# Cost Benefit Analysis across the EU-28 in promotion of Near Zero CO2 Emission Buildings due to energy use

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## Overview

With Directive 2012 / 27 / & Directive 2010 / 31 Energy Performance of Buildings and Energy Efficiency produces a potential breakthrough in European policies. The objectives and tools of intervention and verification oblige member countries to immediately adopt a clear strategy for the improvement of the performances of the buildings. The EU Directive proposes that after 2020 all new buildings must be zero energy buildings and those buildings will also be near zero CO2 emission buildings due to energy use (NZCO2EB). Although there has been much recent focus on measures to reduce the emissions from new buildings, the existing building stock remains largely untouched and many refurbishment projects miss opportunities to reduce emissions and deliver low CO2 buildings.

Action to dramatically enhance the energy efficiency of buildings is an essential step to reducing demand for energy and as a consequence lowering CO2 emissions. In creating regional policy adaptions, it will create healthier and more affordable environments, a great many jobs and stimulate economies. With careful deployment of renewable energy sources and with demand side reduction, led by action on building energy use, can energy supply be decarbonised rapidly enough. At present, across most of the EU, the political will for such action appears to be diverse.

At the start of this decade, carbon emissions rose faster than ever while current projections of global energy use indicate rising emissions for decades with increased consumption of fossil fuels. Policies adapted as part of the Zeroco2 will shape the energy picture over the long term. An accelerated transition to a renewable energy source supply system seems to offer the only route to effective and rapid greenhouse gas reduction.

EU climate change targets for 2020 are now seen to be insufficient. The EU can once more show leadership by demonstrating accelerated growth of renewables and accelerated reduction of emissions in the short term. But such change will only be possible with a simultaneous acceleration of progress in energy efficiency, especially that where you get greater impact, so careful targeting of buildings is required.  Energy efficiency has delivered far more greenhouse gas saving in recent decades than has been, or will be, achieved by transformation of energy supply. Yet energy efficiency is still relatively ignored by governments compared to energy supply. Progress in energy efficiency has been far slower than it could have been but there is much more saving still to be had. Making this saving is now absolutely necessary if there is to be effective action on the reduction of energy and hence CO2 from buildings, this will also have great impact on climate change targets at a macro level. Achieving this saving is possible through innovation within Europe.

Action on energy efficiency will bring many related benefits, some of which are outlined below. Presently, improvement in energy efficiency across the EU is far less than planned and far less than is required. Buildings are responsible for approximately 40 per cent of EU energy-related greenhouse gas emissions and energy efficient buildings represent the greatest opportunity for energy saving and greenhouse gas reduction. Knowledge of how to build new excellent energy-efficient buildings and how to refurbish existing buildings to achieve great improvements in energy efficiency & CO2 reduction is already in place and often makes economic sense, like any innovation once volume is increased costs will decrease. There are demonstrations of what is possible but many barriers to widespread mainstream effective action remain.

One of the biggest barriers is lack of political consistency across the EU28 to accelerate progress in energy efficiency sector. New build ambition is insufficient and the rate of building refurbishment to achieve high standards of energy efficiency is far too low. The Energy Roadmap 2050 is encouraging but is long-term. Accelerated action is necessary before 2020, hence the need for policy adaption in the regions of ZEROCO2, thus showing what is possible. There exist many new innovative concepts, such as passivhaus and the like. There are many innovative standards across the EU28 but for the purpose of this paper I will refer to passivhaus and similar inferring that codes are evolving. Adopting passivhaus or a similar quality as the standard now for both new build and refurbishment of existing buildings will bring many benefits, some of which are outlined below.

Demand side energy use will be minimised, providing financial security for occupants. The poor health outcomes associated with energy inefficient buildings will be eliminated. Building performance will be as designed because of the quality built into design and construction. The healthy internal environments will promote well-being. Skills and supply chains will be enhanced so promoting job creation and competitiveness.

Energy efficiency and energy supply are inextricably linked. The current structure of energy supply, reflecting 20th century priorities, makes rapid progress in energy efficiency very difficult to achieve; these difficulties are compounded by the continuing subsidies received by fossil fuels and nuclear power that far outweigh all subsidies received by renewables and particularly for energy efficiency measures. Yet the cost of electricity from renewables is dropping fast while low energy building design quality can dramatically reduce energy use in buildings. Transforming the built environment infrastructure will create the capacity to transform energy supply and storage, thus allowing for an expansion of renewable energy sources to be deployed. Energy efficient & near zero CO2 buildings are key to the ability to tackle greenhouse gas emissions. With political determination, the EU can create a new reality and demonstrate leadership on energy supply, energy storage and energy efficiency. Political will to transform buildings will demonstrate EU leadership on climate action post the Paris accord.

Regions can lead this change, through adopting low and ultra-low energy building design for both new and retrofit schemes. The adaption of regional polices will show ambition that will bring economic benefits, health benefits and security benefits. From the reverse perspective, if there is no action of this kind to transform buildings, while 2050 targets may be met, by then, it will be far too late to prevent potentially very dangerous climate change.

Buildings present the greatest single opportunity for a low carbon economy. We know from real-life examples across both northern and southern EU regions of what to do and how to do it. The challenge is to overcome the barriers that presently mean best practice is just a few isolated examples in order to make best practice mainstream across Europe. Less than 10 per cent of worldwide research and development expenditure on energy has been spent on energy efficiency, which is a very reveal statistic. Energy efficiency is a poor relation compared to nuclear, fossil fuels and macro renewable energy generation, yet is key to tackling set targets.

Recent research has shown that over 70 per cent of global energy use could be saved by practically achievable design. The greatest savings are available in promoting passive and other similar ultra-low and near zero CO2 emission buildings that are dominated by heating and cooling spaces. These savings could be achieved by designing buildings to the passivhaus and similar standards across the EU28. We already have the knowledge to make these savings, it is policy change that will drive the reductions in both consumed energy and CO2 emissions.

Given the information contained above, it would be very sensible to increase spend much more than we do on energy efficiency. It is known that to meet targets billion Euro investments are needed up to 2020 to develop new energy supply capacity and to strengthen the electricity and gas grids into smarter solutions, it is debatable that this is what it would cost to bring the entire housing stock up to or near to passivhaus or similar standards. Almost no energy will then be needed for heating and cooling homes. Once the building fabric is improved to this degree then the zero-emissions building or even the energy-plus building become viable options. A focus on energy efficient buildings will bring systems thinking to the fore and promote energy efficiency more widely.

With such investment in buildings, total energy use will be significantly reduced and the occupants of these buildings will also be living or working in much healthier and more pleasant homes or workplaces. The construction industry will of necessity have become up-skilled and globally competitive and supply chains within the construction industry will have been developed that are equally competitive. There can be a focus on renewable energy supply rather than inappropriate investment in nuclear and fossil technologies meaning that the energy supply industry also can become globally competitive. An appropriate mix of support and penalties can stimulate the necessary investment but innovative thinking will be needed to find the most effective pathways.

Ensuring the necessary financial stimulus to accelerate building refurbishment to passivhaus or similar standard will be a most effective use of public funds compared to the massive historical support and subsidy for energy supply by fossil fuels and nuclear. If this investment to upgrade buildings is not made there will be lock-in of energy inefficiency and of greenhouse gas emissions because the renewal and refurbishment that does occur will be to lower standards than could be achieved. Lack of progress in transforming buildings towards near zero CO2 emission Buildings means lack of progress in tackling climate change at a macro level.

# The route towards Near Zero CO2 Energy Emission Buildings

What happens in refurbishment will be influenced by the standards that are agreed for new buildings? If these fall short of what is feasible and possible, then the regulations, the skills, and the supply-chain to make possible 'deep refurbishment' of the existing building stock may be inadequate for the task. A Near Zero CO2 energy emission Building can only be called this if it performs this way in practice. Low-energy, near zero emission design is meaningless without real-life data on energy use. Developing standards for the future must acknowledged that ensuring what is designed is actually delivered will represent a significant challenge for the whole industry - including designers, the supply chain, and housebuilders.

## 1 Current Situation and consequences of not making ambitious standards

Proposed new standards fall short of what is possible and it is freely acknowledged that the delivered quality is almost certain to fall short of even this standard across many parts of EU28. This is likely to mean lock-in of carbon emissions, more expense for owners and occupiers, and poorer quality.

The UK Committee on Climate Change has estimated that an additional 6TWh of renewable electricity supply will be needed by 2030, costing consumers in excess of £100m at today's prices, because of the weakening of the UK standard proposed for so-called "zero carbon homes". This extra investment in supply may be compared with the potential saving of £40billion suggested by WWF in a recent report if there is effective action in the UK on energy efficiency and, in particular, on energy efficiency in the building stock. Across the EU, such saving could possibly be multiplied ten-fold: around €500billion no longer needing to be spent on constructing new energy supply.

These extra costs, resulting from weaker standards, show that supposed cost savings to business by not having to meet more demanding energy efficiency standards are misleading as the costs merely reappear somewhere else. But the extra unnecessary costs to consumers in less energy efficient buildings will be paid year after year. Focusing on maximising energy efficiency as the priority, rather than energy supply with energy efficiency trailing behind, makes economic as well as environmental sense. This UK decision to weaken standards for new homes will have negative impacts over decades for industry, for consumers, for innovation and, crucially, in the ability to undertake 'deep' low-carbon refurbishment of the existing building stock.

A concern about the UK example is that it is also true in other EU28 regions having the effect of undermining efforts to promote energy efficiency in buildings, it is important that such misguided decision-making is avoided if near zero CO2 emissions building are to become the mainstream of construction standards.

# 2 Energy Efficiency across the EU28

Across the EU, the current ambition of a 20 per cent reduction in energy consumption by 2020 is unlikely to be achieved. Projections indicate a likely reduction by 2020 of approximately 10 per cent or even less. The reason for this lack of action is lack of political and financial support for energy efficiency and for energy efficient buildings. The EU has admirable long-term intentions to decarbonise buildings by 2050 but, short-term, energy efficiency remains the poor relation to energy generation and supply. Some long-term projections assume continuing need for heating/cooling in 2050 because progress in energy efficiency will have been limited, this is true across a number of EU28 countries.

## 2.1 The German Model as a Good Practice

Germany is one of the most advanced European economies in the promotion of renewable energy and in demonstrating 'deep' refurbishment of buildings to save 75% or more of energy use. The German Energy Concept has a renovation roadmap targeting an 80% reduction in primary energy demand by buildings by 2050. Germany seeks to cut electricity consumption by 25% by 2050 which will be possible if there is sustained and ambitious progress in energy efficiency. In other EU28 regions, in contrast, electricity consumption is projected to at least double by 2050. A major reason for the difference is the lack of ambition for energy efficiency.

Even in Germany, the need to double the rate of building refurbishment is acknowledged but there are fragmented pathways to enable this to happen. Across the EU28, the rate must at least triple. Lack of urgency across the EU28 explains why the EU is falling so far short of the 2020 target for energy efficiency. There seems no credible strategy so far for making up lost ground while the urgent need now is to go even faster than planned.

In Germany, the Energy Strategy for 2050, announced in 2010, calls for primary energy consumption to be 20 per cent lower in 2020 than in 2008 and 50 per cent lower by 2050 (with, as noted above, electricity consumption also 25% lower in 2050).

The contrast to other EU28 regions, where electricity consumption is projected to increase very substantially by 2050, is a consequence of the German ambition to achieve major cuts in energy consumption – in other words, to make energy efficiency a reality. The benefit of setting targets is that a roadmap to achieving them becomes possible in contrast to reliance on ill-defined 'market forces'. Already, as a result of support by the German Federal Bank for Reconstruction, the Kreditanstalt für Wiederaufbau (KfW), low-carbon refurbishment of domestic properties is proceeding at a rate greater than 1 per cent per annum.

As noted above, The Energy Strategy makes clear that to achieve the energy reduction targets, this rate must double to around 2 per cent a year. The existing rate of low-carbon refurbishment in Germany has safeguarded or created at least 200,000 jobs in Germany. KfW provides loans of up to €75,000 for refurbishment with interest subsidies and partial debt relief (the details and incentives depend on the extent of the refurbishment planned and the energy savings expected).

It is such financial incentives, absent from other EU28 regions, that have stimulated the refurbishment activity in Germany alongside investment in renewables. At the beginning of the decade, from €20billion invested by KfW, €9billion went towards energy efficiency in the housing sector.

Depending on the city or state, further subsidy may be available. Hamburg, for example, has provided extra incentives to promote low-carbon refurbishment. There are centres of advice for homeowners across Germany, which allow the end user to be part of the process. It is recognised that an in-depth survey, necessary if good advice on low-carbon refurbishment is to be provided, cannot be achieved in a couple of hours. A full day, or even two, may be needed. Homeowners must pay for this advice but can often get subsidies that may reduce this cost significantly. The benefit of this approach is that the homeowner can be confident that the advice given is likely to be good.

### 2.2 Lessons to be learnt

If the aforementioned investment to upgrade buildings is not made there will be lock-in of energy inefficiency and of greenhouse gas emissions because the renewal and refurbishment that does occur will be to lower standards than could be achieved. Lack of progress in transforming buildings means lack of progress in tackling climate change at a macro level.

## 2.3 Lower life Cycle Costs

An ultra-low energy (incorporating $CO_2$ emission) building has a lower energy demand than comparable conventional types. This implies reduced energy costs for the consumer/tenant. The energy price is important for economic comparisons of this kind. Evidence shows that ultra-low energy houses in general have lower Life Cycle Costs than conventional houses for a high energy price trend. The Life Cycle Assessments have demonstrated that ultra-low energy buildings in general have a lower environmental impact than conventional types, they use less primary energy and cause less greenhouse gas emissions over an accepted time span of 30 years

# 3 The Need for Effective target setting and action on energy efficiency

The EU non-mandatory target for a 20 per cent improvement in energy efficiency by 2020 will, on present trends, be missed by a wide margin. There is no compelling EU vision on energy efficiency in general or in buildings via 'deep' renovation in particular. This means that effective, wide-scale programmes for building refurbishment to 'deep' low carbon standards incorporating near zero $CO_2$ emissions are very difficult to develop. Exceptions are countries such as Denmark and Germany that have demonstrated commitment to renewables and to energy efficiency over many years, the structures and priorities of government can exacerbate this problem, this is especially true in regional government policies. Attitudes and mindsets within government that reflect a continuing focus on centralised electricity supply can inhibit the innovation and investment necessary to drive the transition to a renewable energy system incorporating near zero emission buildings as well as undermining ambition in energy efficiency.

Yet with very energy efficient buildings, local generation, together with local storage, can become a major component in an energy system integration that brings energy efficiency to the fore. Without a transformation in thinking and leadership from government, however, this can never happen. Costs will then remain high, buildings less energy efficient than they could be, fossil fuels cannot be eliminated nearly so fast, and climate greenhouse gas emission be effectively addressed.

A transformation within governments to bring energy efficiency to the fore seems a pre-requisite for progress across the EU28. Misguided thinking that sees benefit in reduced environmental standards must be eliminated. Only Governments can truly create the necessary "alternative reality". Germany's success in promoting renewable energy as well as 'deep' renovation of buildings shows that commitment by government, and targets for energy efficiency that reflect the urgency of the need, are essential.

Now is the time to set targets within regional policies for renewables and for energy efficiency that match need.

# 4 Focus on standards for new build and refurbishment

Moving to, or close to, passivhaus or similar standard provides the confidence that buildings will be constructed as designed and will perform as planned. Award of impressive standards, codes, or Energy Performance Certificates (EPCs) at the design stage to buildings designed in the conventional way may imply low-energy performance but may mean little in practice, and it is arguable that the audits used to certify EPC is not consistent across the EU28. A low-energy/low emission building is only low-carbon if it performs in situ as such.

Several studies on low carbon construction point out that buildings do not achieve their design criteria, in energy efficiency terms, when tested post-completion. It is extraordinary that so little priority is attached to seeing how buildings perform in practice. Such issues will apply in most countries across the EU28, so a level of consistency is sought.

Building new or retrofitting to passivhaus or similar standard transforms this current situation where there is general ignorance about building performance and sometimes much poorer performance than specified. This is one of four important reasons why designing or refurbishing to passivhaus or similar standard provides great benefit:

- Energy use for space heating/cooling is minimised,
- Performance is as designed,
- The internal environment promotes well-being, and
- Construction is undertaken to high quality standards.

The building is modelled in detail so that thermal performance is known and, once the design is completed, no changes that could affect thermal performance are allowed. Quality is demanded at every stage during design and during construction. The result is a building that is effectively guaranteed to perform as specified.

Once energy use for space heating/cooling is minimised, then it becomes much more straightforward to address other sources of energy use such as water heating and appliances, and also to help building occupiers to understand how their behaviour impacts on overall energy use and to help them modify behaviour to achieve savings.

# 5 Conclusion

There exists a number of different transnational and national definitions and concepts for low energy and ultra-low energy buildings that incorporate CO2 emissions. Some of them focus also on the renewable energy production on site.

There are many reasons why it is important to build ultra-low-energy buildings; political, economic and ecological. This paper has provided detail of why the EU28 should build ultra-low energy near zero CO2 emissions properties:

- To take action against climate change and reduce energy consumption
- Ultra-low-energy houses in general have a lower environmental impact
- Lower Life Cycle Costs for Ultra-low-energy houses in general with a high energy price
- To fulfil political agreements, EU directives and regional policies.

# Evidence Based Example

The property built in 1975 according to the system of prefabricated construction. The building had no cellar and utilized attic. The net flor area of the building is 365 $m^2$

The walls were built from prefabricated elements of plasterboard, thermal insulation in the form of mineral wool with a thickness of 10 cm and salonite facade panels with plaster. The ceiling of the building was made of a wooden structure covered with gypsum cardboard panels, thermal insulation with a thickness of 15 cm and boards. 15 windows with a total area of 75.0 $m^2$ are built in.

In 2014, the building was partly energy renovated. The old windows were replaced with new windows with triple glazing and wooden frames. The facade was made on the principle of thin wall insulation with insulation made of rock wool with a thickness of 16 cm. Attic was insulated with insulation SUPAFIL LOFT with a thickness of 20 cm. With the energy renovation, only measures on the building envelope were carried out. The heating system had remained the same as before.

The building was heated with a heating system on natural gas, which contained the heating of the building and the preparation of hot sanitary water. The boiler room has a built in a hot-water boiler on natural gas - Heat Master 85 with a rated output of 17.2 kW - 85 kW. The hot water boiler was built in 2008.

## 5.1 Variant 1 – Biomass + Photovoltaics

In order to eliminate the CO2 produced due to energy use of the building we have to install technical systems running on renewable sources of energy. The first variant includes the use of biomass and photovoltaics. With the installation of a wood pellet boiler with a rated output of 25 kW of heating power we are able to reduce the CO2 emissions from 9.056 kg/a to 4.741 kg/a. The next step is the installation of a Photovoltaic system to reduce the remaining 4.741 kg/a of CO2 which are the product of electricity production.

## 5.2 Varient 2 – Heat pump + Photovoltaics

The second option to transform the building into nearly zero-emission building is the installation of heat pump (25 kW heating power) for heating and hot water preparation in combination with photovoltaics. In this variant, we increased the electricity consumption. This is after the installation of the heat pump 17.436 kWh/a. The CO2 emissions amounted to 9.241 kg/a. Next, we have to determine the required power of the PV system to provide at least 17.436 kWh of electricity per year.

The cost benefit due to the replacement of the existing energy systems with renewable energy systems regarding the reduction of the annual fuel cost in the building is presented in table above. The maintenance and depreciation costs have not been included. In the table are also presented the payback periods of the investments of the two variants.

| | Building- current status | Building – NZCO2EB measures Variant 1 | Building – NZCO2EB measures Variant 2 |
|---|---|---|---|
| Energy need for heating kWh/a | 21.578 | 21.798 | 21.997 |
| Energy need for cooling kWh/a | 1.352 | 1.355 | 1.352 |
| Use of electricity kWh/a | 8.945 | 8.945<br>9.090 (produced) | 17.436/18.200 (produced) |
| CO2 emissions kg/a | 9.056 | 4.741 /0 | 9.241/0 |
| Operating costs per year (EUR/a) (heating and electricity) | 2.800 | 1.060 | 0 |

*Table 1 Comparison Analysis*