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Copenhagen Economics

Multiple benefits of investing in energy efficient renovation of buildings

APPENDIX

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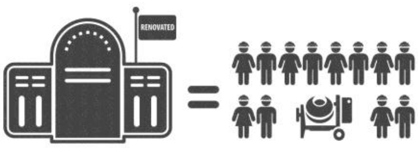

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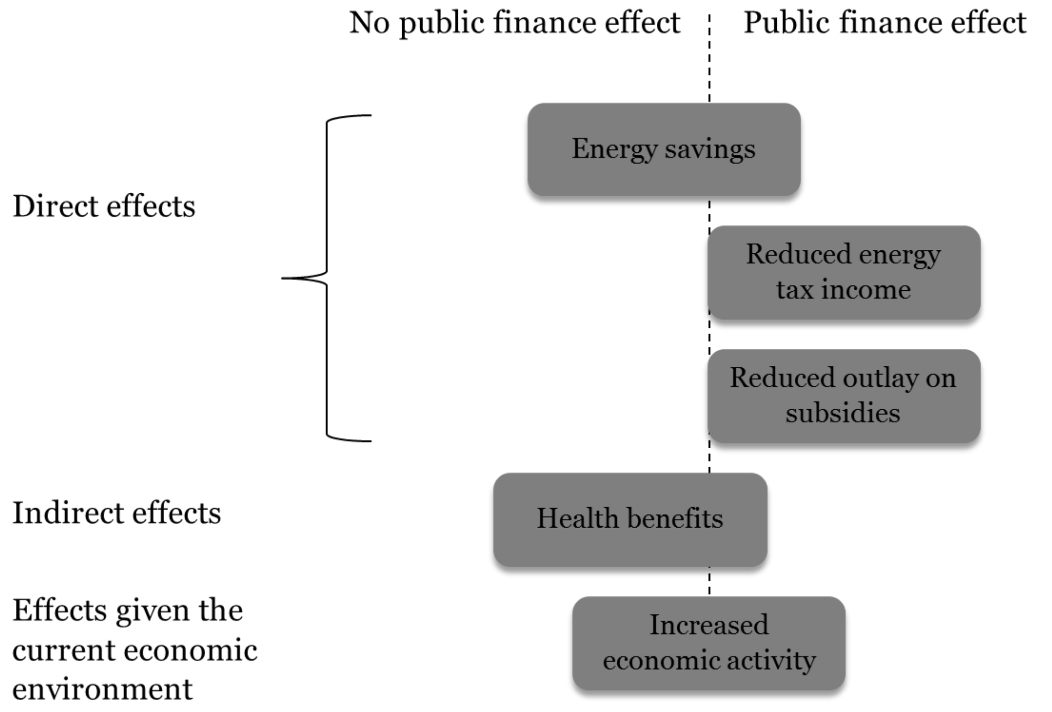
Appendix A
Calculating the benefits from energy efficiency investments

In this appendix we present the assumptions and calculations behind our assessment of the benefits related to investments in improving energy efficiency in existing buildings. Our point of focus is on energy efficiency improvements through renovating existing buildings. Concretely, this could for example be through floor and wall insulation, replacing windows and window frames and replacing heating systems. We do not focus on the efficiency potential that exist through replacing old appliances such as washing machines and refrigerators with more efficient ones. We do, however, consider ventilation systems and air conditioning, as such installations are typically a more integral part of buildings.

A.1 General description of our modelling approach

Enhancing the energy efficiency of the existing building stock induces benefits through several channels. While some of these benefits occur directly through e.g. reduced energy consumption, other benefits occur more indirectly through e.g. improved health over several years. In addition, some of these benefits have direct positive effects on public budgets while others are benefits to society at large without having specific public finance effects. Our mapping of the different benefits is presented in Figure A.1, and discussed in the following section.

Figure A.1 Effects of energy efficient renovation of buildings



Source: Copenhagen Economics

Energy savings through reduced energy consumption is a direct benefit stemming from increased energy efficiency. In privately owned buildings the benefits will typically accrue to the owner or the user of the building,[1] while in publicly owned buildings the benefits will accrue to the public or the users of publicly rented apartments. Given the proper distribution of benefits between public entities, this will improve public budgets. The benefit from energy savings implicitly also includes the avoided capital cost of building additional power plants, as these capital costs are included in the price of electricity.

As energy efficient renovation of buildings will reduce energy consumption, it will have a negative effect on public budgets through reduced tax revenue from energy consumption taxes.

The European Member States are currently subsidising both fossil fuel consumption and deployment of renewable energy technologies. By reducing energy consumption through energy efficient renovation of buildings, both types of subsidy can be reduced. This will have a positive effect on public finances.

A more indirect benefit occurs through *health benefits*. Most energy efficiency measures will improve the indoor temperature, and by choosing renovation measures that also improve the indoor climate, health benefits can be obtained through fewer diseases, reduced

[1] We will discuss the principal agent problem related to owners/tenants in the section related to reduced energy consumption below.

mortality, improved worker productivity, and improved overall quality of life. While most of these benefits accrue to society in general, public budgets may also be improved through fewer hospital expenses and fewer sick days.

Health benefits also occur as power and heat production from power plants, combined heat and power plants (CHP) and local heating is reduced. Power and heat generated in these facilities give rise to air pollution such as NO_x, SO_2, small particle matters (PM2.5) and CO_2, and by reducing energy consumption this air pollution can be reduced.

Given the current economic downturn, energy efficiency investments can *increase economic activity*, and improve public budgets by reducing unemployment benefits and increasing tax revenue from the increased economic activity. Positive effects from this include, increased tax revenue (including VAT, labour income tax, corporate income tax etc.) from increased activity and employment, reduced unemployment expenses. This effect will be most pronounced during periods of economic crises, when there is spare capacity in the economy.

A.2 Scenarios

In the following calculations, we consider two different scenarios for the level of energy efficiency investments. These scenarios have been developed by Fraunhofer et al (2009) who has created a comprehensive database for energy efficiency investment potentials in all EU countries. The available potential for energy efficiency depends on the level of policy commitment to e.g. break down barriers to energy efficiency investments.

In our calculations we follow Fraunhofer et al 's (2009) definition of two scenarios. The first scenario assumes a high level policy intervention which makes it possible to undertake all energy efficiency investments which is considered cost-effective by Fraunhofer et al ("HPI" in Fraunhofer et al). The second scenario is the upper level for possible energy efficiency investments ("Technical" in Fraunhofer et al) and is defined as full penetration of current best practice technologies, such as replacing all washing machines with the most energy efficient model, upgrading all heating systems to the most efficient model etc. In our calculations we refer to these as "Low Energy Efficiency (EE) scenario", and "High Energy Efficiency (EE) scenario".

The low EE scenario, includes investments in energy-efficiency measures which are cost-effective for the end-user.[2] This means, that investments will only be undertaken if they are cost effective in the sense that the energy savings resulting from the investment will be higher than the cost of the investment. The low EE scenario also assumes a high level of policy ambition in terms of removing barriers to energy efficiency investments. The more barriers that are removed, the higher the potential will be.

The *high EE scenario* basically includes all investments in energy efficiency measures that are technically feasible. This means both investments that are cost-effective, and those

[2] Fraunhofer ISI et al (2009) defines which measures are "cost-effective" based on several assumptions among others energy prices, and consumer discount rates.

that are not cost-effective. The scenario only includes technologies that are technically viable, and not extremely expensive. Even though these investments may not be cost-effective from a purely energy savings perspective, they bring additional benefits through improved health, reduced subsidies to RE technologies etc., and may achieve cost effectiveness when these parameters are included. This is the reason that we consider this scenario as well.

Price of energy
In the model calculations, we make use of projections of the price of energy in 2020 and 2030. For this, we use figures from DG Energy (2010), projecting energy prices in 2020 and 2030.[3] These energy prices, depicted in Table A.1, are also used to construct the energy efficiency potential in the Fraunhofer et al (2009) study.

Table A.1 Projected energy prices, 2020 and 2030

	2020 (EUR/MWh)	2030 (EUR/MWh)
Electricity - post tax (average)	141	141
Electricity - pre tax	121	120
Heating oil price	76	81
Natural gas price	41	44
Hard coal price	12	13

Note: Electricity post tax is an average of industry, services and households

Source: DG Energy (2010)

The DG Energy projections assume that the price of CO_2 in the ETS sector is €16.5 / ton CO_2 in 2020 (2008 prices). This projection assumes, among others, that Member States achieve their national targets under the Renewables directive 2009/28/EC and the GHG effort sharing decision 2009/406/EC in 2020.

There is some uncertainty related to the fuel input in heating in the Fraunhofer et al (2009) study. This mix determines the average price of heating and thus the value of energy savings from renovation projects. The proper calculation of the price of heating is determined by the heating sources used by the buildings in which Fraunhofer et al has identified the energy efficiency potential. It seems as though Fraunhofer uses heating oil as the primary heating source, even though this has not been confirmed. This may be the result of identifying the largest potential in buildings that are primarily heated by heating oil, which is typically the case in the residential sector in countries with limited district heating. In the following, we will maintain the input mix of heating used by Fraunhofer et al (2009).

[3] DG Energy (2010), page 45. We use the reference scenario implying that recent policy initiatives (in 2010) have been taken into account. The projections are based on simulations from the PRIMES model.

A.3 Identifying and characterising the energy efficiency potential

The potential for energy efficiency investments in Europe has been defined in an extensive study for DG Energy and Transport in 2009 by Fraunhofer et al (2009). The central part of the identification of energy saving potentials is the bottom-up MURE simulation tool.[4] This tool includes a rich technological structure for the demand sectors. The project refined the MURE model with further details. The MURE database can be found here: www.mure2.com. Identification of the concrete potential for energy efficient renovations of buildings in Europe is based on a country-specific evaluation. This evaluation takes into account the specific building stock in all EU Member States including its age, the energetic standard of the buildings (U-values), the different climatic zones including the amount of heating degree days, and the energy demand in the different countries. This allow the authors to calculate energy consumption per square meter for different building types in specific countries. Country specific information on material cost, labour costs, and very detailed cost structure for different types of refurbishment is also taken into account, including learning curves for different technologies and the implied cost reductions over time.

The energy saving potential is derived for several different renovation measures, and for both the residential, commercial and industry sector. The energy saving potential is available both for the existing building stock and for new buildings. We focus only on the existing building stock. With respect to the different measures, we have focused on the following, which are related to renovation of existing buildings:[5]

- Heating improvements from heating systems (heating pumps etc.)
- Heating improvements from refurbishment of existing buildings (insulation, window improvements, better ventilation and air conditioning etc.)
- Water heating
- Appliances in the service sector (only air conditioning and ventilation)
- Lighting systems

According to the database on energy saving potentials, the accumulated energy saving potential in 2020 (a baseline has been deducted) in the low EE scenario in the mentioned categories is 65 Mtoe, while investing in all technically feasible energy savings (the high EE scenario) will generate 95 Mtoe in energy savings, cf. Table A.2. This corresponds to 5 and 8 per cent of EU final energy demand respectively.[6] The largest source of energy savings comes from renovations that improve heating systems and insulation in households, followed by heating and insulation in the service sector, and in the industry.

[4] Mesures d'Utilisation Rationelle de l'Énergi

[5] We have not looked at e.g. household appliances such as washing machines etc., efficiency potential in construction new buildings, improving the efficiency of industrial processes, or efficiency in the transport sector.

[6] Based on DG Energy (2010)

Table A.2 Energy saving potentials from different sources, 2020

Renovation source	Energy saving potentials - low EE scenario (Mtoe)	Energy saving potentials – high EE scenario (Mtoe)
Households - heating and insulation	31.0	47.8
Households - water heating	2.6	4.9
Service sector - heating and insulation	13.5	19.5
Service sector appliances (air conditioning & ventilation)	3.8	3.8
Industry – heating and insulation	9.0	13.5
Households - lighting	1.8	2.4
Service sector - lighting	3.1	3.1
Total savings	**65**	**95**

Note: The savings potentials are accumulated from 2012-2020.
These estimates do not include the rebound effect
Heating and insulation also contains reduced heating demand from better ventilation and air conditioning

Source: Copenhagen Economics, based on Data Base on Energy Saving Potentials - http://www.eepotential.eu/

The accumulated potential increases towards 2030, where the energy saving potential is 127 Mtoe and 190 Mtoe in the two scenarios respectively, cf. Table A.3. This corresponds to 11 and 16 per cent of EU final energy demand respectively.[7]

Table A.3 Energy saving potentials from different sources, 2030

Renovation source	Energy saving potentials - Low EE scen (Mtoe)	Energy saving potentials – High EE scen (Mtoe)
Households - heating and insulation	65.0	101.1
Households - water heating	5.3	10.2
Service sector - heating and insulation	21.8	31.4
Service sector appliances (only air conditioning & ventilation)	6.5	6.5
Industry – heating	15.4	24.9
Lighting	13.3	16.0
Total savings	**127**	**190**

Note: The savings potentials are accumulated from 2012-2030.
These estimates do not include the rebound effect
Heating and insulation also contains reduced heating demand from better ventilation and air conditioning

Source: Copenhagen Economics, based on Data Base on Energy Saving Potentials - http://www.eepotential.eu/

These energy saving potentials are not equally spread out across Member States, but will depend on the size and the state of the existing building stock. Countries with a smaller existing building stock will naturally have a smaller absolute potential for renovations. We find that the largest potential is present in Germany (24 per cent), France (13 per

[7] Based on DG Energy (2010)

cent), UK (12 per cent), and Italy (10 per cent) in the low EE scenario, cf. Table A.4. These four countries constitute 59 per cent of EU's total energy savings potential. A similar picture shows in the high EE scenario.

Table A.4 Country specific energy saving potentials 2030

Member States	Total saving potentials - Low EE scen (MToe)	pct. of EU wide	Total saving potentials - High EE scen (MToe)	pct. of EU wide
Austria	3	2	4	2
Belgium	4	3	7	3
Bulgaria	2	1	2	1
Cyprus	0	0	0	0
Czech Republic	5	4	7	4
Denmark	2	1	3	1
Estonia	0	0	0	0
Finland	1	1	2	1
France	17	13	26	14
Germany	30	24	43	22
Greece	2	2	3	2
Hungary	2	2	4	2
Ireland	1	1	1	1
Italy	12	10	18	10
Latvia	0	0	1	0
Lithuania	0	0	1	0
Luxembourg	0	0	0	0
Malta	0	0	0	0
Netherlands	4	3	7	4
Poland	8	6	11	6
Portugal	2	1	2	1
Romania	4	3	6	3
Slovakia	1	1	2	1
Slovenia	1	1	1	0
Spain	8	6	11	6
Sweden	3	2	4	2
United Kingdom	15	12	24	13
Total	**127**		**190**	

Note: The total row does not equal the sum of the country specific numbers due to rounding off.

The energy saving potential is accumulated from 2012-2030. The distribution of energy savings is relatively similar across time periods.

Source: European Commission Data Base on Energy Saving Potentials - http://www.eepotential.eu/

A.4 Gross investment costs

The above stated energy saving potentials can be realised through investments in renovation projects. While extensive work has been undertaken on identifying the energy saving potential, the total size of investments needed to fulfil this potential has been subject to less research. One of the estimates was made by the European Commission (2012), Annex I, where it is found that annualised investments of €60 billion per year is needed from

2012-2020 to reach the potential corresponding to our low EE scenario in both the existing building stock, and in *new buildings*. We use the same method applied by the Commission, but only considers the potential in the existing building stock. We begin by taking the MAC-curves presented in ECF (2010), page 54 and read off the net investment cost (or saving) per investment type per GJ.

By combining the net cost of investment per GJ with the energy saving potential for each measure, we can transpose the net cost of investment into a total cost in EUR. The net cost of investment is by definition equal to the gross cost of investment minus the annualised achievable savings from reduced energy consumption. Since we know both the energy saving potential, and the price of energy used in the ECF (2010) study (both for electricity and heating inputs), we can deduce the gross cost of investment.

We find that for EU27 the annualised gross investment costs needed to achieve the renovation measures in the low EE scenario from 2012-2020 to be €41 billion, and €78 billion in the high EE scenario, cf. Table A.5. A similar annual amount is needed to reach the potential going from 2020-2030.

Table A.5 Gross annualised investment cost of energy saving investments, 2012-2020

Renovation source	Gross investment cost - low EE scenario (bn EUR)	Gross investment cost - high EE scenario(bn EUR)
Households – heating and insulation	20.8	40.5
Households - water heating	2.8	5.5
Service sector – heating and insulation	8.6	16.1
Service sector appliances (air conditioning & ventilation)	0.7	0.7
Industry – heating and insulation	7.0	12.7
Households – lighting	0.2	1.0
Service sector – lighting	1.1	1.1
Total gross investment costs	**41**	**78**

Note: In order to calculate investment cost, we have assumed that all water heating is generated by use of electricity, and all that all heating is generated by use of heating oil.

Source: Copenhagen Economics, based on ECF (2010) and methodology in European Commission (2012)

It should be noted that these estimates are calculated on the basis of MAC-curves. MAC-curves typically only include the costs related to the actual investment including the operation and maintenance costs. Other costs, such as transaction costs related to e.g. the use of scarce management time are not included in the analyses. This means that the net savings we derive overestimate the true benefits of the measures, when taking into account of all relevant costs. Consequently, we may underestimate the actual annualised investment costs.

A.5 Savings through reduced energy consumption

As shown in the previous section, there is a potential for achieving energy savings from investments in energy efficiency in buildings. These savings have a very direct and concrete benefit through reduced cost of energy consumption. By using the assumptions on the price of electricity and heating in 2020, as stated in Section A.2, we find that there are annual savings worth of €66 billion in the low EE scenario, and €94 billion in the high EE scenario in 2020, cf. Table A.6. If investments are continued towards 2030, annual energy savings can be increased by €65 billion and €98 billion in the two scenarios respectively.

Table A.6 Gross value of energy savings

	Value of energy savings - Low EE scenario (bn EUR)	Energy savings - High EE scenario (bn EUR)
Households - heating and insulation	27.3	42.0
Households - Water heating	4.3	8.0
Service sector - heating and insulation	11.9	17.1
Service sector - appliances (air conditioning and ventilation)	6.2	6.2
Industry - heating and insulation	7.9	11.9
Households – lighting	3.0	3.9
Service sector – lighting	5.1	5.1
Total	**66**	**94**

Note: * For industry we only consider the potentials from heating, and not from e.g. industrial process.

These estimates do not include the rebound effect

Heating and insulation also contains reduced heating demand from better ventilation and air conditioning

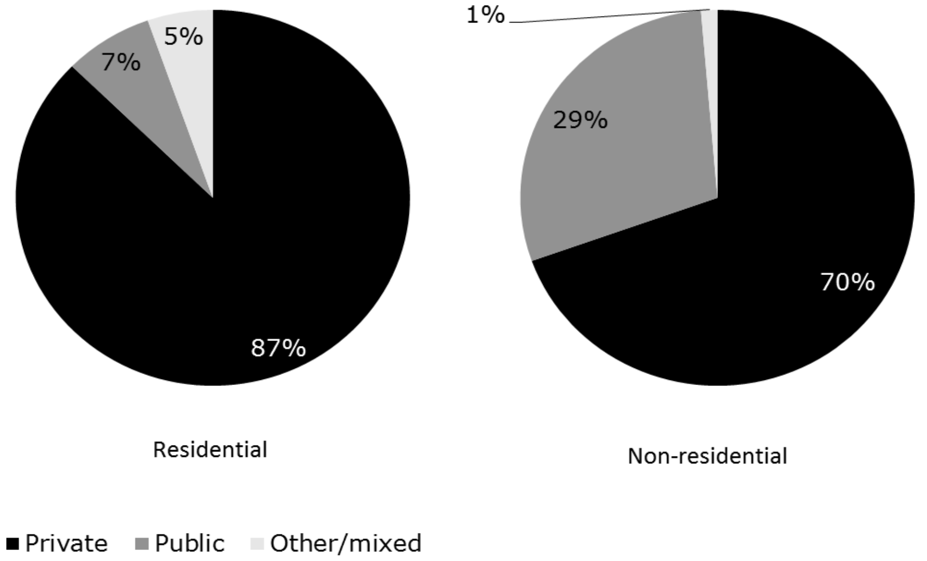
Source: Copenhagen Economics based on data from Data Base on Energy Saving Potentials and estimates for the price of electricity and heating oil as mentioned in the earlier section

These savings in energy consumption will be a specific and direct benefit to the owners and/or users of houses, apartments, office buildings etc. The distribution of these benefits will depend on the structure of the European building stock, including public/private ownership.

The average publicly owned share of residential buildings in EU27 is 7 per cent, while the privately owned share is 87 per cent, cf. Figure A.2. Publicly owned residential buildings are typically social housing. For non-residential buildings the public ownership share is 29 per cent compared with 70 per cent private, cf. Figure A.2. Publicly owned buildings is typically e.g. schools, hospitals, and administration buildings.[8]

[8] According to BPIE (2011), 17 per cent of non-residential buildings in EU are educational, 7 per cent are hospitals, and 51 per cent are wholesale, retail and offices. 26 per cent are hotels, restaurants, sport facilities and others.

Figure A.2 Ownership of building structure



Note: Ownership share is calculated of the number of dwellings (residential) and buildings (non-residential)

Source: BPIE (2011)

From this ownership structure we can deduce how the value of energy savings from Table A.6 is distributed between savings for the public budgets and savings for the overall society respectively. We find that from a public finance point of view, public expenditure can be reduced by €11 billion (€15 billion in the high EE scenario) in 2020, cf. Table A.7. The majority of these savings (€9.0 bn.) in the low EE scenario comes from energy savings in non-residential buildings, while publicly owned residential buildings generate fewer savings (€2.4 bn.) primarily since the public sector owns less residential buildings.

Table A.7 Benefits to society and public finances – energy saving

Overall benefits to society	Value of energy savings - Low EE scenario (bn EUR)	Energy savings - High EE scenario (bn EUR)
Savings from reduced energy consumption in residential buildings	34.5	54.0
Savings from reduced energy consumption in non-residential buildings	31.1	40.3
Total	**66**	**94**

Benefits to public finances (sub section of benefits to society)	Value of energy savings - Low EE scenario (bn EUR)	Energy savings - High EE scenario (bn EUR)
Savings from reduced energy consumption in residential buildings- publicly owned	2.4	3.8
Savings from reduced energy consumption in non-residential buildings- publicly owned	9.0	11.7
Total	**11**	**15**

Note: These estimates does not include the rebound effect

Source: Copenhagen Economics, based on Data Base on Energy Saving Potentials and BPIE (2011).

This calculation assumes that the energy consumption in dwellings/buildings is the same, irrespective of whether the buildings are publicly or privately owned. For residential dwellings this is most likely quite accurate; however for non-residential buildings the assumption may not be 100 per cent precise. A hospital e.g. will most likely not use the same amount of energy as a restaurant or a hotel. However, it is not obvious that the results are biased in one particular direction as a result of this.

In addition, we assume that public budgets will be improved with the value of the energy savings. In reality, energy savings achieved in e.g. a public school may not be channelled back in the general government's budget. However, we still consider this as an overall saving for the public, as the benefit will either accrue to the general government budget or to the local government entity (the school) and materialise in better quality of the provided services. The same reasoning holds in the residential sector, where the rent in public owned apartments can be increased to extract the economic benefit, without making the tenant worse off.

A.6 Reduced tax income from energy taxation

All EU Member States levy taxes or excise duties on energy consumption. Hence, when European energy consumption is reduced, so is government tax revenue from energy taxation. We assess the governments' loss of tax revenue by looking at the taxation on electricity consumption, and the excise duty on natural gas and coal used for heating purposes.

There are vast differences between the European countries' tax on electricity. In our calculations, we use an average tax measure on electricity in the EU which is €20 per MWh, cf. Table A.8.

Table A.8 Pre and post tax price of electricity

EUR/MWh	2020	2030
Pre tax price of electricity	121	120
Post tax price of electricity	141	141

Note: Post tax price of electricity is measured as an average of household, service and industry use.

Source: DG Energy (2010)

For excise duties on heat consumption, we use the excise duties in Germany. Again there are differences within countries. We use the German tax rate as it is a little higher than an average EU country. This implies that we overestimate the loss of tax revenue to a little extent. Including the VAT and the assumed share of input in European heating, we find that the average tax on heating input for business use is €0.96 per GJ, and €1.23 per GJ for non-business use, cf. Table A.9.

Table A.9 Excise duty on heating input

€ / GJ	Business use	VAT	Non business use	VAT
Natural gas	1.14	0.19	1.53	0.19
Coal	0.3	0.19	0.3	0.19
Average	**0.96**		**1.23**	

Source: DG TAXUD (2012)

Based on these tax rates and the reduced energy consumption implied by the two energy efficiency scenarios, we estimate that European governments stand to lose €5.2 billion annually in the low EE scenario and €7.2 billion annually in the high EE scenario in 2020, cf. Table A.10.

Table A.10 Tax revenue lost from reduced energy consumption, 2020

2012-2020	Reduced consumption - Low EE scenario (Mtoe)	Reduced energy tax income (bn €)	Reduced consumption - High EE scenario (Mtoe)	Reduced energy tax income (bn €)
Heating	53.5	2.5	80.8	3.9
Electricity	11.3	2.7	14.2	3.4
Sum	**65**	**5.2**	**95**	**7.2**

Note: These estimates do not include the rebound effect

Source: Copenhagen Economics based on DG TAXUD (2012), and DG Energy (2010).

If investments are continued towards 2030, the annual loss of tax revenue will be increased by €4.6 billion or €6.6 billion in the two scenarios respectively, cf. Table A.11.

Table A.11 Tax revenue lost from reduced energy consumption, 2030

2020-2030	Reduced consumption - Low EE scenario (Mtoe)	Reduced energy tax income (bn €)	Reduced consumption - High EE scenario (Mtoe)	Reduced energy tax income (bn €)
Heating	48.7	2.3	76.6	3.7
Electricity	9.4	2.3	12.0	2.9
Sum	**58**	**4.6**	**89**	**6.6**

Note: These estimates do not include the rebound effect

Source: Copenhagen Economics based on DG TAXUD (2012), and DG Energy (2010).

A.7 Reduced outlay on subsidies – energy consumption

Several EU governments grant some sort of energy consumption subsidy to its citizens and industry. Subsidies to energy intensive industry are typically safeguards against *carbon leakage*; that is the loss of competitiveness by especially energy intensive companies. We do not focus on the subsidies related to energy intensive industries. Instead, we focus on energy consumption subsidies to regular consumers e.g. through tax exemptions to input in power production or excise tax exemptions to natural gas purchases in households. Based on extensive work by the OECD, we find that such energy consumption subsidies in the EU OECD countries constitute €11.7 billion annually, cf. Table A.12. For all of EU we therefore expect this number to be slightly higher.

Table A.12 Energy consumption subsidies in EU OECD

Country	Reduced VAT or taxes on energy consumption	€ billion
Belgium	Fuel Tax Reduction for Certain Professional Uses	1.52
France	Excise tax exemptions and reduced rates	0.47
Germany	Excise tax exemptions and reduced rates	3.54
Hungary	Excise tax exemptions and reduced rates	0.15
Italy	Excise tax exemptions and reduced rates	0.11
Netherlands	Excise tax exemptions and reduced rates	0.26
Spain	Fuel Tax Reductions	1.37
Sweden	Excise tax exemptions and reduced rates	0.51
United Kingdom	Reduced Rate of VAT for Fuel and Power	3.72
Total		**11.7**

Note: Reduced taxes has been considered for all EU OECD countries.

Source: OECD (2011c)

The energy efficiency investments will reduce energy consumption by app. 6 per cent in the low EE scenario, and app. 9 per cent in the high EE scenario. This corresponds to a reduced outlay on subsidies for energy consumption by €0.7 billion in the low EE scenario and €1.1 billion in the high EE scenario, cf. Table A.13.

Table A.13 Reduced outlay on energy consumption subsidies

billion €	Low EE scen	High EE scen
Saved energy consumption subsidies (2012-2020)	0.7	1,1
Saved energy consumption subsidies (2020-2030)	0.7	1.1

Source: Copenhagen Economics, based on OECD (2011c).

In some countries, production of energy based on fossil fuels is also subsidised. These subsidies are however of relatively small, and decreasing magnitude. In Germany e.g. where subsidies to coal production historically has been sizeable, it is being gradually phased out and currently stands at €1.7 billion in 2010 down from about €5 billion in 1999.[9] This subsidy includes support for closing down coal fired power plants. Subsidies of this kind will not be affected by a lower energy consumption spurred e.g. by increased energy efficient renovation of buildings, and is therefore not included in our assessment.

A.8 Reduced outlay on subsidies - renewable energy deployment

The EU Member States have agreed to the ambitious "climate and energy package", including the three 20-20-20 targets:[10]

- A reduction in EU greenhouse gas emissions of at least 20% below 1990 levels
- 20% of EU energy consumption to come from renewable resources
- A 20% reduction in primary energy use compared with projected levels, to be achieved by improving energy efficiency.

Investing in energy efficient renovation of buildings clearly contributes to the third target, but it also contributes to the first and second target by lowering EU energy consumption and thus greenhouse gas emissions.

All EU Member States have put forward detailed plans on how to achieve the second objective: increasing the share of renewable energy in energy consumption to 20 per cent on average. These plans involve expanding different types of renewable energy in both electricity and heat generation. By reducing the total energy consumption through energy efficiency renovations, the RE-target will be cheaper to meet by definition.

In this section we will calculate a rough estimate of how much cheaper it will be to meet the same RE-target, as the increase in renewable energy in in electricity and heat production can be lower.

[9] See OECD (2011), Inventory of budgetary support and tax expenditure for fossil fuels – Germany, page 3.
[10] DG Climate webpage. http://ec.europa.eu/clima/policies/package/index_en.htm

The energy efficiency investment potential towards 2020 can reduce energy consumption by 65 or 96 Mtoe respectively in the two scenarios. This implies that EU27 can avoid expanding RE equal to 20 per cent of the reduction in energy consumption and still meet the objective that 20 per cent of energy consumption must come from renewable energy. This equals 13 or 19 Mtoe respectively, cf. Table A.14.

Table A.14 Reduced energy consumption, 2020

Scenario	Abatement potential / Reduced energy consumption (Mtoe)	20 per cent of reduced energy consumption
Low EE scenario	65	13
High EE scenario	95	19

Source: Copenhagen Economics

According to the Member States' National Renewable Energy Action Plans, the primary drivers of renewable energy expansion from 2010-2020 will be biomass in heat (28.7 Mtoe) and onshore wind (16.8 Mtoe) followed by offshore wind and biomass in electricity (11.5 and 11.0 respectively), cf. Table A.15. We have combined the expected expansion path with estimates for the cost of the respective technologies.[11] These costs range from 31-47 €/MWh for geothermal energy (low and high estimates respectively) to 214-300 €/MWh for wave/tidal (low and high estimates respectively). There is substantial uncertainty about the actual costs of these technologies, especially going forward towards and beyond 2020. Increased technological progress and supply chain management is likely to drive the levelised cost of energy down, while conversely the marginal expansion may be more expensive as e.g. the most profitable offshore wind locations are utilised first leaving the more expensive for the marginal expansion.

Table A.15 Expansion of renewable energy in EU27 from 2010-2020

Technology	Expected expansion (MToe)	Cost of expansion - Low estimate (€/MWh)	Cost of expansion - High estimate (€/MWh)
Wave and tidal	0.6	214	300
Solar PV	5.5	140	248
Solar thermal	1.6	132	163
Offshore wind	11.5	70	93
Heat pumps	8.2	30	79
Biomass electricity and heat	39.7	39	62
Onshore wind	16.8	39	47
Hydro	2.3	16	70
Geothermal	0.4	31	47
Sum	**87**		

Note: Sorted by highest cost of expansion

Source: ECN (2011), Open Energy Info, http://en.openei.org/apps/TCDB/ ,and Pöyry (2008)

[11] These cost estimates are taken Open Energy Info, http://en.openei.org/apps/TCDB/

The implicit subsidies to the different technologies are calculated by subtracting the expected price of electricity or heating input from the technology specific generation cost. We estimate that EU governments can reduced their outlay on subsidies to renewable energy deployment by €2-10 billion depending on the high or low cost estimates for renewable, cf. Table A.16.[12] The estimate is the same for both scenarios as the assumed high price of electricity in 2020 will render most renewable energy technologies profitable without government subsidies.

Table A.16 Value of avoided RE expansion – cost effective scen.

Technology	Avoided expansion (Mtoe)	Implicit subsidy - Low price €/MWh	Implicit subsidy - High price €/MWh	Saved subsidy - High price (million €)	Saved subsidy - Low price (million €)
Wave and tidal	0.6	93	179	1,251	651
Solar PV	5.5	19	128	8,163	1,214
Solar thermal	1.6	11	42	786	209
Offshore wind	5.3	0	0	-	-
Heat pumps		0	42		
Biomass electricity and heat		0	0		
Onshore wind		0	0		
Hydro		0	0		
Geothermal		0	10		
Sum	**13.0**			**10,201**	**2,074**

Note: Price of electricity: 121 €/MWh

Weighted price of heating fuels: 37 €/MWh

The conversion factor between toe and MWh is 11.63 MWh per toe.

Source: Copenhagen Economics

A.9 Health benefits

Renovating buildings in order to increase energy efficiency has positive benefits on the overall state of health in society. The benefits accrue from at least two different channels:

1. Increasing energy efficiency will lead to lower energy consumption and consequently lower energy "production". As production of energy in terms of electricity and heat gives rise to air pollution through both power and CHP plants, and local heating, this pollution will be reduced.
2. Renovations such as insulation, ventilation, better heating systems, and improved lighting may improve the indoor climate giving rise to better overall health and well-being, fewer respiratory diseases such as e.g. asthma, increased worker productivity, reduced occurrence of seasonal affective disorder (SAD), and even better educated students.[13] In addition, energy efficiency will tend to increase the

[12] We implicitly assume that Member States can coordinate on postponing the most expensive technologies.

[13] See e.g. IEA (2012)

average room temperature, which may prevent energy-poverty related diseases and mortality.[14]

These benefits to health can be appraised. However, the level of uncertainty – especially with respect to overall health benefits (item 2 above) – of such estimates is relatively high, and increasing as we attempt to replicate country-specific results for all EU Member States. It is less uncertain to calculate the benefits from reduced air pollution (item 1 above), as the emission factors of air pollution from different inputs, and their health impact is well defined. In the following we therefore calculate the economic value of reducing air pollution, and include this estimate in the aggregate benefits. For the health benefits from insulation, ventilation, lighting etc., we will describe the findings from the different studies, and give a very rough estimate of what this may mean for EU as a whole. However, we will not include this rough estimate in the aggregate benefits, as we believe the uncertainty of aggregating over all EU Member States is high.

1. **Health benefits from reduced air pollution from power and heating plants**

In this section we estimate how much air pollution can be reduced by reducing the conversion of energy to electricity and heat. In order to calculate the benefits from reduced air pollution, we need to know the following:

- The input mix in electricity and heat production in EU27
- The air pollution emissions from different inputs
- The health value of reducing air pollution emissions

Firstly we look at the amount of energy which can be reduced due to energy efficiency investments. In 2020, annual energy consumption will be reduced by 65 Mtoe in the low EE scenario. 54 Mtoe will be reduced heating and 11 Mtoe will be reduced electricity consumption, cf. Table A.17. In the high EE scenario, heating will be reduced by 81 Mtoe, and electricity by 14 Mtoe. Continuing investments towards 2030 will further reduce annual energy consumption by a similar amount

Table A.17 Reduced energy consumption, 2020

2012-2020	Reduced consumption - Low EE scenario (Mtoe)	Reduced consumption - High EE scenario (Mtoe)
Heating	54	81
Electricity	11	14
Sum	**65**	**95**

Note: These estimates do not include the rebound effect

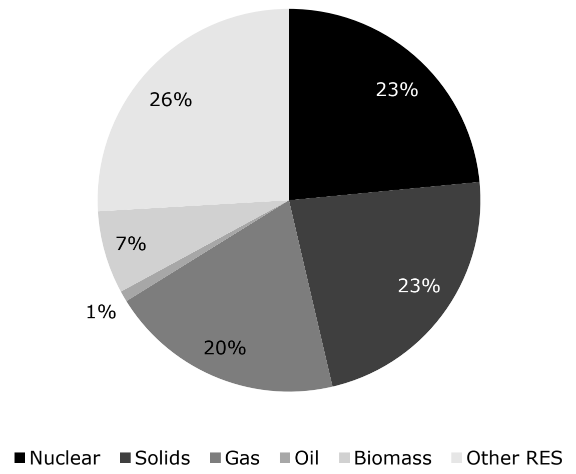
Source: Copenhagen Economics

The input mix in EU27 electricity production in 2020 is expected to consist of 33 per cent renewable energy, 23 per cent of solids (mainly coal) and nuclear respectively, and 20 per cent gas, cf. Figure A.3. Out of the 33 per cent renewable energy, biomass constitutes app. 7 per cent of total energy consumption. This distinction becomes important, as biomass

[14] See e.g. IEA (2012)

emits a significant amount of air pollution, especially small particle matters (PM2.5), while other renewable sources such as wind do not.

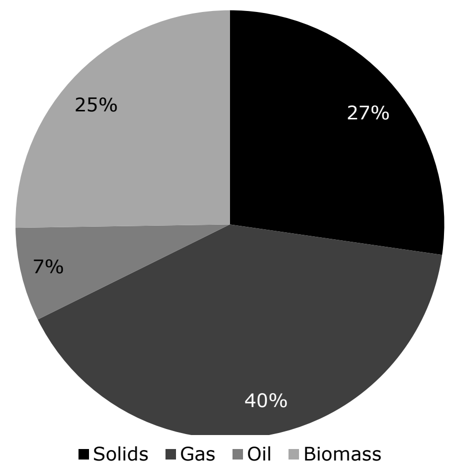
Figure A.3 Expected share of EU electricity production, 2020



Source: DG Energy (2010) page 42

Gas and solids (primarily coal) constitutes app. 40 per cent and 27 per cent respectively of the expected heat production in EU in 2020, cf. Figure A.4.

Figure A.4 Expected share of EU heat production, 2020



Note: The calculation only includes the EU OECD countries

Source: IEA (2012), Energy Statistics OECD countries

To calculate the amount of air pollution from the different input sources, we use so called emission factors. Production of electricity and heat emits several different air pollution sources, including SO_2, NO_x, and small particle matter (PM). The emission of each source is different depending on the input used in production. Natural gas, e.g. has relatively low SO_2 and PM emissions, while it emits relatively more NO_x than both coal and fuel oil, cf. Table A.18.

Table A.18 Emission factors for an average European power and district heating plant

(kg/GJ)	SO_2	PM2.5	NOx	CO_2
Nuclear	0	0	0	0
Biomass	0.028	0.001	0.060	0.000
Coal	0.083	0.004	0.065	94.197
Gas	0.075	0.000	0.037	56.911
Oil	0.221	0.019	0.513	76.052

Note: Emission factors have been calculated as a weighted average of the existing power plants and district heating plants in Europe, 2012

Source: GAINS model

We assume that the reduction in energy production will reduce the input use proportionally to the expected input-mix in 2020. We also use estimates on the value of reducing the harmful effect of air pollution from DG Transport (2008). We find that by reducing energy consumption, and consequently electricity and heat production, the economic value to EU citizens from reduced air pollution will be in the magnitude of app. €5.2 billion in the low EE scenario, and 7.7 billion in the high EE scenario, cf. Table A.19.

Table A.19 Value of reduced air pollution

2012-2020	Reduced emissions (Ton)	Value of each emission reduction (€/ Ton)	Total value of reductions (billion €)
Low EE scenario			
SO_2	185,713	3,138	0.6
NO_x	202,286	2,676	0.5
PM	7,069	10,805	0.1
Sum			**5.2**
High EE scenario			
SO_2	275,883	3,138	0.9
NO_x	301,559	2,676	0.8
PM	10,517	10,805	0.1
Sum			**7.7**

Note: The value of emission reductions has been calculated as an average between city districts and rural districts

Source: Copenhagen Economics, DG Transport (2008) and GAINS model

2. Health benefits from improved indoor climate

Energy efficient renovation of buildings can improve personal health. The health effects stem primarily from alleviating inadequate warmth through better insulation and more effective heating systems, more daylight and ventilation. Colder houses place more physiological stress on older people, sick people and babies, who have less robust thermoregulatory systems, and are more likely to spend more time inside.[15] Studies have shown that respiratory and circulatory hospitalisations have been reduced by insulating houses, as these diseases have shown to be particularly responsive to the effects of temperature.[16] Cold houses are also likely to be damp, which can lead to the growth of mould, which can cause respiratory symptoms. Improved ventilation and access to daylight may increase worker productivity, and students' learning abilities.

By making Energy efficient renovation to buildings, overall health and worker productivity may therefore be improved.[17] In addition, by improving e.g. indoor air qality and the inflow of light, worker productivity and the learning capabilities of students may increase.[18]

We broadly identify three quantifiable types of health benefits from previous studies. The benefits accruing to individuals come from improvements in personal well-being (e.g. less illness, general improvements in quality of life, and reduced mortality), reduced days of work missed due to illnesses related to poor indoor environmental quality, and lower spending on health care due to these types of illnesses.

We have collected the estimates available from the literature which has attempted to quantify health effects from specific energy efficiency renovations. We have used studies that have stated both the costs of the renovations, and the value of the health improvements. Based on primarily four available studies we calculate cost-benefit ratios by comparing the cost of implementing the programmes with the estimated health benefits the improvements give rise to. The results from these studies are stated in Table A.20.

[15] Barnard et al (2011), page 11.
[16] Barnard et al (2011), page 11.
[17] See e.g. IEA (2012), and REHVA (2006)
[18] See e.g. Slotsholm (2012), which find that Danish GDP may increase by €173 million due to better air quality in primary schools.

Table A.20 Quantifiable health benefits in the literature

		Threlfall (2011) - AWARM programme	Lidell et al (2011) - Kirklees Warm Zone	Barnard et al (2011) - Warm Up New Zealand	UK Department of Health (2010)
Heating	Better life quality	14.79 months extended lifetime (improved health)	758,500 GBP	9 NZD per household	
	Less public health spending				42 pct
	Fewer missed days of work				
Insulation	Better life quality	11.96 months extended lifetime (improved health)	15.2 Quality adjusted life years	465 NZD per household in reduced mortality	
	Less public health spending			75 NZD per household	42 pct
	Fewer missed days of work			59 NZD per household	

Source: Based on the sources in the table

Based on these estimates and the cost of the specific energy efficient projects, we can calculate a cost-benefit ratio of each single health benefit. When the different studies have given different results, we have constructed an interval from the lowest estimate to the highest estimate. The ratios are generally below unity, with the exception of benefits from improved well-being associated with improving insulation which equals 1.64, cf. Table A.21. This result comes from the reduced mortality rate from low indoor temperature.[19]

Table A.21 Cost-benefit ratios

Cost benefit ratios	Health benefits - better life quality	Less public health spending	Fewer missed days of work
Heating	0.36-0.46	0.42	0
Insulation	0.12-1.64	0.42-0.99	0.78

Source: Own calculations based on Threlfall (2011), Liddell et al. (2011), Barnard et al. (2011), and UK Department of Health (2010).

By applying these cost-benefit ratios to the amount of investments needed to realize the energy saving potentials in the EU identified above, we arrive at estimates of the health benefits associated with these investments, cf. Table A.22. Please note that these estimates are highly uncertain at an EU level, since the uncertainty related to the estimate of each study is accentuated by applying it to the EU as a whole. Moreover, e.g. less public health spending is highly dependent on the specific health system in each country.

[19] Note that this result is taken from the project in New Zealand, and the condition of New Zealandic houses may not be directly comparable to European houses. However, the notion of a "European house" it not suitable as the condition varies across countries. This is the primary driver of the conundrum that cold-related deaths is higher in the warmer Southern European countries than in the colder Northern European countries.

Note also that we equalised the "value of a statistical life" which took different values across the UK and NZ study. We have used the UK estimate.

Table A.22 Overall benefits to society of health improvements

Billion €		Low EE scenario	High EE scenario
Heating	Better life quality	3.9 - 5.0	7.6 - 9.7
	Less public health spending	4.6	8.8
	Fewer missed days of work	0	0
Insulation	Better life quality	2.2 - 30.5	4.3 - 58.6
	Less public health spending	7.8 - 18.4	15.0 - 35.5
	Fewer missed days of work	14.5	27.8
Total		**33 - 73**	**64 - 140**

Note: We have aggregated over several studies. These studies differ in the way they calculate the value of health benefits. For example, the New Zealand study uses a statistical value of life of NZD 150,000 (approx. EUR 90,000), while the AWARM study uses a value of GBP 20,000 (approx. €24,000). In order to ensure comparability between the estimates, we apply the lower value to the benefits in the New Zealand study.

Source: Own calculations based on Threlfall (2011), Liddell et al. (2011), Barnard et al. (2011), and UK Department of Health (2010).

The public finance effects are primarily related to the reduced public health spending. Note that the lower estimate on public health spending (€7.8 and €15.0 billion respectively) is derived from the UK health system, and the higher estimate (€17.3 and €33.2 billion respectively) from the New Zealand health system. It is difficult to apply these figures directly to an aggregate European level, as they are very dependent on the level of publicly paid health care. When interpreting these numbers, this should be kept in due attention.

It should also be noted that these studies are based on specific programmes; two in the United Kingdom and one in New Zealand. Hence, there may be country-specific factors related to e.g. local climate which makes generalizations to other countries less reliable. Furthermore, the British studies specifically target low-income areas. Assuming that energy saving renovation take place in higher income households as well, applying results from these studies may lead to overestimation of the health benefits, as it is likely to be the low-income households that suffer from heating related diseases.

Studies have also been conducted regarding the relationship between improved indoor climate and productivity in offices. One literature survey concludes that productivity can be significantly affected by improving indoor environmental quality, cf. Table A.23. The same study concludes that very small increases in productivity of say 0.1 per cent can pay for an increase in energy cost of 20 per cent, or an increase in productivity of 0.66 per cent can pay for an increase in investments of 10 per cent.

Table A.23 Indoor environmental quality

Effect	Temperature	Ventilation	Indoor air quality
	Productivity is reduced by 5-15 per cent when temperature is above the thermal comfort zone	Productivity is increased by 1 per cent for every two-fold increase in outdoor air supply	Performance of text typing improves significantly, when indoor air quality is increased

Source: REHVA (2006)

One study shows that the indoor air quality significantly affects children's ability to learn.[20] The study concludes that by improving the indoor air quality in Danish schools so the amount of fresh air was increased to the level in Swedish schools, this would improve the learning ability of these students, and implicitly the productivity of future workers, which would improve Danish GDP annually by €173 million and public finances by €37 million annually.

A.10 Benefits from stimulating economic activity during a period of recession

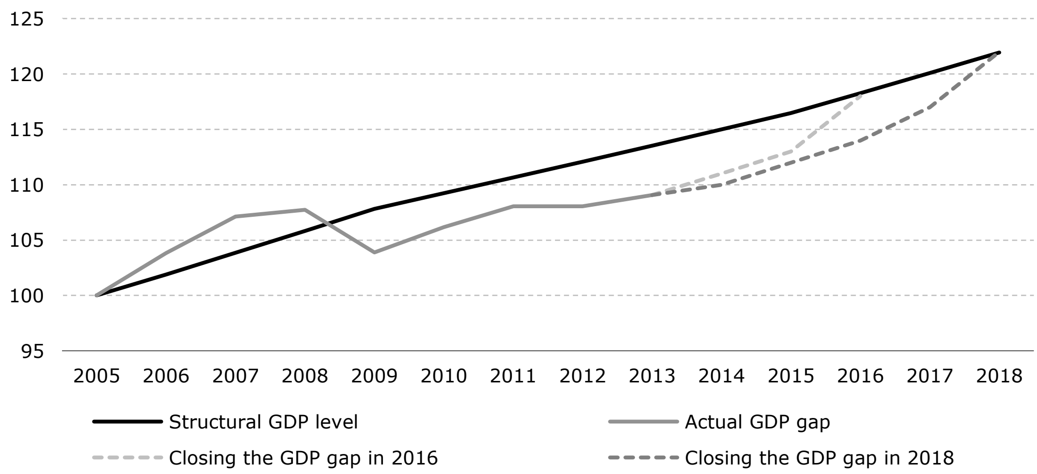
Investments in energy efficient renovation of buildings will stimulate economic activity. The beneficial effects of increased investments depend to a very large degree on the current economic circumstances. If investments are to increase during an economic boom, the result would most likely be increased wage pressure in the construction sector, and very little additional activity, as the economic potential in terms of available capacity would be limited. However, during an economic recession, capacity, especially in terms of labour, is more readily available. As energy efficiency investments induce a boost to economic activity during such a period of available capacity, this will bring people from unemployment into employment, to the advantage of overall society and to the public budgets.

It should be stressed that the benefits calculated in this section are the gross benefits in the sense that they do not include any costs from the actual investments (this is taken into account when measuring the aggregate benefits) or from the cost of incentivising the investments. Hence, we implicitly assume that the investments will be undertaken without any public subsidies, but conversely by breaking down regulatory barriers that prevents the private sector from realising the economic potential of energy efficiency investments. We describe a number of such barriers in Chapter 2.

Potential for increasing economic activity in the current situation
The economic crisis has led to a significant reduction in GDP compared with the so called structural GDP, which is a measure of the GDP in absence of an economic recession or boom. This gap between actual GDP and structural GDP is known as the output gap. When the output gap is negative, there are available resources in the economy (this can for example be relatively high unemployment). As a result of the economic crisis the output gap for Europe is expected to be negative for several years to come. In fact, IMF estimates that the output gap will be negative at least until 2017, cf. Figure A.5.

[20] Slotsholm (2012), Socio-economic consequences of better air quality in primary schools

Figure A.5 Output gap in the European economy



Source: Copenhagen Economics, based on OECD Economic Outlook 91 database

This implies that stimulating economic activity through investments in energy efficient renovation of buildings is a particularly good idea going towards 2017, as this will help the economy towards its structural level.

Investment path

In the earlier sections we have derived the expected potential for energy efficient renovation of buildings from 2012-2020, and 2020-2030. In this section we focus on a hypothetical investment path that will reach the identified renovation potential in 2017, when the economy is expected to reach its structural level. We assume that such an investment path will increase in intensity, as barriers to especially the cost-effective investments begin to be broken down.

We construct the investment path in order for it to fulfil the renovation potential in 2020 with a slightly increasing investment rate. Our estimates suggest that in order to meet the potential in 2020, a yearly investment of €40 billion is needed in the low scenario, and €76 billion in the high scenario. Our estimate of €40 billion can be compared to the estimate by the European Commission[21] of €60 billion. We consider the same scenario, however the Commission considers also energy savings from new buildings, while we consider only the potential from renovating the existing building stock.

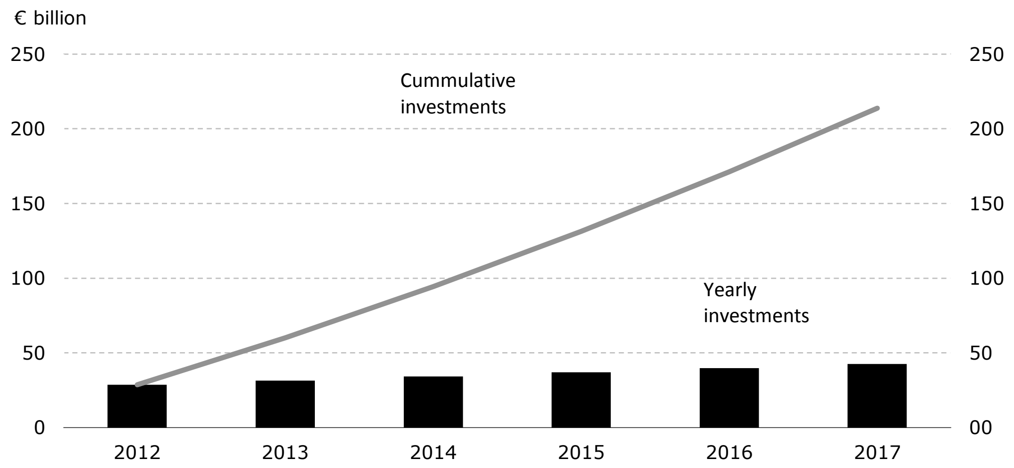
We construct the investments path towards 2020 by increasing the investment rate with €2.8 billion each year. This allows us to think of the investments as permanent towards 2017, as the investment amount in the following year is slightly higher. This increase is then considered permanent towards 2017, as it will be repeated and enhanced in the next

[21] See European Commission (2012)

year. This implies that the investment in 2012 will be below €40 billion, while the investment will be above €40 billion in 2020, such as the annualised average investment equals €40 billion in the period 2012-2020.

With the assumed investment path, Europe will have invested for a total of app. €215 billion in 2017 in the low scenario, cf. Figure A.6. By following the investment path, all of EU's identified energy efficiency potential in 2020 will be reached in 2020.

Figure A.6 Assumed investment path (low EE scenario)



Source: Copenhagen Economics based on http://www.eepotential.eu/esd.php

We can now begin to calculate the impacts on GDP from following this investment path. We focus on two positive impacts on GDP: 1) The direct impact from an increase in investments in energy efficient renovation of buildings, and 2) the indirect impact from the indirect effects increased household consumption, extra demand in connected sectors etc.

We begin by deriving the direct impact:

Direct impact on employment

In order to calculate the effect of increased investments in energy efficient renovation of buildings on GDP and the public finances, we need to know how many jobs are "created" per € invested.[22] A study that reviewed 35 different cases found that on average, €1 million invested results in 19 jobs in the sector cf. Table A.24.[23]

[22] One should be careful with the expression: "created jobs" as the "creation" of one job typically crowds out employment in another job. In this example where European economies are in recession, we assume that the unemployed labour capacity will fill up new jobs. This implies that the amount of net jobs created is equal to the amount of gross jobs created.

[23] It is not always clear from the studies whether or not indirect jobs have been included.

Table A.24 Gross employment effect of increased investments

Study	Hypothetical size of investment	Increased number of jobs (average)	Production per job (€)
Janssen and Staniaszek (2012), How many jobs? A survey of the Employment Effects of Investment in Energy Efficiency of Buildings	€ 1 million	19	52,600

Note: Production per jobs is measured as the size of the investment divided by the increased number of jobs needed to complete the investment.

Source: The study mentioned in the table

Direct impact on GDP

In order to calculate the effects on GDP we use the gross value added (GVA) per employed in sectors we believe can be associated with energy efficiency investments in buildings. One natural starting point would be the GVA per employed in the construction sector, which is €55,740, cf. Table A.25. In the sectors we believe are associated with energy efficiency investments, such as manufacture of glass and glass products (to manufacture windows), manufacture of ceramic insulators and insulation, and plumbing, heat and air conditioning installations, the GVA per employee is lower, ranging from 46,110 to 52,220, cf. Table A.25.

Table A.25 Gross value added per employee in relevant sectors

Sector	Gross value added per employee (EUR)
Total manufacturing	55,770
Construction of buildings	55,740
Manufacture of glass and glass products	52,220
Manufacture of ceramic insulators and insulating fittings	46,870
Manufacture of central heating radiators and boilers	48,560
Manufacture of lighting equipment and electric lamps	52,090
Construction of residential and non-residential buildings	46,110
Plumbing, heat and air conditioning installation	46,110
Other construction installation	49,980
Roofing activities	47,600

Source: Eurostat, structural business statistics [sbs_na_con_r2]

Based on these statistics, we construct a low, an average, and a high estimate for GVA per employee from energy efficiency measures in buildings, cf. Table A.26.

Table A.26 Gross value added per employee

	Gross value added per employee (EUR)
Low estimate	46,110
Average estimate	49,476
High estimate	55,740

Note: - Low estimate: the lowest GVA value corresponding to plumbing, heat and air conditioning installations

- Average estimate: an average of all sectors in Table A.25, except Total manufacturing
- High estimate: the GVA in the sector Construction of buildings

Source: Copenhagen Economics, based on Eurostat, structural business statistics [sbs_na_con_r2]

By investing a hypothetical €1 billion in energy efficiency investments, the expected direct impact on GDP ranges from app. €0.88 -1.06 billion, cf. Table A.27.

Table A.27 Direct impact on GDP

Size of investment (€ billion)	Gross jobs created	Impact on GDP - low estimate (bn EUR)	Impact on GDP - average estimate (bn EUR)	Impact on GDP - high estimate (bn EUR)
1	0.019	0.88	0.94	1.06

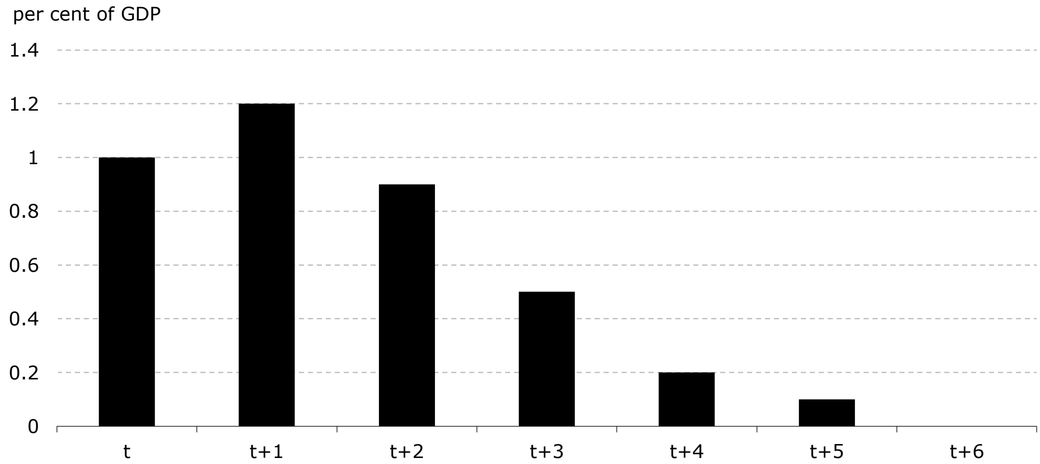
Source: Copenhagen Economics

We now turn to the indirect effects:

Indirect impact on GDP

The direct effect on GDP will have a relatively immediate impact. In the year following the increased investment, the indirect effects from increased household consumption and the impact on other sectors kicks in. As inflationary pressure starts to grow, the positive stimulating impact from the increased investment will gradually crowd out other uses of the same resources. By the 6th year after the initial stimulus the effect will be completely crowded out, cf. Figure A.7.

Figure A.7 Dynamics of a permanent increase in public spending



Note: The effect is showed for the euro area.

Source: OECD (2001)

By combining the assumed investment path of Figure A.6 we can derive the effect on GDP from investing in order to meet the identified potential for energy efficient renovation of buildings in Europe. We do this by assuming that an increase in the energy efficiency renovations is equal to an increase in public spending. Since we have derived the investment path as an increase in the permanent investment level, we can use the multipliers related to a permanent increase in public spending.

We apply the average direct estimate on GDP from Table A.27 as the first year effect, and the multipliers from Figure A.7 to calculate the effects on the following years. We find that the accumulated increase in GDP from investing in energy efficient renovation of buildings during the period of spare capacity to be 1.19 per cent, cf. Table A.28. This equals €153 billion.[24] By the same method, we find that in the high EE scenario the accumulated effect on GDP is 2.26 per cent, equalling €291 billion.

[24] Based on 2012 GDP in current prices

Table A.28 Accumulated impact on GDP, low EE scenario

Pct. increase in GDP as increase in public spending	2012	2013	2014	2015	2016	2017	Total impact on GDP (in percent per year)
Increase in "permanent" investments (€ billion)	28.7	2.8	2.8	2.8	2.8	2.8	
Derived increase in public spending (per cent)	0.23	0.02	0.02	0.02	0.02	0.02	
2012	0.23						0.23
2013	0.28	0.02					0.30
2014	0.21	0.03	0.02				0.25
2015	0.11	0.02	0.03	0.02			0.18
2016	0.05	0.01	0.02	0.03	0.02		0.12
2017	0.02	0.00	0.01	0.02	0.03	0.02	0.10
Total							**1.19**

Note: The single elements do not always equal the total impact due to rounding.

Source: Copenhagen Economics based on OECD (2001).

Effects on public finances

When economic activity is stimulated in a period of economic downturn it creates jobs for people who were formerly unemployed. This improves public finances by reducing expenses to unemployment benefits, and increasing tax revenues e.g. through increased VAT revenue from increased economic activity. In order to assess the size of this effect, we use so called fiscal multipliers which indicate how much public budgets are improved/deteriorated when GDP is increased/decreased. The primary driver of these multipliers is the increase in tax revenue and avoided unemployment benefits, but the multipliers essentially captures any improvements in public budgets from increasing GDP. The average fiscal multiplier for EU27 is 0.44, cf. Table A.29, which means that every time GDP is increased by €1 million, public budgets are improved by €0.44 million.

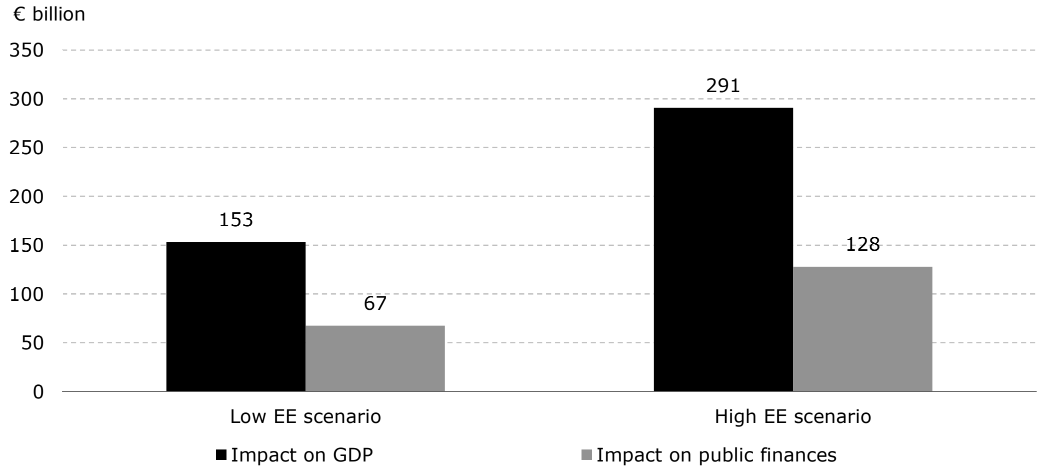
Table A.29 Fiscal multipliers for EU27

Country	(Semi) Elasticities (year 2011)
AT	0.47
BE	0.51
BG	0.33
CY	0.43
CZ	0.36
DE	0.51
DK	0.65
EE	0.30
EL	0.42
ES	0.43
FI	0.58
FR	0.53
HU	0.44
IE	0.44
IT	0.49
LT	0.29
LU	0.44
LV	0.30
MT	0.38
NL	0.62
PL	0.38
PT	0.45
RO	0.32
SE	0.61
SI	0.45
SK	0.33
UK	0.46
Average EU 27	**0.44**

Source: DG ECFIN (2012)

This implies that the accumulated effect on public finances from 2012-2017 is €67 billion and €128 billion respectively in low and high scenario, cf. Figure A.8.

Figure A.8 Benefit from increased economic activity



Source: Copenhagen Economics based on the stated sources in the above calculation steps.

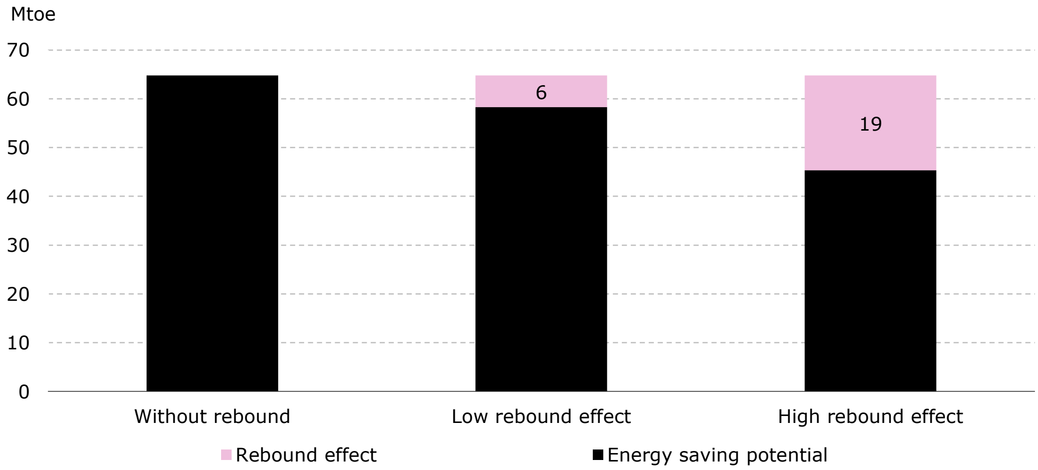
As investments continue to take place after 2017, there will continue to be an increasing pressure on economic activity. However, as this will take place at a time where the economy is expected to be on or above its structural level, we do not consider this is a benefit to the total economy. Instead, such economic activity will most likely crowd out already existing economic activity, and will increase wage and inflationary pressure.

A.11 Aggregating the benefits

The benefits of investing in energy efficient renovation of buildings constitute of several different elements as listed in the above description. While some of the benefits are direct and tangible, such as cost savings from reduced energy consumptions, other benefits are less direct and tangible such as e.g. the value in terms of health of reduced air pollution. In this section we nonetheless aggregate the different benefits with a view to which of the benefits can be attributed to improving public finances. When interpreting the overall benefits, one should therefore be aware of the different levels of uncertainty and timing of the benefits.

As mentioned in the report, several studies find that there is a relatively small, but significant rebound effect of conducting energy efficient renovation of buildings. These renovations essentially make it cheaper to consume energy, which will increase energy consumption. Based on a survey of the economic literature on rebound effects we apply a rebound effect of 10-30 per cent. This corresponds to 6-19 Mtoe less reduced energy consumption in the low EE scenario in 2020 than would have taken place without a rebound effect, cf. Figure A.9.

Figure A.9 Energy saving potential with rebound



Note: The figures depicts the low energy efficiency in 2020

Rebound effect is measured for room heating improvements (including insulation)

Source: Copenhagen Economics based on Greening et al (2010)

By taking a 20 per cent rebound effect into account, we estimate that the overall annual benefits to society is between €85-124 billion in the low EE scenario in 2020, and €135-203 billion in the high EE scenario, cf. Table A.30. These benefits include the health benefits from improved renovation on e.g. respiratory diseases, asthma etc, where the estimates are quite uncertain. If investments are continued towards 2030 these annual benefits will be approximately doubled in 2030.

Table A.30 Overall annual gross benefits to society, 2020

Overall benefits to society (incl rebound)	Value - low EE scenario (bn EUR)	Value - high EE scenario (bn EUR)
Direct annual effects		
Energy savings	52.5	75.5
Reduced outlay on subsidies	2.2 - 8.7	2.5 - 9.0
Indirect annual benefits		
Reduced air pollution	4	6
Health benefits (uncertain)	26.4 - 58.3	50.8 – 112.3
Total (bn EUR)	**85 – 124**	**135 - 203**
Total (pct. of GDP)	**0.7 – 1.0**	**1.0 – 1.6**

Note: Rebound effect has been included

Source: Copenhagen Economics

We also estimate that public budgets will be improved annually by €17-42 billion in 2020 in the low EE scenario, and €28-51 billion in the high EE scenario, cf. Table A.31. This includes the health benefits from improved renovation on e.g. respiratory diseases, asthma etc, where the estimates are quite uncertain. If investments continue towards 2030, these annual benefits will be approximately doubled in 2030.

Table A.31 Annual improvement of public finances, 2020

Improvement of public finances (incl. rebound)	Value - low EE scenario (bn EUR)	Value - high EE scenario (bn EUR)
Direct annual benefits		
Energy savings	9.1	12.4
Lost tax revenue from energy taxation	-4	-6
Reduced outlay on subsidies	2.2 – 8.7	2.5 – 9.0
Indirect annual benefits		
Reduced air pollution	0	0
Health benefits (uncertain)	10.0 – 28.2	19.0 – 35.4
Total	**17.1 – 42.0**	**28.1 – 51.0**
Total (pct. of GDP)	**0.1 – 0.3**	**0.2 – 0.4**

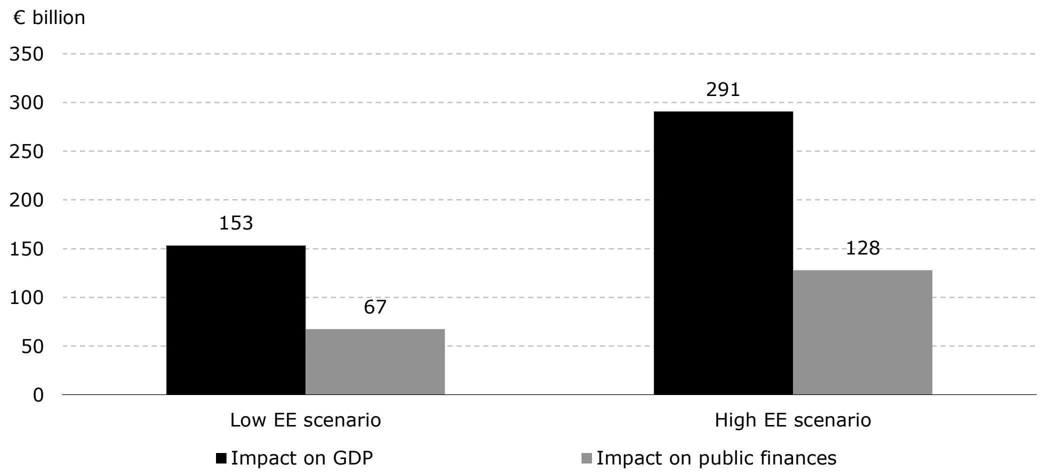
Note: Rebound effect has been included

Annual improvements of public finances are a subset of overall benefits to society.

Source: Copenhagen Economics

In addition to these annual benefits, there will be a one-off benefits to GDP and public budgets from increasing economic activity. This corresponds to €153 billion impact on GDP and €67 billion increased revenue to public budgets in the low EE scenario, cf. Figure A.10. If the high EE scenario is followed, the benefits will be €291 billion impact on GDP and an increase in public revenue of €128 billion.

Figure A.10 Benefit from increased economic activity



Source: Copenhagen Economics based on the stated sources in the above calculation steps.