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Common metrics to calculate the carbon dioxide equivalence of greenhouse gases

Report on the workshop on common metrics to calculate the carbon dioxide equivalence of greenhouse gases

Note by the secretariat

Summary

This report provides a summary of the workshop on common metrics to calculate the carbon dioxide equivalence of greenhouse gases, which was held on 3 and 4 April 2012 in Bonn, Germany. At the workshop, participants from Parties and the scientific community shared information and their views on four topics: uncertainties; new and refined areas or metrics; policy goals; and the relationship between policy frameworks and metrics. In addition, representatives of the Intergovernmental Panel on Climate Change (IPCC) Working Group I and Working Group III provided information on the status of the work on metrics that the IPCC is developing under the Fifth Assessment Report of the IPCC.

Contents

I. Introduction

A. Mandate

1. The Subsidiary Body for Scientific and Technological Advice (SBSTA), at its thirtieth session, initiated its consideration of common metrics to calculate the carbon dioxide (CO_2) equivalence of anthropogenic greenhouse gas (GHG) emissions by sources and removals by sinks (hereinafter referred to as common metrics).[1]

2. The SBSTA, at its thirty-fourth session, expressed its appreciation to the Intergovernmental Panel on Climate Change (IPCC) for holding an expert meeting, held in Oslo, Norway, from 18 to 20 March 2009, on the science of alternative metrics, following an invitation to the IPCC by the Ad Hoc Working Group on Further Commitments for Annex I Parties under the Kyoto Protocol at its sixth session.[2] At that session, the SBSTA welcomed the report[3] on that meeting and its conclusions and recommendations relating to the Convention and to the scientific community regarding research needs and the scoping phase of the Fifth Assessment Report of the IPCC.

3. At the same session, the SBSTA requested the secretariat to organize, subject to the availability of resources, a workshop on common metrics, to be held in the first half of 2012, with a focus on uncertainties, new and refined areas or metrics, policy goals and the relationship between policy frameworks and metrics.[4]

B. Scope of the note

4. This report contains information about the proceedings of, and discussions during, the workshop. This information is expected to serve as a basis for continued consideration by the SBSTA at its thirty-sixth session of common metrics under the methodological issues under the Convention.

II. Proceedings of the workshop

5. The workshop was organized by the secretariat and was held in Bonn, Germany, on 3 and 4 April 2012. The workshop was chaired by Mr. Richard Muyungi, Chair of the SBSTA, who addressed the participants at the opening of the workshop.

6. The workshop covered four topics: uncertainties; new and refined areas or metrics; policy goals; and the relationship between policy frameworks and metrics. In addition, representatives of the IPCC Working Group I (WG I) and Working Group III (WG III) provided information on the status of the work on metrics that these groups are currently developing under the Fifth Assessment Report of the IPCC.

7. Thirteen representatives of Parties not included in Annex I to the Convention (non-Annex I Parties), 17 representatives of Parties included in Annex I to the Convention (Annex I Parties), nine scientific experts working on the Fifth Assessment Report of the IPCC, four representatives of the IPCC and one observer attended the workshop.

[1] FCCC/SBSTA/2009/3, paragraph 116.
[2] FCCC/KP/AWG/2008/5, paragraph 45.
[3] <http://www.ipcc.ch/pdf/supporting-material/expert-meeting-metrics-oslo.pdf>.
[4] FCCC/SBSTA/2011/2, paragraph 101.

8. The workshop was divided into five parts. In each part of the workshop, representatives of Parties and of the scientific community made relevant presentations,[5] which were followed by questions from the participants. At the end of each part, a general discussion on the topics presented was facilitated by the workshop chair. In the first part, after the secretariat presented the mandate, background and objectives of the workshop, representatives of the IPCC made two presentations introducing the work on metrics of WG I and WG III and their approach and contribution to the IPCC Fifth Assessment Report on this matter. The second part covered the uncertainties of common metrics and contained five presentations, three by representatives of Parties and two by scientific experts. The third part covered the new and refined areas or metrics and contained five presentations, one by a representative of a Party and four by scientific experts. The fourth part covered the policy goals and contained three presentations, all by representatives of Parties. The final part of the workshop covered the relationship between policy frameworks and metrics and contained six presentations, four by representatives of Parties and two by scientific experts. At the end of the workshop, the Chair of the SBSTA addressed the participants with his closing remarks, highlighting that the workshop was a very important step forward in the consideration of the common metrics and in promoting a space for the exchange of views on this topic between the Parties and the scientific community.

III. Summary of discussions

9. This chapter provides a summary of the main points presented by the representatives of Parties and by the scientific community during each part of the workshop and of the discussions by the participants and speakers that took place at the end of each part.

A. Intergovernmental Panel on Climate Change work on metrics under its Fifth Assessment Report

10. The presentations by the IPCC representatives introduced the work on common metrics of WG I and WG III. The first speaker indicated in his presentation that in the contribution of WG I (*Climate Change 2013: the Physical Science Basis*) to the IPCC Fifth Assessment Report, a special section on GHG and other metrics, including the global warming potential (GWP) and the global temperature change potential (GTP), has been incorporated in chapter 8 (anthropogenic and natural radiative forcing). Regarding the cause–effect chain from emissions to climate change and damage, it was indicated that uncertainties are increasing as the policy relevance of the effects is increasing. Also, it was indicated that by May 2013 it is expected that the final draft of this contribution will be completed and that by September 2013 the WG I plenary will approve the final document, while it is expected that the Synthesis Report of WG I will be available by October 2014.

11. The second speaker clarified in his presentation that although no dedicated section on common metrics is envisaged in the contribution of WG III to the IPCC Fifth Assessment Report, metrics will be covered in the chapter on framing issues, in particular under the section on social, economic and ethical concepts and methods, with links given to other sections and chapters of the report. During the presentation, he highlighted that there are various challenges for the WG III assessment, mainly related to the complexity of the socio-economic systems to be analysed and to the large dependence of policy pathways or directions and the goals to be achieved, which influence the metrics to be chosen and their

[5] All presentations, the agenda of the workshop and the participants list are available at <http://unfccc.int/methods_and_science/other_methodological_issues/items/6737.php>.

evolution, with particular focus on metrics for short-lived gases. Several objectives of the WG III assessment on metrics were mentioned, including the following:

(a) An explicit indication of how metrics are used;

(b) A conceptual clarification of alternative emission metrics and their relationships, including both physical and more comprehensive economic metrics;

(c) The establishment of relationships between alternative emission metrics and the purposes of analysis;

(d) Quantitative comparisons and/or assessment of numerical values for alternative metrics, as appropriate;

(e) Communication of the underlying uncertainties and value judgements.

B. Uncertainties

12. The presentations in this part of the workshop covered the structural and scientific uncertainties of emission metrics, the political and economic uncertainties in the implementation of common metrics, the uncertainties of different policy approaches to deal with GHGs and other climate forcers and the implications for common metrics of short-lived climate forcers (SLCFs).

13. The first speaker clarified that the GWP is a metric based on pulses of different gases integrated up to a chosen time horizon and that this metric has a strong and artificial memory of the emissions (i.e. it overestimates the effects of pulse emissions of short-lived GHGs on climate change). Also, this metric does not include the climate response, but indicates the accumulated radiative forcing imposed on the system, and it does not provide an equivalence in temperature of different GHGs. In contrast, the GTP addresses the issue of the temperature response. The GWP and the GTP show large differences for short-lived GHGs because they are fundamentally different in their nature. The speaker indicated that the term 'structural uncertainties' refers to the consequences of using different types of metric or to choices of key aspects (e.g. impact parameter, lifetimes, policy choices and/or time horizon) and that the term 'scientific uncertainties' refers to the range of values that can be calculated for a given metric due to incomplete knowledge of important aspects of the climate or economic systems (e.g. climate impacts, damages and/or mitigation costs).

14. In addition, the speaker noted that the relative uncertainty of the GWP (to the CO_2 impulse response function) is independent of the GHGs and is not very dependent on the time horizon, and that the relative uncertainty of the GTP (to the temperature response function) increases with the time horizon but decreases with the lifetime of particular GHGs. Also, he indicated that the use of the GWP in the multigas approach (basket) and the choice of a time horizon was useful in the process leading up to the Kyoto Protocol, because it increased flexibility in the policy choices and may have reduced costs. However, he noted that anthropogenic emissions and mechanisms go beyond political processes and that it is very difficult to force these into a single scale or metric; for this reason, and to overcome such difficulties, different options to address these issues might be suggested, for example separate baskets for long-lived and short-lived GHGs or even a gas-by-gas approach, for which no common metrics would be needed. Finally, he clarified that metrics should not define the policy goal, because they are tools for policy choices and any assessment of metrics should be performed in the context of different multigas policies.

15. The second speaker highlighted the different uncertainties in the current knowledge and use of metrics, which may be classified as physical, structural, economic (e.g. choice of discount rate, potential for perverse incentives) and political (e.g. ease of communication,

stability) uncertainties. Also, he indicated that value choices are necessary for all metrics and that these choices could refer to policy goals (e.g. the 2 °C limit), the definition of basket of GHGs, revisions of the values of specific metrics due to new scientific knowledge (e.g. values provided in different IPCC assessment reports), choice of type of metric (e.g. GWP, GTP) and choice of time horizon, for which metrics are particularly sensitive.

16. The third speaker highlighted that the climate sensitivity parameter affecting the absolute GWP and absolute GTP (AGWP and AGTP) should be considered as a source of large uncertainty in the estimation of these metrics.

17. Another presentation discussed how the Montreal Protocol successfully implemented a multi-basket approach to deal with the problem of stratospheric ozone depletion. The presentation indicated that a single-basket approach, adopted under the Kyoto Protocol, can lead to some level of ambiguity and high uncertainties in the climate impact of the relevant regulation. For example, when using a single-basket approach, if a regulation on some group of gases (e.g. hydrofluorocarbons) has the inadvertent affect of delaying CO_2 regulation, this may have implications for the climate over many centuries.

18. The last presentation, which focused on SLCFs, indicated that the uncertainties in estimating their radiative forcing are becoming smaller over time, owing to the large amount of research, and that the GWPs for SLCFs are becoming more reliable. At the same time, it was recognized that the GTP is a straightforward metric for policy control of SLCFs under specific temperature increase, although there are still large uncertainties in the climate sensitivities of SLCFs and CO_2.

19. During the general discussion on this part of the workshop, a participant suggested the possibility of adjusting metrics over time as scientific knowledge evolves, since there is no real knowledge of climate sensitivity and because some metrics by definition change over time. However, another participant highlighted the importance and value of having a common metric constant over time, in order to support a consistent approach to policy decisions. Other participants indicated that, from the perspective of policymakers, a simple metric that is robust and well-based on science is necessary and that this metric should address the first priorities and the short-term goals (e.g. related to CO_2 mitigation). Also, it was indicated that the several uncertainties presented during the workshop are rather complex and very difficult to communicate to policymakers, and this should be addressed by the IPCC authors. In addition, a participant indicated that the uncertainties of metrics should not be an impediment to discussing metrics and taking action on their use, because policy relevance does not necessarily inversely correlate to uncertainties.

20. Also, it was mentioned that the scientific community should be clear in providing information on the relationship between policy goals and common metrics, which ideally should allow finding trade-offs between achieving the long-term and short-term policy goals, and clear definitions of long-lived and short-lived gases. In addition, a participant indicated that policymakers need clear guidance on the impacts and uncertainties of different metrics, in addition to the information that the scientific community is expected to provide, such as the GWP and GTP values for different gases. However, another participant warned that introducing concepts of long-lived and short-lived gases is difficult because there are no clear criteria for them and that the IPCC authors may not be in a position to assist in clarifying this concept, because of the different structural uncertainties of scientific character. Another participant indicated that there are incentives to work on these uncertainties, but that there is no definition of where the trade-offs among different considerations may lie (e.g. security, stability and flexibility for long-term policies or uncertainties of a metric).

21. During the discussion, the issue of the time frame in selecting metrics was identified as critical, since the choice of a 100-year time horizon, for example for the purposes of the

Kyoto Protocol, is not based on scientific criteria. The choice of the time frame may be critical when selecting a snapshot common metric such as the GTP, but is not necessarily the case for the GWP, which results from integration, and also when considering the goals for future commitments (the 2 °C limit). In this case, information on irreversible damage should be part of any consideration when defining a time horizon for selecting metrics. In addition, it was expressed that the cumulative amount of CO_2 is important as well as its reduction, and this last is related to a long-term horizon, however, it was noted that scientific assessment cannot enter into value judgement, which should be made by policymakers.

C. New and refined areas or metrics

22. The presentations in this part of the workshop covered the inclusion of the rate of change in emission metrics, the integrated global temperature change potential (iGTP), the cost-effective temperature potential (CETP), new interpretations and new metrics beyond the GWP and the relevance of carbon emission metrics to metrics for non-CO_2 GHGs.

23. The first speaker indicated that it is possible to construct a metric based purely on physical science that includes both the rate of temperature change and a level-based constraint (a long-term stabilization target). However, such a metric requires additional value judgement on the rate constraint, which is additional to the constraint of a long-term stabilization target (e.g. the 2 °C limit). In addition, it was noted that the value of this metric would be equal to or less than the GWP, with a 100-year time horizon in the early phase for SLCFs. This would indicate a need to consider the rate of change as an independent environmental issue and to regulate the SLFCs in a separate basket for which this metric could be used. In commenting on the presentation, participants noted that such a metric, changing over time and having peaks, would be difficult to communicate to policymakers, including the uncertainty on climate sensitivity, even though an average value during a commitment period could be calculated.

24. The second speaker discussed the iGTP and indicated that in the early stages of research on the GWP the research focused on the iGTP, but that the link evolving from radiative forcing to temperature was later not considered. The presentation also noted that nitrous oxide (N_2O) would be a better reference gas than CO_2, because its GWP, GTP and iGTP values are approximately equal. If CO_2 is used as a reference gas, the GWP and iGTP values are approximately equal for most gases, except for very short-lived species. This is because these two metrics are integrations, while the GTP is a pathway (instantaneous) metric. CO_2 is therefore good enough as a reference gas for integrated metrics and its importance is underappreciated, and if integrated temperature is the goal of climate policy the GWP is a simple metric with a similar response than the iGTP. A consequence of this is that in a hypothetical use of a multi-basket approach different reference gases could be used.

25. The third presentation indicated that the GWP was not designed to facilitate the basket approach in a cost-effective climate stabilization regime. This is in contrast to the global cost potential (GCP), which is a metric based on the assumption that a climate target should be met at the lowest possible abatement cost (cost-effective trade-off ratios). However, this metric is based on optimization of integrated assessment models, which are complex and not transparent for most climate scientists and policymakers and include a range of very uncertain parameters and uncertain structural relationships. Taking this into account, the CETP constitutes an approximation to the GCP and includes information on the physics, an estimate of the stabilization year and a discount rate. For this metric, the choice of the discount rate is as important as the choice of the time horizon. Neither the CETP and the GCP, nor the GTP, take into account climate effects in the short term.

However, the CETP and the GCP take into account climate effects in the long-term (beyond stabilization), while the GTP does not. In addition, this presentation concluded that a GWP with a 100-year time horizon would set a high price on short-lived gases in years far from when climate stabilization occurs, while the opposite is true for the years close to when stabilization occurs. Some participants acknowledged the need for a process to calculate metrics that is robust and credible from a scientific point of view, because the policy choices will depend on the countries concerned. In addition, participants acknowledged that combination of considerations concerning both physics and economics, for example discount rates, will impose more difficulties for policy choice.

26. Another speaker emphasized that the choice of parameters (e.g. radiative forcing, temperature change, sea level rise, economic impacts, or the rate of change of these), of the type of emission (e.g. pulse, sustained), of the time horizon and of the value, at a given time, integrated over a given time horizon and/or discounted, will affect decisions as to whether it is best to separate short-lived or long-lived gases, and that the choice of metric depends on the policy goals. He also highlighted some deficiencies in the GWP (e.g. failure to incorporate damage and abatement costs, assumption that metric values remain constant over time, independence of the ultimate goal). Nevertheless, the GWP enabled the multigas climate policy under the Kyoto Protocol, and moving away from it would be costly. This presentation further indicated that physical metrics may be more acceptable to policymakers, because they have fewer assumptions and more transparency, and that the GWP may be reinterpreted in terms of physical science meaning (e.g. iGTP, sustained GTP), including economics. Further, he presented the TEMP index, which is the best multiplier for achieving an agreement on simulating historical temperature changes due to methane (CH_4) and N_2O emissions by their CO_2 equivalent emissions using the GWP.

27. In addition, this presentation indicated that a two-basket approach could be used for a target-based policy by setting a cumulative emissions limit for long-lived gases (using the GWP with CO_2 as a reference gas) and a maximum future rate of emission for short-lived gases (using the GWP with CH_4 as a reference gas). Some participants suggested that aggregation problems are mostly related to understanding damages, but not to regional differences for emissions, which is an issue for very short-lived species. In addition, some participants emphasized the special considerations on common metrics needed for the UNFCCC process, such as robustness and reliability, and that a clear separation of physics and economics is not appropriate.

28. The last presentation highlighted the different roles of short-lived gases (trimming the peak of GHG concentrations) and long-lived gases (determining the stabilization level of GHG concentrations) in discussing climate stabilization and the limitations of the single-basket approach. It indicated that a two-basket approach with a GTP for short-lived gases and cumulative emissions (CE) as a metric for long-lived gases would serve for addressing issues of climate stabilization level and for transient climate response. However, it may be necessary to constrain ocean heat uptake in order to improve the validity of the CE as a common metric.

29. During the general discussion on this part of the workshop, a participant asked about dealing with small-scale anthropogenic climate effects over time (regional climate impacts) and the construction of metrics for taking such effects into account given that short-lived gases most likely have regional effects. He indicated also that policy makers in respective regions would be interested in such developments. However, some participants acknowledged that even though there are some studies on the small-scale effects of NO_X and carbon monoxide, and there are expectations about future efforts in Europe on research into this matter, it will be necessary to wait for some years before putting forward some conclusions of this research for consideration by policymakers. In addition, some

participants indicated that construction of metrics for taking regional effects into account may not work and that it is not possible to use regional modelling for this purpose.

30. A participant noted that complex issues, such as damage owing to climate change, the use of different baskets, the separate treatment of long-lived and short-lived gases or even the treatment of long-lived and short-lived CO_2 in the atmosphere, are difficult to deal with in climate change negotiations. For this reason, such issues would need to be clarified first by the scientific community, which should find compromises and provide simple, robust and reasonable inputs to policymakers. Another participant indicated that the choices between the common metrics need to be clearly explained, together with the associated uncertainties, and trade-offs should be well understood (e.g. the choice of the metric to track mitigation efforts or the metric for reporting GHG inventories); the participant encouraged the scientific community to continue interaction and discussion on these issues with policymakers with the aim of helping them to make well-informed decisions based on different choices. In addition, it was highlighted that communication between Parties and the scientific community should be enhanced.

31. During the discussions it was stated that developing a metric with a policy goal and fixed time horizon that is either constant over time or to be changed at some point over time, and/or in addition considers the future beyond the achievement of the goal, is a problem that can technically be solved, but that the scientific community considers that this is not a role for it but for the decision makers. A participant indicated that a multi-basket approach purely based on the life of gases is scientifically more appropriate when considering the calculation of metrics and that a further development based on economic sectors could be a better construct for these baskets. Another participant indicated that uncertainties in the use of the multi-basket approach are lower than the uncertainties associated with different values for the GWP or the GTP.

32. Some participants acknowledged the progress made in scientific knowledge since the IPCC workshop on common metrics held in Oslo in 2009 (see para. 2 above) and the number of recommendations that have been implemented in the development of the IPCC Fifth Assessment Report (e.g. stratification of different metrics). However, some participants noted that among the recommendations from the IPCC workshop that should be given more prominence in the IPCC Fifth Assessment Report is the provision of information and direction to policymakers, including areas of convergence or middle ground between policy goals and scientific knowledge regarding metrics. A participant stressed that, in principle, metrics based on economics perform the same functions as other metrics presented during the workshop. However, the level of the complexity of these metrics is very difficult to asses and a change in metrics is a decision for the policymakers only, which should be done only if the need for a change is very clear. Finally, a participant recalled that the GWP is a simple metric, which is its advantage, and for this reason the GWP could be considered good enough to continue to be used.

D. Policy goals

33. The presentations in this part of the workshop covered the cost-effectiveness and implications of GWPs and GTPs under alternative policy goals, the policy goals and common metrics implications, and the policy goals and frameworks.

34. The first presentation indicated that the use of the GWP does not provide a cost-effective way of comparing GHGs when the main policy goal is to limit long-term climate change. However, few studies have explored the cost and climate policy implications of other metrics based on physics that could replace the GWP. The presentation also indicated that as a result of studies and modelling, the use of fixed GTPs results in higher CO_2 prices

and higher total mitigation costs than the use of GWPs, but lower prices and costs for CH_4. The use of time-dependent GTPs (focusing on the year 2100) result in lower CO_2 prices and lower total mitigation costs than when using GWPs, while prices and costs for CH_4 are lower initially but much higher later. In the presentation it was also stated that assumptions about agriculture mitigation potential have a larger effect on global costs than the use of alternative metrics and that different long-term stabilization targets have a much larger effect than alternative metrics. It was indicated that different, but equivalent, metrics do not result in equivalent environmental outcomes, but differences in costs are smaller than those arising from other assumptions. Finally, the presentation provided some questions to the policy community regarding the importance for the policy process to have a metric that is optimal for a particular policy goal but, almost by definition, will not be optimal for other policy goals, the sustainability of the implementation of a metric that implies an escalating cost of CH_4 emissions globally, the social and political benefits and costs of continuously updating a metric to achieve optimality and the implications of different metrics for regional and sectoral engagement with climate change.

35. The second presentation emphasized that in 2011 Parties agreed at the United Nations Climate Change Conference in Durban, South Africa, on holding the increase in global average temperature below 2 °C or 1.5 °C above pre-industrial levels. However, there are a number of pending related questions, such as the existence of a limit in time for this goal, the trajectory to achieve it, the existence of intermediary goals and the possibility of trajectory corrections and the possibility of overshooting. The presentation indicated that the Kyoto Protocol adopted the basket approach and the use of the GWP for providing flexibility in mitigation options to Annex I Parties. The GWP is a metric that later propagated to other policy aspects, such as GHG inventories, mitigation options (policies and projections) and cost–benefit mitigation analyses. In this sense, the presentation stressed the need for Parties to keep archived estimates of individual GHGs in mass units, because this is basic information on emissions and because the approach to the use of metrics can change.

36. This presentation also indicated that for Annex I Parties the use of an inappropriate metric may lead to different contributions to climate change mitigation, while for non-Annex I Parties the use of an inappropriate metric may lead to incorrect evaluations of the contribution of projects to mitigation, for example under the clean development mechanism (CDM). It was also indicated that dangerous anthropogenic interference with the climate system should be prevented on the basis of equity and that while emissions from a GHG have the same influence from the point of view of the atmosphere regardless of the anthropogenic source, from equity's point of view anthropogenic sources may have different evaluations (e.g. emissions from fossil fuel combustion or from food production). Therefore, historical responsibility for climate change was deemed as a key in establishing emissions budgets when sharing the burden and a common metric has to reflect this. One specific metric will not necessarily be appropriate for all situations in which a basket of gases is used (e.g. scenarios and projections, selection of trajectory, evaluation of responsibility, burden sharing).

37. The last presentation in this part of the workshop covered the policy goals and frameworks from a Party's perspective and emphasized that long-lived GHGs are the key challenge and that the climate process must facilitate actions on these gases. Also, it indicated that the basket approach adopted for the Kyoto Protocol enabled more policy options and flexibilities, provided a signal for economy-wide action, targeted the key GHGs, helped to avoid negotiations on targets for individual GHGs, is economically efficient and as a key requirement it has an agreed common metric (the GWP) to aggregate emissions, which has proven to be a robust and practical metric.

38. In this presentation it was indicated that a metric should provide a robust scientific basis for quantifying and comparing the potential climate impacts of the basket of GHGs, provide a common view of the relative importance of emissions, enable an agreed basis for target setting and tracking progress on targets over defined periods, allow fungible trading of gases, avoid biases and perverse outcomes, provide a fair basis for assessing equivalent effort and support achievement of global temperature goals. This presentation indicated that the following were among the main characteristics of the metrics: use for well-mixed and evenly distributed gases; unbiased over the basket of gases; easy to understand and having links with climate responsibility; practical and stable; based on objective physical properties; facilitation of cost-effective abatement; useable for the achievement of the objectives and mechanisms of the Convention in an appropriate time frame; and acceptable to the Parties.

39. In this presentation some of the problems in the design of metrics were noted, such as the shortcomings of GWPs because the integration period results in different values, the revisions required based on changes in atmospheric concentrations and the difficulties in extending to short-lived radiative forcers. It was recognized that other metrics also have shortcomings. Also, it was indicated that for changes in metrics it is necessary to understand the following: differences between concepts and the scientific basis; advantages/disadvantages, assumptions, limitations and uncertainties involved; impacts on mitigation actions, targets and the markets; and consideration of timescales for implementing the changes of metrics, because in a number of cases current metrics are used in domestic legislation (trading schemes), their use requires certainty over defined operational periods and solid communication channels to key stakeholders and the public should be established before any decision. Changing metrics would require a major revision of the assessment of emissions and would have implications for policies, markets, target setting and monitoring progress.

40. During the general discussion on this part of the workshop, some participants noted that for an international treaty such as the Convention that involves a significant number of Parties no exceptions can be made for single Parties and that no other metric is available at this point of time, making a change from the GWP very difficult. Some other participants, however, indicated that there is no reason in principle to continue to use the GWP as a metric, which from a scientific point of view, it is not perfect. Other participants recognized that no metric can consider the whole complexity of climate change phenomena and that having the GWP as an imperfect metric was part of a policy choice when the Kyoto Protocol was agreed upon. A participant noted that there are possibilities to discuss these issues among Parties when negotiating the Durban Platform for Enhanced Action or the third commitment period of the Kyoto Protocol. Other participants highlighted that the climate negotiation process is probably one of the most scientifically driven processes and, as indicated before, the new process under the Durban Platform for Enhanced Action would benefit from scientific inputs from this workshop. A participant stressed that interaction between scientists and policymakers does not seem to happen continuously and that for this reason this dialogue and process of exchange of information should continue.

41. A number of participants noted that there could be a certain benefit from, or good reasons for, changing the metric from the currently used GWP to a new one, even though the GWP has been useful so far under both the Convention and its Kyoto Protocol. Moreover, not only a change of metric but also a change in the basket approach was deemed possible by some participants, but such a change should be underpinned by a clear and credible guidance from the scientific community.

42. Some participants indicated the need for considering SLCFs and aerosols, the use of two baskets, one for short-lived gases and the other for long-lived gases, and the limitations of GWPs in this context. However, some other participants indicated the lack of inventory

methodologies for SLCFs and aerosols that are currently treated by other conventions and the need to avoid that these are also treated under the Convention.

43. The importance of keeping archived absolute quantities of individual GHGs in inventories, and that one metric probably does not fit all purposes, were emphasized by some participants. Therefore, differentiation of GHGs for different purposes could be taken into account when dealing with goals and scenarios, and Parties may look only at physical variables or in other cases should include cost-effectiveness variables.

E. The relationship between policy frameworks and metrics

44. The presentations in this last part of the workshop covered the variations in CO_2 equivalence of CH_4, a conceptual framework for the economic evaluation of climate metrics, factors to be considered when choosing metrics, interactions of metrics and alternative policy settings at the country level (a national case study and implications for policy frameworks), the change in GWPs along representative concentration paths (RCPs) and the implication of different common metrics on mitigation policies (a country case).

45. The first presentation indicated that multigas abatement strategies are mostly sensitive to the CO_2 equivalence of CH_4, because other long-lived GHGs have either a too small radiative forcing effect (e.g. sulphur hexafluoride (SF_6) or nitrogen trifluoride (NF_3)) or an almost invariant CO_2 equivalence (e.g. N_2O) to make a difference from a climate perspective. The CO_2 equivalence for short-lived species tends to increase as climate change unfolds. This presentation also discussed another metric, the global damage potential (GDP), which is a pulse metric (idealized with a quadratic damage function and a 2 per cent discount rate) that is comparable with the GWP with a 100-year time horizon. For an idealized GDP, the CO_2 equivalence of CH_4 is essentially determined by socio-economic parameters that involve a value judgement on impacts and discounting.

46. This presentation highlighted that climate metrics are used in multiple applications, including estimating GHG emission national totals, formulating emission targets at the international level and trading emissions in international schemes or offsetting emissions through Kyoto Protocol mechanisms (e.g. the CDM), with implications for investment decisions across different GHGs. It also highlighted that there is no reason for a CO_2 equivalence to remain constant over time, for example for the GTP (an end point metric) when the target is approached or for the GDP as climate change unfolds with a damage function. Pulse metrics are useful (certainty versus stability) for trading emission units of CH_4 and CO_2 in trading schemes and the CDM, as they present a snapshot of a country's emissions. However, it is less clear whether the same metric should be used to formulate a long-term stabilization climate target.

47. The second speaker proposed a change in the perspective of the many alternative metrics presented during the workshop showing an economy-based approach, for which explicit or implicit assumptions about the marginal utility of emissions abatement of different gases are made. He showed the interrelation between different approaches in designing metrics, following the cause–effect chain: emissions, concentration change, radiative forcing, temperature change and damage. He suggested that a temporal weighting function could be used to categorize alternative metrics and to make explicit value judgements associated with each metric, and that most metrics can be constructed as special cases or simplified versions of the GDP.

48. The presentation also showed a qualitative assessment of different metrics, where explicit uncertainties (scientific, value-based and scenario uncertainties) were lower for the GWP and increased gradually for the GTP, the GCP and the GDP, while implicit uncertainties (structural) were higher for the GWP and decreased gradually for the GTP, the

GCP and the GDP, indicating the need of a trade-off between policy relevance and the capacity for making the metrics operational. The presentation concluded that any application of metrics in an economic context (e.g. emissions trading) makes explicit or implicit assumptions about the marginal utility of emissions abatement of different gases.

49. The third presentation emphasized that change in atmospheric concentrations of various gases cannot be compared directly and indicated that 'achieving least cost' is not the dominant principle of the Convention, therefore using the relative average/marginal emission reduction cost as a basis for metrics is not adequate. It indicated that mitigation costs are not of a global nature and future costs are not predictable (a scenario is merely one of the many possibilities). It showed that a number of parameters, such as change or rate of change in atmospheric energy balance, temperature increase, sea level rise and damages, could all be considered when defining metrics pertinent to the ultimate objectives and principles of the Convention. However, the speaker acknowledged that quantifying some of these parameters, for example damage, and achieving consensus among Parties during negotiations may not be an easy task.

50. The presentation indicated that there is a need for more research on the implications of the effect chosen as the basis for comparison among gases with the purpose of informing Parties for their consideration of metrics. This effect should respond linearly to the amount of emissions of these gases and the metrics should not be influenced by specific model assumptions and uncertainties of model parameters. It also indicated that measuring the effect at one particular point of time may miss useful information, since climate change and its impacts occur all the time. In addition, it was highlighted that choosing the time frame when considering metrics may greatly influence the results and the time frame is a policy choice; for example, for holding the increase in global average temperature below 2 °C above pre-industrial levels throughout the twenty-first century, 100 years may be an appropriate option.

51. The presentation further indicated that the physics of actual emissions in the atmosphere is much more complex that pulse or sustained emissions, as both, pulse or sustained emissions, are simplifications. Therefore, selecting the effect due to annual emissions (currently reported by Parties in their GHG inventories) may be more relevant to the policy framework and, in the case of short-lived gases, measuring the effect due to a constant increase in emissions within a chosen time frame would be more relevant. The presentation concluded by pointing out that even though the GWP was not designed with a particular policy goal in mind, it is a robust and valuable metric, as radiative forcing lies ahead of other impacts in the cause–effect chain, and any other impact can be derived from radiative forcing.

52. The fourth speaker indicated that, globally, different metrics would have only a minor impact on mitigation costs if all countries follow a cost-minimizing emissions pathway to limit long-term radiative forcing. He also indicated that metrics affect mitigation costs for an individual country in multiple, interconnected ways, for example through agricultural production costs, competitiveness and international agricultural commodity prices. The presentation, based on a modelling study, highlighted that metrics have different effects regionally; in most regions, the decision to impose a cost (e.g. fully expose agriculture to the cost of its emissions) has a larger effect than the choice of metric. In addition, if metrics are an important factor influencing net mitigation costs in some Parties, alternative policy scenarios are much more important, and for these Parties GTPs would mute both positive and negative effects. Nevertheless, the speaker highlighted that it is necessary to be cautious with the results of this study, because there is a weak link between models and idealized scenarios, and it is necessary to analyse whether it makes sense to evaluate the economic effects of metrics in isolation.

53. The fifth speaker emphasized that strict calculation of GWPs using time-varying concentrations from RCPs leads to a large increase of the GWP of CH_4 with time; this is mainly due to the evolution of specific radiative forcing of CO_2. In addition, it was indicated that the sensitivity of the metric to a chosen time horizon is also large.

54. The last speaker showed the results of the GHG inventory of a Party using GWP and GTP values to highlight the difference in the total net GHG emissions and the importance of the metrics discussion. Also, he showed the importance of the CDM activities for this Party and the impact of the use of different metrics on these activities. The presentation showed that the benefit of CH_4 CDM projects to climate change mitigation may be overestimated when using the GWP in comparison with the GTP. Accordingly, the use of the GTP to assess the mitigation benefit would reduce revenues from CH_4 CDM project activities in this Party.

F. Way forward

55. During the general discussion on the fourth part of the workshop and during the discussion at the end of the workshop, a number of participants acknowledged with appreciation that the workshop provided an excellent opportunity to better understand what policymakers consider to be the relevant information in relation to metrics for further consideration by the scientific community. Also, they acknowledged that the useful exchange of views helped to clarify that a wider range of input parameters for the definition of metrics is not necessary. The most relevant information for metrics design are the policy goals, and responding to such goals was deemed to be the main purpose of any metrics. The participants acknowledged that the most important elements in the consideration of metrics include transparency, robustness and certainty on how metrics can evolve in the future, given that most metrics may not remain constant over time.

56. Many participants emphasized that the workshop was very useful in identifying and understanding better the different facets of metrics and their use in the political and economic contexts. Also, the workshop was useful in understanding that metrics can behave differently in different circumstances and with different assumptions for their design, and that therefore it is necessary to be cautious in the analysis and choice of metrics. In addition, participants emphasized that the discussion on metrics and policy goals has wider implications in the broader context of the discussion on the objectives outlined in the Durban Platform for Enhanced Action and that more opportunities for continuing this discussion should be identified in the future.

57. Some participants indicated that exchange of information on common metrics should be facilitated in the future under the SBSTA, with a view to discussing the feedback from the use of common metrics with regard to policy goals. This could help to avoid numerous inputs from the policy community that may not necessarily contribute to directing the efforts by the scientific community and that could create unrealistic expectations on metrics in relation to policy goals. In that sense, participants acknowledged that the useful work during the workshop should be continued in the future, including during the period of provision of comments on the draft parts of the IPCC Fifth Assessment Report and earlier reports of the IPCC working groups by governments and experts. Finally, it was emphasized that the IPCC Fifth Assessment Report may not necessarily provide all the answers on metrics that the policy community expects, and that this should be taken into account when planning future negotiations on the matter.