COMBI

Calculating and Operationalising the Multiple Benefits of Energy Efficiency in Europe

WP3 Air pollution/health

Draft methodology for quantifying air pollution and human health impacts

D3.2

Grant Agreement No. 649724

The University of Manchester

Authors

Nora Mzavanadze

Manchester, May 2016

Coordinated by

Wuppertal Institut

Project partners

ABUD Advanced Building & Urban Design

Copenhagen Economics

Universiteit Antwerpen

The University of Manchester

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 649724. This document reflects only the author's view. The Agency is not responsible for any information it contains.

Content

List of figures

Tables

1 Background

1.1 Project description

The COMBI project aims at quantifying the multiple non-energy benefits of energy efficiency. It is coordinated by the Wuppertal Institute for Climate, Environment and Energy and implemented together with the research partners University of Antwerp, University of Manchester, Copenhagen Economics and ABUD/Advanced Buildings and Urban Design. The multiple benefits of energy efficiency are gaining relevance in the research and the current policy discourse, but scientific evidence is yet scarce and scattered. Therefore, this projects will gather existing approaches and evidence from the EU area, develop modelling approaches and come up with consolidated data on different benefits such as emissions (effects on health, ecosystems, crops, built environment), resources (biotic/abiotic, energy/non-energy), social welfare (disposable income, comfort, health), macroeconomy (labor market, public finance, GDP), and the energy system (grid, supply-side, energy security). All project outcomes will be available at an open-source online database and be analysable via a graphic online-visualisation tool for personalising the findings as to their geographic location and selected benefits. To this end, the development of an aggregation methodology is of central importance to avoid double-counting and presenting the various benefits on their various dimensions. Finally, insights for policy relevance will be derived and policy recommendations will be elaborated to facilitate the communication of the non-energy benefits in the relevant policy areas. In addition, the project is in touch with on-going processes of how to include multiple energy efficiency benefits into policy evaluation.

1.2 Aim of this report

Based on the literature reviews conducted for individual multiple impacts (MI), the second main step of the COMBI project is to develop a methodology to quantify and monetise MIs. Monetisation of single (sub-)MI is conducted where possible. For the set of defined EEI actions (see D2.2 report), energy saving potentials in the year 2030 are being developed reflecting official EU PRIMES scenarios (energy efficiency vs. baseline scenario) (see D2.1 report). The general COMBI approach follows the additionality principle: Only additional effects (both energy and non-energy impacts) relative to an action baseline are considered.

2 Scope of investigation

2.1 Definition of impacts, end-points and metrics/indicators

Literature review report 3.1 has determined three broad groups of receptors of air pollution impacts: human health, vegetation and the built environment.

2.1.1 Avoided air pollution emissions

Intermediary calculations of ancillary air pollution benefits of energy efficiency improvement actions involve estimating the quantities of avoided air pollution emissions of various pollutants and may be kept as an important sub-impact to inform the air pollution policies. As the COMBI literature review has demonstrated, only a few studies complete the whole methodological chain of estimating the damage on air pollution receptors; many studies are limited to estimation the quantities of avoided air pollution emissions (Mzavanadze, 2015). Avoided air pollution emissions depend on the scale of energy savings, the fuel type saved, technology, air pollution control equipment.

Definition

Quantities of air pollution emissions that would have been emitted into the environment unless energy efficiency improvements actions had been taken.

Physical metrics

- Avoided emissions of air pollutant x (tonnes)

2.1.2 Avoided climate change emissions

This is the most studied impact category of energy efficiency studies. Other impacts are considered to be ancillary. Avoided climate change emissions will be modelled in COMBI according to energy efficiency potentials and pre-determined in scenarios.

Definition

Quantity of climate change emissions that would have been emitted into the environment unless energy efficiency improvements actions had been taken.

Physical metrics

- Avoided climate change emissions (tonnes of CO_2 equivalent)

2.1.3 Other impact categories

The option of having other impact categories for this work package depend on the methodological approach applied for the assessment of avoided air pollution impacts.

In case no advanced air pollution modelling tools are used in COMBI, e.g., GAINS model, further specification of physical impact categories may not be possible (see 4 for explanation of the methodological approach)

In case GAINS air pollution and greenhouse gas model is used, further specification of such physical metrics can be facilitated in a geospatial manner:

- Extent of premature mortality due to air pollution exposure (years of life lost o disability adjusted life years)
- Area of ecosystems affected by excess acidification, eutrophication and ground-level ozone exposure (km^2 or % of total)
- Potential crop losses (%)
- Annual mean concentrations of air pollution for different scenarios

2.2 EEI actions relevant for air pollution impact end-points

In principle, all 30 energy efficiency actions have implications for impacts of avoided air pollution. As long as energy savings potential is provided for all of them together with details of the energy carrier (fuel type and electricity mix), the effect of all 30 energy efficiency actions could be assessed. Depending on the method chosen (see 4), there may as well be certain input data disaggregation requirements.

2.3 Definition of system boundaries

2.3.1 Life-cycle analysis: Use vs. production phase

The study of air pollution impacts of energy consumption is possible via the lens of life-cycle analysis. Air pollution emissions happen at different stages of the energy extraction, transportation, processing and consumption stages (see Figure 1). All studies of relevance to COMBI limit their scope of research only to studying the end-use related avoided air pollution emissions and their impacts (Mzavanadze, 2015). Studying upstream or fugitive air pollution emissions are possible, but an additional input component may be needed – origin of the energy carrier (European Environmental Agency, 2015; Fritsche & Rausch, 2009). For this reason, life cycle approach may become too cumbersome especially with future projections of fuel origins. Furthermore, including the upstream air pollution emissions in the assessment would expand the geographical scope of COMBI beyond EU-28 as a large share of energy resources are imported from third countries.

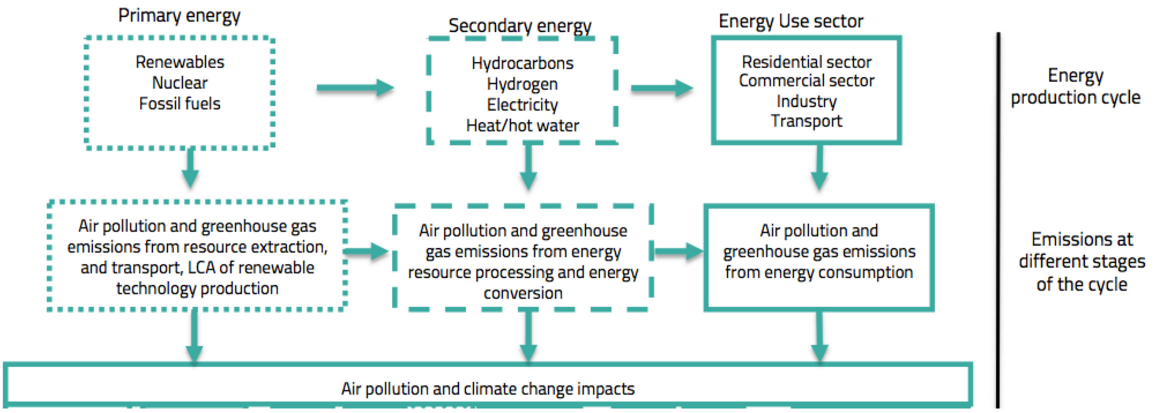

Figure 1. Life cycle approach versus the suggested COMBI scope for studying avoided air pollution emissions.

Source: based on Wilkinson, Smith, Joffe, & Haines, 2007. (Dotted line – outside the scope, dashed line – some aspects fall into the scope of COMBI, like electricity generation and district heating and hot water and line – scope of COMBI)

On the other hand, reduced energy resource imports may not necessarily mean reduced energy resource extraction rates in the origin country. According to theory of economics, reduced energy consumption in importing countries would in short-term translate in increased energy resource supplies in the international market which would lower their price on the global market and encourage more consumption. That in turn may reduce the incentives for energy efficiency and conservation and exacerbate policy action.

Therefore, life cycle assessment of avoided air pollution impacts, especially of the upstream stages, may neither be practical to assess, nor realistic to occur. Assessment of avoided climate change impacts will follow the same logic with regard to upstream climate change emissions.

2.3.2 Other regional system boundaries: spill-over

Air pollution emission reductions are likely to result in diminishing transboundary/regional air pollution flows within Europe and also beyond.

Climate change emission reductions in Europe would have a global effect. On the other hand, decreases in Europe may be compensated with rising emissions elsewhere.

2.4 Evaluation perspectives

The quantification of all avoided air pollution and climate change impacts will be carried out using a societal perspective.

2.5 Context dependency

Context dependencies for avoided air pollution related impacts are numerous and different air pollution modelling tools account for some/most of them in one way or another (Amann et al., 2011; European Commission, 1995; Rabl, Spadaro, & Holland, 2014):

- Type of fuel or fuel mix in the case of centralized energy production (electricity, district heating and hot water);
- Geographical and climatic conditions;
- Meteorological conditions and atmospheric transport;
- Atmospheric chemistry;
- Spatial distribution of receptors and pollution sources;
- Baseline air pollution concentrations and natural sources of air pollution;
- Variation in receptor sensitivity;
- Height of the emission stack;
- Technology and air pollution control equipment.

See 4 for a discussion on methodological options and their implications.

3 MI interactions and side effects

3.1 Impact pathways

Generic impact pathways have been constructed based on two sources – energy production chain as depicted in (Wilkinson et al., 2007) and air pollution impacts as depicted in (Guerreiro, Leeuw, Foltescu, Horálek, & European Environment Agency, 2014).

Depending on the methodological approach applied for the assessment, the list of air pollutants may need to be updated.

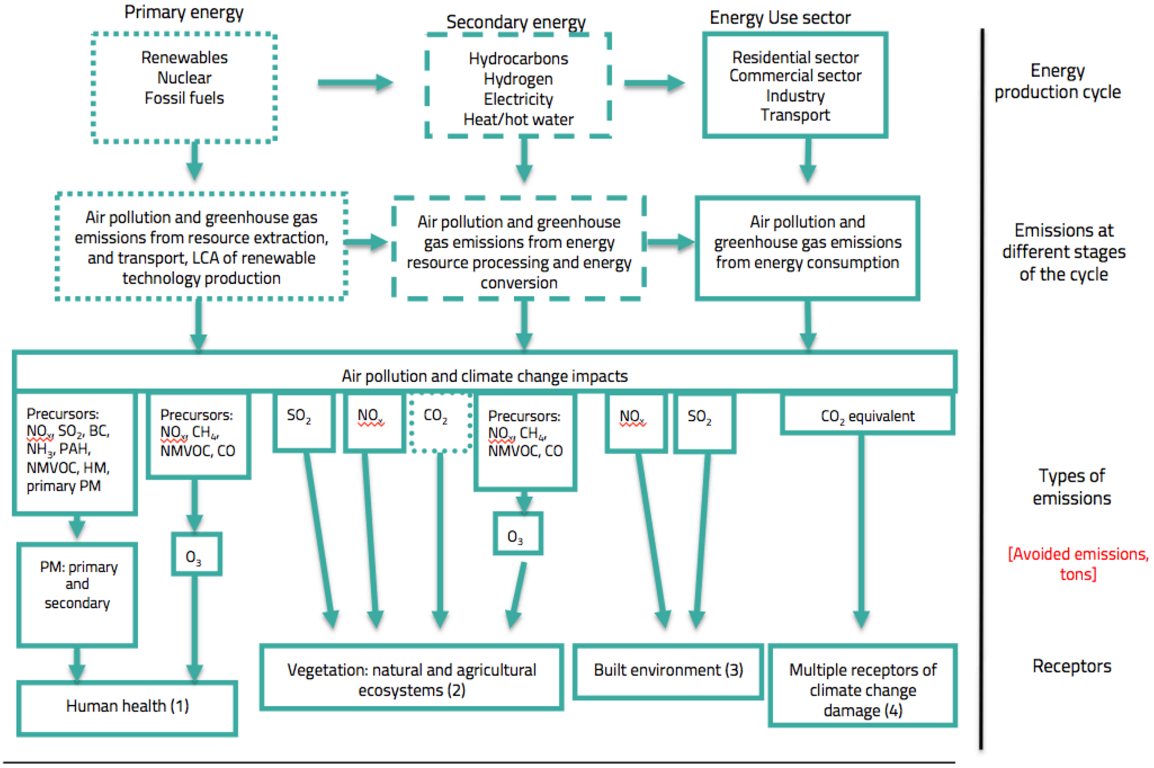

Figure 2. Generic pathways for avoided air pollution and avoided climate change impacts.

3.2 Interaction with other impacts

Table 1: Interactions of air pollution with other impacts

MI Air pollution (WP3)		Type of interaction
Air Pollution	Health	
	Eco-system	
	Crops	
	Built environment	
Resources	Organic resources	(1) Increased timber growth and production as a result of possible reductions in acid rain and ozone exposure.
	Non-organic resources	
	Energy resources	
Social welfare/ commercial productivity	Disposable income/fuel poverty reduction	
	Improved comfort	
	Health	(1) Links between outdoor and indoor air pollution and related illnesses. Outdoor air quality is a proxy for indoor air quality, therefore, it will largely be addressed in WP3.
	Productivity in commercial buildings	(1) Better health due to avoided air pollution may translate into increased productivity.
Macro	Employment	
	GDP	(1) Increases in agriculture and forestry production due to reduced acid rains and ozone exposure.
	Public budget	(1) Reduced burden on public health care budgets as a result of a reduction in air pollution related disease treatment. (2) Increased budget revenue as a result of sales of extra agricultural and forestry output.
Energy system/security	Energy system costs	
	Energy security	

3.3 Rebound effects

Rebound effects will be agreed upon with COMBI project partners and will be included in climate change mitigation modelling of scenarios. The rebound effect will decrease the extent of the avoided air pollution impacts.

4 Approach for impact quantification and monetization

4.1 Quantification approaches

Two options have been identified as suitable to assess the avoided air pollution impacts of energy efficiency improvement actions:

- A generic approach used widely in cost-benefit analyses that multiplies activity data with emission factors to estimate air pollution emission quantities. Activity data will be modelled in scenarios (energy use scenarios and fuel mixes). Emission factors – coefficients that link fuel type and air pollution emissions – can be found in the EU emission inventory report to the LRTAP Convention (European Environmental Agency, 2015). Monetization is carried out multiplying air pollution emission quantities per pollutant with an estimate of damage cost of that pollutant per tonne based on ExternE research project results and its newest follow up projects (Holland & European Commission, 1995). This approach bears the highest scientific uncertainty of results and the least policy-relevance on the geographical scale of assessment and in the context of availability of other more advanced tools. All necessary data for this methodological approach is accessible on-line free of charge. This method requires inputs disaggregated by EU member state, and its outputs will be per member state as well.

- GAINS air pollution and greenhouse gas modelling tool could be used to increase policy-relevance, to decrease scientific uncertainty and to provide an insight into the spatial distribution of avoided air pollution impacts. Access to GAINS modelling tool is secured, however, it is still unclear if the scenario inputs from WP2 can be transformed into a suitable format for GAINS model input. At the time of writing of this report, this question could not be answered. Therefore, both approaches are described. The model provides results on the whole EU level, and it is unclear in member state level disaggregation is possible.

Avoided climate change emissions will be modelled in scenarios (WP2 input data) and will be converted into tons of CO_2 equivalent.

4.2 Monetization approaches

In case a generic approach is followed (see 4.1), monetization is part of the ExternE methodology. Damage estimates to human health, ecosystems and the built environment in economic terms are provided per ton of pollutant for every country separately. The quantities of avoided air pollution emissions will need to be multiplied with ExternE economic estimates per tonne of pollutant per country. The latest economic damage estimates are provided by the NEEDS research project – "New Energy Externalities Development for Sustainability"(Ricci & ISIS, 2012).

In case GAINS modelling tool is employed, monetization of the outputs will have to be done separately:

- Human health consequences can be monetized using estimates derived from contingent valuation studies on the value of human life.
- The damage to the agricultural ecosystems can be monetized using the actual market prices of crops per ton.
- The damage to the forest ecosystems can be monetized estimating the increased forest growth in the absence of air pollution and monetized using the actual market prices of timber per ton. However, due to a relatively short time frame of COMBI, the impact is not likely to be significant.
- It is unclear how to monetize the damage of eutrophication.
- Damage estimates per ton of air pollution emissions to the built environment is provided by the NEEDS project reports and datasets (Ricci & ISIS, 2012).

4.3 Preliminary draft impact equation

In case a generic approach is followed (see 4.1), the impact equation for avoided air pollution economic damage estimate can be written like this:

$$Avoided\ damage\ per\ air\ pollutant = \Delta\, AD \times EF \times ME$$

where AD is activity data and is a direct input from scenarios from WP2 on the type and quantity of fuels used per country and the difference in quantities between the scenarios; EF – emission factor is a coefficient that helps to convert activity data to air pollution emissions and depends on technology used; ME – is monetary estimate per ton of air pollutant.

In case GAINS modelling tool is used, detailed impact equations of multiple-step assessment process can be found in this article - (Amann et al., 2011).

5 References

Amann, M., Bertok, I., Borken-Kleefeld, J., Cofala, J., Heyes, C., Höglund-Isaksson, L., … Winiwarter, W. (2011). Cost-effective control of air quality and greenhouse gases in Europe: Modeling and policy applications. *Environmental Modelling & Software*, *26*(12), 1489–1501. http://doi.org/10.1016/j.envsoft.2011.07.012

European Commission (Ed.). (1995). *ExternE: externalities of energy:: [studies]. Vol. 2: Methodology: [method for estimation of physical impacts and monetary valuation for priority impact pathways]*. Luxembourg: Off. for Official Publ. of the Eur. Communities.

European Environmental Agency. (2015). *European Union emission inventory report 1990–2013 under the UNECE Convention on Long-range Transboundary Air Pollution (LRTAP)*. Luxembourg: Publications Office of the European Union.

Fritsche, U., & Rausch, L. (2009). *Life Cycle Analysis of GHG and Air Pollutant Emissions from Renewable and Conventional Electricity, Heating, and Transport Fuel Options in the EU until 2030* (ETC/ACC Technical Paper 2009/18). Bilthoven, Netherlands: The European Topic Centre on Air and Climate Change (ETC/ACC). Retrieved from http://acm.eionet.europa.eu/reports/ETCACC_TP_2009_18_LCA_GHG_AE_options_2013-2030

Guerreiro, C., Leeuw, F. de, Foltescu, V., Horálek, J., & European Environment Agency. (2014). *Air quality in Europe 2014 report*. Luxembourg: Publications Office. Retrieved from http://bookshop.europa.eu/uri?target=EUB:NOTICE:THAL14005:EN:HTML

Holland, M., & European Commission (Eds.). (1995). *ExternE: externalities of energy:: [studies]. Vol. 1: Summary*. Luxembourg: Off. for Official Publ. of the Eur. Communities.

Mzavanadze, N. (2015). *Literature review on avoided air pollution impacts of energy efficiency measures*. Retrieved from http://combi-project.eu/wp-content/uploads/2015/09/D3.1.pdf

Rabl, A., Spadaro, J. V., & Holland, M. (2014). *How much is clean air worth?: calculating the benefits of pollution control*. Cambridge, United Kingdom: Cambridge University Press.

Ricci, A., & ISIS. (2012). *NEEDS. New Energy Externalities Development for Sustainability. Policy Use of the NEEDS results*. Retrieved from http://www.needs-project.org/docs/Needs.pdf

Wilkinson, P., Smith, K. R., Joffe, M., & Haines, A. (2007). A global perspective on energy: health effects and injustices. *The Lancet*, *370*(9591), 965–978. http://doi.org/10.1016/S0140-6736(07)61252-5