Workshop Background Document

Integrating air quality and climate change mitigation – Is there a need for new metrics to support decision making?

1. Introduction

The idea of integrating action on air quality and climate change is no longer new. The relevance and impact of combined air pollution and climate policy strategies has been suggested and investigated for a number of years now (UNEP/WMO, 2011; Shindell et al., 2012; Nemet et al., 2010; IGBP/IGAC, 2012; Raes and Seinfeld, 2009; Rypdal et al., 2005; Williams, 2012; Fiore et al., 2012; van Aardenne et al., 2010; and many others).

This concept of integration can lead to effective policy making. This has been demonstrated within the Convention on Long-Range Transboundary Air Pollution (CLRTAP), where integrated assessment modelling and the critical loads concept led to a multi-pollutant, multi-effect approach that was more cost-effective than the individual pollutant approach that had been pursued previously. An argument that is also valid in relation to tackling air pollution and climate change [e.g. (Reis et al., 2012)].

With air pollution and climate change being strongly linked with regard to their causes, effects and mitigation options (Jacob and Winner, 2009), the integration of policies that steer air pollutant and greenhouse gas emission reductions might result in cheaper, more effective and thus more sustainable tackling of the two problems. However, one of the challenges is the fact that often air pollution and climate change are treated at national and international level as separate problems under different regulatory or thematic frameworks and different policy departments.

Recent activities showed that the concept of air quality and climate change policy integration is widely accepted amongst the various stakeholder groups in the European Union but that the degree of integration between the air quality and climate change policy areas needs to be carefully evaluated in order to prevent delays in action at the thematic level (Air Quality and Climate Change Policies – Separate or Joint Challenges, Brussels, 21 May 2013, summary available on climpol.iass-potsdam.de).

2. Aim of the workshop

This workshop focuses on how the scientific knowledge base on air-climate interactions can be best made available to the users of this information such as policy makers and other stakeholders. There are two important topics in this regard:

First, it requires an understanding on the type and format of data on air-climate interactions that can help policy makers/stakeholders in understanding these linkages and their trade-offs and co-benefits and the format and timing needs of such information to have the most significant impact on the policy processes.

Second, in order to avoid giving the impression that everything is related to everything, it is important to identify priorities, i.e. those air-climate linkages that are the strongest in term of trade-offs, co-benefits and as a consequence have the potential to make policy more effective and less costly to implement.

The identification of the most significant co-benefits and trade-offs requires the application of appropriate metrics that are well rooted in science, easy to understand and reflect the needs of policy, industry and the public for informed decision making. For the purpose of this workshop, metrics are loosely defined as a quantified measure of effect or impact used to inform decision-making and to evaluate mitigation measures.

The aim of the workshop is therefore to discuss whether current available metrics are "fit for purpose" or whether there is a need to develop alternative metrics or reassess the way current metrics are used and communicated in relation to a better integration of air pollution and climate change policies, in particular mitigation policies.

With this workshop, we will take note of key policy questions (section 3), while working from the current foundation (section 4) and building off of previous work and dialogues on this topic (section 5) during a 2 day multi-disciplinary exchange to inform the research, development, and application of such metrics. In all cases we aim to be forward looking, focusing on the progress needed, based on past achievements, but not re-evaluating the past.

3. Policy perspectives on air-climate interactions

In order to appreciate the challenges of the situation for policy makers and to best support policy making towards integrated air-climate policies, it is important to understand how policy is dealing with air-climate interactions, what the key policy questions are and what information is required to address them?

Based on interviews held with scientists, policy makers, and the private sector (IGBP/IGAC, 2013) integration of air quality and climate change policies in both developed and developing countries is limited by one or more of the following barriers: institutional settings, thematic regulatory frameworks, the importance of environmental problems in relation to societal problems and understanding of the complex science behind air-climate interactions.

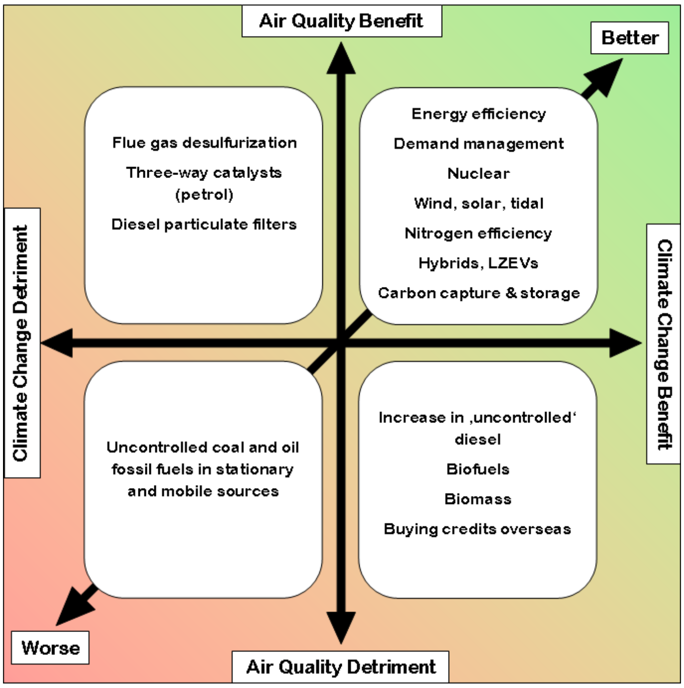
Concerning key policies and their goals in the U.S.A., the U.S. Clean Air Act has a greater focus on addressing climate change next to primarily targeting air quality, and a number of respective regulatory actions have been included. In addition there are a number of voluntary programs focused on promoting clean and efficient energy. Air-climate linkages are indirectly taken into account with U.S. EPA and states implementing programs to reduce energy use as part of their air quality management strategies, and there is growing recognition on the impacts to climate change. Air pollution related co-benefits of climate change mitigation regulations are being considered. Examples of important questions and related information-needs to be addressed include the determination of the health benefits of different GHG reduction measures and the cost to integrate air quality and climate mitigation planning. (Information source: Kimber Scavo, U.S. EPA; personal communication).

The key EU policies on air pollution mitigation (National Emissions Ceiling Directive) and climate change mitigation (EU climate and energy package) fall under two different regulatory frameworks and the policy development and implementation are addressed by separate departments. The usefulness of integration is widely accepted within the EU and in fact proposals for new/revised legislation need to identify coherence and synergies with other policies.

However, EU policy makers expressed that the degree of policy integration needs to be evaluated carefully in order to prevent delays or other inefficiencies. As a prerequisite for efficient joint action specific targets with respect to air and climate policy in the EU are needed, and source policies should be considered, specifically agriculture, non-road mobile machinery, and domestic solid fuel combustion. Concerning information-needs and effective integration of policies, a first step requires that gaps in the monitoring and data management across Europe need to be filled. (Information source: (Air Quality and Climate Change Policies – Separate or Joint Challenges, Brussels, 21 May 2013, summary available on climpol.iass-potsdam.de)

4. Air-climate interaction and the concept of metrics.

Air pollutants influence climate through their effect on radiative forcing, as well as indirect effects and feedbacks, while climate change has implications for the emissions of air pollutants (e.g., hotter temperatures can lead to increased emissions). The same goes for air quality and climate policy since sources of pollutants are to a large extent, the same. There are distinct synergies and trade-offs within the policy options (see figure Williams, 2012, adapted in von Schneidemesser and Monks, 2013).



So called 'win-win' scenarios exist for those options that benefit both air quality and climate, e.g., switching from fossil fuels to renewable forms of energy which reduces both air pollutant (PM, SO_2, etc.) and CO_2 emissions. A 'win-lose' scenario would benefit either climate or air quality, but not both, e.g., replacement of gasoline with biofuels or biomass energy usage are both beneficial to climate change (less CO_2), but detrimental to air quality e.g. because of increased particulate emissions.

Currently, effective ways of quantifying and communicating such co-benefits and trade-offs of air quality and climate policies are being applied, investigated, and developed. One crucial aspect of this integrated assessment is metrics. Several metrics, especially from the field of climate science are available are and attempts are being made to apply them to the air-climate interaction questions. However, typical climate metrics such as Global Warming Potential (GWP) were not designed with policy goals in mind, but have been adopted in international policy (Kyoto Protocol).

While a metric such as GWP is most suited for long-lived greenhouse gases (LLGHGs) such as CO_2, the role of medium- (methane) and short-term climate forcers (some air pollutants) have gained increasing attention. This includes air pollutants such as ozone and particulate matter, especially black carbon. The desire to evaluate radically different atmospheric emissions using a metric to create an equivalence of various emissions has created a significant body of research evaluating and debating the many issues associated with such metrics.

What are metrics?

There are many different types of metrics. To facilitate and provide a framework for the workshop, we will consider metrics (loosely defined) as a quantified measure of effect or impact used to inform decision-making and to evaluate mitigation measures.

Climate emission metrics can be used to inform understanding of, and to communicate, the relative contribution to climate change of emissions (or reductions in emissions) of different gases or substances (e.g., CO_2 versus non-CO_2 gas contributions, Shine et al., 2007), or of emissions from different countries or sectors (IPCC Alternative Metrics Meeting Report, https://www.ipcc-wg1.unibe.ch/meetings/alternativemetrics/oslometrics.html). Air quality metrics, generally representing short-term ambient concentrations rather than emissions, are primarily used to assess the current state of air quality against regulatory prescriptions. In both cases, metrics are the 'currency' of climate and air quality policy. They are for the evaluation of mitigation options. Climate metrics often attempt to place some kind of equivalence on different emissions.

A brief definition of some key metrics from both sectors is given below. This is by no means a complete list. For more information, we would refer you to the (*) papers in the references section.

Example air quality metrics

- **Ambient concentrations**: A concentration guideline set to protect human health or ecosystems that is either recommended or legally binding. E.g., 50 ppb daily 8-hour mean for ozone (WHO guideline to protect human health).
- **SOMO35 (for ozone)**: The annual sum of daily maximum values over 35 ppbv (based on 8-hour running means), expressed in $\mu g\ m^{-3}\ h$. A human health-based guideline.
- **AOT40 (for ozone)**: Accumulated ozone over 40 ppbv from 8 am to 8 pm over May to July, expressed in $\mu g\ m^{-3}\ h$ and based on hourly data. An ecosystems-based guideline.

Most of the air quality related metrics are legally binding target values or thresholds.

Example climate metrics

- 450 ppm CO_2: This value indicates a (politically derived) target value or concentration of CO_2 in the atmosphere by the year 2100 to limit global warming. It is neither legally binding nor part of any international agreement.
- "2°C climate goal": This value indicates as well a (politically derived) target value or temperature threshold not to be exceeded by the year 2100 to limit global warming. It is not legally binding but supported by a significant number of countries.
- **Global warming potential (GWP)**: The time-integrated radiative forcing due to a pulse emission of a unit mass of gas relative to CO_2; used to be able to compare or trade greenhouse gas emissions. The time horizon can be determined (20 years, 50 years, 100 years etc.). The Kyoto Protocol has adopted GWP_{100}.
- **Global temperature change potential (GTP)**: The temperature change at the end of the chosen time horizon due to a pulse emission of the component in consideration relative to that of CO_2. The most commonly investigated and applied alternative climate metric.

Other metrics

- **Years of Life Lost (YOLL)**: An estimate of the average years a person would have lived if he/she had not died prematurely. A measure of premature mortality.
- **Global Cost Potential (GCP)**: The GCP is an economic metric that minimizes the cost of emission abatement of all components simultaneously.

Currently, there is a limited number of climate and air quality metrics with some cross application, e.g., climate metrics, such as GWP or GTP, applied to air pollutants to assess their climate impact. Behavior, advantages and shortcomings of the metrics themselves and their application to short-lived species are discussed in the literature (e.g., Fuglestvedt et al., 2010, O'Neill 2000, Shine 2009, Tanaka et al., 2013).

A number of challenges remain with respect to comparing air pollution and climate change, and those species that influence both areas. For one, various pollutant emissions have different atmospheric lifetimes, which affect their mixing and distribution across the globe, but also significant differences in their emission hotspots. Once emitted CO_2 remains in the atmosphere for a century or longer which allows for global distribution. In contrast, an air pollutant like particulate matter will only remain in the atmosphere for days to weeks, which means that not only are the health impacts much more local, but also any effect on radiative forcing. Also, due to air pollutants' direct effects on human health and ecosystems their ambient concentrations are a key parameter while for climate forcers amounts emitted over time are used to inform decision making. Another issue is the value judgement required – most climate change mitigation policies will not have immediate effects, but longer-term ones (future generations), whereas air quality mitigation typically has almost immediate effects (today's population). Furthermore, certain air pollutants with significant adverse health effects, e.g., sulfate aerosols, are also reflective (scatter light) and therefore cool the climate. Selectively reducing warming aerosols, and not reducing cooling aerosols could be beneficial to climate, but still represent a significant health risk, requiring a value judgment. Crucial to these challenges are the use of metrics. Is the information we have, communicated through metrics, sufficient to inform air quality and climate change policy decisions?

5. Overview of existing work/workshops

Significant efforts in the area of metrics and integrating air quality and climate change have been undertaken previously. So as to build on these efforts, highlights mainly from a selection of workshop reports/grey literature is included here. Further detail can be found in the documents themselves which are referenced at the end of this summary. By no means is this comprehensive, especially not in the case of the peer-reviewed literature on metrics.

Information Source	Main Messages
2013, Survey, *IGBP/IGAC Air Pollution & Climate Science-Policy Dialogue*	• Interviewees emphasized the need for an improvement in metrics, especially with respect to being able to quantify co-benefits or for trading mechanisms that involve numerous pollutants. • Development of integrated metrics could improve understanding of complex relationships and help policymakers conceptualize the bigger picture of a given policy and its multitude impacts.
2013, Peer-reviewed Article, Smith and Mizrahi	• The climate benefit from reductions in short-lived forcing agents was smaller than previously estimated; reductions of methane and black carbon would likely have only a modest impact on near-term global climate warming. • While the near-term climate benefits of an idealized SLCF-reduction policy are relatively modest and uncertain, reduction of methane (and thereby ozone) and particulate matter (including BC) would have substantial global health benefits and could potentially be justified on this basis alone. • While a comprehensive climate policy (including action on air pollution sources) would have significant effect, reductions in greenhouse gas emissions need to remain the focus of any climate-mitigation policy. • The authors do not comment on integrated AQ/CC policy, but focus on SLCP options for climate mitigation; they do emphasize the need for consideration of the full energy system and not simply each sector in isolation.
2013, Conference, *Translating Co-benefits Research into Action in Asia: Science, Models, Projects and Policies*	• Air quality remains a significant concern for many countries, and may offer a better entry point for co-benefits than climate change. • Depending on whether a regional or global approach is desired, will impact which pollutants are focused on. For example, if a regional approach to co-benefits is taken, targeting the ozone precursors NOx and VOCs, will affect local/regional ozone, whereas reductions in methane would have a much larger impact on background ozone. • It was emphasized that SLCP mitigation will not resolve the world's air pollution problems, but that understanding co-emissions and aligning policies will be critical for developing successful emission-reduction scenarios and action plans.
2013, Workshop, *Taking international air pollution policies into the future*	• Particular interest was noted on combined air pollution and climate change policies, suggesting that the revised National Emissions Ceilings (NEC) Directives could be used as a first step in this vein – addressing air quality and health benefits, as well as near term climate benefits for emissions of ozone precursors (methane and carbon monoxide). • The synergies between air pollution and climate change, air pollution control could effectively contribute to the mitigation of short-term and local warming.

2013, *Scoping Paper on Air Pollution and Climate Change Mitigation*, EEA and European Topic Center	• Promoting combined strategies presents a number of advantages. • The issue of integrated policy should be considered in a broader perspective than air pollution and climate change alone. • The choice and definition of indicators should consider the target audience, and the geographical and temporal coverage. • The scoping paper is not yet published, but available on request.
2011, Workshop, *Greening Growth in Asia: Making Co-benefits Mainstream*	• Integration of co-benefits into the policy decision making process will be increasingly important. • Effort is also needed surrounding the communication of integrated air quality and climate change policies – e.g., the need for changing the perception that quantifying co-benefits is difficult with not enough incentives to overcome the difficulty.
2011, Workshop, *Examining the role of stakeholders in the assessment of the climate effects of aviation*	• Lack of appropriate communication between climate scientists and stakeholders remained an obstacle to progress. The problem was not necessarily that the information needed was not available, but that it was not easily accessible to those outside of the research community.
2009, Meeting, *IPCC Expert Meeting on the Science of Alternative Metrics*	• The effectiveness of use of any metric depends primarily on the policy goal; GWP_{100}, although adopted by the Kyoto Protocol, was not designed with a policy goal in mind and alternative metrics may be preferable. • Recommendations to the scientific community included continued work on improving and communicating uncertainties with regard to the various processes influencing climate, to develop metrics for policy targets other than limits to temperature change, assess regional differences especially for short-lived pollutants, and determine the degree to which physical metrics approximate more comprehensive (e.g., including economics) metrics. • There is interest in extending emission metrics to short-lived species in order, for instance, to convey the positive or negative climate implications of different air quality control policies. • Uncertainty: While framing metrics in terms of cost-benefit or impact on human or natural systems can be very useful and/or appealing, the amount of uncertainty in these types of metrics is much higher than those which consider radiative forcing, or atmospheric concentration.

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