File S2

The GAINS model: an overview.

The GAINS model explores cost-effective emission control strategies that simultaneously tackle local air quality and greenhouse gases to maximize benefits at all scales.

GAINS is now implemented for the whole world, distinguishing 165 regions including 48 European countries and 46 provinces/states in China and India. This website provides interactive access to the implementations for the following world regions:

Europe (for 48 countries)

Asia, with separate implementations for China (31 provinces and India (15 States)

For Annex I countries of the UNFCCC Convention

About GAINS

GAINS was launched in 2006 as an extension to the RAINS model which is used to assess cost-effective response strategies for combating air pollution, such as fine particles and ground-level ozone.

GAINS provides an authoritative framework for assessing strategies that reduce emissions of multiple air pollutants and greenhouse gases at least costs and minimize their negative effects on human health, ecosystems, and climate change.

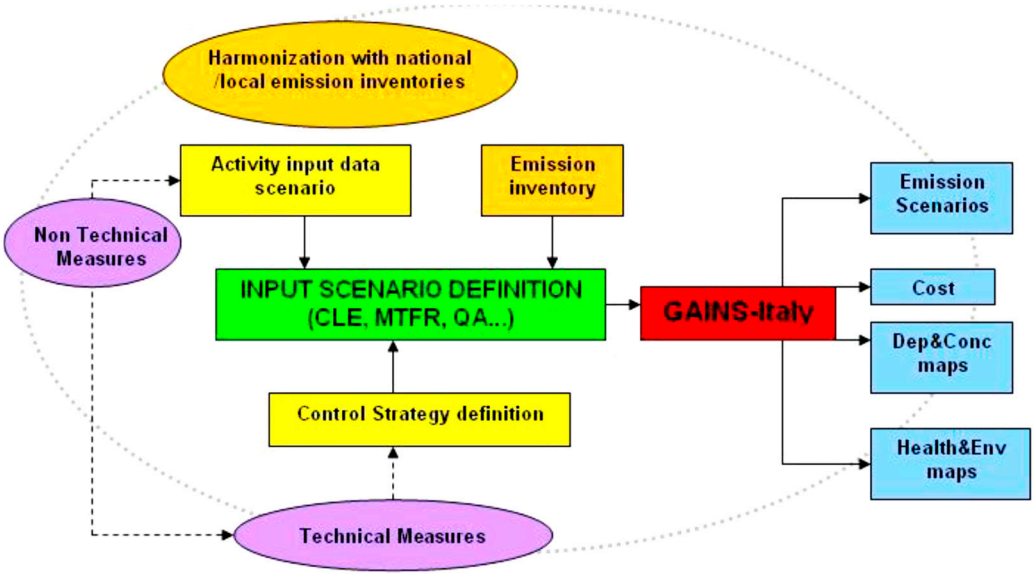
GAINS is used for policy analyses under the Convention on Long-range Transboundary Air Pollution (CLRTAP), e.g., for the revision of the Gothenburg Protocol, and by the European Commission for the EU Thematic Strategy on Air Pollution and the air policy review. Scientists in many nations use GAINS as a tool to assess emission reduction potentials in their regions. For the negotiations under the United Nations Framework Convention on Climate Change (UNFCCC), a special version of GAINS has been developed to compare greenhouse gas mitigation efforts among the Annex-I countries. More information

GAINS-Europe

The GAINS model explores synergies and trade-offs between the control of local and regional air pollution and the mitigation of global greenhouse gas emissions. Its European implementation covers 43 countries in Europe including the European part of Russia. GAINS estimates emissions, mitigation potentials and costs for the major air pollutants (SO2, NOx, PM, NH3, VOC) and the six greenhouse gases included in the Kyoto Protocol.

How GAINS works

GAINS estimates historic emissions of 10 air pollutants and 6 GHGs for each country based on data from international energy and industrial statistics, emission inventories and data supplied by countries themselves. It assesses emissions on a medium-term time horizon, with projections being specified in five-year intervals through the year 2050.



Source: Vialetto G. & Pignatelli T. (2014). https://www.enea.it/it/seguici/events/lifeforest_22-23gen14/Vialetto_GAINSPignatelli.pdf

GAINS estimates for each country/region the potential emission reductions that are offered by about 2000 specific emission control measures and their costs. For user-specified packages of measures, GAINS calculates effects on ambient air quality (fine particles, ground-level ozone, deposition of sulphur and nitrogen), and the subsequent impacts on human health and ecosystems (see figures generated by GAINS showing estimates of losses in statistical life expectancy estimates under two GHG emissions scenarios (below).

The GAINS model can be operated in two ways:

a) In the "scenario analysis" mode, it follows emission pathways from sources to impacts, providing estimates of regional costs and the environmental benefits of alternative emission control strategies.
b) In "optimization" mode, it identifies where emissions can be reduced most cost-effectively. The models identify a balance of concrete measures for different pollutants, sectors, and countries/regions that achieve air quality and greenhouse gas reduction targets at least cost, considering the contributions of different pollutants to different air quality and climate problems.

The most recent description of the GAINS integrated assessment framework is given in the journal article:

Amann M, Bertok I, Borken-Kleefeld J, Cofala J, Heyes C, Höglund-Isaksson L, Klimont Z, Nguyen B, Posch M, Rafaj P, Sandler R, Schöpp W, Wagner F, Winiwarter W. (2011) *Cost-effective control of air quality and greenhouse gases in Europe: Modeling and policy applications*. Environmental Modelling & Software, 26(12):1489-1501 (December 2011) (Published online 15 September 2011) [doi:10.1016/j.envsoft.2011.07.012]

GAINS documentation

The following reports provide details of aspects of the model methodology specific to the GAINS model:

Höglund-Isaksson L., Winiwarter W., Klimont Z., Bertok I. (2006) Emission Scenarios for methane and Nitrous Oxides from the Agricultural Sector in the EU-25. IIASA Interim Report IR-06-019.

Klaassen G., Berglund C., Wagner F. (2005) The GAINS model for Greenhouse Gases - Version 1.0: Carbon Dioxide (CO2) IIASA Interim Report IR-05-53

Höglund-Isaksson L. and Mechler R. (2005) The GAINS model for Greenhouse Gases - Version 1.0 : Methane (CH4) IIASA Interim Report IR-05-54

Winiwarter W. (2005) The GAINS model for Greenhouse Gases - Version 1.0: nitrous oxide (N2O) IIASA Interim Report IR-05-55

Tohka A. (2005) The GAINS model for Greenhouse Gases - Version 1.0: HFC, PFC and SF6. IIASA Interim Report IR-05-56

Klaassen, G., Amann, M., Berglund, C., Cofala, J., Höglund-Isaksson, L., Heyes, C., Mechler, R., Tohka, A., Schöpp, W., Winiwarter, W. (2004) The Extension of the RAINS model to Greenhouse Gases. An interim report describing the state of work as of April 2004. IIASA Interim Report IR-04-015.

Höglund-Isaksson L. and Mechler R. (2004) The GAINS model for Greenhouse Gases: Emissions, Control Potentials and Control Costs for Methane. IIASA Interim Report IR-04-078

Höglund-Isaksson L., Gómez-Sanabria A., Klimont Z., Rafaj P. and Schöpp W. (2020) Technical potentials and costs for reducing global anthropogenic methane emissions in the 2050 timeframe – results from the GAINS model. Environ. Res. Commun., 2(2): 025004. https://doi.org/10.1088/2515-7620/ab7457