

# Sensitivity analysis of cost effective climate protection in the EU building stock

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## Keywords

EPBD, energy efficiency investments, EU building stock, energy price, price scenarios, energy cost savings, profits, price sensitivity, optimum U-values

## Abstract

The impact of the Energy Performance Directive (2002/92/EC), and an extended EPBD for the EU-25 Member States were analysed and quantified. The EPBD was proved to be highly cost-effective for demand reducing measures in the building stock<sup>1</sup> it was demonstrated that the EPBD will have a significant impact on the CO<sub>2</sub> emissions of the building stock, with insulation measures of existing buildings offering the main saving potential. Coupling energy-efficiency measures with general maintenance and retrofit measures in the building sector, these measures are highly cost effective.

Since the energy market is highly volatile a sensitivity analysis was carried out to assess the effects of modified energy prices on the economic results.

Five energy price scenarios were analysed and justified, building the basis for the sensitivity analysis. The effects of these scenarios on the cost effectiveness of insulating a pitched roof of a residential building in a moderate climate based on a reference building were calculated.

The effects of modified energy prices on the economic results are assessed for the technical potentials for energy saving and cost savings. For both the present EPBD and a possible extended EPBD the energy cost savings are compared for the

scenarios. Profits on the investments increase up to a factor larger than 3.

## Introduction

The European Directive on Energy Performance of Buildings (Directive 2002/91/EC) which came into force 16 December 2002, and is implemented in the legislation of Member States by 4 January 2006.

In addition to the aim of improving the overall energy efficiency of new buildings, large existing buildings, having more than 1000m<sup>2</sup> heated floor area, will become a target for improvement, as soon as they undergo significant renovation. The building sector is responsible for about 40 % of Europe's total primary energy consumption and hence this Directive is an important step for the European Union in order that it should reach the level of saving required by the Kyoto Agreement. In this the EU is committed to reduce CO<sub>2</sub>-emissions by 8 per cent until 2010 relative to the base year of 1990.

But how large could be the impacts of extending the present EPBD obligation for energy efficiency retrofitting towards smaller buildings and are the corresponding retrofit measures cost effective?

When coupling energy-efficiency measures with general maintenance and retrofit measures in the building sector, investments in energy efficiency improvement of the building envelope are in any way highly cost effective. The investments in improving measures for a better thermal performance of the building envelope focus on roof insulation, wall-and floor insulation and replacing single glazing by high efficient double glazing. By this the energy losses through the building envelope are reduced and thus the energy demand is reduced consider-

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1. Eurima studies: [http://www.eurima.org/document\\_library/eurima\\_publications.cfm](http://www.eurima.org/document_library/eurima_publications.cfm)

ably. As a consequence the existing boiler is replaced then by a condensing boiler with lower capacity.

The optimum insulation thickness for roof, wall and floor is calculated with parameters like material costs, fixed costs, labour costs, fuel costs, depreciation, inflation, lifetime, etc. Fuel cost for heating are an important factor in the calculations on the profitability of the energy efficiency investments. And therefore also the extension of the EPBD towards smaller buildings (single family houses) is more and more under discussion when energy prices tend to rise.

Since the energy market is highly volatile a sensitivity analysis was carried out to assess the effects of modified energy prices on the economic results.

Five energy price scenarios were analysed and justified, building the basis for the sensitivity analysis. The effects of modified energy prices on the economic results are assessed for the technical potentials for energy saving and cost savings. For both the present EPBD and a possible extended EPBD to small buildings, the energy cost savings are compared for the scenarios.

### ENERGY SAVING POTENTIAL IN THE BUILT ENVIRONMENT

Two studies<sup>2</sup> carried out for EURIMA investigated the impact of the EPBD, the Energy Performance Directive 2002/92/EC, on the EU building stock. They analysed the heating related CO<sub>2</sub> emissions of the EU building stock, quantified the required investments in energy efficiency measures and analysed their cost-effectiveness which must be demonstrated in order to mobilise the total energy conservation potential in the EU building stock. These studies took into account the energy price level of the year 2002.<sup>3</sup>

### CO<sub>2</sub>-EMISSIONS SAVINGS IN EU15<sup>4</sup>

The studies identified a significant impact of the EPBD on the heating related CO<sub>2</sub> emissions of the EU-15 building stock. Compared to a business as usual (BAU) scenario under which common practice for energy efficiency is applied to new buildings and retrofit measures, the current EPBD leads to CO<sub>2</sub> emission reductions of 34 Mt/a in the year 2010. However, since single-family houses represent the largest share of buildings (45 %) in the EU-15 countries, CO<sub>2</sub> emissions could be reduced even more significantly if the scope of the Directive were extended to include smaller buildings. Extension of the scope of the Directive to all buildings would create an additional emission savings potential of 36 Mt/a.

### ECONOMIC IMPACTS EU15

The cost analysis for the EU-15 reveals that fairly significant additional investments will be required: It is estimated that full implementation of the EPBD for new and large buildings in all countries will lead to an annual investment of nearly 10 Billion Euros beginning in 2006. Extending the scope of the EPBD to all buildings, the annual investments would increase

to about 25 Billion Euros. However, in the context of total EU construction activities energy efficiency measures represent a minor share of only 1-3 % of the total turnover. In economic terms these investments would result in net annual cost reductions for national economies making such measures profitable. Converting investments into annual capital expenditure and relating them to annual energy cost savings displays the profitability of applying energy saving measures at the EU level. Implementation of the EPB-Directive would result in yearly cost reductions amounting to around 4 Billion Euros in the year 2010 rising to 7,5 Billion Euros if the scope of the Directive were to be extended to all house types.

### CO<sub>2</sub>-EMISSIONS SAVINGS IN EU8<sup>5</sup>

Next to the growth in size and population, the EU has developed into the globally largest economic single market. In order to enable the achievement of this historic milestone, the new Member States had to adapt their policy and legislation to the general legal framework of the EU. This is especially valid for the climate protection issues. Although improvements in energy efficiency already took place the energy intensity in 2000 was still more than twice compared to that in the EU-15 countries. The average of the building stock in the new Member States can be characterized by a lack of maintenance resulting in an urgent need for refurbishment.

Taking into account the development factors on the building stock over time such as retrofitting, new building, demolition etc. scenarios are developed to show the development of emissions induced by the EPBD and its potential extensions over time.

Additionally it was assumed that retrofit programmes increase the retrofit rate for those buildings, which are subject to the EPBD. This results in emission reductions of 5 Mt/a for the EPBD in 2010. For the extension to buildings >200 m<sup>2</sup> and to all buildings, emission reductions of 8 and 14 Mt/a can be effected respectively.

### ECONOMIC IMPACTS IN THE EU8

The annual investments required to activate these emission reductions are 2.7 Billion Euros per year for EPBD, 4.3 Billion Euros per year for a potential extension of the EPB to buildings >200 m<sup>2</sup> and 8.1 Billion Euros per year for an extension of the EPBD to all buildings. Of these costs, roughly 40 % are energy-related. Converting the energy related share of these investments into annual capital expenditure and relating them to annual cost savings displays the profitability of the energy efficiency measures. The annual profit amounts to 154 Million Euros per year for the EPB in 2010 and rises to 371 Million Euros per year if the scope of the EPB were to be extended to all house types.

2. Ecofys reports II and III carried out for EURIMA: "Mitigation of CO<sub>2</sub> Emissions from the Building Stock" and "Cost-Effective Climate Protection in the EU Building Stock" see: [http://www.eurima.org/document\\_library/eurima\\_publications.cfm](http://www.eurima.org/document_library/eurima_publications.cfm)

3. Average annual crude oil price 2002 (IEA) \$25/barrel, energy mix for EU15

4. EU15: the "old" EU member states: Finland, Sweden, Austria, Germany, Belgium, Ireland, Denmark, Luxembourg, France, The Netherlands, United Kingdom, Greece, Italy, Portugal, Spain.

5. As of 1 May 2005, the EU has grown by 10 new Member States. The new EU Member States include the Baltic countries (Estonia, Latvia and Lithuania), the Central-European countries Poland, Slovakia, Slovenia, the Czech Republic and Hungary as well as the Mediterranean islands of Malta and Cyprus. The data for Malta and Cyprus are not taken into account as they have a minor impact on the results. Remaining a "EU8" for the studies.

### AGGREGATED FOR THE EU-15 + EU-8 COUNTRIES: CO<sub>2</sub>-EMISSIONS SAVINGS AND COST ANALYSES.

The presented studies assessed the impact of the Directive and the impact of a possible extension with requirements for small buildings for the EU-15 and the 8 new eastern European member states.

By implementing the EPBD emission reductions of 39 Mt/a are possible in 2010 in the EU-15 + new EU-8. For the extension the EPBD to buildings >200 m<sup>2</sup> and to all buildings, emission reductions of 50 and 84 Mt/a can be effected.

The implementation of the EPB-Directive would result in yearly cost reductions amounting to around 4 Billion Euros in the year 2010 rising to 8 Billion Euros if the scope of the Directive were to be extended to all house types.

### ENERGY PRICE

The conclusions clearly support the removal of the 1000 m<sup>2</sup> threshold for existing buildings. However all the above mentioned savings and cost analyses were based on the average energy price level for 2003. The average energy price, driven by the crude oil price, has a big impact on the outcome. To analyse the sensitivity of the economic results, five energy price scenarios are investigated. Since 2003, the energy prices, against many forecasts, further increased (see Figure 2).

Hence, in the following scenarios the prices successively increase up to a peak price scenario, starting from the energy prices of the existing EU-15 study:

- Scenario 1: 2003 EU-15 prices (applied in the original reports for EU15 and EU8)
- Scenario 2: forecast 2005 EU-15 prices
- Scenario 3: forecast 2005 plus current price for CO<sub>2</sub> certificates
- Scenario 4: high price scenario
- Scenario 5: peak price scenario

### Scenario 1: 2003 EU15 prices.

#### Criteria

- In scenario 1 the price basis is taken from the existing study on the EU15 countries.
- These data were deduced from Eurostat statistics from 1992 until 2002 and have been projected to the future.
- This leads to an increase rate of 1,5 % per year, kept for all energy carriers.

Table 1: Energy price scenario 1

Scenario 1			
Increase rate	1,5%	Average 2002 -2032	2002
Gas	cent/kWh	5,16	4,03
Oil	cent/kWh	4,71	3,68
Electricity	cent/kWh	11,32	8,84
District heating	cent/kWh	6,40	5,00
Wood	cent/kWh	4,24	3,61

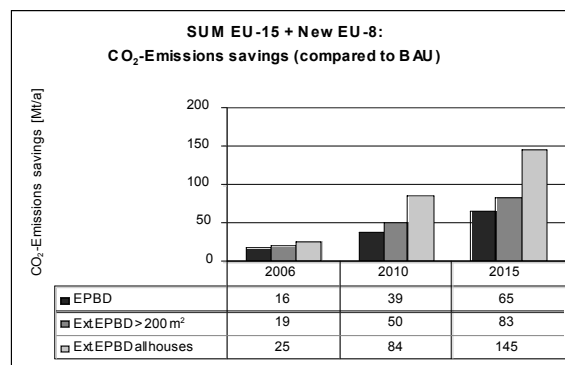


Figure 1: Cost analyses for EU

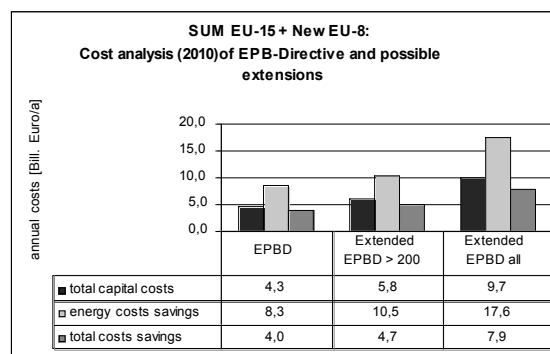


Figure 2: CO<sub>2</sub> emissions savings EU

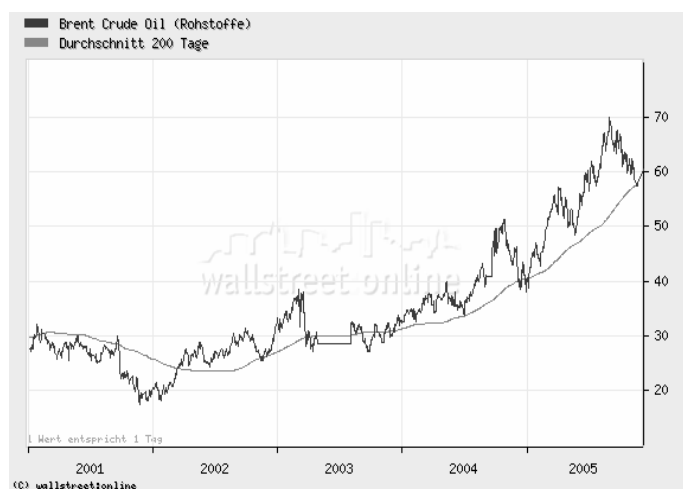


Figure 3: Oil price (Brent crude oil in USD)

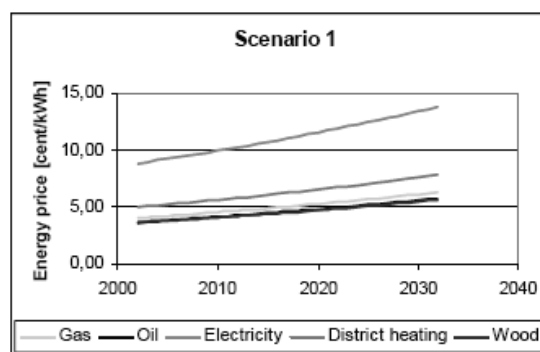


Figure 4: Energy price scenario 1

**Scenario 2: Forecast 2005 EU-15 Prices***Criteria*

- Due to the increase of the energy prices since 2003 (see Figure 3) the price analysis made in the year 2003 is updated in consideration of the actual oil price developments (December 2005), leading to a new forecast for the energy prices.
- Due to the coupling of the gas price to the oil market, the prices for gas are calculated according to the ratio of costs between gas and oil prices in 2002.
- Several reliable studies assume only a moderate increase of the electricity price on long term which is in line with Scenario 1. Therefore the electricity price is kept according to Scenario 1.
- For wood the prices are also kept.
- Since district heating is partly depending on the oil and gas price a moderate increase is assumed.
- The increase rate is kept at 1,5 % p.a.

**Table 2: Energy price scenario 2**

Scenario 2			
Increase rate	1,5%	Average 2002 -2032	2002
Gas	cent/kWh	5,69	4,44
Oil	cent/kWh	5,19	4,05
Electricity	cent/kWh	11,32	8,84
District heating	cent/kWh	6,73	5,25
Wood	cent/kWh	4,24	3,61

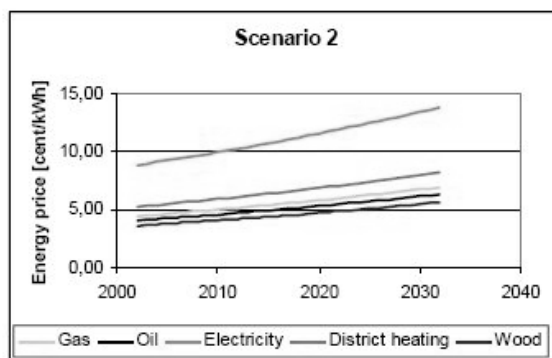


Figure 5: Energy price scenario 2

**Scenario 3: Forecast 2005 plus current price for CO<sub>2</sub> certificates***Assumptions*

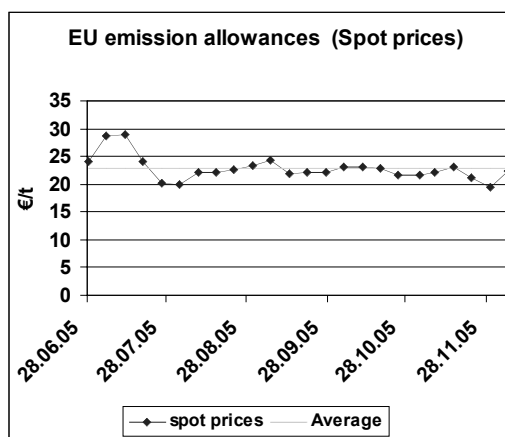
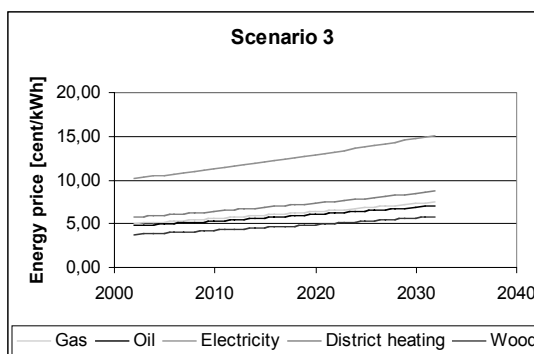
In this scenario the costs for CO<sub>2</sub> emissions should be taken into account, either as avoided damage costs or as mitigation costs. The costs for emission allowances related to the emissions trading scheme were taken into account by adding the current price for CO<sub>2</sub>-certificates to the prices as described in scenario 2.

The average certificate price of the second half of 2005 amounts to 23 €/t (see Figure 6). Depending on the emission factors for the different energy carriers the prices presented in Table 1: CO<sub>2</sub> costs per energy carrier.

**Table 3: Energy price scenario 3**

Gas	0,202	t/MWh	0,46	cent/kWh
Oil	0,266	t/MWh	0,61	cent/kWh
Electricity	0,528	t/MWh	1,21	cent/kWh
District heating	0,167	t/MWh	0,38	cent/kWh
Wood	0,02	t/MWh	0,05	cent/kWh

Scenario 3			
Increase rate	1,5%	Average 2002 -2032	2002
Gas	cent/kWh	6,15	4,91
Oil	cent/kWh	5,80	4,67
Electricity	cent/kWh	12,53	10,05
District heating	cent/kWh	7,11	5,64
Wood	cent/kWh	4,29	3,66

Figure 6: Price ETS CO<sub>2</sub>

### Scenario 4: High price scenario

#### Criteria

- The high price scenario is derived from the deferred investment scenario of the World Energy Outlook 2005 of the IEA. In the Deferred Investment Scenario the international crude oil price is significantly higher over the projection period than in the Reference Scenario of IEA (which is comparable to scenario 1 presented in this sensitivity analysis)<sup>6</sup>. The deferred investment scenario analyses how global energy markets might evolve if investment in the upstream oil industry of MENA countries were to be substantially lower than projected in the Reference Scenario. That might occur because of domestic production policies or difficulties in securing capital in some countries, leading to higher prices.
- Analogous to scenario 3, the external demand costs were taken into account according to the emissions trading scheme
- As in scenario 2, the prices for gas and district heating are linked again to the development of the oil price.
- The prices for wood and electricity are kept the same as in scenario 3.

Table 4: Energy Price Scenario 4

Scenario 4			
Increase rate	1,5 %	Average 2002 -2032	2002
Gas	cent/kWh	7,08	5,63
Oil	cent/kWh	6,66	5,33
Electricity	cent/kWh	12,53	10,05
District heating	cent/kWh	7,69	6,09
Wood	cent/kWh	4,29	3,66

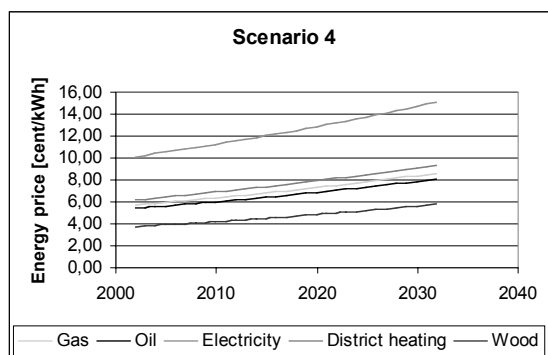


Figure 8: Energy Price Scenario 4

### Scenario 5: Peak Price Scenario

#### Criteria

- In this scenario, it is assumed the peak price from the last decade for Brent crude oil at the stock exchange (70 USD/barrel) becomes average in the future. This price was paid at a short period in August 2005 and already decreased to below 60 USD/barrel in December 2005. The price of 70 USD/barrel corresponds in the year 2032 to 117 USD in nominal terms.
- Thereby the usual price difference from stock exchange to final customer was taken into account.
- The other energy carriers were set at the value calculated in Scenario 4 for the year 2032 (end of lifetime of investigated packages).

Table 5: Energy (Peak) Price Scenario 5

Scenario 5			
Increase rate	1,5 %	Average 2002 - 2032	2002
Gas	cent/kWh	10,82	10,82
Oil	cent/kWh	10,07	10,07
Electricity	cent/kWh	15,03	15,03
District heating	cent/kWh	9,31	9,31
Wood	cent/kWh	5,69	5,69

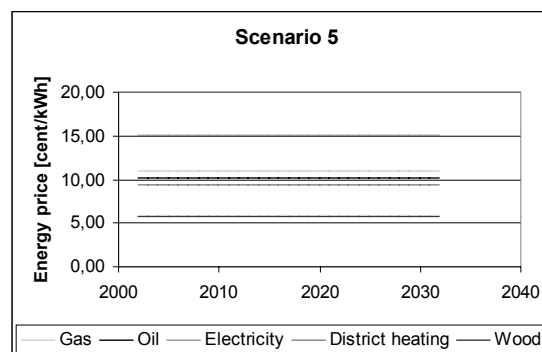
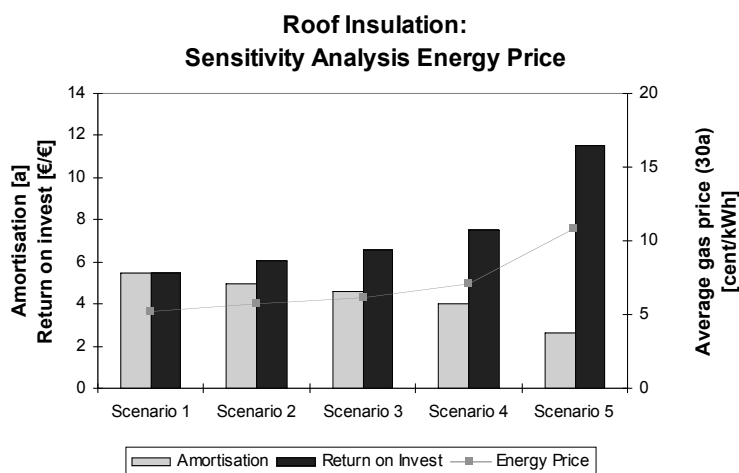


Figure 9: Energy Price Scenario 5 (Peak Price)

6. In the reference Scenario, the average IEA import price is assumed to fall back from recent highs to around \$35 (in year-2004 dollars) in 2010, and then to rise slowly to \$39 in 2030. In the Deferred Investment Scenario, the price increases gradually over time, relative to the Reference Scenario. It is about \$13 higher in 2030, or \$21 in nominal terms – an increase of almost one-third. Natural gas prices rise broadly in line with oil prices.

**Table 6: Sensitivity analysis roof insulation in the moderate climate**

		scenario 1	scenario 2	scenario 3	scenario 4	scenario 5
U-value before	W/m <sup>2</sup> K	1,50	1,50	1,50	1,50	1,50
U-value after	W/m <sup>2</sup> K	0,17	0,17	0,17	0,17	0,17
reduction of energy demand	kWh/m <sup>2</sup> .a	96	96	96	96	96
reduction of gas consumption	kWh/m <sup>2</sup> .a	106	106	106	106	106
gas price 2002	cent/kWh	4,03	4,44	4,91	5,63	10,82
price increase rate	-	1,5 %	1,5 %	1,5 %	1,5 %	0,0 %
including price CO <sub>2</sub> -certificates	euro/t CO <sub>2</sub>	0,00	0,00	23,00	23,00	23,00
average gas price 30 years	cent/kWh	5,16	5,69	6,15	7,08	10,82
annual saved energy costs	Euro/m <sup>2</sup> .a	5,48	6,04	6,54	7,53	11,50
saved energy costs over 30 years	Euro/m <sup>2</sup>	164,50	181,30	196,10	2259,00	345,10
investment costs	Euro/m <sup>3</sup>	30,00	30,00	30,00	30,00	30,00
Return per Euro invested	Euro/Euro	5,48	6,04	6,54	7,53	11,50
Amortisation	a	5,47	4,96	4,59	3,98	2,61

*Figure 10: Sensitivity Analysis, Amortisation and ROI***EXAMPLE: ROOF INSULATION AND ENERGY PRICE**

In the example of insulating a pitched roof of a residential building in a moderate climate zone it is illustrated what will be the effect of increased energy prices on the return of investment and on the amortisation. The economic optimum for the applied insulation thickness of a roof construction of course depend on the energy price: increasing energy costs do increase the economic optimum insulation thickness.

However in order to demonstrate the effect of increasing energy prices on it self for a selected fixed thermal improvement of a roof construction, a fixed U-value improvement (from 1,50 W/m<sup>2</sup>K to 0,17 W/m<sup>2</sup>K) is analysed. In this example the application of the improvement measure would need an invest-

ment of 30 Euro per m<sup>2</sup>, leading to annual energy savings of 5.45 Euro per m<sup>2</sup> roof, which demonstrates a pay-back period of less than 6 years. Over a period of 30 years, more than a five-fold return on the investment equal to 165 Euro per m<sup>2</sup> roof per year would be achieved. This is a return of 5.5 Euro per Euro invested.

Table 6 and Figure 10 give an overview of the effects of modified energy prices on the economic results. The return on investments increase from 5.5 Euro-per-Euro invested to 11.50 Euro-per- Euro in scenario 5. Respectively the pay-back period decreases from 5.5 year to less than 3 years.

**CONCLUSIONS ON THE BASIS OF THE AGGREGATED RESULTS FOR THE EU-25**

The effects of modified energy prices on the economic results for the EU-25 are assessed for the technical potentials as well as for the EPBD implementation as well for the proposed extension of the scope of the EPBD.

For the technical potential Figure 11 presents the energy cost savings in the EU-25. Compared to price scenario 1 (the 2003 price level) the energy cost savings for scenario 5 (the peak price scenario) are more than doubled.

The reality of a phased implementation of thermal renovation, coupled to the renovation cycle of buildings, is very challenging and still very interesting for society and stakeholders. The higher the energy price will be there more money we are spoiling. Or should we say: wasting energy and money?

Table 7 presents that the energy cost savings in scenario 5 are compared to the scenario 1 more than doubled, whereas the annual profit (see Table 8) increases by a factor larger than 3.

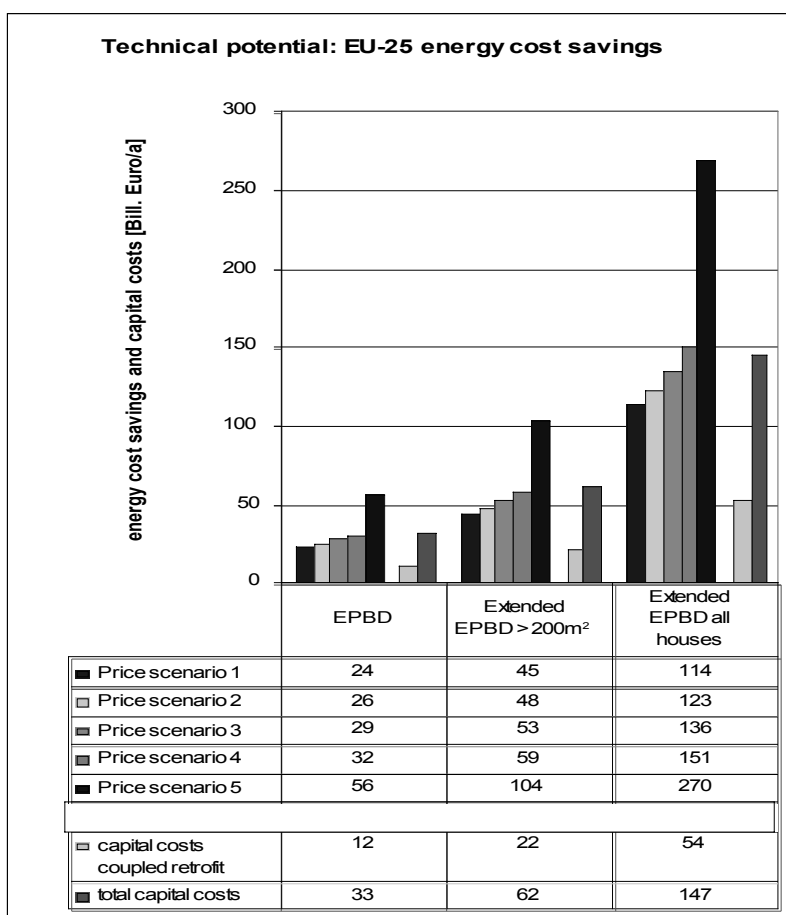


Figure 11: EU25 technical Potential for the price scenarios

Table 7: Cost savings Energy in 2010 for a phased implementation

Energy cost savings 2010	EU-25		
In Billion EURO	EPBD	Ext. EPBD > 200 m²	Ext. EPBD all houses
Price scenario 1: 2002 EU-15 prices	8,6	11,0	18,5
Price scenario 2: 2005 EU-15 prices	9,3	11,8	19,8
Price scenario 3: 2005 plus current price for CO2 certificates	10,3	13,1	22,0
Price scenario 4: high price scenario	11,4	14,5	24,3
Price scenario 5: peak price scenario	17,8	22,6	38,0

Table 8: Total annual profit 2010 for phased implementation

Total annual profit 2010	EU-25		
In Billion EURO	EPBD	Ext. EPBD > 200 m²	Ext. EPBD all houses
Price scenario 1: 2002 EU-15 prices	4,3	5,2	8,7
Price scenario 2: 2005 EU-15 prices	4,9	6,0	10,1
Price scenario 3: 2005 plus current price for CO2 certificates	5,9	7,3	12,3
Price scenario 4: high price scenario	7,0	8,7	14,6
Price scenario 5: peak price scenario	13,4	16,8	28,3

## FINDINGS AND RESULTS LOOKING INTO 2010 WITH A REVISED EPBD AND INCREASED OIL PRICES

### Enlarged possibilities with increasing energy prices:

- **Savings**  
Comparing energy prices from 2002 with a peak price scenario (related to oil price USD 25 respectively USD 70 per barrel) with full application of the present Energy Performance Directive, savings in energy costs more than double
- **Profit:**  
As savings also require investments finally by 2010 the annual profit of implementing the present EPBD will increase from 4.3 Billion Euro to 13.4 Billion Euro if the price for 1 barrel oil is increasing from 25 USD to 70 USD: a factor 3

### Enlarged possibilities in a revised EPBD, deleting the 1000 m<sup>2</sup> threshold

- **Savings**  
If a revision of the Energy Performance Directive is extended to all buildings (releasing the threshold of 1000 m<sup>2</sup>) then savings will increase from 8.6 Billion Euro to 18,5 Billion Euro at the basis of 2002 energy prices: a factor 2
- **Savings:**  
Releasing the threshold of 1000 m<sup>2</sup> in a revised EPBD and in a scenario where energy prices raise to 70 USD/barrel the savings will rise from 8.6 Billion Euros to 38 Billion Euros: a factor 4!

### Enlarged possibilities with no 1000 m<sup>2</sup> threshold in a revised EPBD and peak priced energy

- **Profit:**  
if the revision of the EPBD will cover all houses (no 1000 m<sup>2</sup> threshold) then a profit of 28,3 USD can be made in 2010: compared to 2002 situation more than a factor 6!

## FINDINGS AND RECOMMENDATIONS FOR HEAT TRANSMISSION VALUES

The economic optimum for the insulation thickness in the building components wall, roof and floor are depending on energy prices, material and labour costs, interest and inflation rate, the existing construction and the climate conditions.

Combining the results from the Price Sensitivity study with the latest study on Optimum U-values for 100 European cities roughly the following indication can be given on the present U-values in existing buildings, present U-value requirements and calculated U-value optima. The U-value optima are calculated on the basis of the energy price scenarios and the earlier mentioned parameters for the economic optimum and for meeting the post-Kyoto targets. The external climate conditions were defining the energy demand for heating and cooling.

The analyses learn that:

- It is economically justified to apply more stringent U-value requirements for wall, roof and floor constructions all over Europe
- Complementary to the requirement of the EPBD to apply a whole building energy assessment, U-value requirements can be applied for both for existing residential buildings and for new residential buildings.
- Assessing the existing U-value requirements for the building components wall, roof and floor, there is much room for improvement.
- As retrofit measures and renovations of buildings in average take place every 25 to 30 years the thermal upgrading should target the optimum insulation thickness at least based on the World Energy Outlook 2006 oil price scenario.

Table 9

ROOF		U - average	U-requirement	U-optimum retrofit		
climate	example	existing stock	2007	2002	WEO 2006	Peak price
Cold	Ivalu-Finland	0,50 W/m <sup>2</sup> K	0,16 W/m <sup>2</sup> K	0,15 W/m <sup>2</sup> K	0,12 W/m <sup>2</sup> K	0,11 W/m <sup>2</sup> K
Moderate	Amsterdam-NL	1,50 W/m <sup>2</sup> K	0,37 W/m <sup>2</sup> K	0,23 W/m <sup>2</sup> K	0,17 W/m <sup>2</sup> K	0,14 W/m <sup>2</sup> K
Warm	Roma-Italy	3,40 W/m <sup>2</sup> K	0,46 W/m <sup>2</sup> K	0,43 W/m <sup>2</sup> K	0,25 W/m <sup>2</sup> K	0,21 W/m <sup>2</sup> K

Table 10

WALL		U - average	U-requirement	U-optimum retrofit		
Climate	example	existing stock	2007	2002	WEO 2006	Peak price
Cold	Ivalu-Finland	0,50 W/m <sup>2</sup> K	0,25 W/m <sup>2</sup> K	0,17 W/m <sup>2</sup> K	0,15 W/m <sup>2</sup> K	0,14 W/m <sup>2</sup> K
Moderate	Amsterdam-NL	1,50 W/m <sup>2</sup> K	0,37 W/m <sup>2</sup> K	0,38 W/m <sup>2</sup> K	0,21 W/m <sup>2</sup> K	0,18 W/m <sup>2</sup> K
Warm	Roma-Italy	2,60 W/m <sup>2</sup> K	0,50 W/m <sup>2</sup> K	0,48 W/m <sup>2</sup> K	0,32 W/m <sup>2</sup> K	0,28 W/m <sup>2</sup> K