*Supplement of*

Global scenarios of anthropogenic mercury emissions

Flora M. Brocza1,2, Robert Sander1, Fabian Wagner1, Jenny M. Jones2, Zbigniew Klimont1, and Peter Rafaj1

1International Institute for Applied Systems Sciences, Schlossplatz 1, 2361 Laxenburg, Austria

2School of Chemical and Process Engineering, University of Leeds, LS2 9J, United Kingdom

*Correspondence to*: Flora M. Brocza ([brocza@iiasa.ac.at](mailto:brocza@iiasa.ac.at))

Contents

[S1 – GAINS sectors and activities 3](#_Toc152108212)

[S2 – Mercury control technologies and their removal efficiencies in GAINS 6](#_Toc152108213)

[S3 – Details on applied mercury control strategies of the displayed scenarios 9](#_Toc152108214)

[S3.1 – Mercury control strategies 9](#_Toc152108215)

[S3.2 – PM and SO2 control strategies 13](#_Toc152108216)

[S4 – The No Control Scenario 16](#_Toc152108217)

[S5 – GAINS regions 17](#_Toc152108218)

[S6 – Monte Carlo Simulation to estimate uncertainties of unabated mercury emissions. 19](#_Toc152108219)

[S7 – Additional plots. 21](#_Toc152108220)

[References. 22](#_Toc152108221)

# S1 – GAINS sectors and activities

Table S1. List of sector-activity combinations in GAINs which are associated with mercury emissions.

|  |  |  |  |
| --- | --- | --- | --- |
| Aggregated category | Category | Associated subsectors | Associated activity |
| **Artisanal and small-scale gold production** | | |  |
| ASGM | Small-scale and artisanal gold production | |  |
|  |  | Small-scale artisanal gold production | NOF |
|  |  |  |  |
| **Combustion** |  |  |  |
| COMB\_IND | Industrial combustion | |  |
|  |  | Combustion in boilers (transformation sector, chemical industry, paper/pulp production, other sectors [>50 MWth, <50 MWth]), Other combustion | OS1, OS2, BC, DC, HC, GSL, HF, LPG, MD |
| COMB\_POWER | Power Plants | |  |
|  |  | Power & district heat plants with internal combustion engines | GSL, HF, MD |
|  |  | Power and district heat plants (Existing/new, <50 MWth/ >50 MWth) | OS1, OS2, BC, DC, HC, GSL, HF, MD |
|  |  | Integrated Gasification Combined Cycle (IGCC) plants | OS1, OS2, BC, HC, HF |
|  |  | Modern power plants (coal: ultra- and supercritical) | OS1, BC, HC |
|  |  | Power plants combined with carbon capture and storage (modern / IGCC) | OS1, BC, HC |
| COMB\_OTHER |  |  |  |
|  | Combustion conversion | | |
|  |  | Fuel production: combustion (grate firing, fluidized bed, pulverized coal) | OS1, OS2, BC, DC, HC, GSL, HF, LPG, MD |
|  | Domestic combustion | | |
|  |  | Combustion for residential, commercial, services, agriculture purposes; | OS1, GSL, HF, LPG, MD |
|  |  | Residential/commercial combustion in fireplaces, kerosene lamps, boilers (<40 kW / <1 MW, <50 MW), open pit fires, cooking stoves, heating stoves | OS1, BC, DC, HC, GSL |
|  |  |  |  |
| **Industrial Processes** | | | |
| GOLD | Gold production | | |
|  |  | Large-scale gold production | NOF |
| NFME | Non-ferrous metal production | |  |
|  |  | Non-ferrous metals production; primary and secondary (Pb, Zn, Cu, Ni,…) | NOF |
| CEM | Cement production | |  |
|  |  | Cement production | NOF |
| IND\_PROC | Other industrial processes | |  |
|  |  | Primary Aluminum production | NOF |
|  |  | Iron and steel production (Coke ovens, basic oxygen furnace, electric arc furnace, pig iron production in blast furnace, open hearth furnace, | NOF |
|  |  | Bricks production | NOF |
|  |  | Chlorine and caustic soda production by electrolysis using mercury cells | NOF |
|  |  | Fertilizer production | NOF |
|  |  | Glass production | NOF |
|  |  | Lime production | NOF |
|  |  | Paper pulp mills | NOF |
|  |  | Crude oil and other products (input to petroleum refineries) | NOF |
|  |  |  |  |
| OTHER |  |  |  |
|  | Transport |  |  |
|  |  | Other transport (non-road, agriculture and forestry, civil aviation, mobile sources in construction and industry, inland waterways, off-road with 4-stroke engines, off-road with 2-stroke engines, rail) | GSL, LPG, MD, BC, DC, HC |
|  |  | Maritime (large/medium vessels) | HF, MD |
|  |  | Road transport (buses, trucks, motorcycles / mopeds / cars with 2-stroke engines, light duty vehicles with 4-stroke engines, others) | GSL, LPB, MD |
|  | Waste |  |  |
|  |  | Industrial waste from industry | NOF |
|  |  | Municipal solid waste (non-recycled fraction, rural/urban) | NOF |
|  | Others |  |  |
|  |  | Non-energy use of fuels | HF |
|  |  | Other Hg emissions not included separately in GAINS and statistical differences | NOF |
|  |  | Share of population cremated annually | NOF |

Table S2. Full list of activities connected to Hg emissions in GAINS.

|  |  |  |
| --- | --- | --- |
| **Activity** | **Parent activity** | **Long name** |
| ARD | OS1 | Agricultural residuals - direct use |
| BC1 |  | Brown coal/lignite grade 1 |
| BC2 |  | Brown coal/lignite grade 2 (also peat) |
| BMG | OS1 | Biomass gasification |
| CHCOA | OS1 | Charcoal |
| DC |  | Derived coal (coke, briquettes) |
| DNG | OS1 | Dung |
| FWD | OS1 | Fuelwood direct |
| GSL |  | Gasoline and other light fractions of oil (includes kerosene) |
| HC1 |  | Hard coal, grade 1 |
| HC2 |  | Hard coal, grade 2 |
| HC3 |  | Hard coal, grade 3 |
| HF |  | Heavy fuel oil |
| LPG |  | Liquefied petroleum gas |
| MD |  | Medium distillates (diesel, light fuel oil) |
| NOF |  | No fuel use |
| OS1 |  | Biomass fuels |
| OS2 |  | Other biomass and waste fuels |

# S2 – Mercury control technologies and their removal efficiencies in GAINS

Table S3. Abbreviations used in GAINS for Hg control technologies.

|  |  |
| --- | --- |
| **Abbreviation** | **Description** |
| BAN | Ban of sector (small-scale gold mining, chlor-alkali production using Hg cells) |
| CYC\_REM | Cyclone - remaining capacity |
| ESP1 | Electrostatic precipitator - 1 field |
| ESP2 | Electrostatic precipitator - 2 fields |
| FFSINJ | Sorbent injection before an additional fabric/baghouse filter |
| HED | High-efficiency deduster |
| LHGCO | Low-mercury coal or halide(Br, Cl)-treated coal in the power sector |
| LHGCO\_PM | Combination of LHGCO and particulate matter control with ESP1, ESP2 or HED |
| LHGCO\_PM\_FGD | Combination of LHGCO and FF\_FGD |
| LHGCO\_REM | LHGCO, applied in absence of other particulate matter control or desulfurization technologies. |
| MINE\_GP | Good practice in mining (ASGM) |
| PM\_FGD | Particulate matter control (ESP1, ESP2, HED)- combined with flue gas desulphurization |
| PM\_REM | Electrostatic precipitator (ESP1, ESP2, HED) - remaining capacity without overlap from other pollutant controls |
| PMSINJ | Sorbent injection before an existing electrostatic precipitatior (ESP1, ESP2, HED) |
| PR\_AP | Acid plant equipped with mercury removal process (e.g. Boliden-Norzink), applied in industrial processes |
| PRF\_GP1 | Good practice: ind.process - stage 1; (for cement, lime production: 10\% of operating time in dust shuttling mode) |
| PRF\_GP2 | Good practice: ind.process - stage 2; (for cement, lime production: 20\% of operating time in dust shuttling mode) |
| SINJ | Sorbent injection in the power sector, combined with particulate matter control via electrostatic precipitation (ESP1, ESP2, HED) |
| SPC | Sorbent polymer catalyst modules |
| STH\_GP | Good practice in storage & handling |
| SWD\_COMP | Managed solid waste disposal sites, compressed without cover |
| SWD\_COVER | Managed solid waste disposal sites, compressed with cover, no gas recovery |
| TREAT\_INC\_ENE | Mixed waste incineration with energy recovery |
| WSCRB\_REM | Wet scrubber - remaining capacity |

Table S4. Control technologies and their removal efficiencies for combustion sectors.

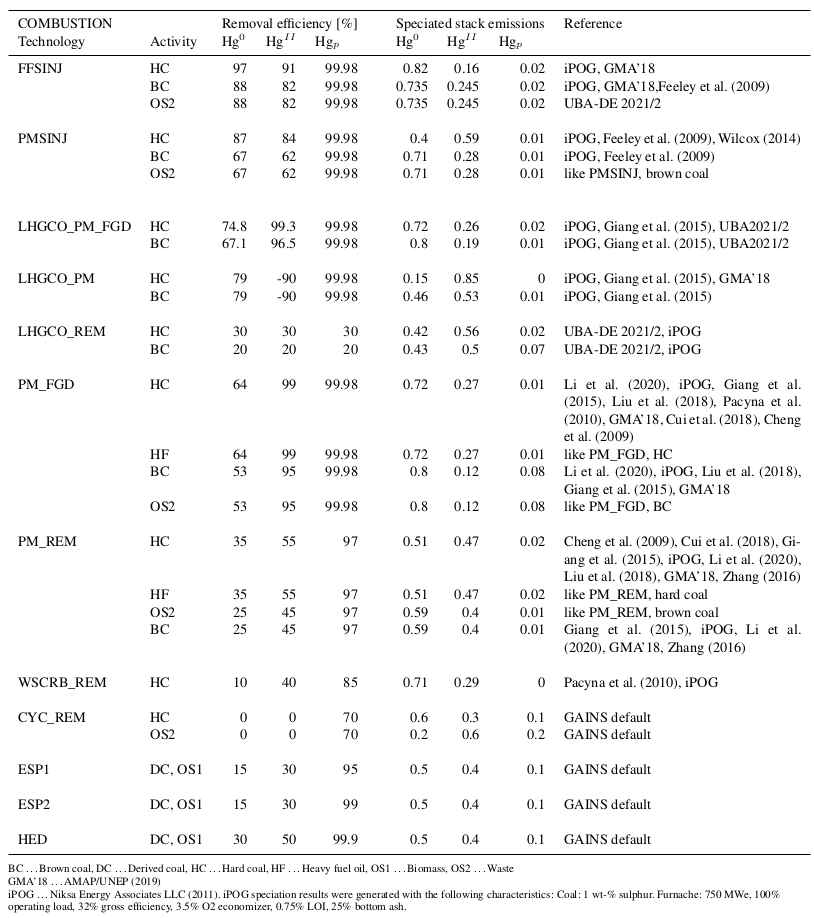


Table S5. Control technologies and their removal efficiencies for industrial processes.

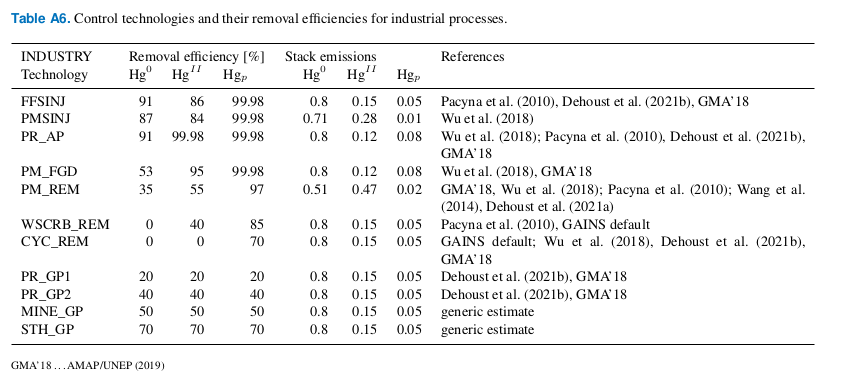


Table S6. Control technologies and their removal efficiencies for waste sectors.

A white sheet with black text and black letters

Description automatically generated

# S3 – Details on applied mercury control strategies of the displayed scenarios

## S3.1 – Mercury control strategies

Table S7. Hg-specific changes to the Current Legislation (CLE) control strategies were made in the following sectors, to better reflect current Hg emission limit values and policy.

A screenshot of a white sheet

Description automatically generated

Table S8. Full control strategy of the Hg-MFR scenario in 2050. The full list of activities, sectors and technologies in GAINS can be found in the GAINS glossary: https://gains.iiasa.ac.at/gains/GOD/abbreviations.info

|  |  |  |  |
| --- | --- | --- | --- |
| **Sector** | **Activity** | **Technology** | **%** |
| AU\_LGP | NOF | PR\_AP | 100 |
| AU\_SGP | NOF | BAN | 100 |
| CON\_COMB | DC | IN\_HED | 100 |
| CON\_COMB | HF | FFSINJ | 100 |
| CON\_COMB | OS1 | IN\_HED | 100 |
| CON\_COMB | OS2 | FFSINJ | 100 |
| CON\_COMB1 | BC1 | FFSINJ | 100 |
| CON\_COMB1 | BC2 | FFSINJ | 100 |
| CON\_COMB1 | HC1 | FFSINJ | 100 |
| CON\_COMB1 | HC2 | FFSINJ | 100 |
| CON\_COMB1 | HC3 | FFSINJ | 100 |
| CON\_COMB2 | BC1 | FFSINJ | 100 |
| CON\_COMB2 | BC2 | FFSINJ | 100 |
| CON\_COMB2 | HC1 | FFSINJ | 100 |
| CON\_COMB2 | HC2 | FFSINJ | 100 |
| CON\_COMB2 | HC3 | FFSINJ | 100 |
| CON\_COMB3 | BC1 | FFSINJ | 100 |
| CON\_COMB3 | BC2 | FFSINJ | 100 |
| CON\_COMB3 | HC1 | FFSINJ | 100 |
| CON\_COMB3 | HC2 | FFSINJ | 100 |
| CON\_COMB3 | HC3 | FFSINJ | 100 |
| DOM | HF | GHDOM | 100 |
| DOM | MD | GHDOM | 100 |
| DOM\_FPLACE | FWD | FP\_NEW | 100 |
| DOM\_LIGHT | GSL | LED | 100 |
| DOM\_MB\_A | BC1 | MB\_HED | 100 |
| DOM\_MB\_A | BC2 | MB\_HED | 100 |
| DOM\_MB\_A | DC | MB\_HED | 100 |
| DOM\_MB\_A | FWD | MB\_HED\_F | 100 |
| DOM\_MB\_A | HC1 | MB\_HED | 100 |
| DOM\_MB\_A | HC2 | MB\_HED | 100 |
| DOM\_MB\_A | HC3 | MB\_HED | 100 |
| DOM\_MB\_M | BC1 | MB\_CYC | 100 |
| DOM\_MB\_M | BC2 | MB\_CYC | 100 |
| DOM\_MB\_M | DC | MB\_CYC | 100 |
| DOM\_MB\_M | FWD | MB\_HED\_F | 100 |
| DOM\_MB\_M | HC1 | MB\_CYC | 100 |
| DOM\_MB\_M | HC2 | MB\_CYC | 100 |
| DOM\_MB\_M | HC3 | MB\_CYC | 100 |
| DOM\_SHB\_A | FWD | SHB\_HED | 100 |
| DOM\_SHB\_M | BC1 | SHB\_NEW\_C | 100 |
| DOM\_SHB\_M | DC | SHB\_NEW\_C | 100 |
| DOM\_SHB\_M | FWD | SHB\_PLESP | 100 |
| DOM\_SHB\_M | HC1 | SHB\_NEW\_C | 100 |
| DOM\_SHB\_M | HC2 | SHB\_NEW\_C | 100 |
| DOM\_SHB\_M | HC3 | SHB\_NEW\_C | 100 |
| DOM\_STOVE\_C | ARD | STV\_NEW\_B | 100 |
| DOM\_STOVE\_C | BC1 | STV\_NEW\_C | 100 |
| DOM\_STOVE\_C | BC2 | STV\_NEW\_C | 100 |
| DOM\_STOVE\_C | DC | STV\_NEW\_C | 100 |
| DOM\_STOVE\_C | DNG | STV\_NEW\_B | 100 |
| DOM\_STOVE\_C | FWD | STV\_NEW\_B | 100 |
| DOM\_STOVE\_C | HC1 | STV\_NEW\_C | 100 |
| DOM\_STOVE\_C | HC2 | STV\_NEW\_C | 100 |
| DOM\_STOVE\_C | HC3 | STV\_NEW\_C | 100 |
| DOM\_STOVE\_H | ARD | STV\_NEW\_B | 100 |
| DOM\_STOVE\_H | BC1 | STV\_NEW\_C | 100 |
| DOM\_STOVE\_H | BC2 | STV\_NEW\_C | 100 |
| DOM\_STOVE\_H | DC | STV\_NEW\_C | 100 |
| DOM\_STOVE\_H | DNG | STV\_NEW\_B | 100 |
| DOM\_STOVE\_H | FWD | STV\_PLESP | 100 |
| DOM\_STOVE\_H | HC1 | STV\_BRIQ | 100 |
| DOM\_STOVE\_H | HC2 | STV\_NEW\_C | 100 |
| DOM\_STOVE\_H | HC3 | STV\_NEW\_C | 100 |
| IN\_BO\_CHEM | BC1 | FFSINJ | 100 |
| IN\_BO\_CHEM | BC2 | FFSINJ | 100 |
| IN\_BO\_CHEM | HC1 | FFSINJ | 100 |
| IN\_BO\_CHEM | HC2 | FFSINJ | 100 |
| IN\_BO\_CHEM | HC3 | FFSINJ | 100 |
| IN\_BO\_CHEM | HF | FFSINJ | 100 |
| IN\_BO\_CHEM | OS1 | IN\_HED | 100 |
| IN\_BO\_CHEM | OS2 | FFSINJ | 100 |
| IN\_BO\_CON | BC1 | FFSINJ | 100 |
| IN\_BO\_CON | BC2 | FFSINJ | 100 |
| IN\_BO\_CON | HC1 | FFSINJ | 100 |
| IN\_BO\_CON | HC2 | FFSINJ | 100 |
| IN\_BO\_CON | HC3 | FFSINJ | 100 |
| IN\_BO\_CON | HF | FFSINJ | 100 |
| IN\_BO\_CON | OS1 | IN\_HED | 100 |
| IN\_BO\_CON | OS2 | FFSINJ | 100 |
| IN\_BO\_OTH | DC | IN\_HED | 100 |
| IN\_BO\_OTH | HF | FFSINJ | 100 |
| IN\_BO\_OTH | OS1 | IN\_HED | 100 |
| IN\_BO\_OTH | OS2 | FFSINJ | 100 |
| IN\_BO\_OTH\_L | BC1 | FFSINJ | 100 |
| IN\_BO\_OTH\_L | BC2 | FFSINJ | 100 |
| IN\_BO\_OTH\_L | HC1 | FFSINJ | 100 |
| IN\_BO\_OTH\_L | HC2 | FFSINJ | 100 |
| IN\_BO\_OTH\_L | HC3 | FFSINJ | 100 |
| IN\_BO\_OTH\_S | BC1 | FFSINJ | 100 |
| IN\_BO\_OTH\_S | BC2 | FFSINJ | 100 |
| IN\_BO\_OTH\_S | HC1 | FFSINJ | 100 |
| IN\_BO\_OTH\_S | HC2 | FFSINJ | 100 |
| IN\_BO\_OTH\_S | HC3 | FFSINJ | 100 |
| IN\_BO\_PAP | BC1 | FFSINJ | 100 |
| IN\_BO\_PAP | BC2 | FFSINJ | 100 |
| IN\_BO\_PAP | HC1 | FFSINJ | 100 |
| IN\_BO\_PAP | HC2 | FFSINJ | 100 |
| IN\_BO\_PAP | HC3 | FFSINJ | 100 |
| IN\_BO\_PAP | HF | FFSINJ | 100 |
| IN\_BO\_PAP | OS1 | IN\_HED | 100 |
| IN\_BO\_PAP | OS2 | FFSINJ | 100 |
| IN\_OC | DC | IN\_HED | 100 |
| IN\_OC | HF | FFSINJ | 100 |
| IN\_OC | OS1 | IN\_HED | 100 |
| IN\_OC | OS2 | FFSINJ | 100 |
| IN\_OC1 | BC1 | FFSINJ | 100 |
| IN\_OC1 | BC2 | FFSINJ | 100 |
| IN\_OC1 | HC1 | FFSINJ | 100 |
| IN\_OC1 | HC2 | FFSINJ | 100 |
| IN\_OC1 | HC3 | FFSINJ | 100 |
| IN\_OC2 | BC1 | FFSINJ | 100 |
| IN\_OC2 | BC2 | FFSINJ | 100 |
| IN\_OC2 | HC1 | FFSINJ | 100 |
| IN\_OC2 | HC2 | FFSINJ | 100 |
| IN\_OC2 | HC3 | FFSINJ | 100 |
| IN\_OC3 | BC1 | FFSINJ | 100 |
| IN\_OC3 | BC2 | FFSINJ | 100 |
| IN\_OC3 | HC1 | FFSINJ | 100 |
| IN\_OC3 | HC2 | FFSINJ | 100 |
| IN\_OC3 | HC3 | FFSINJ | 100 |
| INW\_OTH | NOF | INDOTH\_INC | 0 |
| INW\_OTH | NOF | INDOTH\_INC\_ENE | 100 |
| INW\_OTH | NOF | UNC\_BURN | 0 |
| MSW\_RUR\_OTH | NOF | SWD\_COMP | 0 |
| MSW\_RUR\_OTH | NOF | SWD\_COVER | 0 |
| MSW\_RUR\_OTH | NOF | SWD\_FLA | 0 |
| MSW\_RUR\_OTH | NOF | SWD\_UNM\_HIGH | 0 |
| MSW\_RUR\_OTH | NOF | SWD\_UNM\_LOW | 0 |
| MSW\_RUR\_OTH | NOF | SWD\_USE | 0 |
| MSW\_RUR\_OTH | NOF | TREAT\_INC | 0 |
| MSW\_RUR\_OTH | NOF | TREAT\_INC\_ENE | 100 |
| MSW\_RUR\_OTH | NOF | UNC\_BURN | 0 |
| MSW\_URB\_OTH | NOF | SWD\_COMP | 0 |
| MSW\_URB\_OTH | NOF | SWD\_COVER | 0 |
| MSW\_URB\_OTH | NOF | SWD\_FLA | 0 |
| MSW\_URB\_OTH | NOF | SWD\_UNM\_HIGH | 0 |
| MSW\_URB\_OTH | NOF | SWD\_UNM\_LOW | 0 |
| MSW\_URB\_OTH | NOF | SWD\_USE | 0 |
| MSW\_URB\_OTH | NOF | TREAT\_INC | 0 |
| MSW\_URB\_OTH | NOF | TREAT\_INC\_ENE | 100 |
| MSW\_URB\_OTH | NOF | UNC\_BURN | 0 |
| PP\_ENG | HF | TIWEUV | 17 |
| PP\_ENG | HF | TIWEUVI | 83 |
| PP\_ENG | MD | TIWEUVI | 100 |
| PP\_EX\_L | BC1 | FFSINJ | 100 |
| PP\_EX\_L | BC2 | FFSINJ | 100 |
| PP\_EX\_L | HC1 | FFSINJ | 100 |
| PP\_EX\_L | HC2 | FFSINJ | 100 |
| PP\_EX\_L | HC3 | FFSINJ | 100 |
| PP\_EX\_OTH | DC | HED | 100 |
| PP\_EX\_OTH | HF | PM\_FGD | 100 |
| PP\_EX\_OTH | OS1 | HED | 100 |
| PP\_EX\_OTH | OS2 | CYC | 22 |
| PP\_EX\_OTH | OS2 | FFSINJ | 100 |
| PP\_EX\_S | BC1 | FFSINJ | 100 |
| PP\_EX\_S | BC2 | FFSINJ | 100 |
| PP\_EX\_S | HC1 | FFSINJ | 100 |
| PP\_EX\_S | HC2 | FFSINJ | 100 |
| PP\_EX\_S | HC3 | FFSINJ | 100 |
| PP\_IGCC | BC1 | FFSINJ | 100 |
| PP\_IGCC | BC2 | FFSINJ | 100 |
| PP\_IGCC | HC1 | FFSINJ | 100 |
| PP\_IGCC | HC2 | FFSINJ | 100 |
| PP\_IGCC | HC3 | FFSINJ | 100 |
| PP\_IGCC | OS2 | FFSINJ | 100 |
| PP\_MOD | BC1 | FFSINJ | 100 |
| PP\_MOD | BC2 | FFSINJ | 100 |
| PP\_MOD | HC1 | FFSINJ | 100 |
| PP\_MOD | HC2 | FFSINJ | 100 |
| PP\_MOD | HC3 | FFSINJ | 100 |
| PP\_MOD\_CCS | BC1 | FFSINJ | 100 |
| PP\_MOD\_CCS | BC2 | FFSINJ | 100 |
| PP\_MOD\_CCS | HC1 | FFSINJ | 100 |
| PP\_MOD\_CCS | HC2 | FFSINJ | 100 |
| PP\_MOD\_CCS | HC3 | FFSINJ | 100 |
| PP\_NEW | HF | PM\_FGD | 100 |
| PP\_NEW | OS1 | HED | 100 |
| PP\_NEW | OS2 | FFSINJ | 100 |
| PP\_NEW\_L | BC1 | FFSINJ | 100 |
| PP\_NEW\_L | BC2 | FFSINJ | 100 |
| PP\_NEW\_L | HC1 | FFSINJ | 100 |
| PP\_NEW\_L | HC2 | FFSINJ | 100 |
| PP\_NEW\_L | HC3 | FFSINJ | 100 |
| PR\_ALPRIM | NOF | PM\_REM | 100 |
| PR\_BAOX | NOF | FFSINJ | 100 |
| PR\_BRICK | NOF | TK\_EOF | 100 |
| PR\_CEM | NOF | FFSINJ | 100 |
| PR\_COKE | NOF | FFSINJ | 100 |
| PR\_CSP | NOF | BAN | 100 |
| PR\_EARC | NOF | PR\_HED | 100 |
| PR\_FERT | NOF | PR\_HED | 100 |
| PR\_GLASS | NOF | FFSINJ | 100 |
| PR\_HEARTH | NOF | FFSINJ | 100 |
| PR\_LIME | NOF | FFSINJ | 100 |
| PR\_OT\_NFME | NOF | PR\_AP | 100 |
| PR\_PIGI | NOF | FFSINJ | 100 |
| PR\_PULP | NOF | FFSINJ | 100 |
| PR\_REF | NOF | FFSINJ | 100 |
| TRA\_OT\_AGR | GSL | LFEUVI | 100 |
| TRA\_OT\_AGR | LPG | LFEUII | 100 |
| TRA\_OT\_AGR | MD | CAGEUVI | 100 |
| TRA\_OT\_CNS | GSL | LFEUVI | 100 |
| TRA\_OT\_CNS | LPG | LFEUVI | 100 |
| TRA\_OT\_CNS | MD | CAGEUVI | 100 |
| TRA\_OT\_INW | GSL | LFEUVI | 100 |
| TRA\_OT\_INW | MD | TIWEUVI | 100 |
| TRA\_OT\_LB | GSL | LFEUVI | 100 |
| TRA\_OT\_LB | LPG | LFEUII | 100 |
| TRA\_OT\_LB | MD | HDEUVI | 100 |
| TRA\_OT\_LD2 | GSL | MMO2III | 100 |
| TRA\_OT\_RAI | GSL | LFEUII | 100 |
| TRA\_OT\_RAI | MD | TIWEUVI | 100 |
| TRA\_OTS\_L | HF | STLHCM | 30 |
| TRA\_OTS\_L | HF | STLSCR | 70 |
| TRA\_OTS\_L | MD | STLSCR | 100 |
| TRA\_OTS\_M | MD | STMCM | 100 |
| TRA\_RD\_HDB | GSL | HDSEIII | 100 |
| TRA\_RD\_HDB | LPG | HDSEIII | 100 |
| TRA\_RD\_HDB | MD | HDEUVI | 100 |
| TRA\_RD\_HDT | GSL | HDSEIII | 100 |
| TRA\_RD\_HDT | LPG | HDSEIII | 100 |
| TRA\_RD\_HDT | MD | HDEUVI | 100 |
| TRA\_RD\_LD2 | GSL | MMO2III | 100 |
| TRA\_RD\_LD4C | GSL | LFEUVI | 100 |
| TRA\_RD\_LD4C | LPG | LFEUVI | 100 |
| TRA\_RD\_LD4C | MD | MDEUVI | 100 |
| TRA\_RD\_LD4T | GSL | LFEUVI | 100 |
| TRA\_RD\_LD4T | LPG | LFEUVI | 100 |
| TRA\_RD\_LD4T | MD | MDEUVI | 100 |
| TRA\_RD\_M4 | GSL | MOT4III | 100 |
| TRA\_RD\_OTH | GSL | OTHIII | 100 |

## S3.2 – PM and SO2 control strategies

Historically, the power sector has been regulated with the most stringent emission limit values (e.g., ICSC 2019). Already in the CLE control strategy, some kind of particulate matter control is present for >98% of all installed capacity in the coal sector (industrial combustion, power plants) for all study years (2015-2050) (see Table S9). There are differences in the CLE and co-MFR control strategies in the PM removal efficiency of applied controls: The share of high efficiency dedusting (HED) is steadily increasing in both scenarios relative to the less efficient electrostatic precipitators (ESP1 and ESP2). For power plants, HED application reaches a peak application on 77% of total global capacity in all coal combustion sectors in the CLE scenario in 2050 but is applied on 98% of total capacity in the same year in the co-MFR control strategy. However, for the implementation of the Hg control strategy, the differences in Hg removal efficiency between ESP1, ESP2 and HED are not implemented in the GAINS model at the current time and all three technologies are summarized as ‘Particulate matter control’ (see Table S3). For SO2 controls, the share of flue gas desulfurization devices (FGD), which have a Hg removal efficiency associated with them, climbs up to >90% in 2050 for the CLE scenarios but reaches >97% in the co-MFR scenario for coal power stations. For industrial combustion, the application rates are lower and more markedly different: 65% application of FGDs in 2050 in the CLE, and up to 87% in the co-MFR, globally. However, the reduction potential varies greatly between regions, especially in sectors and world regions (see Figure S3 in the SI) where stringent air control policies are not yet mandated. As a result, even on a global scale, only 12.5% reduction in Hg emissions can be seen in the power sector in 2050.

Table S9. Global average application rates of pollution control measures in selected sectors in %.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Control Strategy** | **Sector** | **Activity** | **Pollutant** | **Technology (long name)** | **Technology (abbreviation)** | **2015** | **2020** | **2025** | **2030** | **2035** | **2040** | **2045** | **2050** |
| CLE, MINA | COMB\_IND | Coal | PM2.5 | Cyclone | CYC | 1.28 | 0.67 | 0.62 | 0.62 | 0.62 | 0.62 | 0.61 | 0.6 |
| CLE, MINA | COMB\_IND | Coal | PM2.5 | Electrostatic precipitator: 1 field | ESP1 | 74.46 | 70.11 | 73.58 | 75.43 | 78.8 | 80.62 | 81.94 | 82.77 |
| CLE, MINA | COMB\_IND | Coal | PM2.5 | Electrostatic precipitator: 2 fields | ESP2 | 3.91 | 11.14 | 9.35 | 8.89 | 8.17 | 7.49 | 6.92 | 6.62 |
| CLE, MINA | COMB\_IND | Coal | PM2.5 | High efficiency deduster | HED | 3.52 | 7.06 | 9.1 | 10.92 | 9.35 | 8.45 | 7.89 | 7.53 |
| CLE, MINA | COMB\_IND | Coal | PM2.5 | Wet scrubber | WSCRB | 14.08 | 8.91 | 5.64 | 2.78 | 2.58 | 2.4 | 2.25 | 2.12 |
| co-MFR | COMB\_IND | Coal | PM2.5 | Cyclone | CYC | n.a | n.a | 2.76 | 1.64 | 0.78 | 0.14 | 0.14 | 0.13 |
| co-MFR | COMB\_IND | Coal | PM2.5 | Electrostatic precipitator: 1 field | ESP1 | n.a | n.a | 58.03 | 42.44 | 26.59 | 9.65 | 10.19 | 10.95 |
| co-MFR | COMB\_IND | Coal | PM2.5 | Electrostatic precipitator: 2 fields | ESP2 | n.a | n.a | 5.82 | 4.17 | 1.97 | 0.02 | 0 | 0 |
| co-MFR | COMB\_IND | Coal | PM2.5 | High efficiency deduster | HED | n.a | n.a | 27.28 | 48.69 | 67.97 | 87.78 | 87.42 | 86.8 |
| co-MFR | COMB\_IND | Coal | PM2.5 | Wet scrubber | WSCRB | n.a | n.a | 5.64 | 2.78 | 2.58 | 2.4 | 2.25 | 2.12 |
| CLE, MINA | COMB\_IND | Coal | SO2 | Industry - wet flue gases desulphurisation | IWFGD | 36.07 | 59.11 | 62.54 | 66.92 | 66.36 | 65.88 | 65.3 | 64.52 |
| CLE, MINA | COMB\_IND | Coal | SO2 | In-furnace control - limestone injection | LINJ | 23.65 | 13.49 | 13.65 | 12.83 | 11.86 | 11.14 | 10.6 | 10.17 |
| CLE, MINA | COMB\_IND | Coal | SO2 | Low sulphur coal (0.6 %S) | LSCO | 17.46 | 2.43 | 1.84 | 1.64 | 1.65 | 1.53 | 1.49 | 1.47 |
| co-MFR | COMB\_IND | Coal | SO2 | Industry - wet flue gases desulphurisation | IWFGD | n.a | n.a | 68.4 | 77.02 | 77.26 | 87.82 | 87.54 | 87.14 |
| co-MFR | COMB\_IND | Coal | SO2 | In-furnace control - limestone injection | LINJ | n.a | n.a | 12.51 | 10.56 | 14.29 | 7.39 | 7.41 | 7.41 |
| co-MFR | COMB\_IND | Coal | SO2 | Low sulphur coal (0.6 %S) | LSCO | n.a | n.a | 1.1 | 1.02 | 0.6 | 1.11 | 1.02 | 0.98 |
| CLE, MINA | COMB\_POWER | Coal | PM2.5 | Cyclone | CYC | 0.02 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| CLE, MINA | COMB\_POWER | Coal | PM2.5 | Electrostatic precipitator: 1 field | ESP1 | 21.36 | 15.64 | 5.3 | 4.1 | 4.41 | 4.47 | 4.71 | 4.8 |
| CLE, MINA | COMB\_POWER | Coal | PM2.5 | Electrostatic precipitator: 2 fields | ESP2 | 34.75 | 19.24 | 18.17 | 11.43 | 12.84 | 14.01 | 15.12 | 16.1 |
| CLE, MINA | COMB\_POWER | Coal | PM2.5 | High efficiency deduster | HED | 43.87 | 64.89 | 76.06 | 83.83 | 81.89 | 80.37 | 78.58 | 77.05 |
| CLE, MINA | COMB\_POWER | Coal | PM2.5 | Wet scrubber | WSCRB | n.a | n.a | n.a | n.a | n.a | n.a | n.a | n.a |
| co-MFR | COMB\_POWER | Coal | PM2.5 | Cyclone | CYC | n.a | n.a | 0 | 0 | 0 | n.a | n.a | n.a |
| co-MFR | COMB\_POWER | Coal | PM2.5 | Electrostatic precipitator: 1 field | ESP1 | n.a | n.a | 4.16 | 2.41 | 1.68 | 0.79 | 0.84 | 0.85 |
| co-MFR | COMB\_POWER | Coal | PM2.5 | Electrostatic precipitator: 2 fields | ESP2 | n.a | n.a | 12.02 | 6.05 | 4.47 | 2.31 | 2.81 | 3.28 |
| co-MFR | COMB\_POWER | Coal | PM2.5 | High efficiency deduster | HED | n.a | n.a | 83.8 | 91.53 | 93.85 | 96.9 | 96.34 | 95.87 |
| co-MFR | COMB\_POWER | Coal | PM2.5 | Wet scrubber | WSCRB | n.a | n.a | n.a | n.a | n.a | n.a | n.a | n.a |
| CLE, MINA | COMB\_POWER | Coal | SO2 | In-furnace control - limestone injection | LINJ | 4.56 | 2.09 | 1.64 | 1.41 | 1.5 | 1.58 | 1.71 | 1.88 |
| CLE, MINA | COMB\_POWER | Coal | SO2 | Low sulphur coke (0.6 %S) | LSCK | 0.07 | n.a | n.a | n.a | n.a | n.a | n.a | n.a |
| CLE, MINA | COMB\_POWER | Coal | SO2 | Low sulphur coal (0.6 %S) | LSCO | 0.6 | 0.59 | 0.54 | 0.58 | 0.6 | 0.65 | 0.75 | 0.87 |
| CLE, MINA | COMB\_POWER | Coal | SO2 | Wet flue gases desulphurisation (retrofitted) | PRWFGD | 8.72 | 4.32 | 2.09 | 1.2 | 0.68 | 0.28 | 0.27 | 0.24 |
| CLE, MINA | COMB\_POWER | Coal | SO2 | Wet flue gases desulphurisation | PWFGD | 68.72 | 46.86 | 44.32 | 43.14 | 44.05 | 46.18 | 47.06 | 48.3 |
| CLE, MINA | COMB\_POWER | Coal | SO2 | High efficiency flue gases desulphurisation | RFGD | 1.56 | 34.91 | 44.36 | 49.06 | 48.05 | 45.7 | 43.96 | 41.82 |
| co-MFR | COMB\_POWER | Coal | SO2 | In-furnace control - limestone injection | LINJ | n.a | n.a | 1.48 | 1.04 | 1.49 | 0 | 0 | 0 |
| co-MFR | COMB\_POWER | Coal | SO2 | Low sulphur coke (0.6 %S) | LSCK | n.a | n.a | 0 | 0 | 0.01 | 0.01 | 0.01 | 0.01 |
| co-MFR | COMB\_POWER | Coal | SO2 | Low sulphur coal (0.6 %S) | LSCO | n.a | n.a | 0.02 | 0.18 | 0.18 | 0.18 | 0.21 | 0.24 |
| co-MFR | COMB\_POWER | Coal | SO2 | Wet flue gases desulphurisation (retrofitted) | PRWFGD | n.a | n.a | 2.09 | 1.2 | 0.68 | 0.28 | 0.27 | 0.24 |
| co-MFR | COMB\_POWER | Coal | SO2 | Wet flue gases desulphurisation | PWFGD | n.a | n.a | 39.76 | 33.33 | 43.85 | 8.4 | 8 | 8.04 |
| co-MFR | COMB\_POWER | Coal | SO2 | High efficiency flue gases desulphurisation | RFGD | n.a | n.a | 49.76 | 61.01 | 51.36 | 89.68 | 89.76 | 89.4 |

# S4 – The No Control Scenario

To establish a theoretical maximum of yearly anthropogenic mercury emissions in the present scenarios, it is useful to compare the current legislation scenario to a hypothetical “no control” endpoint, conceptualized in the ‘No Control’ (BAS\_NOC) scenario (plotted in the SI, Figure S1). This scenario assumes unabated emissions factors, as if no PM, SO2 or Hg air pollution control were implemented (see Table 2). Comparing the No Control and Baseline (BAS\_CLE) scenarios, the full extent of emissions reductions from current clean air policy becomes apparent, highlighting the co-benefits for Hg of already existing clean air policies and the impact of the CLE control strategy used in the Baseline scenario. In 2015, global emissions are 5273 t Hg in the No Control scenario, more than twice as high as in the Baseline (2321 t Hg). From Figures S2 and 3, it can be seen that the difference between No Control and the Baseline is larger than between the Baseline and the other, stricter control strategy scenarios (MINA, co-MFR, Hg-MFR), illustrating that already, more than 50% of potential unabated Hg emissions are avoided through clean air policy.

Most co-benefit reductions occur in the NFME sector: In 2015, NFME emissions alone would have been 2334 t/a without any APDCs in place, 6.7 times higher than in the Baseline, owing to the high unabated emission factors in this sector, the high Hg removal efficiency of co-benefit controls (in this case, acid plants), and the already high application rates of these technologies in the baseline control strategy. Other sectors which are significantly higher without emission controls than reported in 2015 include the power sector COMB\_POWER (3.0 x higher), industrial combustion COMB\_IND (2.7 x higher) and cement production (1.7 x higher), indicating that these sectors are already largely controlled through particulate filters and even desulfurization measures in many world regions. A more extensive discussion for the control strategy compared to a No Control scenario can be found in Amann et al. (2020).

Figure S1. No Control scenario (00\_BAS\_NOC), compared to all other control strategies on the baseline scenario. Refer to Tables 1 & 2 of the main text for details of the abbreviations in the legend.

A graph of different colored bars

Description automatically generated

# S5 – GAINS regions

Table S10. Regional aggregation of countries and GAINS model regions (consistent with IEA (2022) regional grouping).

|  |  |  |
| --- | --- | --- |
| Region | Countries | GAINS regions |
| North America: | Canada, Mexico and United States | CANA\_WHOL, MEXI\_WHOL, USAM\_ALAS, USAM\_MAIN |
| Central and South America: | Argentina, Plurinational State of Bolivia (Bolivia), Brazil, Chile, Colombia, Costa Rica, Cuba, Curaçao, Dominican Republic, Ecuador, El Salvador, Guatemala, Haiti, Honduras, Jamaica, Nicaragua, Panama, Paraguay, Peru, Suriname, Trinidad and Tobago, Uruguay, Bolivarian Republic of Venezuela (Venezuela), and other Central and South American countries and territories | ARGE\_WHOL, BOLV\_WHOL, BRAZ\_WHOL, CHIL\_WHOL, COLO\_WHOL, CARB\_WHOL, CEAM\_WHOL, ECUA\_WHOL, PARA\_WHOL, PERU\_WHOL, URUG\_WHOL, VENE\_WHOL |
| Europe: | European Union regional grouping and Albania, Belarus, Bosnia and Herzegovina, North Macedonia, Gibraltar, Iceland, Israel, Kosovo, Montenegro, Norway, Serbia, Switzerland, Republic of Moldova, Türkiye, Ukraine and United Kingdom. | European Union and ALBA\_WHOL, BELA\_WHOL, BOHE\_WHOL, ICEL\_WHOL, ISRA\_WHOL, KOSO\_WHOL, MACE\_WHOL, MOLD\_WHOL, MONT\_WHOL, NORW\_WHOL, SERB\_WHOL, SWIT\_WHOL, TURK\_WHOL, UNKI\_WHOL, UKRA\_WHOL |
| European Union: | Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain and Sweden | UST\_WHOL, BELG\_WHOL, BULG\_WHOL CROA\_WHOL, CYPR\_WHOL, CZRE\_WHOL, DENM\_WHOL, ESTO\_WHOL, FINL\_WHOL, FRAN\_WHOL, GERM\_WHOL, GREE\_WHOL, HUNG\_WHOL, IREL\_WHOL, ITAL\_WHOL, LATV\_WHOL, LITH\_WHOL, LUXE\_WHOL, MALT\_WHOL, NETH\_WHOL, POLA\_WHOL, PORT\_WHOL, ROMA\_WHOL, SKRE\_WHOL, SLOV\_WHOL, SPAI\_WHOL, SWED\_WHOL |
| Africa: | North Africa (Algeria, Egypt, Libya, Morocco and Tunisia) and sub-saharan Africa (Angola, Benin, Botswana, Cameroon, Republic of the Congo (Congo), Côte d’Ivoire, Democratic Republic of the Congo, Eritrea, Ethiopia, Gabon, Ghana, Kenya, Mauritius, Mozambique, Namibia, Niger, Nigeria, Senegal, South Africa, South Sudan, Sudan, United Republic of Tanzania (Tanzania), Togo, Zambia, Zimbabwe and other African countries | EAFR\_WHOL, EGYP\_WHOL, KENY\_WHOL, NAFR\_WHOL, NIGE\_WHOL, RSAF\_WHOL, TANZ\_WHOL, WAFR\_WHOL |
| Middle East: | Bahrain, Islamic Republic of Iran (Iran), Iraq, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syrian Arab Republic (Syria), United Arab Emirates and Yemen | IRAN\_WHOL, SAAR\_WHOL, MIDE\_WHOL |
| Eurasia: | Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan, the Russian Federation (Russia) | ARME\_WHOL, AZER\_WHOL, GEOR\_WHOL, KAZA\_WHOL, KYRG\_WHOL, RUSS\_ASIA, RUSS\_EURO, TAJI\_WHOL, TKME\_WHOL, UZBE\_WHOL |
| Asia Pacific: | Southeast Asia regional grouping and Australia, Bangladesh, Democratic People’s Republic of Korea (North Korea), India, Japan, Korea, Mongolia, Nepal, New Zealand, Pakistan, People’s Republic of China (China), Sri Lanka, Chinese Taipei, and other Asia Pacific countries and territories. | Southeast Asia regional grouping and AFGH\_WHOL, AUTR\_WHOL, BANG\_DHAK, BANG\_REST, BHUT\_WHOL, CHIN\_ANHU, CHIN\_BEIJ, CHIN\_CHON, CHIN\_FUJI, CHIN\_GANS, CHIN\_GUAD, CHIN\_GUAX, CHIN\_GUIZ, CHIN\_HAIN, CHIN\_HEBE, CHIN\_HEIL, CHIN\_HENA, CHIN\_HONG, CHIN\_HUBE, CHIN\_HUNA, CHIN\_JILI, CHIN\_JINU, CHIN\_JINX, CHIN\_LIAO, CHIN\_NEMO, CHIN\_NINX, CHIN\_QING, CHIN\_SHAA, CHIN\_SHAN, CHIN\_SHND, CHIN\_SHNX, CHIN\_SICH, CHIN\_TIAN, CHIN\_TIBE, CHIN\_XING, CHIN\_YUNN, CHIN\_ZHEJ, INDI\_ANPR, INDI\_ASSA, INDI\_BENG, INDI\_BIHA, INDI\_CHHA, INDI\_DELH, INDI\_EHIM, INDI\_GOA, INDI\_GUJA, INDI\_HARY, INDI\_HIPR, INDI\_JHAR, INDI\_KARN, INDI\_KERA, INDI\_MAHA, INDI\_MAPR, INDI\_ORIS, INDI\_PUNJ, INDI\_RAJA, INDI\_TAMI, INDI\_UTAN, INDI\_UTPR, INDI\_WHIM, JAPA\_CHSH, JAPA\_CHUB, JAPA\_HOTO, JAPA\_KANT, JAPA\_KINK, JAPA\_KYOK, KORN\_WHOL, KORS\_NORT, KORS\_PUSA, KORS\_SEOI, KORS\_SOUT, MONG\_WHOL, NEPA\_WHOL, NZEL\_WHOL, PAKI\_KARA, PAKI\_NMWP, PAKI\_PUNJ, PAKI\_SIND, SRIL\_WHOL, TAIW\_WHOL |
| Southeast Asia: | Brunei Darussalam, Cambodia, Indonesia, Lao People’s Democratic Republic (Lao PDR), Malaysia, Myanmar, Philippines, Singapore, Thailand and Viet Nam. These countries are all members of the Association of Southeast Asian Nations (ASEAN) | BRUN\_WHOL, CAMB\_WHOL, INDO\_JAKA, INDO\_JAVA, INDO\_REST, INDO\_SUMA, LAOS\_WHOL, MALA\_KUAL, MALA\_PENM, MALA\_SASA, MYAN\_WHOL, PHIL\_BVMI, , PHIL\_LUZO, PHIL\_MANI, SING\_WHOL, THAI\_BANG, THAI\_CVAL, THAI\_NEPL, THAI\_NHIG, THAI\_SPEN, VIET\_NORT, VIET\_SOUT |

# S6 – Monte Carlo Simulation to estimate uncertainties of unabated mercury emissions.

Table S11. Uncertainty estimations used as input to Monte Carlo Simulation. UEF … Unabated Emission Factor. GMA’18 … AMAP/UNEP (2019), Global Mercury Assessment 2018.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Sector |  | 1 Standard Deviation | Distribution | Source |
| ACTIVITY DATA | | | | |
| ASGM |  | ± 0.5 x activity | normal | GMA’18 |
| CEM  COMB\_IND  COMB\_OTHER  COMB\_POWER  GOLD  IND\_PROC  NFME  OTHER | EU27  North America  USA  Japan | ± 0.05 x activity | normal | GMA’18 |
| All others | ± 0.1 x activity |
| Waste |  | ± 0.2 x activity | normal | own estimate |
| UNABATED EMISSION FACTORS (UEF) | | | | |
| Coal sectors  COMB\_IND  COMB\_OTHER  COMB\_POWER | All countries | ± 0.3 x UEF | normal | GMA’18 |
| CEM  GOLD  IND\_PROC  NFME  ASGM | All countries | ± 0.5 x UEF | normal | GMA’18 |
| OTHER | All countries | 0.3x UEF – 3x UEF | log-normal | GMA’18 |

Table S12. Global results of the Monte Carlo Simulation for 00\_BAS\_NOC after 10000 runs.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Sector | Mean simulated emissions (50th percentile) in tons | Upper range estimate (95th percentile) (t) | Lower range estimate (5th percentile) (t) | GAINS emissions (t) | % error (lower) | % error (upper) |
| ASGM | 951.34 | 1370.94 | 600.97 | 952.61 | 36.83 | 44.11 |
| CEM | 334.74 | 378.26 | 291.43 | 335.06 | 12.94 | 13.00 |
| COMB\_IND | 141.87 | 149.26 | 134.61 | 141.86 | 5.12 | 5.21 |
| COMB\_OTHER | 104.63 | 109.07 | 100.18 | 104.63 | 4.26 | 4.25 |
| COMB\_POWER | 791.84 | 846.70 | 739.33 | 792.08 | 6.63 | 6.93 |
| GOLD | 103.03 | 128.88 | 77.55 | 103.12 | 24.73 | 25.10 |
| IND\_PROC | 160.84 | 173.33 | 148.02 | 160.75 | 7.97 | 7.76 |
| NFME | 2333.95 | 2733.50 | 1930.90 | 2334.21 | 17.27 | 17.12 |
| OTHER | 353.74 | 753.37 | 199.18 | 352.08 | 43.69 | 112.97 |

Figure S2. Global Hg emissions in the Baseline scenario (01\_BAS\_CLE) in 2015. Error bars represent the range of 95% confidence interval.

A graph of different colored bars

Description automatically generated with medium confidence

# S7 – Additional plots.

Figure S3: Global mercury emissions for the BAS activity pathway and all different Hg control strategies – by region.

A group of colorful bars

Description automatically generated with medium confidence

# References.

AMAP/UNEP. 2019. Technical Background Report to the Global Mercury Assessment 2018. Troms: Arctic Monitoring & Assessment Programme, Oslo, Norway / UN Environment Programme, Chemicals; Health Branch. <https://www.mercuryconvention.org/sites/default/files/documents/forms_and_guidance_document/BAT_BEP_E_interractif.pdf>.

Cheng, Chin-Min, Pauline Hack, Paul Chu, Yung-Nan Chang, Ting-Yu Lin, Chih-Sheng Ko, Po-Han Chiang, Cheng-Chun He, Yuan-Min Lai, and Wei-Ping Pan. 2009. “Partitioning of Mercury, Arsenic, Selenium, Boron, and Chloride in a Full-Scale Coal Combustion Process Equipped with Selective Catalytic Reduction, Electrostatic Precipitation, and Flue Gas Desulfurization Systems” 23 (10). American Chemical Society (ACS): 4805–16. doi:[10.1021/ef900293u](https://doi.org/10.1021/ef900293u).

Cui, Jian, Lunbo Duan, Ying Jiang, Changsui Zhao, and Edward John Anthony. 2018. “Migration and Emission of Mercury from Circulating Fluidized Bed Boilers Co-Firing Petroleum Coke and Coal.” Fuel 215 (March). Elsevier BV: 638–46. doi:[10.1016/j.fuel.2017.11.062](https://doi.org/10.1016/j.fuel.2017.11.062).

Dehoust, G., Gebhardt, P., Tebert, C., and Köser, H. 2021a. “Quecksilberemissionenaus industriellen Quellen - Status Quo und Perspektiven. Abschlussbericht - Teil 1: Quecksilber-Entstehungs- und Verbreitungspfade der Industriebranchen in Deutschland”, Umweltbundesamt TEXTE, 67/202.

Dehoust, G., Gebhardt, P., Tebert, C., and Köser, H. 2021b. “Quecksilberemissionenaus industriellen Quellen - Status Quo und Perspektiven. Abschlussbericht - Teil 2: Quecksilberminderungstechniken und Überführung von Quecksilber in Senken”, Umweltbundesamt TEXTE, 68/2021.

Feeley, Thomas J., Andrew P. Jones, Lynn A. Brickett, B. Andrew O’Palko, Charles E. Miller, and James T. Murphy. 2009. “An Update on DOEs Phase II and Phase III Mercury Control Technology R& D Program.” Fuel Processing Technology 90 (11). Elsevier BV: 1388–91. doi:[10.1016/j.fuproc.2009.05.012](https://doi.org/10.1016/j.fuproc.2009.05.012).

Giang, Amanda, Leah C. Stokes, David G. Streets, Elizabeth S. Corbitt, and Noelle E. Selin. 2015. “Impacts of the Minamata Convention on Mercury Emissions and Global Deposition from Coal-Fired Power Generation in Asia.” Environmental Science & Technology 49 (9). American Chemical Society (ACS): 5326–35. doi:[10.1021/acs.est.5b00074](https://doi.org/10.1021/acs.est.5b00074).

Han, Young-Ji, Pyung-Rae Kim, Gang-San Lee, Jae-In Lee, Seam Noh, Seok-Min Yu, Kwang-Su Park, Kwang-Seol Seok, Hyuk Kim, and Young-Hee Kim. 2017. “Mercury Concentrations in Environmental Media at a Hazardous Solid Waste Landfill Site and Mercury Emissions from the Site.” Environmental Earth Sciences 76 (10). Springer Science; Business Media LLC. doi:[10.1007/s12665-017-6700-z](https://doi.org/10.1007/s12665-017-6700-z).

International Centre for Sustainable Carbon (ICSC). 2019. “Emissions Standards”. <https://www.sustainable-carbon.org/download/34924/>, last access: 29 November 2023.

IEA. 2022. World Energy Outlook 2022. Paris: IEA. https://www.iea.org/reports/world-energy-outlook-2022, License: CC BY 4.0 (report); CC BY NC SA 4.0 (Annex A)

Lee, Sung-Woo, Gregory V. Lowry, and Heileen Hsu-Kim. 2016. “Biogeochemical Transformations of Mercury in Solid Waste Landfills and Pathways for Release.” Environmental Science: Processes & Impacts 18 (2). Royal Society of Chemistry (RSC): 176–89. doi:[10.1039/c5em00561b](https://doi.org/10.1039/c5em00561b).

Li, Jiashuo, Sili Zhou, Wendong Wei, Jianchuan Qi, Yumeng Li, Bin Chen, Ning Zhang, et al. 2020. “Chinas Retrofitting Measures in Coal-Fired Power Plants Bring Significant Mercury-Related Health Benefits.” One Earth 3 (6). Elsevier BV: 777–87. doi:[10.1016/j.oneear.2020.11.012](https://doi.org/10.1016/j.oneear.2020.11.012).

Lindberg, Steve E., George R. Southworth, Mary Anna Bogle, T.J. Blasing, Jim Owens, Kelly Roy, Hong Zhang, et al. 2005. “Airborne Emissions of Mercury from Municipal Solid Waste. I: New Measurements from Six Operating Landfills in Florida.” Journal of the Air & Waste Management Association 55 (7). Informa UK Limited: 859–69. doi:[10.1080/10473289.2005.10464684](https://doi.org/10.1080/10473289.2005.10464684).

Liu, Kaiyun, Shuxiao Wang, Qingru Wu, Long Wang, Qiao Ma, Lei Zhang, Guoliang Li, Hezhong Tian, Lei Duan, and Jiming Hao. 2018. “A Highly Resolved Mercury Emission Inventory of Chinese Coal-Fired Power Plants.” Environmental Science & Technology 52 (4). American Chemical Society (ACS): 2400–2408. doi:[10.1021/acs.est.7b06209](https://doi.org/10.1021/acs.est.7b06209).

Niksa Energy Associates LLC. 2011. Interactive Process Optimization Guidance. User Guide and Tutorial. Niksa Energy Associates LLC.

Pacyna, Jozef M., Kyrre Sundseth, Elisabeth G. Pacyna, Wojciech Jozewicz, John Munthe, Mohammed Belhaj, and Stefan Aström. 2010. “An Assessment of Costs and Benefits Associated with Mercury Emission Reductions from Major Anthropogenic Sources.” Journal of the Air & Waste Management Association 60 (3). Informa UK Limited: 302–15. doi:[10.3155/1047-3289.60.3.302](https://doi.org/10.3155/1047-3289.60.3.302).

Wang, Zhaojun, Yangjie Zhang, Lei Wang, Xu Li, Xuhang Zhou, Xiangyun Li, Mengping Yan, et al. 2021. “Characteristics and Risk Assessments of Mercury Pollution Levels at Domestic Garbage Collection Points Distributed Within the Main Urban Areas of Changchun City.” Toxics 9 (11). MDPI AG: 309. doi:[10.3390/toxics9110309](https://doi.org/10.3390/toxics9110309).

Wilcox, J.: Atomistic-Level Models, in: Mercury Control, John Wiley & Sons, Ltd, 389–412, <https://doi.org/10.1002/9783527658787.ch24>, 2014.

Wu, Qingru, Guoliang Li, Shuxiao Wang, Kaiyun Liu, and Jiming Hao. 2018. “Mitigation Options of Atmospheric Hg Emissions in China.” Environmental Science & Technology 52 (21). American Chemical Society (ACS): 12368–75. doi:[10.1021/acs.est.8b03702](https://doi.org/10.1021/acs.est.8b03702).

Zhang, S.; Hui, L.; Wang. 2016. “Potential of Co-Benefit Mercury Control for Coal-Fired Power Plants and Industrial Boilers in China.” Natural Resource Defence Council. <https://www.nrdc.org/sites/default/files/co-benefit-mercury-control-report.pdf>.