculate the cost of losing millions of jobs in terms of GDP. It has been argued in many studies that deep renovation of buildings can create jobs, especially for those that have construction sector skills and experience. A recent study[12] estimates that approximately 17 jobs are created per million invested in improving energy efficiency in buildings. According to EEP Impact Assessment[13] published in Brussels in 2011, European Commission estimates that up to 2 million of jobs can be created investing in energy efficiency.

It is hard to quantify the local (city) socio-economic impact of enabling large scale refurbishment interventions into the existing city building stock taking place. Besides the direct benefit of project permit

10 J. Noordegraaf, P.Matthijssen et all (2004): A comparative LCA of Building Insulation Products.

G. Sequeira (2012): Environmental impacts of the life cycle of termal insulation materials of buildings.

11 Vacuum insulation in the building sector: Systems and Applications. Information can be found in: http://www.ecbcs.org/docs/Annex_39_Report_Subtask-B.pdf

12 Urge-Vorsatz, D. (2011) et al. Employment Impacts of a Large-Scale Deep Building Energy Retrofit Programme in Hungary. Center for Climate Change and Sustainable Energy Policy - Central European University & European Climate Foundation

13 P. Sweatman (2012): Financing Mechanisms for Europe's Building Renovation, Assesment and structuring recommendations for Funding European 2020 Retrofits Targets.

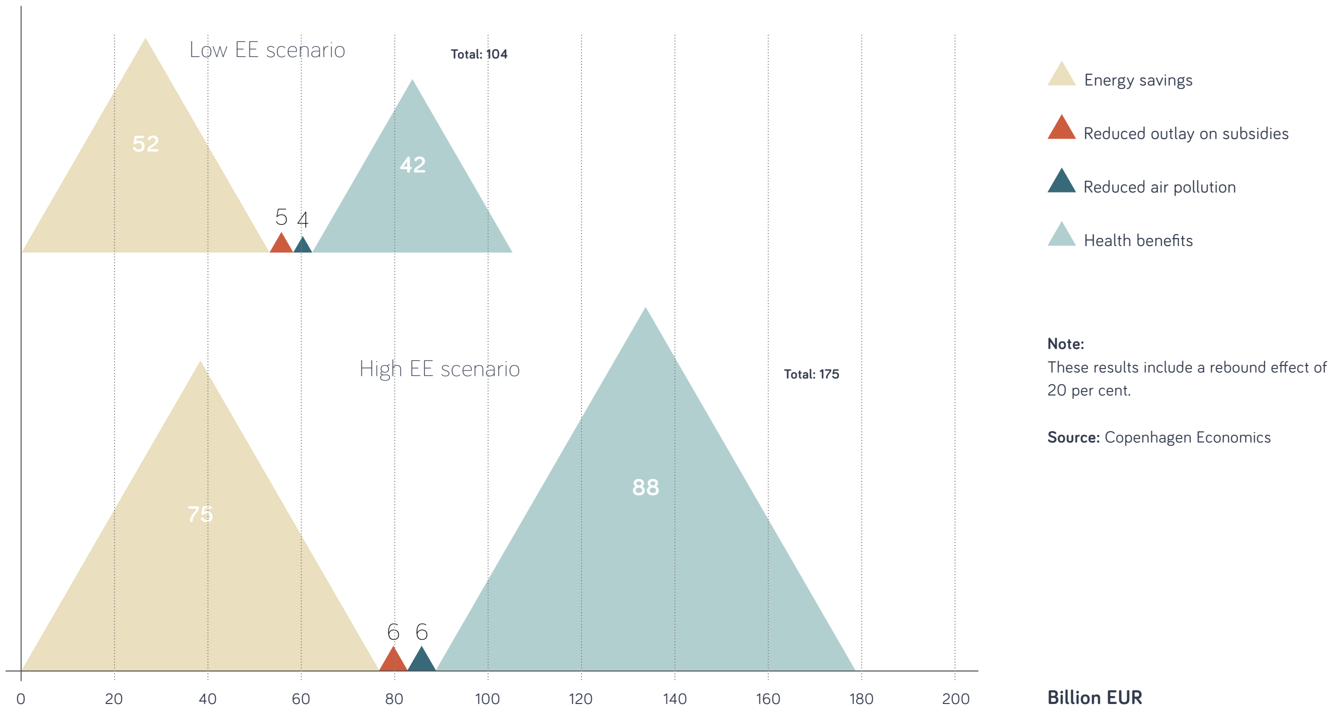
levies and taxes, the creation of local jobs and local business added turnover is clear. In addition, energy efficiency refurbishments seldom come alone; they are typically packaged into a wider range of refurbishment measures that make the buildings more attractive after refurbishment: they will contribute to a better quality of life in the neighbourhoods, to higher occupancy rates (reduced numbers of empty buildings) and they can even reduce crime and social feelings of insecurity.

According to a study carried out by Copenhagen Economics[14], refurbishment of buildings may create the needed stimulus to European economy and may also achieve some related co-benefits such as reduced expenses on government subsidies, improved health due to improved air quality in cities and better-quality indoor climate. These last two factors will lead to fewer hospitalisation and improved work productivity.

the EC- DG Energy and Transport in 2009. The 'High EE' scenario assumes full penetration of best available technologies, which would for example include all windows to be upgraded with the most efficient models on the market. The less ambitious 'low EE' scenario assumes cost-effective solutions but not necessarily the most energy efficient packages being implemented.

The above **GRAPH 5** represents calculations by energy saving, outlay on subsidies, reduction in air pollution and health benefits; these lead to health benefits which when monetized reach levels that are comparable to the benefits in terms of energy savings. Even if the assumptions made here might have led to some degree of over-estimation of these financial impacts of refurbishment in cities, we can quite safely assume that such health benefits are substantial, and that they

GRAPH 5. Annual gross benefits to society from energy efficient renovation of buildings.



The graph below (**GRAPH 5**) compares two different scenarios (Low Energy Efficiency and High Energy Efficiency) considered in an extensive study performed for

might grow as urban populations in Europe become older on average (aging population).

From the **GRAPH 5** we can see that the deep retrofitting scenario offers of course the highest energy sav-

14 Copenhagen Economics (2012): Multiple benefits of investing in energy efficient renovation of buildings.

ings and health benefits. Regarding health benefits, the model used takes into account the reduced air pollution due to CO_{2eq} reductions from power plants, heating plants and local heating production and the improved health from enhanced indoor quality air in well insulated houses. The air quality improvement reduces respiratory suffering and thus reduces hospitalisation and other healthcare costs. Studies have shown that well insulated dwellings result in reduced respiratory and circulatory suffering induced hospitalisations.

Light reflecting coatings increase the amount of natural light that can be used; this generally improves perceived comfort at home and improves indoor climate in office buildings that is believed to increase productivity as well. Maintaining a pleasant, stable indoor climate also helps to increase wellbeing of occupants of the building.

Refurbishment when done right is a relatively safe investment; typical refurbishment candidate buildings are normally found in neighbourhoods that are quite well located on the city map, but which have often lost attractiveness due to a mismatch between building performance, building interior distribution, deteriorated exterior and interior finishing etc. Bringing such buildings back to a competitive quality level normally leads to better occupancy rates and higher rents than can be demanded (in case of open market situations). As explained, the adoption of smart materials-enabled refurbishments as a key strategy offers cities energy efficiency gains, high-quality air conditions, re-development of challenged neighbourhoods, relatively low risk, bankable investments and job creation.

In addition, the adoption of 'cool roof' coatings on a large scale in major urban areas can significantly reduce the summer outdoors temperature and heat island effect in urban areas. As stated by Ronnen Levinson of the Lawrence Berkeley National Laboratory in the US:

> *'The citywide installation of cool roofs can lower the average surface temperature, which in turn cools the outside air.*
>
> *Cool roofs thereby help mitigate the "daytime urban heat island" by making cities cooler in summer. This makes the city more habitable, and saves energy by decreasing the need for air conditioning in buildings. For example, a program to install cool roofs, cool pavements, and trees over about 30% of the surface of the Los Angeles basin has been predicted to lower the outside air temperature by about 3°C. Additional annual building energy savings expected from the cooler outside air are estimated to be about half those resulting from the cool roof itself. Cooler outside air improves air quality by slowing the temperature-dependent formation of smog. Decreasing the outside air temperature in the Los Angeles basin by 3°C is predicted to reduce smog (ozone) by about 10%, worth about $300M/yr in avoided emissions of smog precursors (e.g., NOx).*
>
> *Cool roofs decrease summer afternoon peak demand for electricity, reducing the strain on the electrical grid and thereby lessening the likelihood of brownouts and blackouts.'*

3. Additional Requirements for Deployment

The large scale adoption of smart chemically produced materials into refurbishments (and new builds) requires a number of boundary conditions to be fulfilled:

- Increased awareness throughout the value chain, from the buyer of construction materials in the contracting company, the architect, the building manager and the building owner right through to the regulator.

- Tendering procedures that take into account the lifetime cost of the building, from cradle to cradle and including energy consumption throughout the lifetime

- Performance based selection of intervention package chosen for a specific building; for example avoiding that the interest is focussed on ICT intensive solutions just because these may have a perceived high degree of 'innovativeness' around them even when perhaps 'down to earth' measures like insulating foams or reflective paints offer more performance for the same or a lower investment.

- Availability of sufficient amounts of qualified workers that are able to use these smart materials and integrate them into cost effective, durable and reliable solution packages.

- Incentive schemes that could either consist of subsidies, special loans for these kinds of investments or innovative financial schemes (investor who gets a pay-back based on energy savings), tax breaks or even penalties for 'bad' buildings, or a combination of these policy instruments. Incentive schemes should make attractive for the owner to refurbish his(her) property

- Building regulations that take into account the full Life Cycle Impact of a building, from construction, use towards demolition and waste recycling. Such regulations should be solution-agnostic: performance requirements should be set, but the approach to reach the required performance should be open, avoiding mandatory adoption of specific solutions that may not be optimal in specific cases. For example, the obligatory incorporation of specific technologies such as PV panels or thermosolar systems can consume budget that might be more effectively applied investing in wall insulation.

Example 1

BEFORE

AFTER

BUILDING DATA
Type of building: Multi-family
Location: Lübeck (Germany)
Energy use before renovation: 148,7 kWh/(m²a)
Technologies used: Insulation of the exterior wall, top floor ceiling and basement ceiling, Solar thermal energy for hot water, Ventilation system without heat recovery, Replaced windows and outer doors

Energy use after renovation: 61,5 kWh/(m²a)
Energy savings: 5,72 €/m²
Energy savings: 59%

3.1 Governance and regulation

Any regulatory pressure on building owners to upgrade the energy efficiency of their existing building stock would greatly stimulate the private market uptake of Smart materials enabled refurbishments. The city of Brussels for example is stimulating such activities both by financial incentives as well as by aggressive adoption of future EPBD requirements into its local building / refurbishment permit requirements.

For new buildings such regulatory forces are already quite clearly planned into the latest European Building Directive, earmarked to be converted into national laws by 2016 in most member states. For refurbishment, regulations are not as clearly defined on a European level, as the financial consequences for building owners are very hard to foresee. As a result present regulations oblige existing buildings to be rated according to an energy efficiency labelling scheme, but do not attach an obligation to do something about bad energy efficiency performance.

Example 2

BEFORE

AFTER

BUILDING DATA
Type of building: Residential Building
Year of construction: 1975
Total m²: 4.000
Location: North Italy
Energy use before renovation*: 130 kWh/m² year
Technologies used: Thermal Insulation system on the external walls

Investment: 50 €/m²
Energy use after renovation*: 23 kWh/m² year
Payback time: 6 years
Energy savings (year) : 9,50 €/m²
Energy savings: 80%

m²: square meter of peripheral wall
* energy used to balance the heat loss through the peripheral wall only

3.2 Suitable local conditions

Anywhere in Europe, suitable local conditions can be found; in every city and in every country. Suitable local conditions include of course high energy prices, poor energy performance of the present building stock, high awareness by the general public and local financial capabilities to invest in a long term return of medium risk.

Roof top coatings are especially effective in commercial low-rise buildings such as shopping malls, warehouses, large surfaces stores and have the most effect in climate zones with abundant sunshine and hotter temperatures. Internal light optimising coatings are useful in any building especially in combination with advanced daylight regulating windows, and can also be combined very well with LED lighting.

Insulation foams come in a wide variety of shapes and forms and application processes, allowing to find a solution for almost any building. In the South of Europe, still many buildings exist which have no internal wall cavity filling of insulation material, something that in the North of Europe has been adopted to a wider extent (although also in the North, still substantial numbers of buildings remain which wall cavities have not been filled up with insulation).

3.3 Stakeholders to involve

The Suschem platform has been engaging with its value chain allies in the area of building refurbishment for more than 8 years now. In order to successfully introduce the smart materials enabled refurbishment into urban Europe we will need construction firms, contractors, specialized tradesmen, architects, building owners and building managers to commit to this venture. Beyond the value chain actors, we also very much need the financial sector engaged in this project, providing our final clients with financial instruments that allow building owners to make these investments at acceptable risks and with acceptable timeframes for recovery of their investments.

It will be especially important to develop the capabilities and processes inside refurbishment contractors enabling them to execute refurbishments fast, efficiently and with guaranteed quality and durability of the result. Using new materials in some cases requires proper adjustment of working procedures; not necessarily making them more complex, but making them perhaps slightly different from 'business as usual'.

To ensure that innovative approaches do not meet with unfounded rejections when building certifications need to be obtained, it is crucial to also involve all actors involved in building certification and quality control, making them aware of how these new materials can be used effectively and reliably, and training them on how to perform the necessary quality control activities.

3.4 Supporting infrastructure required

No specific additional infrastructure is needed to benefit from the proposed innovations. One thing that the above does suggest is that training infrastructure to the construction and refurbishment sector would be important to have in place, allowing to have more construction sector professionals be prepared for the opportunity and the work to implement the refurbishments that can be done. However in most member states such infrastructure exists, even if perhaps the training courses and the training material still needs to be developed.

Example 3

BEFORE

AFTER

BUILDING DATA
Type of building: Residential House
Year of construction:
Total m²: 100 m² floor space
Location: Brunck District, Ludwigshafen
Energy use before renovation (heating): 210 kWh/(m²a)
Technologies used: PCM

Energy use after renovation (heating): 30 kWh/(m²a)
Energy savings (year) : * 10,80 €/m²
Energy savings (heating): 86%

* Data from EU database: cost of energy in Germany

3.5 Interfaces with other technologies

As described before the proposed innovation package can very well be integrated into a larger package of building interventions that target energy efficiency as well as comfort, building attractiveness, health and safety. The interfaces between the proposed innovation and those other innovations do not present specific issues. In some cases the introduction of the proposed innovations facilitates adopting others; for example the introduction of foam layers onto facades is often used to also add cable ducts in an out-of-view way. Another example would be how reflective paints can reduce the external heat load while increasing amounts of ICT equipment increase the internal heat load.

The technologies proposed are normally offered to building developers or owners as part of the packaged solution. Normally such an offer would include upgrading of facades (involving insulation, coatings, advanced glass and sunlight regulating devices or layers); upgrading of wall insulation, introduction of advanced low energy cooling concept, introduction of high efficiency heating concept, mechanical ventilation with heat recovery and advanced (LED) lighting concepts. All of these are ideally managed by an advanced building energy management system that consists of a range of ICT components connected (wired and wireless) to each other, to control unit(s) and advanced user interfaces.

The performance of the package is generally more than the mere sum of the separate components. On the other hand a very well insulated building can need so little heating energy, that in some cases quite inefficient (but fast working) heating systems can be allowed. An example is the use of electric resistance heating embedded in the inner pane of a triple glass window in order to heat a bathroom in a passive house apartment in Ludwigshafen; as the bathroom normally just needs 20-30 minutes of warmth, the resistance heating proves to be more efficient overall than a conventional radiator could be.

Thus indeed, the proposed innovations can very well be part of a bigger solution package. On the other hand, an intervention that would only combine the five proposed technologies would already offer quite substantial energy savings at affordable investments and with acceptable payback times.

4. Financial Requirements and Potential Funding Sources

4.1 Financial viability: Financial cost/benefit analysis and return on investment (period)

The cost / benefit equation of an energy efficiency building refurbishment depends very much on local conditions, which can impact both on the investment required (depending on labour costs, taxes, permits, cost of capital) as well as the incomes / benefits generated (energy savings in terms of KWh per m²/ year, cost of kWh in euros, energy mix applied (gas, electricity, nuclear, oil or renewable). Financial feasibility of energy saving measures typically offset the investment made against energy savings achieved in the future. However, the energy savings are not the only benefit to take into account. Possible reductions in size of heating or cooling installations, increased value of the property (either to sell or to rent out), lower crime rates in refurbished neighbourhoods, increased wellbeing and health of occupants are all important benefits which need to be taken into account in addition to the energy savings.

Several general key parameters are important; for example the period during which the future savings are taken into account. Strong differences between various countries exist with regard to the amount of years that building owners are willing to consider when calculating their returns on investment. While owners in Nordic countries are sometimes willing to calculate with a 35 year economic lifetime of a building (or of a major, deep building refurbishment), most building owners in other parts of Europe would often not consider future income streams more than 8 years into the future.

Another factor to take into account when calculating the balance between investment and savings (or future income streams) is the impact that an improved energy performance has on the value of the real estate concerned. Here again large differences can be observed within Europe. In some parts of Sweden, it has been demonstrated that Passive House compliant residences have values some 12% higher than non Passive House compliant residences that are comparable in all other parameters. In the Netherlands, recent studies by MERIT assessing the impact of energy labels on real

Example 4

BEFORE

AFTER

BUILDING DATA
Type of building: Residential Building
Year of construction: 1960
Total m²: 4.500
Location: Terrassa (Barcelona)
Energy use before renovation: 113,5 kWh/(m²a)
Technologies used: Wall Cavity Insulation (15cm of wall cavity)

Investment: 25 €/m²
Energy use after renovation: 86,6 kWh/(m²a)
Payback time: 6 years
Energy savings (year): 4,10 €/m²
Energy savings: 24%

estate value put the added value created by an A-level certification at much less, perhaps 3% of the value of the building. Here, the performance levels of the available building stock and the awareness of buyers with regard to their long term energy bills impact are key factors influencing the price differences in the real market.

In very general terms, it must be highlighted that average households tend to spend between €1.200 and €3.000 per year on energy bills, with of course more being spent in cold climates with poor energy efficiency of their buildings. Given this level of expenditure, one can easily calculate that for a household to invest in a 40% energy bill reduction, the actual savings will in most cases be less than €1.000 per year. If a household then allows itself to take into account for example 7 years of future savings, then this would lead to less than €7.000 being available for the investment. Real estate property value rising due to better energy efficiency could add another €7.000 to this household calculation (taking a conservative estimate between the 12% in Sweden and the 3% in The Netherlands of 5% multiplied by a typical home value of some 150k = €7.500).

Of course, if the same type of calculation were made by a Nordic institutional investor into commercial real estate, the available investment budget would look very different: much longer timeframes being taken into account, a market in which poorly performing buildings suffer heavily from the fact that quite a bit of good energy efficient real estate is available, and commercial real estate in general consuming up to 40% more energy per m².

For these last reasons, commercial real estate (including public non-residential buildings) is generally more likely to offer positive ROI (Return on Investment) for energy efficiency driven refurbishments than residential buildings. As most buildings used as offices or shops tend to be used intensively at least 12 hours per day, they simply have a higher energy consumption level because of these longer 'operational hours'.

Another advantage of addressing non-residential buildings is that usually their owners can take a slightly longer term view than families are able and/or willing to take. Institutional owners (including municipalities) can often have access to relative low interest financing and can balance risks in one building because it is normally part of a portfolio of buildings owned. Also,

Example 5

BEFORE

AFTER

BUILDING DATA
Type of building: Wholesale
Total m²: 14.000
Location: Italy
Energy use before renovation(cooling): 40,1 kWh/(m²a)
Technologies used: High reflectance outdoor coatings
Investment: 13,50 €/m²
Energy use after renovation(cooling): 32,1 kWh/(m²a)
Payback time: 2,8 years
Energy savings (cooling): 20%

institutional building owners are more aware of the long term risks of not refurbishing, in the sense that they actively invest in making their portfolio of buildings 'future-proof'. They do not do this out of idealism; it is rather a necessary strategy to avoid that part of their portfolio of buildings becomes obsolete and therefore impossible to rent out at profitable rates in the near future.

Thus, the decision to refurbish a building for energy efficiency is seldom taken in isolation; typically a building owner seeks to re-position its property in many ways besides the energy efficiency only. Examples in the centre of Brussels have shown that an investment of around €900/m² in deep refurbishment of an office building on the Avenue de Louise can be financially attractive, as the alternative of NOT making the refurbishment investment is to have a prime location office building standing empty for lack of interested tenants (that can choose these days in Brussels from a wide range of available properties, some of which with excellent energy efficiency performance).

Example business case PCM Basically, PCM when installed in interior ceilings and/or walls dampen the oscillation of temperature between day and night. As such, the work especially well in climates that can have hot summer days with bright sunshine, but which have night temperatures even in those hot summer months of well below 21ºC. Typically to work well, some 3kg of PCM is required per m² of used space. At an average cost level (including the plaster(board) and application thereof) of some €36/m², one can assume that for a 120m² dwelling the investment would reach some €4.400. This investment would then on average allow to reduce the use of a 4kW air conditioning by some 300 hours per year. At an electricity cost of €0,17 this would lead to some 4 x 300 x €0,17 = €204 per year. If electricity prices rise then this saving could increase. However, more important for the financial viability, applying PCM allows to downsize the capacity of the AC system. As larger scale AC systems requiring some €2500 / kWh of installed capacity, the savings in the AC system investment would almost compensate directly for the investment done in the PCM. This is an important factor also in another case of a 5.000 m² office building. Here, the combined savings calculated were some €26.400, with an estimated investment of €36 x 5.000 = €180.000. Here, payback would be achieved within 8 years.

It is essential to highlight this additional key factor that makes PCM affordable in many cases: the downsizing of the air conditioning installation, especially in larger buildings. While in small family homes, a single dwelling wall mounted 3 kWh unit may just cost €1.000 including installation, the cost of cooling capacity in bigger installations is estimated at some €2.500 / kWh. In such bigger buildings, the PCM investment is in most cases completely offset against the savings due to the downsizing of the air conditioning system (smaller system, smaller ducts, less vents).

Example business case light enhancing coatings. The added cost of the light enhancing paint compared to a 'normal' high quality paint is actually less than €0,70 per m² of wall / ceiling surface painted (reflective paint costing some €1,20/m²/layer, two layers leads to €2,40/m² excluding the cost of painting which is equal whichever paint you use). As an example case, we can use a small office of 100m² of floor surface and 2,75m ceiling height. This would require some 237,5 m² of paint or an added investment of €166,25. The peculiarity here is that of course, while office buildings are also migrating to low consumption luminaires (LED or fluorescents), the achievable savings decline. In the case of still omnipresent fluorescents, the 100m² office would have some 1600W of lighting installed, working for perhaps (summer and winter, not all spaces lit at any point in time) a total of 4 hours per day, which would consume some 1600 x 4 = 6,4 kWh per day. If the office is lit for 240 days per year this would require 1536 kWh. At €0,17 per kWh that amounts to some 260 euros, of which 20% savings would reflect €52,00. Which would allow a pay-back time of some 3 years considering the energy savings alone. In real life cases, one of the important impacts of applying these paints is the sensation of space and lightness that inhabitants report, creating increased wellbeing and a feeling of spacious comfort especially in smaller rooms.

One must acknowledge that the absolute impact of artificial lighting costs compared to the heating costs of a traditional building are not that relevant; heating and cooling normally covers at least 60-70% of the entire energy consumption. However it is important to note that once buildings become well insulated and adequate measures are installed to make their heating and cooling efficient, then the balance changes and lighting becomes relatively more important. Therefore, it makes sense to optimize lighting consumption especially in buildings which have good thermal performance.

4.2 Sources of Funding from the EU budget available

We would see several EU funding being applicable: EU structural funds as a means to promote investment in smart materials enabled refurbishments. EU funds could also be used to establish training infrastructure towards value chain actors that themselves cannot adopt the knowledge required to use these new materials effectively and to allow them to determine when and how they can best be applied in a given building.

R&D funding and especially innovation funding such as that expected to become available under Horizon2020 could very much stimulate the development of integrated packages of refurbishment interventions that together deliver high energy efficiency gains at minimal investments and maximum economic lifetimes.

The same funding could be used to develop training material to be used in the training infrastructure mentioned above.

However the viability of the proposed solutions does not depend on EU funding; the benefits make the investment attractive even when that investment is not leveraged by any external funding source.

4.3 Funding by financial institutions

We see the financing of long term payback deep refurbishment interventions as a key area where the EIB could facilitate the influx of private capital by acting as a co-investor or as a guarantor for loans that are used to invest in such refurbishments. The EIB would need to (make financial actors) develop long term mortgage like products that can be coupled to a building beyond a possible rental contract duration (as is the financing of the new build investment).

Germany has been quite successful in stimulating deep energy efficiency refurbishments from 2001 to 2009 using smart financing. Through the period 2001-2006, €4 billion of public subsidies from German Alliance for Work and Environment were able to stimulate a private investment of €15 billion in buildings retrofits. The state bank KfW created several programmes that offered lower-than-normal interest rates to stimulate private sector finance. From 2006-2009, KfW's financing activities across various programmes used €27 billion in loans and grants creating a total private investment flow of €27 billion on improving energy efficiency at homes[15].

4.4 Other financial information

It is clear that the long term market trend of rising energy prices and increasingly strong performance by new buildings will drive the demand for deep refurbishments of existing buildings in the long term. We do however feel that the time needed to reach sufficiently compelling market conditions may be longer than what our European society should be willing to wait for. If we agree that EU governance institutions could do more to

15 P. Sweatman (2012): Financing Mechanisms for Europe's Building Renovation, Assesment and structuring recommendations for Funding European 2020 Retrofits Targets.

speed up this market, then a key instrument for accelerating the growth of energy efficiency refurbishment demand would be to adjust the present real estate taxing mechanisms.

In many EU member states, real estate taxation is connected to the amount of square meters, the cadastral value of the property, the location or a combination of these. In none of these tax formulas does the energy performance of the building play a role.

Interestingly, taxation of cars for quite a few years does take into account the energy efficiency of the vehicle bought. The better the energy efficiency label of the car, the lower the tax percentage applied.

One could consider to adopt a similar mechanism in the taxation of real estate, making the energy efficiency of that real estate one of the key factors in the determination of the level of tax to be paid. When implemented correctly and with careful avoidance for negative impact for lower income private households that own real estate, the impact of such tax measures on can be huge.

If properly designed, such a tax scheme adjustment could shift some of the tax burden to larger scale real estate owners, while relaxing the burden on lower income households. Such a shift could be done in such a way that overall tax income for the state is increased, which can at least partially compensate for the lower income derived from building permits.

The consideration of adjustments in tax schemes related to real estate are tightly connected to the transition that municipalities in many EU member states need to make from the last couple of decades of booming real estate building, towards the now to be expected decades of much more moderate rates of new building combined with increasing refurbishment activity. In fact, the rise of refurbishment as an important part of the entire construction industry has been on going for decades, even when new buildings were built all over Europe at a sometimes staggering pace. What is new is that this part of the construction business has up to now played a more modest part in the taxation incomes of municipalities, which will probably need to change in the years to come.

A recommendation could be to establish an EU wide think tank on future municipality financing, which can seek alternative income schemes for municipalities that reduce their 'addiction' to real estate new building development and can make their finances as sustainable as their policies should be.

If you are interested in exploring how the Key Innovations described here could help you to make buildings more energy efficient in an affordable way, or if you want to discuss possible collaborations, then please get in touch with Suschem by sending an e-mail to **Jacques Komornicki**, innovation manager at CEFIC: jko@cefic.org

SusChem
European Technology Platform For
SUSTAINABLE CHEMISTRY

SusChem is a European Technology Platform created in 2004 with main objective to revitalise and inspire European chemistry and industrial biotechnology research, development and innovation in a sustainable way.

SusChem addresses challenges that are specific to the European chemical and industrial biotechnology industry, but also addresses challenges that apply to European society as a whole. We see a European chemical and industrial biotechnology industry that is highly ecologically efficient and competitive through technology leadership and innovation. We see an industry that is seen as a reliable, safe and responsible partner in society. To achieve this vision, SusChem brings together people from across the chemical community and wider society to formulate research and innovation roadmaps. sound.

Our vision is a competitive and innovative Europe where sustainable chemistry provides solutions for future generations, based upon pre-eminent knowledge levels in Europe, coming together in a collaborative public-private, pre-competitive collaboration framework.

Our approach is open, collaborative, cross-disciplinary, cross-sector and inclusive.

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Smart Cities Stakeholder Platform

...brings together people, industry and authorities from across Europe to make our cities more energy efficient, better to live in and growth-friendly.

...is about developing concrete innovative solutions for cities through tailored innovations.

...facilitates the exchange of knowledge and best solutions across smart cities in Europe.