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Transboundary Air Pollution

**Steering Body to the Cooperative Programme for
Monitoring and Evaluation of the Long-range
Transmission of Air Pollutants in Europe**

Working Group on Effects

Seventh joint session

Geneva, 13–16 September 2021

Item 2 (c) of the provisional agenda

**Progress in activities of the Cooperative Programme for
Monitoring and Evaluation of the Long-range Transmission
of Air Pollutants in Europe in 2021 and future work:
integrated assessment modelling**

Integrated assessment modelling

**Report by the Co-Chairs of the Task Force on
Integrated Assessment Modelling**



Summary

The present report describes the results of the fiftieth meeting of the Task Force on Integrated Assessment Modelling under the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP) (online, 21–23 April 2021).

Based on presentations of scenarios during the meeting, the Task Force discussed and identified several draft answers to the questions raised by the Protocol to Abate Acidification, Eutrophication and Ground-level Ozone review group^a and made several additions, including timing of deliverables, that will be included in the next version of the Task Force answers to the review group questions.^b

The Task Force supported efforts to develop a guidance document on non-technical and structural measures (for example, changes in mobility, diets). If the Working Group on Strategies and Review requests that such a guidance document be prepared, a special group will be assigned to carry out that task.

The effectiveness of ammonia in forming secondary fine particulate matter (PM_{2.5}) due to reduced sulfur and nitrogen oxides concentrations in the atmosphere can have effects on the cost-effectiveness of ammonia control to improve human health and shift the deposition pattern of nitrogen on ecosystems. This potential impact needs to be discussed and analysed further.

It would be beneficial to include the recent improvements of the Greenhouse Gas and Air Pollution Interactions and Synergies (GAINS) modelling in South-East Asia in the European module of the GAINS model (including its eastward expansion). These developments include fine scale source receptor modelling (EMEP-u) enabling multi-scale policy modelling with the GAINS model.

Synthesis work as well as new studies reconfirm the substantial costs of inaction on air pollution throughout the United Nations Economic Commission for Europe geographical domain, although with significant regional variation. Damage costs (or costs of inaction) from sectoral activities or projects should include transboundary effects and not cut off at the border.

Short-term studies of air pollution during coronavirus disease (COVID-19) pandemic-induced lockdowns show a decrease of nitrogen dioxide concentrations during 2020. In general, they do show less significant, and variable, impact on fine particulate matter. Long-term effects remain to be studied.

Atmospheric dispersion of microplastics was recognized as an important area of concern, with synergies with emission control of primary particulate matter. However, at this stage, the knowledge base does not appear to be ready for analysis with integrated assessment models.

The Task Force welcomed the initiative to revive the Network of National Integrated Assessment Modellers aimed at achieving more frequent informal contact between national experts and policymakers, and more extended exchange of information than possible during Task Force meetings.

The web broadcast of Task Force meetings (including Russian interpretation) had been functional and should continue during forthcoming (hybrid) sessions, preferably (budget allowing) with interpretation into Russian.

^a The Protocol to Abate Acidification, Eutrophication and Ground-level Ozone (Gothenburg Protocol) review group chaired by Ms. Kimber Scavo (United States of America) and was established by the Working Group on Strategies and Review.

^b See ECE/EB.AIR/2020/3–ECE/EB.AIR/WG.5/2020/3.

I. Introduction

1. The present report describes the results of the fiftieth meeting of the Task Force on Integrated Assessment Modelling under the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP) (online, 21–23 April 2021). The presentations made during the meeting and the reports presented are available online.¹
2. Around 125 experts registered, and at most 100 participated simultaneously, representing the following Parties to the Convention: Austria, Belarus, Belgium, Canada, Croatia, Denmark, European Union, Finland, France, Georgia, Germany, Hungary, Ireland, Italy, Kazakhstan, Netherlands, Norway, Poland, Portugal, Republic of Moldova, Russian Federation, Serbia, Slovakia, Spain, Sweden, Switzerland, Ukraine and United Kingdom of Great Britain and Northern Ireland. Uzbekistan was also represented. Other bodies of the Convention represented were the EMEP Centre for Integrated Assessment Modelling (CIAM), the Task Force on Techno-economic Issues, the Task Force on Hemispheric Transport of Air Pollution, the Task Force on Emission Inventories and Projections, the Task Force on Reactive Nitrogen, the World Health Organization (WHO)/Executive Body Joint Task Force on the Health Aspects of Air Pollution, the International Cooperative Programme on Effects of Air Pollution on Natural Vegetation and Crops (ICP Vegetation), the Meteorological Synthesizing Centre-West and the Working Group on Strategies and Review. In addition, a representative of the Republic of Korea participated in the meeting, as well as representatives of the following organizations: the Joint Research Centre of the European Commission, the European Environment Agency, the World Meteorological Organization Global Atmosphere Watch Urban Research Meteorology and Environment, the European Environment Bureau, the World Resources Institute, the Clean Air Task Force, the International Union of Air Pollution Prevention and Environmental Protection Associations, the International Cryosphere Climate Initiative and the Oil Companies' European Association for Environment, Health and Safety in Refining and Distribution.
3. Mr. Rob Maas (Netherlands) and Mr. Stefan Åström (Sweden) chaired the meeting.

II. Objectives of the meeting

4. Mr. Maas summarized the recent activities under the Task Force and defined the purposes of the fiftieth Task Force meeting: to assess the current status of integrated assessment models; to learn from national and local assessments; and to prepare for the review of the Protocol to Abate Acidification, Eutrophication and Ground-level Ozone (Gothenburg Protocol) (see annex to present document for current workplan of the Task Force for 2020–2021).

III. Updates on European integrated assessments

5. The Task Force took note of the presentation by the head of CIAM on the Greenhouse Gas and Air Pollution Interactions and Synergies (GAINS) model analysis of European air quality futures. He presented scenarios for the European Union Second Clean Air Outlook (CAO2). Several countries had experienced difficulties in meeting the 2005–2020 ammonia reduction obligations. The scenarios also showed the co-benefits from climate and energy policies (including methane reduction from agriculture). Scenarios including the 55 per cent greenhouse gas reduction target in 2030 would be published in June 2021. The CAO2 analyses showed the importance of air quality improvement measures in surrounding countries. Analyses for large cities in Asia also showed a significant contribution from abatement measures in the wider region. According to recent model calculations by the EMEP Meteorological Synthesizing Centre-West, the much larger nitrogen oxides (NO_x) and sulfur dioxide (SO₂) emission reductions compared to ammonia (NH₃) emission reductions had led to less efficient formation of ammonium (NH₄) aerosols and a shorter lifetime of

¹ See https://iiasa.ac.at/web/home/research/researchPrograms/air/policy/past_meetings.html.

reduced nitrogen (NH_3+NH_4) in air. Assuming emission projections consistent with the European Union National Emissions Ceilings Directive² until 2030, reduction of NH_3 emissions became a factor 2.6 less effective to reduce secondary inorganic aerosol concentrations compared to 2005. In winter, the reduction of ammonia might still be efficient to reduce $\text{PM}_{2.5}$. That effect had been considered, to some extent, in CAO2 since the GAINS model source receptor relationships, developed jointly with EMEP, anticipated future reduction of SO_2 and NO_x emissions.

6. The Task Force took note of the presentation by the European Commission Joint Research Centre on the European Union Forum for AIR quality MODelling in Europe project, which focused on supporting improvements in air quality modelling, emission inventories, identification of best practices for air quality management, policy enforcement, emission projections and emissions and air quality modelling. There were several methods to assess the source contribution to secondary aerosols concentrations. To identify effective measures, a brute-force (scenario) approach with air quality models was advised.

7. The Task Force took note of the presentation by experts from France and the United Kingdom of Great Britain and Northern Ireland on a new study on marginal damage costs of air pollution in the European Environment Agency-38/United Kingdom of Great Britain and Northern Ireland region, and on externalities from industrial facilities reporting emissions to the European Pollutant Release and Transfer Register. For the Gothenburg Protocol pollutants, due to new data and knowledge, the estimated marginal damage costs were higher than earlier estimates. One of the conclusions from the new study was that transboundary external effects were important and damage cost assessments should, hence, include both damage in the emitter country and damage to other regions. Future updates of the work should, amongst other things, consider knowledge on new health response relationships and coefficients.

8. The Task Force took note of the presentation by the representative of ICP Vegetation on, inter alia, improved models to estimate grain yield effects of phytotoxic ozone dose is developed, as well as data on relations between ozone fluxes and tree species. Currently, eight species had been mapped. In addition, ICP Vegetation was engaged in outreach research in several African countries. Changes in phytotoxic ozone doses were calculated in the GAINS model to the extent that they were part of the EMEP-model output. The results were rather insensitive for changes in European NO_x and VOC emissions and seemed to depend more on background ozone levels that resulted from hemispheric emissions of methane and other ozone precursors.

IV. Updates on national integrated assessments

9. The Task Force took note of the presentation by the expert from Spain on research to support Spanish greenhouse gas and air pollution emission reduction plans. It was interesting to note that the increased amount of renewable electricity (low-sulfur) analysed in a scenario with electric car use could have the collateral effect of increasing concentrations of gaseous ammonia, due to less formation of secondary aerosols. The impact of increasing the share of renewable electricity should be further analysed in combination with other measures. Increased use of certified biomass in residential heating systems stood out as a measure with negative health impacts.

10. The Task Force took note of a presentation by an expert from the University of Brescia, Italy, on how reduced intake of animal protein for human food could affect emissions of air pollutants, particulate matter-population exposure, metabolic health benefits and associated mortality indices. Through a study of social acceptability, the total applicable rate of reduction of animal protein consumption was currently no more than 25 per cent. Financial compensation had not been included in the study.

² Directive (EU) 2016/2284 of the European Parliament and of the Council of 14 December 2016 on the reduction of national emissions of certain atmospheric pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/EC, *Official Journal of the European Union*, L 344 (2016), pp. 1–31.

11. The Task Force took note of a presentation by representatives of the United Kingdom of Great Britain and Northern Ireland. The country was working with the United Kingdom Integrated Assessment Model to analyse future scenarios in order to assist in setting new PM_{2.5} targets. The latest modelling indicated significant progress over the next decade towards attainment of the current WHO guideline of 10 microgram (µg)/cubic meter (m³), enhanced by abatement measures to meet emission ceilings in 2030. However, despite improvement, there would still be exceedance in London, which had the highest concentrations. Further analysis of emission reduction in urban areas showed remaining large uncertainties related to non-exhaust PM_{2.5}-emissions, for example, from electric vehicles, and overall uncertainty for small-scale domestic wood burning and cooking. Modelling was currently extending out to 2050 and encompassing climate measures. Mr. Xavier Querol asked for inclusion in models of the formation of secondary organic aerosols from biogenic VOC emissions. A representative of the United Kingdom of Great Britain and Northern Ireland stated that the country aimed to co-chair the forum on international cooperation on air pollution.³

12. The Task Force took note of a presentation by an expert from the Italian National Agency for New Technologies, Energy and Sustainable Economic Development. Italy would not fulfil its reduction commitments under the National Emissions Ceiling Directive by 2030. Italy, therefore, would need to implement additional emission control measures. A group of five measures could improve air quality-related human health in Italy with at least some 7 per cent compared to the baseline scenario for 2030. For the Italian regions, the avoided damage costs thanks to the “With additional measures” scenario on top of the “With measures” scenario had ranged from 0.06 to 0.23 per cent of gross domestic product in 2010. Additional measures to meet the 55 per cent greenhouse gas emission targets had not yet been taken into account.

13. The Task Force noted the presentation by an expert from the University of Brescia, Italy, who presented air quality effects of various road transport and electricity production scenarios for northern Italy. The scenarios had been designed and computed through a multi-objective approach to select an optimal mix of energy sources for electricity production and mobility with respect to air quality and greenhouse gas emissions in the region.

14. The Task Force noted the presentation by an expert from Ireland on recent fine spatial scale studies on air, climate and just transition-related policy in the built environment. A fine scale composite index, constructed from available data on buildings, heating systems and household attributes, had enabled the development of an objective mapping system of energy poverty risk. That in turn offered a tool for the assessment of the impacts of air and climate policy measures on that risk. The second study had focused on a national climate policy to install 400,000 air source heat pumps in households by 2030. The preliminary results showed that a special targeting of just 11,000 of those heat pumps on identified PM_{2.5}-concentration hot spots could deliver a strong air quality improvement. Combined with the replacement of solid fuel boilers in those hotspots, such targeting could lower hotspot PM_{2.5} concentrations by up to 35 per cent whilst offering a climate outcome comparable to that of a policy without targeting.

V. Activities aligned with the Gothenburg Protocol review and the Task Force workplan

15. Mr. Åström gave an overview of the Task Force 2020–2021 workplan items and their status and launched a discussion on suggestions for the focus for future workplans. Most of the workplan items were progressing well, but more efforts were required regarding a structured inventory of the Task Force outreach activities. The Task Force acknowledged financial support from the European Commission and Norway and for the implementation of the workplan items 2.1.7 and 2.2.1.

³ See Executive Body decision 2019/5 available at <https://unece.org/decisions>.

16. The Task Force took note of the presentation by the expert from the Swedish Environmental Research Institute on the costs of inaction on current air quality challenges. The costs of environmental damage in most cases tended to exceed those of abatement measures. The damage costs were – as a percentage of gross domestic product – significantly higher in countries of Eastern Europe, the Caucasus and Central Asia/South-eastern Europe than in the European Union and the United States of America.

17. The Task Force took note of the presentation by Mr. Maas on the Assessment report on ammonia (ECE/EB.AIR/WG.5/2021/7) submitted to the fifty-ninth session of the Working Group on Strategies and Review (Geneva (hybrid), 18–21 May 2021). Significant emission reductions were available that would not exceed the damage costs of emissions.

18. The Task Force took note of the presentation by a representative of the Task Force on Techno-economic Issues on available abatement measures for particulate matter that would also significantly reduce emissions of black carbon: residential burning of coal and wood, (agricultural) waste burning, replacing old diesel vehicles. Experts from France produced complementary information to the document entitled Prioritizing reductions of particulate matter from sources that are also significant sources of black carbon – analysis and guidance (ECE/EB.AIR/WG.5/2021/8).

19. The Task Force took note of the presentation by Mr. Guus Velders (Co-Chair, Expert Panel on Clean Air in Cities) on the recent developments regarding the Expert Panel on Clean Air in Cities. In addition to reaching out to policymakers from the city to the global level, the Expert Panel was setting up a database of measures to reduce emissions and improve air (including non-technical measures). The Panel was planning an autumn meeting for 2021.

20. The Task Force took note of the presentation by a representative of CIAM on current and expected work on downscaling, expanding and connecting multiple scales in the GAINS model. Recent examples from the Indian module of GAINS showed promising potential for GAINS Europe. Hopefully, an extended and updated GAINS Europe module would be available by early 2022, which would make it possible to cover all European and Central Asian countries of the United Nations Economic Commission for Europe region with a unified atmospheric calculation scheme. It had already been successfully implemented in South Asia for improved sectoral-spatial source allocation of ambient PM_{2.5} concentrations and cost effectiveness analysis.

21. The Task Force discussed the draft answers to the questions raised by the Gothenburg Protocol review group⁴ and made several additions that would be included in the next version. The Task Force suggested: including measures to reduce ship emissions and emissions from waste treatment in the list of effective remaining abatement options; looking at possibilities of developing a scenario that would meet ecosystems critical loads and WHO air quality guideline values in 2050; and applying multilevel modelling methods to improve local air quality, with a possible link to the local air quality programme of the Russian Federation. GAINS model cost-effectiveness analysis should include sensitivity analyses of including condensables, NO_x from agricultural soils and non-methane VOCs from livestock manures, as well as deposition targets for marine ecosystems. The Task Force advised adapting the timeline for question 2.1.c. (on the impact of transboundary transport on local concentrations) from spring 2021 to spring 2022, in order to be able to apply transfer coefficients in the GAINS model that were based on EMEP model runs that used a finer source-receptor methodology; and question 3.1.d. and e. (on the impact of the “Current legislation” and the “Maximum technically feasible emission reductions” scenarios on health and ecosystems) from autumn 2021 to autumn 2022, in order to include updated emission data from countries of Eastern Europe, the Caucasus and Central Asia and Southeastern Europe. The Task Force supported efforts to develop a guidance document on non-technical and structural measures (for example, changes in mobility, diets), if so desired by the Working Group on Strategies and Review.

22. The Task Force noted progress in the initiative to revive the Network of National Integrated Assessment Modellers aimed at more frequent informal contact between national experts and policymakers, and more extended exchange of information than possible during

⁴ See ECE/EB.AIR/2020/3–ECE/EB.AIR/WG.5/2020/3.

the Task Force meetings.⁵ The Network intended to first focus on national health impact assessments. The Task Force appreciated the offer to provide feedback on Network findings in Task Force meetings.

VI. Effect of the coronavirus disease (COVID-19) lockdown on air quality

23. The Task Force took note of the presentation by a representative of the European Commission Joint Research Centre, which focused on developing a method to separate effects of meteorology from emission reductions during the first coronavirus disease (COVID-19) lockdown in 2021. A numerical application for the Po Valley, Italy, indicated that PM₁₀-concentrations had not been significantly affected by the lockdown in Italy. The large NO_x emission reductions during the lockdown had led to increased ozone, which (via the increase of oxidants) favoured the formation of nitrate. Moreover, PM₁₀ emissions from wood combustion remained high.

24. The Task Force took note of the presentation by the expert from Germany on the effects of the COVID-19 lockdown on air pollution in Germany. Although the lockdown measures had had substantial short-term effects on NO₂ concentrations in Germany, on an annual basis, the effects were around 1µg/m³ for NO₂. Road transport measures were most important for reducing urban NO₂ concentrations. The effect on PM₁₀ concentrations was insignificant.

25. The Task Force took note of the presentation by a representative of the Norwegian Institute for Air Research on the effects of the lockdown on European air quality. Furthermore, significant reductions in NO₂ concentrations had been found, along with small or insignificant effects on PM concentrations. For both, variance was large, and the meteorological conditions must be taken into account.

VII. Any other business

26. The Task Force took note of the potential need to further address microplastics as a specific part of PM pollution. Microplastics were interesting and likely an important area to be covered by air pollution scientists. But the knowledge, for example, on effective measures, appeared not yet to be ready for integrated assessment modelling.

27. There would be numerous interesting meetings and opportunities for the Task Force outreach during the following year. Examples mentioned during the Task Force meeting were:

(a) Webinar: Uncertainty, Transparency and Robustness in Socioenvironmental Systems Modelling and Assessments (28 April 2021);⁶

(b) Organisation for Economic Co-operation and Development report on “The Economic Benefits of Air Quality Improvements in Arctic Council Countries”, virtual launch event (28 April 2021);⁷

(c) Virtual forum on black carbon in the Arctic region (29 April 2021);⁸

(d) Health Effects Institute Virtual Workshop on Air Pollution and Health in South-Eastern Europe – 8 and 9 June 2021;⁹

⁵ See www.umweltbundesamt.de/en/about-niam.

⁶ See www.sesync.org/news/mon-2021-04-12-1914/webinar-uncertainty-transparency-and-robustness-in-socio-environmental.

⁷ See www.oecd.org/environment/agenda-launch-event-economics-benefits-of-air-quality-improvements-in-arctic-council-countries.pdf. Link to register: https://meetoeed1.zoom.us/webinar/register/WN_ZxuKxVisTsGbMziqQAYCAA.

⁸ See <https://blackcarbonarctic.eu/>.

⁹ See www.healtheffects.org.

- (e) Society for Benefit-Cost Analysis summer workshops, especially the Cost-Benefit Analysis of Environmental Health Interventions (12 and 13 July 2021);¹⁰
- (f) Quadrennial Ozone Symposium (3–9 October 2021);¹¹
- (g) European Commission Conference on Modelling for Policy Support (22–26 November 2021);¹²
- (h) Modelling and Simulation Society of Australia and New Zealand Inc., Twenty-fourth International Congress on Modelling and Simulation (5–10 December 2021).¹³

¹⁰ See www.benefitcostanalysis.org/sbca_online_workshops.php#Benefit-Cost%20Analysis%20in%20Low-%20and%20Middle-Income%20Countries.

¹¹ See <http://qos2021.yonsei.ac.kr/>.

¹² See https://knowledge4policy.ec.europa.eu/event/2021-eu-conference-modelling-policy-support-collaborating-across-disciplines-tackle-key_en.

¹³ See <https://www.mssanz.org.au/modsim2021/index.html>.

Annex

Workplan items 2020–2021

(Decided at the thirty-ninth session of the Executive Body
(see ECE/EB.AIR/144/Add.2))

<i>Workplan item</i>	<i>Activity</i>	<i>Outcome</i>	<i>Lead body(ies)</i>	<i>Resources</i>
1.1.1.2	Harmonize and improve approaches to PM inventory emissions and modelling, accounting for so-called condensable compounds	Expert workshop(s) on condensables (2020–2021, as needed) Minutes and report to EMEP Steering Body and other Convention bodies as appropriate (2020–2021)	MSC-W and other relevant bodies, notably CEIP, TFMM, TFEIP, TFIAM, TFTEI	Nordic Council of Ministers / other sources
1.1.3.1	IAM-Framework for the review of the amended Gothenburg Protocol, Assessment of extent to which long-term targets will be met (in 2020–2030–2050), when technical annexes of the amended Gothenburg Protocol will be implemented completely	Position paper for the review of the amended Gothenburg Protocol (2020) Data and scenario analyses (2021)	TFIAM and CIAM	In-kind contributions from participating countries and EMEP mandatory contributions
1.1.3.2	Assessing observed trends in air pollution at the various scales Follow-up on the measurement (twin-sites) and modelling approaches to assess the long-range contribution to urban air pollution. Linkages between global and regional air pollution	Note as a contribution to the review of the Gothenburg Protocol (2020)	TFMM, TFHTAP, TFIAM, MSC-W	In-kind contributions from participating countries
1.1.3.3	Ammonia: Contribute to improve understanding of expected benefit of ammonia mitigation in terms of wet and dry nitrogen deposition (including at high spatial resolution), long-term trends, chemical regimes of secondary inorganic aerosol formation	Ammonia assessment report in 2020	TFIAM with support from TFMM, TFRN and national experts (France, the Netherlands)	In-kind contributions from participating countries
1.1.4.1	EPCAC road map	Position paper on multiscale interactions (2020)	TFIAM with nominated experts	In-kind contributions from

<i>Workplan item</i>	<i>Activity</i>	<i>Outcome</i>	<i>Lead body(ies)</i>	<i>Resources</i>
		Two annual meeting of EPCAC (2020 and 2021)		participating countries
1.1.4.4	Investigations on global scenarios and assessment of global sectoral mitigation measures	Report (2021)	TFIAM and TFHTAP	In-kind contributions from participating countries
2.1.3	Discuss control strategies to recommend for use by the Task Force on Hemispheric Transport of Air Pollution in future scenarios	Development of policy questions; recommendations on priority sectors for analysis	WGSR, TFIAM, TFHTAP	
2.1.6	Undertake a review of the control costs currently used with a view to improving – on an ongoing basis – the cost-effectiveness analyses produced by the GAINS model, including a comparison of cost estimates from different models and the improvement of the cost estimates of the impacts of air pollution on health and ecosystems	Review of control costs currently used and update	TFTEI, TFIAM	Funding needed
2.1.7	Produce a report for policymakers that clearly sets out the costs of controls versus the costs of inaction to encourage ratification and implementation of the Protocols	Report for policymakers	TFTEI, TFIAM	Funding needed
2.2.1	Development of guidance in relation to prioritizing reductions of particulate matter in its sources that are also significant sources of black carbon	Draft guidance document submitted for adoption by the Executive Body at its fortieth session	TFTEI, TFIAM	In-kind contributions by participating countries

Abbreviations: CEIP, Centre on Emission Inventories and Projections; CIAM, Centre for Integrated Assessment Modelling; EMEP, Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe; EPCAC, Expert Panel on Clean Air in Cities; EUA-BCA, European Union Action on Black Carbon in the Arctic; GAINS, Greenhouse Gas and Air Pollution Interactions and Synergies; IAM, Integrated Assessment Modelling; MSC-W, Meteorological Synthesizing Centre-West; PM, particulate matter; TFEIP, Task Force on Emission Inventories and Projections; TFHTAP, Task Force on Hemispheric Transport of Air Pollution; TFIAM, Task Force on Integrated Assessment Modelling; TFMM, Task Force on Measurement and Modelling; TFRN, Task Force on Reactive Nitrogen; TFTEI, Task Force on Techno-economic Issues; WGSR, Working Group on Strategies and Review.