



## CONSULTATION ON EC4MACS MODELLING METHODOLOGY

Please fill in one questionnaire for each model, and provide your comments in the respective boxes.

Please return the questionnaire to the EC4MACS coordinator Hans Benzinger ([benzing@iiasa.ac.at](mailto:benzing@iiasa.ac.at)) before June 15, 2009.

Name	<i>Hélène Lavray</i>
Institution	EURELECTRIC
Country	Belgium
Phone	+ 32 2 515 10 42
E-mail	hlavray@eurelectric.org

Model	<i>GAINS</i>
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## **1 Assessment of model design**

**To what extent does the structure of each model provide a scientifically credible representation of the reality?**

*Structure of the GAINS model is logical and provides a suitable framework.*

*GAINS model relies however on input from other models, such as EMEP which has performance issues on modelling of particulates, for example.*

**What are the limitations of the model structure and the implied system boundaries and to what extent may these restrict the validity of the conclusions and policy**

*Reliance on external models such as EMEP and PRIMES can have limitations on the ability of the model to develop. As one example, it is expected that using the full features of GAINS will require changes to be made to the energy mix, which would result in potential incompatibilities between the supplied exogenous energy projection and the energy supply used within the GAINS model (as well as the underlying assumptions embedded in the models).*

*The requirements on the geographical scale and resolution of the model(s) (grid scale, national, regional boundaries or grid resolution of emission inventory) have often emerged as an issue of discussion – as well as the treatment of the contributions of shipping and non-EU countries.*

*For long term policy, changes due to ‘climate change’ (i.e., ozone concentrations) should potentially be taken into account*

## **2 Representation of reality in the modules**

To what extent does the structure of each model provide a scientifically credible representation of reality?

*We commend the focus on good science which underpins the GAINS approach, and urge that this continues to be the focus in future developments. There are a number of topics which may require more careful assessment:*

- a) the manner in which the full modelling of atmospheric processes in the EMEP model is simplified within the GAINS model has the potential to lose important non-linear features in the relationship between changes in emissions and changes in effects.*
- b) Unlike the other pollutants modelled by GAINS, particulate matter is not the same throughout the model region, and the toxicology of the different components of particulate matter is likely to differ significantly. We urge that GAINS keeps separate account of the important components of particulate matter to enable developing understanding of the toxicity of different components to be built in to the model in future.*
- c) The manner in which population exposure is treated in urban areas should be kept under review and the current treatment examined critically*
- d) It is important that improvements in scientific understanding are reflected in the model. It was surprising to see that the ecosystem-dependent dry deposition treatment has been removed from the most recent set of published model simulations. This would appear to be a retrograde step.*
- e) The treatment of the cost of retrofit of abatement measures to the power sector omits significant factors which could result in an underestimate of these costs. In particular the cost of abatement is strongly influenced by the operation of the plant, and it is highly desirable that separate account is kept of plant running at base load, at mid merit, and at lower load factors. EURELECTRIC has been calling for this improved functionality for many years now.*
- f) In recent applications in the framework of Greenhouse gas mitigation efforts, the energy mix is not regarded anymore as a fully exogenous input (PRIMES), but structural changes are partially allowed for, in the optimization process (fuel and technology switches). A credible representation of reality should include the constraints imposed, e.g., by security of supply and back-up capacity requirements. At present it is not clear how these issue are accounted for in the model.*
- g) Realistic energy scenarios are crucial to the establishment of appropriate and achievable national emission ceilings (in the context of environmental policy the use of over-optimistic projections may lead to the setting of unachievable targets)*

### **3 Treatment of uncertainties**

Have the most policy-relevant uncertainties (related to variability of the system inexactness of input data and lack of knowledge) been adequately addressed?

*Policy-relevant reports based on the use of GAINS in the context of the development of the NECD, for example, have sought to examine the sensitivity of the policy-relevant conclusions to changes in key assumptions. Clearly, this scenario analysis process is very far from an assessment of uncertainty, however. There are many significant sources of uncertainty in the GAINS modelling process as a consequence of uncertainty in input data, uncertainty generated by modelling choices within the model and uncertainties in key inputs from external models.*

*Furthermore, the result of the optimization relies of the imposed set of constraints, as, the imposed limits of applicability of technologies (in particular the 'best available technology' for a given sector-activity combination) and technology potentials (lower and upper limits for the absolute amount of an activity that can be controlled) are essential in selecting and limiting the mix of optimal measures. This final set of imposed constraints in optimization problems, is usually the results of an (iterative?) set of 'educated guesses' by the modeller. Without any access to the optimizer it is impossible for interested Stakeholders to analyze how the solutions have been affected by these (and other) subjective choices of the operator. In cases where, close to the optimum, different technologies share similar costs, small variations in these parameters might substantially affect the final outcome. Would a constrained optimization undertaken by an independent 'third party' reasonably converge to the one proposed by IIASA?*

*It is important that an assessment is performed of the influence of all of these uncertainties together in the level of confidence in the resulting policy decisions.*

*GAINS undertakes a complex optimisation, and it would be helpful to understand more clearly the way in which the non-linear optimisation in the GAINS model performs, and the sensitivity of the outputs to small changes in inputs. Due to the variety, extent and complexity of the model (and its embedded parameters and constraints), as well as the heterogeneity of the involved Stakeholders, it is however difficult to think at a 'universal' sensitivity analysis. Different Stakeholders are mainly interested at verifying the robustness of the conclusions related to different Sectors and/or Member States. Consequently, the best way adequately to address the uncertainties would be to allow the main Stakeholders to undertake sensitivity studies, allowing them to re-run the optimization in order to verify the robustness of the results of interest. At the moment, Stakeholders are not permitted to undertake such sensitivities studies (neither through the web interface nor by allowing them to acquire a release of the code, as implemented by IIASA in the final optimization run).*

*The requirement to judge policy-relevant uncertainties on the basis of reports and/or a web interface to a database containing the main input and output of the model (the so-called online GAINS-model) – although this might guarantee a sense of transparency in the released results – does not however allow any independent testing of the robustness of these results, undermining the belief that policy-relevant uncertainties have been really adequately addressed.*



Is there an alternative formulation conceivable that could provide better policy-relevant insights into uncertainties?

*See the above comments on the need for a full uncertainty analysis of the GAINS modelling process, which could potentially lead to significant policy-relevant insights.*

Do available model results represent uncertainties accurately? Are there other ways conceivable for attaining more robust conclusions?

*No, the representation of uncertainties in the recent applications of the GAINS model has been mainly based on scenario analysis. Uncertainties are not adequately addressed or quantified in published reports and this should be corrected.*

*For some pollutants and Member States, in some of the analyzed scenarios, level of emissions very close to those of the MRR scenario (maximum technically-feasible reductions in the GAINS model, where all available abatement options are supposed to be implemented, irrelevantly of costs) are discussed. In this range, the marginal cost curve tends to be extremely steep and even small uncertainty might result in extreme variation in the implementation costs (or even unattainable emission threshold). Who bears the risk of policy failure and non-attainment of projected reductions?*

*Sensitivity analysis is needed, at country and sector level, addressing the role played by the subjective component in the modelling exercise*

Is there a risk that the model gives policy advice that systematically underestimates or overestimates the need for policy measures to protect the environment? What are the major reasons for a bias, if any?



*In our view the GAINS model should not be seen as giving policy advice. Nor should the GAINS modelling team (who are in practice not separable from the GAINS model) be seen as giving policy advice. It is surely vital that there is a clear separation between the modelling and the policy making process.*

*Potential areas for bias have already been mentioned:*

- a) the lack of ability in the model to distinguish between the health effects of different particulate components*
- b) the approximation in the treatment of urban agglomerates*
- c) the focus on point emissions, as the available abatement measures tend to focus on end-of-pipe abatement measures. Diffuse, areal, linear (transport or shipping) emission and non-technical measures are not described at the same level of detail (neglected or treated as 'frozen' exogeneous contributions) although they might offer less expensive options (also taking into consideration the urban/non-urban spatial location of these emissions)*
- d) The inability of the current GAINS model to reflect the high costs of retrofit to low load factor power plant*

*Furthermore, one has to underline that in the recent application in the framework of the comparison of GHG mitigation potentials and costs (across Annex 1 Parties to the UNFCCC Convention on Climate Change), GAINS has been applied in its 'GAINS' modality (as opposed to the 'RAINS' modality, allowing only for end-of-pipe measures). The GAINS modality strongly increases the flexibility of the model (e.g., including 'emerging' technologies, allowing for fuel switch, changes in the activity levels, energy efficiency improvements). No technical documentation has however been released by IIASA including the main assumptions and/or quantitative estimates used in this analysis. The timing of the present consultation does not allow any considerations about the applications in the 'GAINS modality' although initial results have already been distributed by IIASA.*

*Runs under the 'GAINS modality' would decrease the costs for achieving a given target (trade-off and co-benefits) but may possibly lead to greater uncertainty.*

*In this context it is interesting to notice that the national plans submitted in 2006 under NECD, has been evaluated by AEA in 2007 ([http://ec.europa.eu/environment/air/pdf/nec\\_report.pdf](http://ec.europa.eu/environment/air/pdf/nec_report.pdf)). From the review it has emerged that while for SO<sub>2</sub> only 2 out of 22 Member States are forecasted not to be able to comply with the 2010 NECD Ceiling, the majority of them (12 out of 22) are instead expected to emit more than the Ceiling allowed by NECD for NO<sub>x</sub>. What are the main reasons for this asymmetry in the expected compliance with the NECD Ceilings? Were NO<sub>x</sub> emitting activities, NO<sub>x</sub> emission factors and/or abatement costs underestimated in the original NECD modelling? If yes where was the bias introduced? For which Sector? What can one learn from the past? Have older estimations been assessed and verified?*

## **4 Communication with stakeholders, policy-makers and public**

How do the modelling teams verify the quality of input data that are used in model? Is the quality of the input data obtained from national sources and from other models sufficiently guaranteed? In what way do teams give feedback to providers of input to maximise the robustness of model results?

*We understand that there is a process of stakeholder dialogue between the GAINS team and member states and other stakeholders. We also believe that the GAINS team apply their expertise in determining some important input data. In the presentation of the input and output data (mainly through the web interface to the GAINS database) there is no indication on the origin of the data (i.e., if they are the results of some form of consultation, if they have been extracted from literature, if they have been 'validated' by an independent 'expert group' or if they are just 'best guess' by IIASA staff. The inclusion of metadata documenting the source of the main input data and assessing their quality level would be a valuable further step towards a fully transparent model.*

*The documentation on the SO<sub>2</sub>/NO<sub>x</sub> cost database is now severely out of date, and a clearer audit trail is highly desirable to enable the source of any input data value to be identified. It is currently impossible to know the origin of any particular data value.*

In what way are users and stakeholders involved in the modelling process, and is this sufficient to ensure transparency and acceptability of the results for policy advice?

*In our view the GAINS model sets a high standard in terms of openness and transparency. We have participated in bilateral meetings with the GAINS team, in workshops for GAINS users, and in stakeholder groups such as the TFIAM.*

*The principal way in which stakeholder transparency can be assured, is via the on-line GAINS database. The model has, in some important respects, become less accessible and transparent to stakeholders with each new version.*

*The greenhouse gas part of the model needs more work in providing access to the database of measures and to the country-specific control strategies.*

Are the presentations of the results clear? If not, can the communication and dissemination of the results be improved?



*There are a number of well-developed and understood tabular and graphical methods of displaying summary data from GAINS, and these are very helpful. The on-line GAINS model provides access to more detailed model results, and there are times when this is vital to understand the reasons for some of the high-level conclusions.*

*With respect to the energy sector, the GAINS database tends to express the results in units of 'Energy Consumption [PJ]'. In the treatment of the electricity Sector the use of 'Produced Electricity [TWh]' is more common (allowing a cross-comparison with other statistical sources). The assumptions about the efficiency values required to translate 'Energy Consumption [PJ]' into the corresponding 'Produced Electricity [TWh]' are scarcely documented*

*The weakest part of the presentation of output from the GAINS model is the web-based graphical functionality which is very limited in capability. It is urged that more effort be devoted to the ability for users of the web-based functionality to display a wider range of parameters.*

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Is the model structure transparent? (e.g., are the assumptions clearly exposed and motivated, and is their influence on the model-results explained?)

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*See comments above.*

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## **5 Other comments**

*We would like the full GAINS model to be made accessible to stakeholders, at least for those scenarios used as milestones in the IASA approach. At present the interaction for a typical user of the GAINS web site is limited to a 'look but don't touch' approach to model inputs. Unlike the previous RAINS web model, it is not even possible to change emission scenarios in order to see the effect on environmental end points.*

*Stakeholder confidence in such a complex model can only be guaranteed by providing access to the full code, including the optimising code. EURELECTRIC have requested this access on many occasions over several years and have always been refused access.*

*The timing of the present consultation allows considerations only in relation to GAINS as applied in the 'RAINS modality' (i.e., allowing uniquely for end-of-pipe measures). One has however to notice that GAINS has been recently implemented in its 'GAINS modality' (i.e., including also 'emerging' technologies, allowing for fuel switch, changes in the activity levels, energy efficiency improvements, ...). Although (aggregated) initial results have already been released by IASA in the framework of the comparison of GHG mitigation potentials and costs (across Annex 1 Parties to the UNFCCC Convention on Climate Change), the release has not been complemented by adequate technical documentation (on the main assumptions and/or the quantitative estimates used in this analysis) and the distribution of the results through the GAINS web interface.*

*Due to this information gap, the present response has therefore only to be regarded as related to GAINS, when run in the 'RAINS modality'.*

Thank you for providing this feedback to the EC4MACS team!

Please return this questionnaire to the EC4MACS coordinator Hans Benzinger ([benzing@iiasa.ac.at](mailto:benzing@iiasa.ac.at)) before June 15, 2009.

You will receive information on the EC4MACS review workshop that is planned for October 2009.