# Potential for Energy and $CO_2$ Emission Savings through the application of the Passive House Standard in Ireland

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## Abstract

This paper investigates the potential for energy and $CO_2$ emissions reduction when the passive house space heating standard of 15 kWh/$m^2$ is applied on the Irish new build housing market over the next 20 years. The calculations are based on a computer model representing a national common practice dwelling built as per current 2002 building regulations. Five scenarios of Passive House standard penetration on the new Irish dwelling market are examined – low (1 %), medium (5 %), high (20 %), very high (50 %) and Passive House used as standard (100 %). The findings show that up to 8,222 kWh/year and 2,680 kg$CO_2$/year per typical 100 $m^2$ dwelling may be saved by applying Passive House standard rather than the 2002 Irish building energy performance regulations. Over a twenty-year period the potential for saving across the scenario set could range from 0.691 TWh to 69.067 TWh of space heating energy and 5.02 Mt$CO_2$ to 502.05 Mt$CO_2$ carbon dioxide emissions.

## 1 Introduction

The residential building market in Ireland has seen unprecedented levels of construction over the last ten years. Since 1994 the number of dwellings constructed per year in Ireland has increased by over 300 %, with a record number of 80,957 dwellings being constructed in 2005 [DOEHLG 2006], seen in Figure 1. With such a buoyant building market it is not surprising that in 2004 the residential sector accounted for 25 % of Ireland's total final energy consumption [SEI 2005] and over half of this energy was due to the considerable level of space heating required in the maritime climate.

The significance of these figures is highlighted by the fact that Ireland's greenhouse gas emissions were 23.5 % greater than 1990 levels in 2004 despite a Kyoto Protocol target of +13 % between 2008-2012 [EPA 2006]. With the Energy Performance of Buildings Directive (EPBD) due to come into effect between 2006 and 2009 the awareness of building energy performance will hopefully increase substantially. Given these issues an

ideal opportunity exists for the Passive House concept to be accepted into the construction of Irish dwellings.

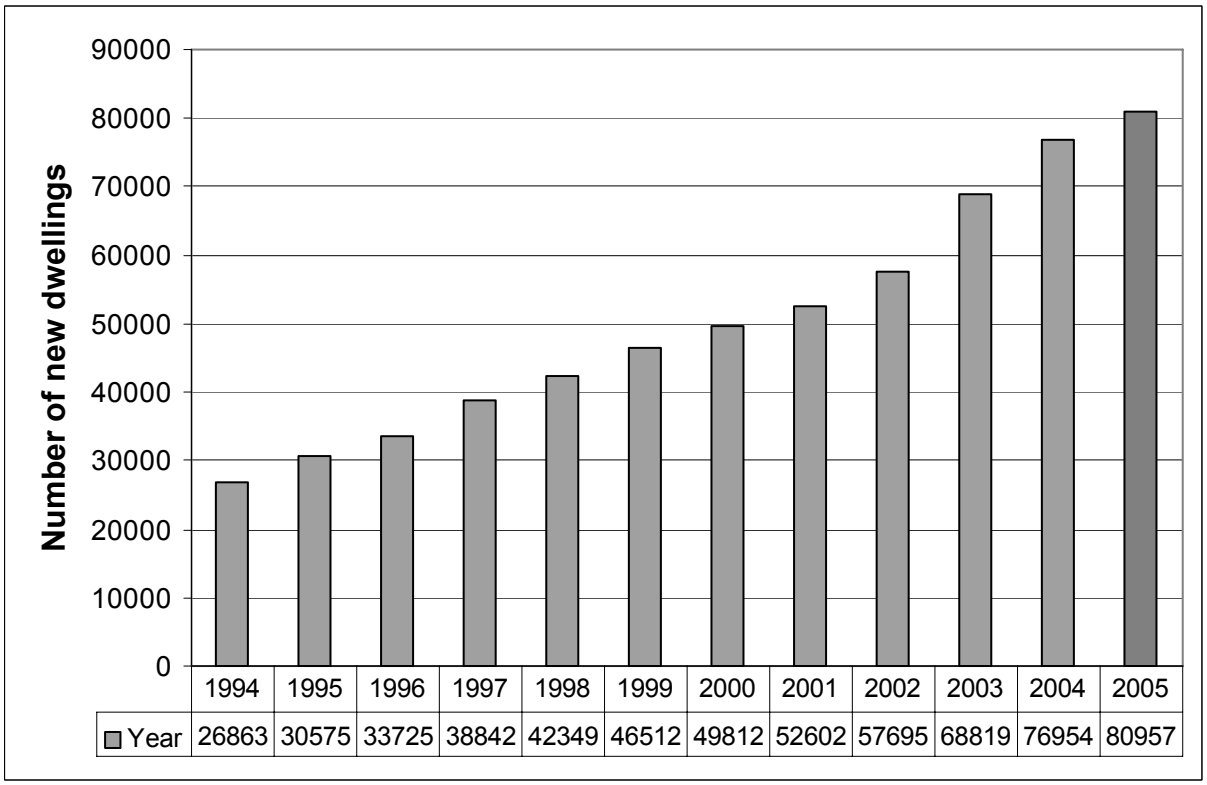


**Figure 1: Total dwelling completions by year**

# 2 Irish Building Regulations and the Passive House Standard

Mandatory regulations concerning the conservation of fuel and energy in dwellings (Technical Guidance Document - Part L) were first introduced to Ireland in 1991, and were revised in 1997 and again in 2002. Part L focuses on reducing energy consumption primarily by lowering required U-values, increasing insulation levels and minimizing thermal bridging. However, with two passive houses being constructed in Ireland since 2002, the wide gap in standards between Part L and the Passive House Standard has been highlighted. Not only are Passive House minimum U-values for ground floor, wall, roof and windows significantly less than Part L, as seen in Figure 2, but Passive House standards go much futher than just elemental regulations by setting such requirements as air tightness, passive solar gains and heat recovery requirements whereas Irish regulations do not.

With Irish building regulations under review pending the implementation of the EPBD, this paper investigates the potential for space heating energy and $CO_2$ emissions reduction when the Passive House space heating standard of 15 kWh/m$^2$ is applied to the Irish new build housing market.

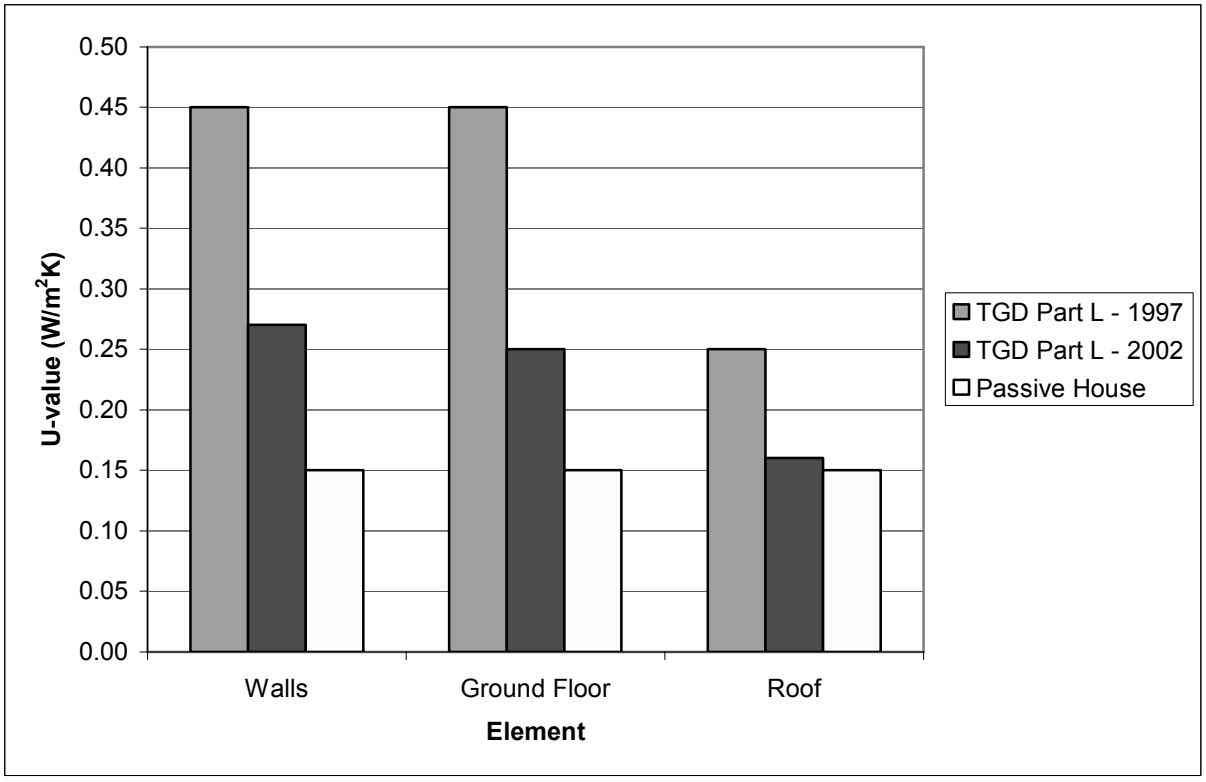


**Figure 2: Comparison of TGD Part L and Passive House minimum requirements**

# 3 Methodology

The tool used in this study was a computer based model, developed as part of Ireland's "Homes of the 21st Century" study [Brophy et al. 1999]. The model was used to predict the energy consumption and $CO_2$ emissions of dwellings with a typical floor area of 100 $m^2$, constructed as per the 2002 building regulations. The model represented a national common practice dwelling by defining it as if heated using the energy source mix used in generating space heating in Irish dwellings. This provided national common practice energy consumption and $CO_2$ emissions figures for electricity, gas, oil and solid fuel (e.g. coal, peat).

For the purposes of determining the $CO_2$ emissions of a Passive House it was estimated that there would be a 50:50 split between the use of gas and wood pellets as an space heating energy source. By comparing these figures it was possible to establish the variation in energy consumption and $CO_2$ emissions between national common practice and Passive House standard for one dwelling.

Using this data, five scenarios representing different levels of application of Passive House Standards were investigated. These scenarios, detailed in Table 1, represented the energy and $CO_2$ emission saving potential of a low, medium, high, very high and standard construction of the Passive House standard.

| Application | Percentage of New Dwellings (based on new build rate of 40,000/year) | Number of New Dwellings |
|---|---|---|
| Low | 1 % | 400 |
| Medium | 5 % | 2,000 |
| High | 20 % | 8,000 |
| Very High | 50 % | 20,000 |
| Passive House as standard | 100 % | 40,000 |

**Table 1: Scenarios of Passive House application**

Although new dwelling construction figures, outlined in Figure 1, show that over 80,000 dwellings were constructed in 2005 it is likely that this new build rate will decline significantly over the next 20 years. For this reason the five scenarios investigated were applied to approximately the average new build dwelling construction of the last 20 years, 40,000 dwellings.

# 4 Results

Using the calculation model it was found that a typical Irish dwelling, constructed as per 2002 building regulations, consumes 9,722kWh/year of delivered energy on space heating and as a result releases 2,855 kg$CO_2$/year into the atmosphere. The space heating requirements for the same size of dwelling built to Passive House standards was found to be only 1,500 kWh/year of delivered energy which equates to 176kg$CO_2$/year. The difference in delivered energy consumption and carbon dioxide emissions between the two construction types for a single building over one year was therefore 8,222kWh/year and 2,680kg$CO_2$/year.

| | National Common Practice (new) | | | Passive House | | |
|---|---|---|---|---|---|---|
| **Energy source** | **Calculated Delivered Energy (kWh/year)** | **Irish conversion factor (kWh/kg$CO_2$)** | **Carbon Dioxide Emissions (kg$CO_2$)** | **Standard (kWh/year)** | **Irish conversion factor (kWh/kg$CO_2$)** | **Carbon Dioxide Emissions (kg$CO_2$)** |
| Electricity | 532 | 0.65 | 345.8 | 0 | 0.65 | 0 |
| Gas | 1935 | 0.184 | 356.0 | 750 | 0.184 | 138 |
| Oil | 2902 | 0.247 | 716.8 | 0 | 0.247 | 0 |
| Solid | 4353 | 0.33 | 1436.6 | 0 | 0.33 | 0 |
| Pellets | 0 | 0.05 | 0 | 750 | 0.05 | 37.5 |
| **Totals** | **9,722** | | **2,855.2** | **1,500** | | **175.5** |

**Table 2: Energy and $CO_2$ emissions for 100m$^2$ typical Irish dwelling and Passive House**

Applying these potential energy and $CO_2$ emissions saving rates to the 20 year average new build dwelling construction rate of 40,000 homes/year the following results were calculated.

| Percentage (and number) of new dwellings built to Passive House standard | Potential energy and $CO_2$ emissions savings per year | Potential energy and $CO_2$ emissions savings after 20 years |
|---|---|---|
| 1% (400) | 3.29 GWh | 0.691 TWh |
| | 1.07 $ktCO_2$ | 5.02 Mt $CO_2$ |
| 5% (2,000) | 16.44 GWh | 3.453 TWh |
| | 5.36 $ktCO_2$ | 25.10 Mt $CO_2$ |
| 20% (8,000) | 65.78 GWh | 13.813 TWh |
| | 21.44 $ktCO_2$ | 100.41 Mt $CO_2$ |
| 50% (20,000) | 164.44 GWh | 34.533 TWh |
| | 53.59 $ktCO_2$ | 251.03 Mt $CO_2$ |
| 100% (40,000) | 328.89 GWh | 69.067 TWh |
| | 107.19 $ktCO_2$ | 502.05 Mt $CO_2$ |

**Table 3: Potential for space heating energy and carbon dioxide savings**

# 5 Conclusions

Although in recent years Ireland has tightened up its regulations concerning dwelling energy performance, it is clear from the results presented above that substantial savings can still be made in this area. With Ireland still lagging behind its Kyoto Protocol requirements and the implementation of the EPBD imminent, an ideal opportunity exists for the application of the Passive House to Ireland. Given such clear indications as to the advantages of Passive House the reasons for the current lack of pentration of the Passive House concept in Ireland, need to be tackled. A primary barrier to improved penetration is a lack of knowledge in the public domain as to its benefits. By increasing public awareness as to the potential savings which Passive House standards could make over traditional constructions and reinforcing the fact that an increase in energy performance does not mean a decrease in comfort conditions (and often could mean an improvement in comfort conditions) a significant increase in Passive House application in Ireland may result.

# 6 References

[Brophy et al. 1999] Brophy, V.; Clinch, J.P.; Convery, F.J., Healy, J.D.; King, C. and Lewis, J.O.: 1999. ***Homes for the 21st Century – The Costs & Benefits of Comfortable Housing for Ireland***. Report prepared for Energy Action. Ltd.

[DOEHLG 2002] Department of the Environment, Heritage and Local Government, 2002. Technical Guidance Document Part L: ***Conservation of fuel and energy***.

[DOEHLG 2006] Department of the Environment, Heritage and Local Government, 2006. ***Housing Statistics***. Available from:

http://www.environ.ie/DOEI/DOEIPub.nsf/wvNavView/RegularPublications?OpenDocument&Lang=en#I2 (Accessed March 2006).

[EPA 2006] Environmental Protection Agency, 2006. ***Ireland's Emissions of Greenhouse Gases – Revised and Updated Figures***.

[SEI 2005] Sustainable Energy Ireland, 2005. ***Energy Consumption and $CO_2$ Emissions in the Residential Sector: 1990-2004***. SEI Energy Policy Statistical Support Unit.

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