Supplementary information

Comparative Life Cycle Assessment of Biomass Co-firing Plants with Carbon Capture and Storage

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# Pulverised coal plant LCI data

Table 1. LCI data for PC plant construction (Bauer, 2008)

|  |  |  |  |
| --- | --- | --- | --- |
| *Plant parameters* |  |  |  |
| Fuel type | Hard coal | Hard coal | Co-firing  (coal and wood) |
| Electric output (MW) | 400 | 800 | 400 |
| Load factor | 85% | 85% | 85% |
| Lifetime (years) | 30 | 30 | 30 |
| Lifetime output (MWh) | 89,352,000 | 178,704,000 | 89,352,000 |
|  |  |  |  |
| *Resources* |  |  |  |
| Transformation, from unknown (m^2) | 4.00E+04 | 8.33E+04 | 6.25E+04 |
| Transformation, to industrial area (m^2) | 2.81E+04 | 5.83E+04 | 4.37E+04 |
| Transformation, to traffic area, road network (m^2) | 1.20E+04 | 2.50E+04 | 1.87E+04 |
| Occupation, industrial area (m^2 a) | 9.28E+05 | 2.04E+06 | 1.53E+06 |
| Occupation, construction site (m^2 a) | 1.61E+05 | 3.33E+05 | 2.50E+05 |
| Occupation, traffic area, road network (m^2 a) | 4.21E+05 | 8.75E+05 | 6.56E+05 |
|  |  |  |  |
| *Materials/fuels* |  |  |  |
| Concrete, normal, al plant/ CH (m^3) | 9.49E+04 | 1.59E+05 | 1.29E+05 |
| Reinforcing steel, at plant/RER (kg) | 7.13E+06 | 1.29E+07 | 9.70E+06 |
| Reinforcing steel, at plant/RER (kg) | 2.87E+06 | 5.18E+06 | 3.90E+06 |
| Steel, low-alloyed, at plant/RER (kg) | 6.04E+06 | 1.09E+07 | 8.21E+06 |
| Chromium steel 18/8, at plant/RER (kg) | 1.64E+07 | 2.97E+07 | 2.23E+07 |
| Steel, electric, un- and low- alloyed, at plant/RER (kg) | 2.42E+05 | 4.37E+05 | 3.29E+05 |
| Building, multi-storey/RER/l (m^3) | 1.73E+04 | 3.12E+04 | 2.35E+04 |
| Aluminium, primary, at plant/RER (kg) | 8.89E+05 | 1.61E+06 | 1.21E+06 |
| Aluminium, secondary, from new scrap, at plant/RER (kg) | 1.05E+05 | 1.89E+05 | 1.43E+05 |
| Aluminium, secondary, from old scrap, at plant/RER (kg) | 5.24E+04 | 9.45E+04 | 7.13E+04 |
| Copper, at regional storage/RER (kg) | 3.08E+05 | 5.56E+05 | 4.19E+05 |
| Brass, at plant/CH (kg) | 1.08E+05 | 1.94E+05 | 1.47E+05 |
| Zinc, primary, at regional storage/RER (kg) | 4.62E+04 | 8.33E+04 | 6.28E+04 |
| Lead, at regional storage/RER (kg) | 3.08E+04 | 5.56E+04 | 4.19E+04 |
| Bitumen, at refinery/RER (kg) | 1.47E+05 | 2.67E+05 | 2.00E+05 |
| Rock wool, at plant/CH (kg) | 1.73E+06 | 3.13E+06 | 2.35E+06 |
| Polyvinylchloride, at regional storage/RER (kg) | 5.65E+05 | 1.02E+06 | 7.68E+05 |
| Polyvinylchloride, at regional storage/RER (kg) | 2.42E+05 | 4.38E+05 | 3.29E+05 |
| Glass fibre, at plant/RER (kg) | 2.42E+05 | 4.38E+05 | 3.29E+05 |
| Polyethylene, HDPE, granulate, at plant/RER (kg) | 6.93E+04 | 1.25E+05 | 9.42E+04 |
| Polypropylene, granulate, at plant/RER (kg) | 3.47E+04 | 6.26E+04 | 4.72E+04 |
| Styrene-acrylonitrile copolymer, SAN, at plant/RER (kg) | 1.16E+04 | 2.09E+04 | 1.58E+04 |
| Flat glass, uncoated, at plant/RER (kg) | 1.17E+04 | 2.11E+04 | 1.59E+04 |
| Glued laminated timber, outdoor use, at plant/RER (m^3) | 3.37E+00 | 6.08E+00 | 4.58E+00 |
| Cast iron, at plant/RER (kg) | 4.35E+05 | 7.85E+05 | 5.92E+05 |
| Epoxy resin, liguid, at plant/RER (kg) | 9.17E+04 | 1.66E+05 | 1.25E+05 |
| Lubricating oil, at plant/RER (kg) | 3.84E+05 | 6.94E+05 | 5.22E+05 |
| Ceramic tiles, at plant/RER (kg) | 1.74E+05 | 3.13E+05 | 2.37E+05 |
| Synthetic rubber, at plant/RER (kg) | 5.26E+04 | 9.49E+04 | 7.15E+04 |
| Electricity, medium voltage, productionCTE, at grid/UCTE (kWh) | 1.31E+07 | 2.36E+07 | 1.78E+07 |
| Electricity, medium voltage, production CENTREL, at grid/CENTREL (kWh) | 1.78E+06 | 3.22E+06 | 2.42E+06 |
| Light fuel oil, burned in industrial furnace 1MW, non-modulating/RER (MJ) | 2.26E+08 | 4.06E+08 | 3.07E+08 |
| Transport, lorry >16t, fleet average/RER (tkm) | 4.38E+06 | 7.90E+06 | 5.96E+06 |
| Transport, freight, rail/RER (tkm) | 1.18E+07 | 2.12E+07 | 1.60E+07 |
|  |  |  |  |
| *Emissions to air* |  |  |  |
| Heat, waste (MJ) | 5.35E+07 | 9.66E+07 | 7.28E+07 |

Table 2. LCI data for PC plants dismantling (Bauer, 2008)

|  |  |  |  |
| --- | --- | --- | --- |
| *Plant parameters* |  |  |  |
| Fuel type | Hard coal | Hard coal | Co-firing (coal and wood) |
| Electric output (MW) | 400 | 800 | 400 |
| Load factor | 85% | 85% | 85% |
| Lifetime (years) | 30 | 30 | 30 |
| Lifetime output (MWh) | 89,352,000 | 178,704,000 | 89,352,000 |
|  |  |  |  |
| *Disposal* |  |  |  |
| building, concrete, not reinforced, to sorting plant/CH (kg) | 2.26E+08 | 3.79E+08 | 3.06E+08 |
| building, reinforcement steel, to sorting plant/CH (kg) | 7.13E+06 | 1.29E+07 | 9.65E+06 |
| building, bitumen sheet, to final disposal/CH (kg) | 1.47E+05 | 2.67E+05 | 2.00E+05 |
| building, mineral wool, to sorting plant/CH (kg) | 1.73E+06 | 3.13E+06 | 2.34E+06 |
| building, polyvinylcholoride products, to final disposal/CH (kg) | 5.65E+05 | 1.02E+06 | 7.66E+05 |
| polyvinylchloride, 0.2% water, to municipal incineration/CH (kg) | 2.42E+05 | 4.38E+05 | 3.28E+05 |
| building, mineral wool, to sorting plant/CH (kg) | 242000 | 4.38E+05 | 3.28E+05 |
| building, polyethylene/polypropylene products, to final disposal/CH (kg) | 1.16E+05 | 2.09E+05 | 1.56E+05 |
| building, glass sheet, to sorting plant/CH (kg) | 1.17E+04 | 2.11E+04 | 1.58E+04 |
| building, waste wood, untreated, to final disposal/CH (kg) | 3.37E+00 | 6.08E+00 | 4.56E+00 |
| building, emulsion paint remains, to final disposal/CH (kg) | 9.17E+04 | 1.66E+05 | 1.24E+05 |
| used mineral oil, 10% water, to hazardous waste incineration/CH (kg) | 3.84E+05 | 6.94E+05 | 5.21E+05 |
| inert waste, 5% water, to inert material landfill/CH (kg) | 1.74E+05 | 3.13E+05 | 2.35E+05 |
| rubber, unspecified, 0% water, to municipal incineration/CH (kg) | 5.26E+04 | 9.49E+04 | 7.11E+04 |

# Ecoinvent data

Table 3. Ecoinvent data (Recipe, Midpoint H) of fuel production and transport.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Impact Category** | *Unit* | Coal (kg) | Wood pellets (kg) | Straw pellets (kg) |
| Climate change | *kg CO2 eq.* | 2.29E-01 | 2.81E-01 | 2.87E-01 |
| Ozone depletion | *kg CFC-11 eq.* | 1.84E-08 | 2.35E-08 | 2.35E-08 |
| Human toxicity | *kg 1.4-DB eq.* | 7.04E-01 | 1.09E-01 | 1.16E-01 |
| Photochemical oxidant formation | *kg NMVOC* | 3.35E-03 | 2.45E-03 | 2.40E-03 |
| Particulate matter formation | *kg PM10 eq.* | 1.18E-03 | 1.03E-03 | 1.03E-03 |
| Ionising radiation | *kg U235 eq.* | 4.23E-02 | 1.26E-01 | 1.34E-01 |
| Terrestrial acidification | *kg SO2 eq.* | 3.74E-03 | 3.22E-03 | 3.24E-03 |
| Freshwater eutrophication | *kg P eq.* | 1.14E-03 | 1.59E-04 | 1.70E-04 |
| Marine eutrophication | *kg N eq.* | 1.36E-03 | 8.37E-04 | 8.33E-04 |
| Terrestrial ecotoxicity | *kg 1,4-DB eq.* | 1.66E-05 | 2.44E-05 | 2.44E-05 |
| Freshwater ecotoxicity | *kg 1,4-DB eq.* | 1.60E-02 | 2.35E-03 | 2.48E-03 |
| Marine ecotoxicity | *kg 1,4-DB eq.* | 1.58E-02 | 2.67E-03 | 2.80E-03 |
| Agricultural land occupation | *m2a* | 1.38E-02 | 4.99E-01 | 2.53E-01 |
| Urban land occupation | *m2a* | 1.61E-02 | 6.13E-03 | 1.33E-03 |
| Natural land transformation | *m2* | 1.34E-04 | 1.14E-04 | 7.94E-05 |
| Water depletion | *m3* | 2.12E-03 | 1.52E-03 | 1.56E-03 |
| Metal depletion | *kg Fe eq.* | 5.08E-03 | 6.09E-03 | 5.26E-03 |
| Fossil depletion | *kg oil eq.* | 6.37E-01 | 8.89E-02 | 9.06E-02 |

Table 4. Ecoinvent data (Recipe Midpoint H) of chemicals pulverised coal plant.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Impact Category** | *Unit* | Activated carbon (kg) | Ammonia (kg) | Limestone (kg) | MEA (kg) | NaOH (kg) | Quicklime (kg) | Sulphuric acid (kg) | TiO2 (kg) | Water (L) |
| Climate change | *kg CO2 eq.* | 1.00E+00 | 2.10E+00 | 1.32E-02 | 3.44E+00 | 1.10E+00 | 9.78E-01 | 1.24E-01 | 1.80E-01 | 0 |
| Ozone depletion | *kg CFC-11 eq.* | 1.01E-08 | 3.38E-07 | 1.80E-09 | 3.24E-07 | 6.70E-08 | 6.82E-08 | 1.27E-08 | 4.95E-09 | 0 |
| Human toxicity | *kg 1.4-DB eq.* | 7.22E-02 | 3.86E-01 | 2.84E-03 | 8.66E-01 | 1.11E+00 | 1.38E-02 | 1.00E-01 | 6.55E-02 | 0 |
| Photochemical oxidant formation | *kg NMVOC* | 1.56E-02 | 3.74E-03 | 7.65E-05 | 8.31E-03 | 2.49E-03 | 1.25E-03 | 1.89E-03 | 6.61E-04 | 0 |
| Particulate matter formation | *kg PM10 eq.* | 8.47E-04 | 2.11E-03 | 8.18E-05 | 3.97E-03 | 1.55E-03 | 3.94E-04 | 2.83E-03 | 6.15E-04 | 0 |
| Ionising radiation | *kg U235 eq.* | 4.65E-02 | 9.53E-02 | 1.18E-02 | 4.92E-01 | 7.97E-01 | 4.86E-02 | 2.97E-02 | 1.68E-02 | 0 |
| Terrestrial acidification | *kg SO2 eq.* | 6.98E-04 | 5.76E-03 | 6.86E-05 | 1.35E-02 | 4.72E-03 | 8.20E-04 | 1.33E-02 | 6.17E-04 | 0 |
| Freshwater eutrophication | *kg P eq.* | 5.57E-05 | 1.89E-04 | 2.68E-06 | 7.69E-04 | 1.08E-03 | 1.33E-05 | 7.23E-05 | 1.02E-04 | 0 |
| Marine eutrophication | *kg N eq.* | 3.13E-04 | 1.08E-03 | 2.46E-05 | 6.20E-03 | 1.07E-03 | 2.51E-04 | 3.18E-04 | 1.76E-04 | 0 |
| Terrestrial ecotoxicity | *kg 1,4-DB eq.* | 3.12E-04 | 3.98E-04 | 3.52E-06 | 3.84E-04 | 1.64E-04 | 1.16E-05 | 1.79E-05 | 1.48E-05 | 0 |
| Freshwater ecotoxicity | *kg 1,4-DB eq.* | 9.31E-04 | 4.58E-03 | 5.70E-05 | 1.42E-02 | 1.65E-02 | 3.60E-04 | 1.67E-03 | 1.74E-03 | 0 |
| Marine ecotoxicity | *kg 1,4-DB eq.* | 9.73E-04 | 8.23E-03 | 7.83E-05 | 1.72E-02 | 1.69E-02 | 2.75E-04 | 1.80E-03 | 1.75E-03 | 0 |
| Agricultural land occupation | *m2a* | 4.29E+00 | 1.35E-02 | 7.78E-05 | 3.75E-02 | 2.88E-02 | 3.13E-04 | 7.86E-03 | 1.13E-01 | 0 |
| Urban land occupation | *m2a* | 4.25E-02 | 4.97E-03 | 1.19E-04 | 1.05E-02 | 5.96E-03 | 3.83E-04 | 1.68E-03 | 2.65E-03 | 0 |
| Natural land transformation | *m2* | 3.17E-04 | 8.67E-04 | 4.57E-06 | 8.16E-04 | 1.37E-04 | 4.66E-05 | 5.00E-05 | 3.07E-05 | 0 |
| Water depletion | *m3* | 9.62E-04 | 4.02E-03 | 1.27E-04 | 1.05E-02 | 1.42E-02 | 7.28E-04 | 4.97E-02 | 1.56E-03 | 0 |
| Metal depletion | *kg Fe eq.* | 1.04E-02 | 7.09E-02 | 1.32E-03 | 1.65E-01 | 8.48E-02 | 2.26E-03 | 3.71E-02 | 1.30E-01 | 0 |
| Fossil depletion | *kg oil eq.* | 3.62E-02 | 9.69E-01 | 4.37E-03 | 1.94E+00 | 3.16E-01 | 1.19E-01 | 4.09E-02 | 6.27E-02 | 0 |

Table 5. Ecoinvent data (Recipe Midpoint H) of waste and by products pulverised coal plant.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Impact Category** | *Unit* | Bottom ash (kg) | Fly ash (kg) | Gypsum (kg) | HSS (kg) | TiO2 disposal (kg) | Waste FGD (kg) |
| Climate change | *kg CO2 eq.* | 0 | 0 | 0 | 1.80E-01 | 1.80E-01 | 4.98E-01 |
| Ozone depletion | *kg CFC-11 eq.* | 0 | 0 | 0 | 4.95E-09 | 4.95E-09 | 3.38E-09 |
| Human toxicity | *kg 1.4-DB eq.* | 0 | 0 | 0 | 6.55E-02 | 6.55E-02 | 4.43E-01 |
| Photochemical oxidant formation | *kg NMVOC* | 0 | 0 | 0 | 6.61E-04 | 6.61E-04 | 3.67E-04 |
| Particulate matter formation | *kg PM10 eq.* | 0 | 0 | 0 | 6.15E-04 | 6.15E-04 | 4.95E-05 |
| Ionising radiation | *kg U235 eq.* | 0 | 0 | 0 | 1.68E-02 | 1.68E-02 | 8.81E-03 |
| Terrestrial acidification | *kg SO2 eq.* | 0 | 0 | 0 | 6.17E-04 | 6.17E-04 | 1.19E-04 |
| Freshwater eutrophication | *kg P eq.* | 0 | 0 | 0 | 1.02E-04 | 1.02E-04 | 1.38E-05 |
| Marine eutrophication | *kg N eq.* | 0 | 0 | 0 | 1.76E-04 | 1.76E-04 | 2.83E-03 |
| Terrestrial ecotoxicity | *kg 1,4-DB eq.* | 0 | 0 | 0 | 1.48E-05 | 1.48E-05 | 1.07E-05 |
| Freshwater ecotoxicity | *kg 1,4-DB eq.* | 0 | 0 | 0 | 1.74E-03 | 1.74E-03 | 2.19E-02 |
| Marine ecotoxicity | *kg 1,4-DB eq.* | 0 | 0 | 0 | 1.75E-03 | 1.75E-03 | 1.93E-02 |
| Agricultural land occupation | *m2a* | 0 | 0 | 0 | 1.13E-01 | 1.13E-01 | 3.44E-04 |
| Urban land occupation | *m2a* | 0 | 0 | 0 | 2.65E-03 | 2.65E-03 | 3.76E-03 |
| Natural land transformation | *m2* | 0 | 0 | 0 | 3.07E-05 | 3.07E-05 | -4.36E-05 |
| Water depletion | *m3* | 0 | 0 | 0 | 1.56E-03 | 1.56E-03 | 3.37E-04 |
| Metal depletion | *kg Fe eq.* | 0 | 0 | 0 | 1.30E-01 | 1.30E-01 | 9.98E-04 |
| Fossil depletion | *kg oil eq.* | 0 | 0 | 0 | 6.27E-02 | 6.27E-02 | 7.52E-03 |

Table 6. Ecoinvent data (Recipe Midpoint H) of chemicals and waste/by products IGCC.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Impact Category** | *Unit* | Claus catalyst (kg) | COS catalyst (kg) | Sulphur (kg) | Selexol (kg) | Slag (kg) | Water (L) | WGS catalyst (kg) |
| Climate change | *kg CO2 eq.* | 1.23E+00 | 4.56E+00 | 0 | 1.85E+00 | 0 | 0 | 1.96E+00 |
| Ozone depletion | *kg CFC-11 eq.* | 1.53E-07 | 7.68E-07 | 0 | 9.11E-08 | 0 | 0 | 1.85E-07 |
| Human toxicity | *kg 1.4-DB eq.* | 6.76E-01 | 1.41E+00 | 0 | 3.59E-01 | 0 | 0 | 7.90E+01 |
| Photochemical oxidant formation | *kg NMVOC* | 4.80E-03 | 1.70E-02 | 0 | 5.20E-03 | 0 | 0 | 2.22E-02 |
| Particulate matter formation | *kg PM10 eq.* | 5.23E-03 | 1.23E-02 | 0 | 1.57E-03 | 0 | 0 | 2.58E-02 |
| Ionising radiation | *kg U235 eq.* | 1.92E-01 | 1.10E+00 | 0 | 2.83E-01 | 0 | 0 | 4.82E-01 |
| Terrestrial acidification | *kg SO2 eq.* | 5.57E-03 | 3.20E-02 | 0 | 4.50E-03 | 0 | 0 | 2.33E-02 |
| Freshwater eutrophication | *kg P eq.* | 4.88E-04 | 1.62E-03 | 0 | 4.46E-04 | 0 | 0 | 4.70E-02 |
| Marine eutrophication | *kg N eq.* | 1.52E-03 | 5.27E-03 | 0 | 1.14E-03 | 0 | 0 | 1.05E-02 |
| Terrestrial ecotoxicity | *kg 1,4-DB eq.* | 2.88E-04 | 3.07E-04 | 0 | 7.83E-05 | 0 | 0 | 6.53E-04 |
| Freshwater ecotoxicity | *kg 1,4-DB eq.* | 3.36E-02 | 3.22E-02 | 0 | 7.38E-03 | 0 | 0 | 9.63E-01 |
| Marine ecotoxicity | *kg 1,4-DB eq.* | 3.52E-02 | 3.41E-02 | 0 | 7.39E-03 | 0 | 0 | 8.95E-01 |
| Agricultural land occupation | *m2a* | 5.58E-03 | 5.81E-02 | 0 | 1.56E-02 | 0 | 0 | 5.77E-02 |
| Urban land occupation | *m2a* | 8.59E-03 | 2.05E-02 | 0 | 3.89E-03 | 0 | 0 | 1.56E-01 |
| Natural land transformation | *m2* | 3.33E-04 | 1.21E-03 | 0 | 2.23E-04 | 0 | 0 | 9.36E-04 |
| Water depletion | *m3* | 4.89E-03 | 7.08E-02 | 0 | 5.96E-03 | 0 | 0 | 5.71E-02 |
| Metal depletion | *kg Fe eq.* | 7.23E-02 | 1.75E-01 | 0 | 5.15E-02 | 0 | 0 | 4.33E+01 |
| Fossil depletion | *kg oil eq.* | 4.09E-01 | 1.77E+00 | 0 | 1.40E+00 | 0 | 0 | 6.00E-01 |

Table 7. Ecoinvent data (Recipe Midpoint H) of plant infrastructure

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Impact Category** | *Unit* | PC 100% coal construction (kWh) | PC co-firing construction (kWh) | PC 100% coal dismantle (kWh) | PC co-firing dismantle (kWh) | CO2 capture (kg CO2) | CO2 compression (kg CO2) |
| Climate change | *kg CO2 eq.* | 1.77E-03 | 2.41E-03 | 7.52E-05 | 1.02E-04 | 2.63E-08 | 2.95E-04 |
| Ozone depletion | *kg CFC-11 eq.* | 1.03E-10 | 1.41E-10 | 6.67E-12 | 9.02E-12 | 3.23E-15 | 4.55E-13 |
| Human toxicity | *kg 1.4-DB eq.* | 1.44E-03 | 1.96E-03 | 1.76E-04 | 2.38E-04 | 5.84E-09 | 1.46E-05 |
| Photochemical oxidant formation | *kg NMVOC* | 5.37E-06 | 7.32E-06 | 4.16E-07 | 5.63E-07 | 1.79E-10 | 5.02E-08 |
| Particulate matter formation | *kg PM10 eq.* | 5.64E-06 | 7.69E-06 | 2.93E-07 | 3.97E-07 | 5.78E-11 | 1.93E-08 |
| Ionising radiation | *kg U235 eq.* | 2.88E-04 | 3.93E-04 | 1.28E-05 | 1.73E-05 | 2.72E-09 | 5.06E-07 |
| Terrestrial acidification | *kg SO2 eq.* | 7.15E-06 | 9.74E-06 | 2.61E-07 | 3.53E-07 | 1.15E-10 | 4.27E-08 |
| Freshwater eutrophication | *kg P eq.* | 9.43E-07 | 1.28E-06 | 1.05E-08 | 1.42E-08 | 4.63E-12 | 6.72E-09 |
| Marine eutrophication | *kg N eq.* | 1.63E-06 | 2.22E-06 | 1.36E-07 | 1.84E-07 | 5.86E-11 | 1.63E-08 |
| Terrestrial ecotoxicity | *kg 1,4-DB eq.* | 3.02E-07 | 4.11E-07 | 5.08E-09 | 6.88E-09 | 3.70E-12 | 1.29E-09 |
| Freshwater ecotoxicity | *kg 1,4-DB eq.* | 7.10E-05 | 9.67E-05 | 3.51E-06 | 4.75E-06 | 1.22E-10 | 1.51E-07 |
| Marine ecotoxicity | *kg 1,4-DB eq.* | 7.52E-05 | 1.03E-04 | 3.33E-06 | 4.50E-06 | 1.34E-10 | 1.75E-07 |
| Agricultural land occupation | *m2a* | 6.17E-05 | 8.41E-05 | 5.09E-07 | 6.89E-07 | 2.07E-10 | 3.72E-08 |
| Urban land occupation | *m2a* | 3.66E-05 | 5.44E-05 | 3.55E-06 | 4.81E-06 | 2.67E-10 | 3.34E-08 |
| Natural land transformation | *m2* | 4.96E-07 | 7.13E-07 | -2.54E-08 | -3.44E-08 | 7.71E-12 | 1.81E-09 |
| Water depletion | *m3* | 1.32E-05 | 1.81E-05 | 4.45E-07 | 6.03E-07 | 1.63E-10 | 2.09E-08 |
| Metal depletion | *kg Fe eq.* | 2.74E-03 | 3.74E-03 | 2.45E-06 | 3.31E-06 | 3.92E-09 | 3.78E-06 |
| Fossil depletion | *kg oil eq.* | 5.12E-04 | 6.98E-04 | 1.67E-05 | 2.25E-05 | 8.73E-09 | 2.04E-06 |

Table 8. Ecoinvent data (Recipe Midpoint H) of direct emissions (per kg) to air.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Impact Category** | *Unit* | CO2 | HCl | HF | Hg | MEA | NH3 | NO | NO2 | PM (mix[[1]](#footnote-2)) | PM (< 10 μm) | Se | SO2 |
| Climate change | *kg CO2 eq.* | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ozone depletion | *kg CFC-11 eq.* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Human toxicity | *kg 1.4-DB eq.* | 0 | 0 | 8.2 | 56600 | 0 | 0 | 0 | 0 | 0 | 0 | 9170 | 0 |
| Photochemical oxidant formation | *kg NMVOC* | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0.081 |
| Particulate matter formation | *kg PM10 eq.* | 0 | 0 | 0 | 0 | 0 | 0.32 | 0.22 | 0.22 | 1 | 0.95 | 0 | 0.2 |
| Ionising radiation | *kg U235 eq.* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Terrestrial acidification | *kg SO2 eq.* | 0 | 0 | 0 | 0 | 0 | 2.45 | 0.56 | 0.56 | 0 | 0 | 0 | 1 |
| Freshwater eutrophication | *kg P eq.* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Marine eutrophication | *kg N eq.* | 0 | 0 | 0 | 0 | 0 | 0.09 | 0.39 | 0.39 | 0 | 0 | 0 | 0 |
| Terrestrial ecotoxicity | *kg 1,4-DB eq.* | 0 | 0 | 0 | 78.7 | 1.32E-02 | 0 | 0 | 0 | 0 | 0 | 18.9 | 0 |
| Freshwater ecotoxicity | *kg 1,4-DB eq.* | 0 | 0 | 0 | 2.52 | 1.13E-03 | 0 | 0 | 0 | 0 | 0 | 10.9 | 0 |
| Marine ecotoxicity | *kg 1,4-DB eq.* | 0 | 0 | 0 | 659 | 6.86E-04 | 0 | 0 | 0 | 0 | 0 | 56.3 | 0 |
| Agricultural land occupation | *m2a* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urban land occupation | *m2a* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Natural land transformation | *m2* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Water depletion | *m3* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Metal depletion | *kg Fe eq.* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Fossil depletion | *kg oil eq.* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table 9. Ecoinvent data (Recipe, Midpoint H) of CO2 transport and storage infrastructure

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Impact Category** | *Unit* | CO2 transport PC (kg CO2) | CO2 transport IGCC (kg CO2) | CO2 storage (kg CO2) |
| Climate change | *kg CO2 eq.* | 5.65E-04 | 5.03E-04 | 2.08E-04 |
| Ozone depletion | *kg CFC-11 eq.* | 3.32E-11 | 2.93E-11 | 2.26E-11 |
| Human toxicity | *kg 1.4-DB eq.* | 2.76E-04 | 2.44E-04 | 4.23E-05 |
| Photochemical oxidant formation | *kg NMVOC* | 2.52E-06 | 2.22E-06 | 2.78E-06 |
| Particulate matter formation | *kg PM10 eq.* | 1.50E-06 | 1.32E-06 | 9.86E-07 |
| Ionising radiation | *kg U235 eq.* | 7.89E-05 | 6.96E-05 | 1.53E-05 |
| Terrestrial acidification | *kg SO2 eq.* | 2.04E-06 | 1.80E-06 | 2.06E-06 |
| Freshwater eutrophication | *kg P eq.* | 2.43E-07 | 2.14E-07 | 3.15E-08 |
| Marine eutrophication | *kg N eq.* | 7.58E-07 | 6.69E-07 | 8.94E-07 |
| Terrestrial ecotoxicity | *kg 1,4-DB eq.* | 1.05E-07 | 9.25E-08 | 1.74E-08 |
| Freshwater ecotoxicity | *kg 1,4-DB eq.* | 7.24E-06 | 6.39E-06 | 7.20E-07 |
| Marine ecotoxicity | *kg 1,4-DB eq.* | 1.11E-05 | 9.82E-06 | 4.43E-05 |
| Agricultural land occupation | *m2a* | 1.09E-05 | 9.59E-06 | 1.16E-06 |
| Urban land occupation | *m2a* | 5.64E-06 | 4.98E-06 | 2.21E-05 |
| Natural land transformation | *m2* | 1.27E-07 | 1.12E-07 | 2.15E-05 |
| Water depletion | *m3* | 5.41E-06 | 4.77E-06 | 3.90E-06 |
| Metal depletion | *kg Fe eq.* | 2.18E-04 | 1.92E-04 | 1.80E-05 |
| Fossil depletion | *kg oil eq.* | 1.58E-04 | 1.39E-04 | 7.34E-05 |

# CO2 balances (exact figures)

Table 10. CO2 emissions (g CO2 eq. per kWh) for pulverised coal (PC) plant and gasification plant (IGCC) cases with and without 30% co-firing wood pellets (W) or straw pellets (S) with and without carbon capture and storage. “Net CO2 emissions” are total emissions minus emissions from co-firing biomass.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Scenario | Coal mining and transport | Pellet production and transport | Direct emissions at power plant | Indirect emissions and processes | CO2 transport and storage | Net CO2 emissions |
| PC | 77 | - | 818 | 8 | - | 903 |
| PC + CCS | 107 | - | 113 | 17 | 1 | 238 |
| PC (30% W) | 54 | -201 | 828 | 8 | - | 689 |
| PC (30% W) + CCS | 76 | -283 | 116 | 17 | 1 | -72 |
| PC (30% S) | 54 | -199 | 832 | 8 | - | 695 |
| PC (30% S) + CCS | 76 | -279 | 117 | 18 | 1 | -67 |
| IGCC | 75 | - | 763 | 2 | - | 840 |
| IGCC + CCS | 101 | - | 103 | 3 | 1 | 208 |
| IGCC (30% W) | 55 | -203 | 812 | 3 | - | 667 |
| IGCC (30% W) + CCS | 73 | -270 | 108 | 4 | 1 | -85 |
| IGCC (30% S) | 55 | -200 | 816 | 3 | - | 673 |
| IGCC (30% S) + CCS | 73 | -267 | 109 | 4 | 1 | -81 |

# Quantitative results (midpoints)

Table 11. Results PC

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Environmental category | Coal mining and transport | Pellet production and transport | Direct emissions at power plant | Indirect emissions and processes | CO2 transport and storage | Total |
| Climate change | 7.73E-02 | - | 8.18E-01 | 7.85E-03 | - | 9.03E-01 |
| Ozone depletion | 6.20E-09 | - | 0.00E+00 | 6.81E-10 | - | 6.88E-09 |
| Human toxicity | 2.38E-01 | - | 4.49E-04 | 2.65E-03 | - | 2.41E-01 |
| Photochemical oxidant formation | 1.13E-03 | - | 3.03E-04 | 2.05E-05 | - | 1.45E-03 |
| Particulate matter formation | 3.98E-04 | - | 1.79E-04 | 1.81E-05 | - | 5.96E-04 |
| Ionising radiation | 1.43E-02 | - | 0.00E+00 | 1.39E-03 | - | 1.57E-02 |
| Terrestrial acidification | 1.26E-03 | - | 4.97E-04 | 3.68E-05 | - | 1.80E-03 |
| Freshwater eutrophication | 3.86E-04 | - | 0.00E+00 | 1.45E-06 | - | 3.87E-04 |
| Marine eutrophication | 4.59E-04 | - | 1.07E-04 | 7.99E-06 | - | 5.74E-04 |
| Terrestrial ecotoxicity | 5.60E-06 | - | 7.52E-07 | 8.28E-07 | - | 7.19E-06 |
| Freshwater ecotoxicity | 5.41E-03 | - | 2.38E-07 | 1.05E-04 | - | 5.51E-03 |
| Marine ecotoxicity | 5.33E-03 | - | 4.18E-06 | 1.10E-04 | - | 5.44E-03 |
| Agricultural land occupation | 4.66E-03 | - | 0.00E+00 | 9.33E-05 | - | 4.75E-03 |
| Urban land occupation | 5.44E-03 | - | 0.00E+00 | 5.84E-05 | - | 5.50E-03 |
| Natural land transformation | 4.52E-05 | - | 0.00E+00 | 1.45E-06 | - | 4.66E-05 |
| Water depletion | 7.17E-04 | - | 0.00E+00 | 9.59E-05 | - | 8.13E-04 |
| Metal depletion | 1.71E-03 | - | 0.00E+00 | 2.94E-03 | - | 4.66E-03 |
| Fossil depletion | 2.15E-01 | - | 0.00E+00 | 1.85E-03 | - | 2.17E-01 |

Table 12. Results PC + CCS

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Environmental category | Coal mining and transport | Pellet production and transport | Direct emissions at power plant | Indirect emissions and processes | CO2 transport and storage | Total |
| Climate change | 1.07E-01 | - | 1.13E-01 | 1.09E-02 | 7.52E-04 | 2.32E-01 |
| Ozone depletion | 8.56E-09 | - | 0.00E+00 | 9.48E-10 | 5.30E-11 | 9.56E-09 |
| Human toxicity | 3.29E-01 | - | 6.21E-04 | 3.66E-03 | 3.17E-04 | 3.33E-01 |
| Photochemical oxidant formation | 1.56E-03 | - | 3.77E-04 | 2.86E-05 | 4.92E-06 | 1.97E-03 |
| Particulate matter formation | 5.50E-04 | - | 1.65E-04 | 2.52E-05 | 2.36E-06 | 7.42E-04 |
| Ionising radiation | 1.97E-02 | - | 0.00E+00 | 1.94E-03 | 9.33E-05 | 2.18E-02 |
| Terrestrial acidification | 1.75E-03 | - | 5.47E-04 | 5.14E-05 | 3.83E-06 | 2.35E-03 |
| Freshwater eutrophication | 5.33E-04 | - | 0.00E+00 | 2.01E-06 | 2.74E-07 | 5.36E-04 |
| Marine eutrophication | 6.34E-04 | - | 1.58E-04 | 1.11E-05 | 1.53E-06 | 8.05E-04 |
| Terrestrial ecotoxicity | 7.74E-06 | - | 1.22E-06 | 1.15E-06 | 1.21E-07 | 1.02E-05 |
| Freshwater ecotoxicity | 7.47E-03 | - | 3.44E-07 | 1.46E-04 | 7.98E-06 | 7.62E-03 |
| Marine ecotoxicity | 7.36E-03 | - | 5.79E-06 | 1.53E-04 | 4.90E-05 | 7.57E-03 |
| Agricultural land occupation | 6.44E-03 | - | 0.00E+00 | 1.29E-04 | 1.20E-05 | 6.58E-03 |
| Urban land occupation | 7.51E-03 | - | 0.00E+00 | 8.10E-05 | 2.45E-05 | 7.62E-03 |
| Natural land transformation | 6.24E-05 | - | 0.00E+00 | 2.01E-06 | 1.83E-05 | 8.28E-05 |
| Water depletion | 9.90E-04 | - | 0.00E+00 | 1.34E-04 | 8.81E-06 | 1.13E-03 |
| Metal depletion | 2.37E-03 | - | 0.00E+00 | 4.07E-03 | 2.37E-04 | 6.67E-03 |
| Fossil depletion | 2.97E-01 | - | 0.00E+00 | 2.57E-03 | 2.23E-04 | 3.00E-01 |

Table 13. Results PC (30% W)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Environmental category | Coal mining and transport | Pellet production and transport | Direct emissions at power plant | Indirect emissions and processes | CO2 transport and storage | Total |
| Climate change | 5.44E-02 | -2.11E-01 | 8.28E-01 | 7.77E-03 | - | 6.79E-01 |
| Ozone depletion | 4.36E-09 | 3.43E-09 | 0.00E+00 | 7.15E-10 | - | 8.51E-09 |
| Human toxicity | 1.67E-01 | 1.60E-02 | 4.05E-04 | 3.20E-03 | - | 1.87E-01 |
| Photochemical oxidant formation | 7.96E-04 | 3.58E-04 | 2.95E-04 | 2.14E-05 | - | 1.47E-03 |
| Particulate matter formation | 2.80E-04 | 1.50E-04 | 1.51E-04 | 1.88E-05 | - | 6.00E-04 |
| Ionising radiation | 1.00E-02 | 1.85E-02 | 0.00E+00 | 1.35E-03 | - | 2.99E-02 |
| Terrestrial acidification | 8.90E-04 | 4.71E-04 | 3.99E-04 | 3.64E-05 | - | 1.80E-03 |
| Freshwater eutrophication | 2.72E-04 | 2.33E-05 | 0.00E+00 | 1.92E-06 | - | 2.97E-04 |
| Marine eutrophication | 3.23E-04 | 1.22E-04 | 1.07E-04 | 7.80E-06 | - | 5.60E-04 |
| Terrestrial ecotoxicity | 3.94E-06 | 3.57E-06 | 6.38E-07 | 8.94E-07 | - | 9.05E-06 |
| Freshwater ecotoxicity | 3.80E-03 | 3.44E-04 | 2.30E-07 | 1.29E-04 | - | 4.28E-03 |
| Marine ecotoxicity | 3.75E-03 | 3.91E-04 | 3.27E-06 | 1.36E-04 | - | 4.28E-03 |
| Agricultural land occupation | 3.28E-03 | 7.30E-02 | 0.00E+00 | 1.33E-04 | - | 7.64E-02 |
| Urban land occupation | 3.83E-03 | 8.97E-04 | 0.00E+00 | 7.63E-05 | - | 4.80E-03 |
| Natural land transformation | 3.18E-05 | 1.66E-05 | 0.00E+00 | 1.68E-06 | - | 5.01E-05 |
| Water depletion | 5.04E-04 | 2.23E-04 | 0.00E+00 | 8.78E-05 | - | 8.15E-04 |
| Metal depletion | 1.21E-03 | 8.91E-04 | 0.00E+00 | 3.93E-03 | - | 6.03E-03 |
| Fossil depletion | 1.51E-01 | 1.30E-02 | 0.00E+00 | 2.06E-03 | - | 1.66E-01 |

Table 14. Results PC (30% W) + CCS

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Environmental category | Coal mining and transport | Pellet production and transport | Direct emissions at power plant | Indirect emissions and processes | CO2 transport and storage | Total |
| Climate change | 7.64E-02 | -2.96E-01 | 1.16E-01 | 1.10E-02 | 7.73E-04 | -9.13E-02 |
| Ozone depletion | 6.12E-09 | 4.82E-09 | 0.00E+00 | 1.01E-09 | 5.44E-11 | 1.20E-08 |
| Human toxicity | 2.35E-01 | 2.25E-02 | 4.59E-04 | 4.50E-03 | 3.26E-04 | 2.63E-01 |
| Photochemical oxidant formation | 1.12E-03 | 5.02E-04 | 3.76E-04 | 3.02E-05 | 5.06E-06 | 2.03E-03 |
| Particulate matter formation | 3.93E-04 | 2.11E-04 | 1.59E-04 | 2.66E-05 | 2.43E-06 | 7.92E-04 |
| Ionising radiation | 1.41E-02 | 2.60E-02 | 0.00E+00 | 1.92E-03 | 9.58E-05 | 4.21E-02 |
| Terrestrial acidification | 1.25E-03 | 6.62E-04 | 5.53E-04 | 5.15E-05 | 3.93E-06 | 2.52E-03 |
| Freshwater eutrophication | 3.81E-04 | 3.27E-05 | 0.00E+00 | 2.70E-06 | 2.82E-07 | 4.17E-04 |
| Marine eutrophication | 4.53E-04 | 1.72E-04 | 1.59E-04 | 1.10E-05 | 1.57E-06 | 7.96E-04 |
| Terrestrial ecotoxicity | 5.53E-06 | 5.01E-06 | 9.83E-07 | 1.26E-06 | 1.25E-07 | 1.29E-05 |
| Freshwater ecotoxicity | 5.34E-03 | 4.83E-04 | 3.35E-07 | 1.81E-04 | 8.20E-06 | 6.01E-03 |
| Marine ecotoxicity | 5.26E-03 | 5.48E-04 | 3.85E-06 | 1.91E-04 | 5.03E-05 | 6.05E-03 |
| Agricultural land occupation | 4.60E-03 | 1.02E-01 | 0.00E+00 | 1.87E-04 | 1.24E-05 | 1.07E-01 |
| Urban land occupation | 5.37E-03 | 1.26E-03 | 0.00E+00 | 1.07E-04 | 2.51E-05 | 6.76E-03 |
| Natural land transformation | 4.46E-05 | 2.33E-05 | 0.00E+00 | 2.36E-06 | 1.88E-05 | 8.91E-05 |
| Water depletion | 7.08E-04 | 3.13E-04 | 0.00E+00 | 1.24E-04 | 9.05E-06 | 1.15E-03 |
| Metal depletion | 1.69E-03 | 1.25E-03 | 0.00E+00 | 5.52E-03 | 2.44E-04 | 8.71E-03 |
| Fossil depletion | 2.12E-01 | 1.82E-02 | 0.00E+00 | 2.90E-03 | 2.29E-04 | 2.34E-01 |

Table 15. Results PC (30% S)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Environmental category | Coal mining and transport | Pellet production and transport | Direct emissions at power plant | Indirect emissions and processes | CO2 transport and storage | Total |
| Climate change | 5.44E-02 | -2.10E-01 | 8.32E-01 | 8.00E-03 | - | 6.85E-01 |
| Ozone depletion | 4.36E-09 | 3.76E-09 | 0.00E+00 | 7.22E-10 | - | 8.85E-09 |
| Human toxicity | 1.67E-01 | 1.85E-02 | 3.31E-04 | 3.35E-03 | - | 1.90E-01 |
| Photochemical oxidant formation | 7.96E-04 | 3.83E-04 | 2.95E-04 | 2.17E-05 | - | 1.50E-03 |
| Particulate matter formation | 2.80E-04 | 1.64E-04 | 1.52E-04 | 1.91E-05 | - | 6.15E-04 |
| Ionising radiation | 1.00E-02 | 2.15E-02 | 0.00E+00 | 1.38E-03 | - | 3.29E-02 |
| Terrestrial acidification | 8.90E-04 | 5.18E-04 | 4.05E-04 | 3.69E-05 | - | 1.85E-03 |
| Freshwater eutrophication | 2.72E-04 | 2.71E-05 | 0.00E+00 | 1.93E-06 | - | 3.01E-04 |
| Marine eutrophication | 3.23E-04 | 1.33E-04 | 1.07E-04 | 8.75E-06 | - | 5.72E-04 |
| Terrestrial ecotoxicity | 3.94E-06 | 3.90E-06 | 5.53E-07 | 9.03E-07 | - | 9.30E-06 |
| Freshwater ecotoxicity | 3.80E-03 | 3.97E-04 | 1.81E-07 | 1.36E-04 | - | 4.34E-03 |
| Marine ecotoxicity | 3.75E-03 | 4.47E-04 | 3.01E-06 | 1.42E-04 | - | 4.34E-03 |
| Agricultural land occupation | 3.28E-03 | 4.04E-02 | 0.00E+00 | 1.33E-04 | - | 4.38E-02 |
| Urban land occupation | 3.83E-03 | 2.12E-04 | 0.00E+00 | 7.77E-05 | - | 4.12E-03 |
| Natural land transformation | 3.18E-05 | 1.27E-05 | 0.00E+00 | 1.67E-06 | - | 4.62E-05 |
| Water depletion | 5.04E-04 | 2.49E-04 | 0.00E+00 | 8.94E-05 | - | 8.43E-04 |
| Metal depletion | 1.21E-03 | 8.40E-04 | 0.00E+00 | 3.94E-03 | - | 5.98E-03 |
| Fossil depletion | 1.51E-01 | 1.45E-02 | 0.00E+00 | 2.08E-03 | - | 1.68E-01 |

Table 16. Results PC (30% S) + CCS

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Environmental category | Coal mining and transport | Pellet production and transport | Direct emissions at power plant | Indirect emissions and processes | CO2 transport and storage | Total |
| Climate change | 7.64E-02 | -2.94E-01 | 1.17E-01 | 1.13E-02 | 7.77E-04 | -8.89E-02 |
| Ozone depletion | 6.12E-09 | 5.28E-09 | 0.00E+00 | 1.02E-09 | 5.47E-11 | 1.25E-08 |
| Human toxicity | 2.35E-01 | 2.60E-02 | 3.96E-04 | 4.71E-03 | 3.27E-04 | 2.66E-01 |
| Photochemical oxidant formation | 1.12E-03 | 5.37E-04 | 3.77E-04 | 3.07E-05 | 5.08E-06 | 2.07E-03 |
| Particulate matter formation | 3.93E-04 | 2.30E-04 | 1.59E-04 | 2.69E-05 | 2.44E-06 | 8.12E-04 |
| Ionising radiation | 1.41E-02 | 3.02E-02 | 0.00E+00 | 1.95E-03 | 9.63E-05 | 4.63E-02 |
| Terrestrial acidification | 1.25E-03 | 7.27E-04 | 5.55E-04 | 5.22E-05 | 3.95E-06 | 2.59E-03 |
| Freshwater eutrophication | 3.81E-04 | 3.80E-05 | 0.00E+00 | 2.72E-06 | 2.83E-07 | 4.22E-04 |
| Marine eutrophication | 4.53E-04 | 1.87E-04 | 1.59E-04 | 1.23E-05 | 1.58E-06 | 8.13E-04 |
| Terrestrial ecotoxicity | 5.53E-06 | 5.47E-06 | 8.63E-07 | 1.27E-06 | 1.25E-07 | 1.33E-05 |
| Freshwater ecotoxicity | 5.34E-03 | 5.57E-04 | 2.66E-07 | 1.91E-04 | 8.24E-06 | 6.09E-03 |
| Marine ecotoxicity | 5.26E-03 | 6.28E-04 | 3.49E-06 | 2.00E-04 | 5.05E-05 | 6.14E-03 |
| Agricultural land occupation | 4.60E-03 | 5.66E-02 | 0.00E+00 | 1.88E-04 | 1.24E-05 | 6.14E-02 |
| Urban land occupation | 5.37E-03 | 2.98E-04 | 0.00E+00 | 1.09E-04 | 2.53E-05 | 5.80E-03 |
| Natural land transformation | 4.46E-05 | 1.78E-05 | 0.00E+00 | 2.36E-06 | 1.89E-05 | 8.37E-05 |
| Water depletion | 7.08E-04 | 3.49E-04 | 0.00E+00 | 1.27E-04 | 9.09E-06 | 1.19E-03 |
| Metal depletion | 1.69E-03 | 1.18E-03 | 0.00E+00 | 5.53E-03 | 2.45E-04 | 8.64E-03 |
| Fossil depletion | 2.12E-01 | 2.03E-02 | 0.00E+00 | 2.93E-03 | 2.30E-04 | 2.36E-01 |

Table 17. Results IGCC

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Environmental category | Coal mining and transport | Pellet production and transport | Direct emissions at power plant | Indirect emissions and processes | CO2 transport and storage | Total |
| Climate change | 7.48E-02 | - | 7.63E-01 | 1.92E-03 | - | 8.40E-01 |
| Ozone depletion | 6.00E-09 | - | 0.00E+00 | 1.20E-10 | - | 6.12E-09 |
| Human toxicity | 2.30E-01 | - | 3.03E-05 | 1.64E-03 | - | 2.32E-01 |
| Photochemical oxidant formation | 1.09E-03 | - | 2.27E-04 | 6.04E-06 | - | 1.33E-03 |
| Particulate matter formation | 3.85E-04 | - | 8.00E-05 | 6.11E-06 | - | 4.71E-04 |
| Ionising radiation | 1.38E-02 | - | 0.00E+00 | 3.17E-04 | - | 1.41E-02 |
| Terrestrial acidification | 1.22E-03 | - | 1.43E-04 | 7.83E-06 | - | 1.37E-03 |
| Freshwater eutrophication | 3.73E-04 | - | 0.00E+00 | 9.77E-07 | - | 3.74E-04 |
| Marine eutrophication | 4.44E-04 | - | 8.78E-05 | 1.84E-06 | - | 5.34E-04 |
| Terrestrial ecotoxicity | 5.42E-06 | - | 5.14E-08 | 3.12E-07 | - | 5.79E-06 |
| Freshwater ecotoxicity | 5.23E-03 | - | 1.71E-08 | 7.50E-05 | - | 5.30E-03 |
| Marine ecotoxicity | 5.15E-03 | - | 2.77E-07 | 7.91E-05 | - | 5.23E-03 |
| Agricultural land occupation | 4.51E-03 | - | 0.00E+00 | 6.30E-05 | - | 4.57E-03 |
| Urban land occupation | 5.26E-03 | - | 0.00E+00 | 4.04E-05 | - | 5.30E-03 |
| Natural land transformation | 4.37E-05 | - | 0.00E+00 | 4.88E-07 | - | 4.42E-05 |
| Water depletion | 6.93E-04 | - | 0.00E+00 | 1.46E-05 | - | 7.08E-04 |
| Metal depletion | 1.66E-03 | - | 0.00E+00 | 2.75E-03 | - | 4.41E-03 |
| Fossil depletion | 2.08E-01 | - | 0.00E+00 | 5.65E-04 | - | 2.09E-01 |

Table 18. Results IGCC + CCS

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Environmental category | Coal mining and transport | Pellet production and transport | Direct emissions at power plant | Indirect emissions and processes | CO2 transport and storage | Total |
| Climate change | 1.01E-01 | - | 1.03E-01 | 2.57E-03 | 6.29E-04 | 2.08E-01 |
| Ozone depletion | 8.12E-09 | - | 0.00E+00 | 1.54E-10 | 4.47E-11 | 8.31E-09 |
| Human toxicity | 3.11E-01 | - | 4.11E-05 | 2.84E-03 | 2.59E-04 | 3.14E-01 |
| Photochemical oxidant formation | 1.48E-03 | - | 2.55E-04 | 8.17E-06 | 4.22E-06 | 1.75E-03 |
| Particulate matter formation | 5.21E-04 | - | 9.36E-05 | 8.31E-06 | 1.99E-06 | 6.25E-04 |
| Ionising radiation | 1.87E-02 | - | 0.00E+00 | 4.20E-04 | 7.66E-05 | 1.92E-02 |
| Terrestrial acidification | 1.66E-03 | - | 1.47E-04 | 1.04E-05 | 3.27E-06 | 1.82E-03 |
| Freshwater eutrophication | 5.05E-04 | - | 0.00E+00 | 1.68E-06 | 2.24E-07 | 5.07E-04 |
| Marine eutrophication | 6.01E-04 | - | 9.91E-05 | 2.51E-06 | 1.31E-06 | 7.04E-04 |
| Terrestrial ecotoxicity | 7.34E-06 | - | 6.96E-08 | 4.24E-07 | 9.94E-08 | 7.93E-06 |
| Freshwater ecotoxicity | 7.08E-03 | - | 2.32E-08 | 1.09E-04 | 6.50E-06 | 7.19E-03 |
| Marine ecotoxicity | 6.97E-03 | - | 3.75E-07 | 1.14E-04 | 4.35E-05 | 7.13E-03 |
| Agricultural land occupation | 6.10E-03 | - | 0.00E+00 | 8.51E-05 | 9.81E-06 | 6.19E-03 |
| Urban land occupation | 7.12E-03 | - | 0.00E+00 | 5.57E-05 | 2.17E-05 | 7.20E-03 |
| Natural land transformation | 5.92E-05 | - | 0.00E+00 | 6.52E-07 | 1.67E-05 | 7.65E-05 |
| Water depletion | 9.38E-04 | - | 0.00E+00 | 1.92E-05 | 7.45E-06 | 9.65E-04 |
| Metal depletion | 2.24E-03 | - | 0.00E+00 | 4.07E-03 | 1.93E-04 | 6.51E-03 |
| Fossil depletion | 2.82E-01 | - | 0.00E+00 | 7.62E-04 | 1.87E-04 | 2.83E-01 |

Table 19. Results IGCC (30% W)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Environmental category | Coal mining and transport | Pellet production and transport | Direct emissions at power plant | Indirect emissions and processes | CO2 transport and storage | Total |
| Climate change | 5.47E-02 | -2.12E-01 | 8.12E-01 | 2.59E-03 | - | 6.57E-01 |
| Ozone depletion | 4.39E-09 | 3.45E-09 | 0.00E+00 | 1.60E-10 | - | 8.00E-09 |
| Human toxicity | 1.68E-01 | 1.61E-02 | 3.82E-05 | 2.22E-03 | - | 1.87E-01 |
| Photochemical oxidant formation | 8.01E-04 | 3.60E-04 | 2.27E-04 | 8.15E-06 | - | 1.40E-03 |
| Particulate matter formation | 2.82E-04 | 1.51E-04 | 8.03E-05 | 8.26E-06 | - | 5.41E-04 |
| Ionising radiation | 1.01E-02 | 1.86E-02 | 0.00E+00 | 4.27E-04 | - | 2.91E-02 |
| Terrestrial acidification | 8.96E-04 | 4.74E-04 | 1.38E-04 | 1.05E-05 | - | 1.52E-03 |
| Freshwater eutrophication | 2.73E-04 | 2.35E-05 | 0.00E+00 | 1.32E-06 | - | 2.98E-04 |
| Marine eutrophication | 3.25E-04 | 1.23E-04 | 8.78E-05 | 2.48E-06 | - | 5.38E-04 |
| Terrestrial ecotoxicity | 3.97E-06 | 3.60E-06 | 4.59E-08 | 4.23E-07 | - | 8.03E-06 |
| Freshwater ecotoxicity | 3.83E-03 | 3.46E-04 | 1.73E-08 | 1.02E-04 | - | 4.28E-03 |
| Marine ecotoxicity | 3.77E-03 | 3.93E-04 | 2.27E-07 | 1.08E-04 | - | 4.27E-03 |
| Agricultural land occupation | 3.30E-03 | 7.34E-02 | 0.00E+00 | 8.57E-05 | - | 7.68E-02 |
| Urban land occupation | 3.85E-03 | 9.02E-04 | 0.00E+00 | 5.95E-05 | - | 4.81E-03 |
| Natural land transformation | 3.20E-05 | 1.67E-05 | 0.00E+00 | 6.96E-07 | - | 4.94E-05 |
| Water depletion | 5.08E-04 | 2.24E-04 | 0.00E+00 | 1.96E-05 | - | 7.51E-04 |
| Metal depletion | 1.21E-03 | 8.96E-04 | 0.00E+00 | 3.74E-03 | - | 5.85E-03 |
| Fossil depletion | 1.52E-01 | 1.31E-02 | 0.00E+00 | 7.58E-04 | - | 1.66E-01 |

Table 20. Results IGCC (30% W) + CCS

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Environmental category | Coal mining and transport | Pellet production and transport | Direct emissions at power plant | Indirect emissions and processes | CO2 transport and storage | Total |
| Climate change | 7.31E-02 | -2.83E-01 | 1.08E-01 | 3.43E-03 | 6.60E-04 | -9.73E-02 |
| Ozone depletion | 5.86E-09 | 4.61E-09 | 0.00E+00 | 2.05E-10 | 4.69E-11 | 1.07E-08 |
| Human toxicity | 2.25E-01 | 2.15E-02 | 5.09E-05 | 3.61E-03 | 2.72E-04 | 2.50E-01 |
| Photochemical oxidant formation | 1.07E-03 | 4.80E-04 | 2.55E-04 | 1.09E-05 | 4.43E-06 | 1.82E-03 |
| Particulate matter formation | 3.76E-04 | 2.02E-04 | 9.45E-05 | 1.11E-05 | 2.09E-06 | 7.11E-04 |
| Ionising radiation | 1.35E-02 | 2.48E-02 | 0.00E+00 | 5.60E-04 | 8.03E-05 | 3.90E-02 |
| Terrestrial acidification | 1.20E-03 | 6.33E-04 | 1.46E-04 | 1.38E-05 | 3.43E-06 | 1.99E-03 |
| Freshwater eutrophication | 3.65E-04 | 3.13E-05 | 0.00E+00 | 2.14E-06 | 2.35E-07 | 3.98E-04 |
| Marine eutrophication | 4.34E-04 | 1.64E-04 | 9.91E-05 | 3.33E-06 | 1.38E-06 | 7.02E-04 |
| Terrestrial ecotoxicity | 5.30E-06 | 4.80E-06 | 6.12E-08 | 5.67E-07 | 1.04E-07 | 1.08E-05 |
| Freshwater ecotoxicity | 5.11E-03 | 4.62E-04 | 2.31E-08 | 1.44E-04 | 6.82E-06 | 5.72E-03 |
| Marine ecotoxicity | 5.03E-03 | 5.25E-04 | 3.03E-07 | 1.51E-04 | 4.56E-05 | 5.75E-03 |
| Agricultural land occupation | 4.40E-03 | 9.80E-02 | 0.00E+00 | 1.14E-04 | 1.03E-05 | 1.03E-01 |
| Urban land occupation | 5.14E-03 | 1.20E-03 | 0.00E+00 | 8.05E-05 | 2.28E-05 | 6.44E-03 |
| Natural land transformation | 4.27E-05 | 2.23E-05 | 0.00E+00 | 9.21E-07 | 1.75E-05 | 8.35E-05 |
| Water depletion | 6.77E-04 | 2.99E-04 | 0.00E+00 | 2.56E-05 | 7.82E-06 | 1.01E-03 |
| Metal depletion | 1.62E-03 | 1.20E-03 | 0.00E+00 | 5.36E-03 | 2.02E-04 | 8.37E-03 |
| Fossil depletion | 2.03E-01 | 1.75E-02 | 0.00E+00 | 1.01E-03 | 1.96E-04 | 2.22E-01 |

Table 21. Results IGCC (30% S)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Environmental category | Coal mining and transport | Pellet production and transport | Direct emissions at power plant | Indirect emissions and processes | CO2 transport and storage | Total |
| Climate change | 5.47E-02 | -2.11E-01 | 8.16E-01 | 2.59E-03 | - | 6.62E-01 |
| Ozone depletion | 4.39E-09 | 3.79E-09 | 0.00E+00 | 1.60E-10 | - | 8.33E-09 |
| Human toxicity | 1.68E-01 | 1.86E-02 | 2.43E-05 | 2.22E-03 | - | 1.89E-01 |
| Photochemical oxidant formation | 8.01E-04 | 3.85E-04 | 2.27E-04 | 8.15E-06 | - | 1.42E-03 |
| Particulate matter formation | 2.82E-04 | 1.65E-04 | 8.04E-05 | 8.26E-06 | - | 5.58E-04 |
| Ionising radiation | 1.01E-02 | 2.16E-02 | 0.00E+00 | 4.27E-04 | - | 3.22E-02 |
| Terrestrial acidification | 8.96E-04 | 5.21E-04 | 1.39E-04 | 1.05E-05 | - | 1.57E-03 |
| Freshwater eutrophication | 2.73E-04 | 2.73E-05 | 0.00E+00 | 1.32E-06 | - | 3.02E-04 |
| Marine eutrophication | 3.25E-04 | 1.34E-04 | 8.78E-05 | 2.48E-06 | - | 5.49E-04 |
| Terrestrial ecotoxicity | 3.97E-06 | 3.92E-06 | 3.94E-08 | 4.23E-07 | - | 8.35E-06 |
| Freshwater ecotoxicity | 3.83E-03 | 3.99E-04 | 1.36E-08 | 1.02E-04 | - | 4.33E-03 |
| Marine ecotoxicity | 3.77E-03 | 4.50E-04 | 2.08E-07 | 1.08E-04 | - | 4.33E-03 |
| Agricultural land occupation | 3.30E-03 | 4.06E-02 | 0.00E+00 | 8.57E-05 | - | 4.40E-02 |
| Urban land occupation | 3.85E-03 | 2.14E-04 | 0.00E+00 | 5.95E-05 | - | 4.12E-03 |
| Natural land transformation | 3.20E-05 | 1.28E-05 | 0.00E+00 | 6.96E-07 | - | 4.55E-05 |
| Water depletion | 5.08E-04 | 2.50E-04 | 0.00E+00 | 1.96E-05 | - | 7.78E-04 |
| Metal depletion | 1.21E-03 | 8.45E-04 | 0.00E+00 | 3.74E-03 | - | 5.80E-03 |
| Fossil depletion | 1.52E-01 | 1.46E-02 | 0.00E+00 | 7.58E-04 | - | 1.68E-01 |

Table 22. Results IGCC (30% S) + CCS

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Environmental category | Coal mining and transport | Pellet production and transport | Direct emissions at power plant | Indirect emissions and processes | CO2 transport and storage | Total |
| Climate change | 7.31E-02 | -2.81E-01 | 1.09E-01 | 3.43E-03 | 6.63E-04 | -9.54E-02 |
| Ozone depletion | 5.86E-09 | 5.05E-09 | 0.00E+00 | 2.05E-10 | 4.71E-11 | 1.12E-08 |
| Human toxicity | 2.25E-01 | 2.49E-02 | 3.24E-05 | 3.61E-03 | 2.73E-04 | 2.53E-01 |
| Photochemical oxidant formation | 1.07E-03 | 5.14E-04 | 2.55E-04 | 1.09E-05 | 4.45E-06 | 1.85E-03 |
| Particulate matter formation | 3.76E-04 | 2.20E-04 | 9.45E-05 | 1.11E-05 | 2.10E-06 | 7.35E-04 |
| Ionising radiation | 1.35E-02 | 2.89E-02 | 0.00E+00 | 5.60E-04 | 8.07E-05 | 4.30E-02 |
| Terrestrial acidification | 1.20E-03 | 6.95E-04 | 1.46E-04 | 1.38E-05 | 3.45E-06 | 2.05E-03 |
| Freshwater eutrophication | 3.65E-04 | 3.64E-05 | 0.00E+00 | 2.14E-06 | 2.36E-07 | 4.03E-04 |
| Marine eutrophication | 4.34E-04 | 1.79E-04 | 9.91E-05 | 3.33E-06 | 1.38E-06 | 7.16E-04 |
| Terrestrial ecotoxicity | 5.30E-06 | 5.23E-06 | 5.26E-08 | 5.67E-07 | 1.05E-07 | 1.13E-05 |
| Freshwater ecotoxicity | 5.11E-03 | 5.33E-04 | 1.81E-08 | 1.44E-04 | 6.85E-06 | 5.79E-03 |
| Marine ecotoxicity | 5.03E-03 | 6.01E-04 | 2.78E-07 | 1.51E-04 | 4.58E-05 | 5.83E-03 |
| Agricultural land occupation | 4.40E-03 | 5.42E-02 | 0.00E+00 | 1.14E-04 | 1.03E-05 | 5.87E-02 |
| Urban land occupation | 5.14E-03 | 2.85E-04 | 0.00E+00 | 8.05E-05 | 2.29E-05 | 5.53E-03 |
| Natural land transformation | 4.27E-05 | 1.70E-05 | 0.00E+00 | 9.21E-07 | 1.76E-05 | 7.83E-05 |
| Water depletion | 6.77E-04 | 3.34E-04 | 0.00E+00 | 2.56E-05 | 7.85E-06 | 1.04E-03 |
| Metal depletion | 1.62E-03 | 1.13E-03 | 0.00E+00 | 5.36E-03 | 2.03E-04 | 8.31E-03 |
| Fossil depletion | 2.03E-01 | 1.94E-02 | 0.00E+00 | 1.01E-03 | 1.97E-04 | 2.24E-01 |

1. 5% > 10 μm, 10% 2.5-10 μm and 85% < 2.5 μm [↑](#footnote-ref-2)