Implied emission factors in the World Bank’s Carbon Pricing Assessment Tool (CPAT)

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# Introduction

The implied emission factors in CPAT are based on the GAINS model. The GAINS model methodology is described in (Amann et al., 2011). It is an integrated assessment model of air pollution, and features both an emissions model for various air pollutants and greenhouse gases (relevant here are primary PM2.5, SO2, NOx, NH3 and VOC, as well as CO2, CH4, BC, OC), as well as impact modules (which have not been used in the present exercise).

The GAINS model has been used under the LRTAP Convention of the UNECE, the European Commission and various other national policy processes to design cost-effective strategies to improve air quality at the regional, national and subnational scale, including the assessments of the National Emissions Ceilings Directive (Amann et al., 2012b; Rafaj et al., 2012; Oenema et al., 2012; Borken-Kleefeld and Ntziachristos, 2012; Cofala and Klimont, 2012; Amann et al., 2012a, 2012d, 2012c; Kiesewetter et al., 2013; Amann et al., 2013, 2014a; Kiesewetter and Amann, 2014; Amann et al., 2014b, 2014c) , as well as for designing a potential flexibility mechanism under the directive (Amann and Wagner, 2014). GAINS is also being used to assess the mitigation potentials and costs of greenhouse gases, and of short-live climate forcers (Höglund-Isaksson, 2017; Klimont et al., 2013; Saunois et al., 2019).

Free access to the model is available through the internet (<https://gains.iiasa.ac.at>). The data collated under this DIO are aggregated to a level that is compatible with the structure and needs of CPAT.

# Data and caveats

The data are based on GAINS, and in particular, on a scenario that reflects both the World Energy Outlook 2018 Energy scenario of the International Energy Agency (IEA)l and air pollution controls at the country level as far as available in GAINS (internal scenario ID: WEO2018\_NPS\_CLE\_CH4c). GAINS currently covers 180 regions globally, some of which represent individual countries, some subnational regions (e.g. for China every province is represented), and some represent larger regions, such as the region Northern Africa except Egypt.

GAINS represents up to 1,000 separate sources of emissions in each region. Each of these sources is represented as a sector and an activity in that sector. For combustion, these activities are the individual fuels. Non-combustion sources include process emissions in industry, VOC emissions and also manure in agriculture. Air pollution control policies are represented as implementation shares of some several hundred emission control technologies.

CPAT has its own classification of relevant sectors and activities. Thus, in order to provide the relevant emission factors in CPAT format it was necessary to map emissions from GAINS to CPAT, while ensuring consistency. For most of the fuels this is straightforward. Sectoral aggregations also had to be made consistent, and we chose to add to the combustion emissions also the process emissions (and normalize with the fuel use). In this way CPAT also includes process emissions; however, this also means that energy efficiency improvements over time may overestimate the resulting emission benefits in CPAT as associated process emissions are assumed to be reduced to, which in reality they are not.

CPAT also operates at the national scale throughout. For cases in which GAINS features a higher resolution (e.g. China), GAINS data were simply aggregated to and normalized (with regional weights) at the national scale. For cases in which CPAT has a higher resolution, i.e. a country not represented individually in GAINS, the results at the level of the GAINS region including this country has been assumed to be representative for each country in the region.

The GAINS team has adapted the GAINS model to many national circumstances and is happy to engage in conversations on how to enhance the model data by with locally available data.

# References

Amann, M., Bertok, I., Borken, J., Cofala, J., Hettelingh, J.-P., Heyes, Ch., Holland, M., Kiesewetter, G., Klimont, Z., Rafaj, P., Paasonen, P., Posch, M., Sander, R., Schoepp, W., Wagner, F., Winiwarter, W., 2013. Policy Scenarios for the Revision of the Thematic Strategy on Air Pollution. TSAP Report #10 (No. TSAP Report # 10). International Institute for Applied Systems Analysis, Laxenburg, Austria.

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. Environ. Model. Softw. 26, 1489–1501. https://doi.org/10.1016/j.envsoft.2011.07.012

Amann, M., Borken-Kleefeld, J., Cofala, J., Hettelingh, J.-P., Heyes, C., Hoglund-Isaksson, L., Holland, M., Kiesewetter, G., Klimont, Z., Rafaj, P., Posch, M., Sander, R., Schoepp, W., Wagner, F., Winiwarter, W., 2014a. The Final Policy Scenarios of the EU Clean Air Policy Package. TSAP Report #11 (No. TSAP Report #11). International Institute for Applied Systems Analysis, Laxenburg, Austria.

Amann, M., Borken-Kleefeld, J., Cofala, J., Heyes, C., Kiesewetter, G., Klimont, Z., Rafaj, P., Sander, R., Schoepp, W., Wagner, F., Winiwarter, W., 2012a. TSAP-2012 Baseline: Health and Envronmental Impacts. TASP Report #6 (No. TSAP Report #6). International Institute for Applied Systems Analysis, Laxenburg, Austria.

Amann, M., Borken-Kleefeld, J., Cofala, J., Heyes, C., Klimont, Z., Rafaj, P., Purohit, P., Schoepp, W., Winiwarter, W., 2012b. Future emissions of air pollutants in Europe - Current legistation baseline and the scope for futher reductions. TSAP Report #1 (No. TSAP Report #1). International Institute for Applied Systems Analysis, Laxenburg.

Amann, M., Borken-Kleefeld, J., Cofala, J., Hoeglund-Isaksson, L., Klimont, Z., Rafaj, P., Winiwarter, W., 2014b. Summary of the Bilateral Consultations with National Experts on the GAINS Input Data (No. TSAP Report #13, updated version). International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria.

Amann, M., Borken-Kleefeld, J., Cofala, J., Hoglund-Isaksson, L., Kiesewetter, G., Klimont, Z., Rafaj, P., Schoepp, W., Winiwarter, W., 2014c. Updates to the GAINS Model Databases after the Bilateral Consultations with National Experts in 2014. TSAP Report #14 (No. TSAP Report #14). International Institute for Applied Systems Analysis, Laxenburg, Austria.

Amann, M., Borken-Kleefeld, J., Kiesewetter, G., Rafaj, P., Wagner, F., 2012c. Compliance with EU Air Quality Limit Values - A First Set of Sensitivity and Optimization Analyses. TSAP Report #8 (No. TSAP Report #8). International Institute for Applied Systems Analysis, Laxenburg.

Amann, M., Heyes, C., Schoepp, W., Wagner, F., 2012d. Scenarios of Cost-effective Emission Controls after 2020. TSAP Report #7 (No. TSAP Report #7). International Institute for Applied Systems Analysis, Laxenburg.

Amann, M., Wagner, F., 2014. A Flexibility Mechanism for Complying with National Emission Ceilings for Air Pollutants. TSAP Reprt #15 (No. TSAP Report #15). International Institute for Applied Systems Analysis, Laxenburg, Austria.

Borken-Kleefeld, J., Ntziachristos, L., 2012. The potential for further controls of emissions from mobile sources in Europe. TSAP Report #4. International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria.

Cofala, J., Klimont, Z., 2012. Emissions from households and other small combustion sources and their reduction potential. TSAP Report #5. International Institute for Applied Systems Analysis, Laxenburg, Austria.

Höglund-Isaksson, L., 2017. Bottom-up simulations of methane and ethane emissions from global oil and gas systems 1980 to 2012. Environ. Res. Lett. 12, 024007.

Kiesewetter, G., Amann, M., 2014. Urban PM2.5 levels under the EU Clean Air Policy Package. TSAP Report #12 (No. TSAP Report #12). International Institute for Applied Systems Analysis, Laxenburg.

Kiesewetter, G., Borken-Kleefeld, J., Heyes, C., Bertok, I., Schoepp, W., Thunis, P., Bessagnet, B., Terrenoire, E., Amann, M., 2013. Modelling compliance with NO2 and PM10 air quality limit values in the GAINS model. TSAP Report #9 (No. TSAP Report #9). International Institute for Applied Systems Analysis, Laxenburg, Austria.

Klimont, Z., Smith, S.J., Cofala, J., 2013. The last decade of global anthropogenic sulfur dioxide: 2000-2011 emissions. Environ. Res. Lett. 8, 014003. https://doi.org/10.1088/1748-9326/8/1/014003

Oenema, O., Velthof, G., Klimont, Z., Winiwarter, W., 2012. Emissions from agriculture and their control potentials. TSAP Report #3. International Institute for Applied Systems Analysis, Laxenburg, Austria.

Rafaj, P., Amann, M., Cofala, J., Sander, R., 2012. Factors determining recent changes of emissions of air pollutants in Europe. TSAP Report #2 (No. TSAP Report #2). International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria.

Saunois, M., Stavert, A.R., Poulter, B., Bousquet, P., Canadell, J.G., Jackson, R.B., Raymond, P.A., Dlugokencky, E.J., Houweling, S., Patra, P.K., Ciais, P., Arora, V.K., Bastviken, D., Bergamaschi, P., Blake, D.R., Brailsford, G., Bruhwiler, L., Carlson, K.M., Carrol, M., Castaldi, S., Chandra, N., Crevoisier, C., Crill, P.M., Covey, K., Curry, C.L., Etiope, G., Frankenberg, C., Gedney, N., Hegglin, M.I., Höglund-Isaksson, L., Hugelius, G., Ishizawa, M., Ito, A., Janssens-Maenhout, G., Jensen, K.M., Joos, F., Kleinen, T., Krummel, P.B., Langenfelds, R.L., Laruelle, G.G., Liu, L., Machida, T., Maksyutov, S., McDonald, K.C., McNorton, J., Miller, P.A., Melton, J.R., Morino, I., Müller, J., Murgia-Flores, F., Naik, V., Niwa, Y., Noce, S., O’Doherty, S., Parker, R.J., Peng, C., Peng, S., Peters, G.P., Prigent, C., Prinn, R., Ramonet, M., Regnier, P., Riley, W.J., Rosentreter, J.A., Segers, A., Simpson, I.J., Shi, H., Smith, S.J., Steele, L.P., Thornton, B.F., Tian, H., Tohjima, Y., Tubiello, F.N., Tsuruta, A., Viovy, N., Voulgarakis, A., Weber, T.S., Weele, M. van, Werf, G.R. van der, Weiss, R.F., Worthy, D., Wunch, D., Yin, Y., Yoshida, Y., Zhang, W., Zhang, Z., Zhao, Y., Zheng, B., Zhu, Qing, Zhu, Qiuan, Zhuang, Q., 2019. The Global Methane Budget 2000&ndash;2017. Earth Syst. Sci. Data Discuss. 1–136. https://doi.org/10.5194/essd-2019-128

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