# Health Impacts of
# Coal Fired Power Stations
# in the Netherlands

**University of Stuttgart on behalf of Greenpeace**

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# A. Assessment of Health Impacts of Coal Fired Power Stations in the Netherlands by Applying EcoSenseWeb.

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# 1 Aim of the Work

**Aim of the work** is to support GREENPEACE (GP) in estimating and interpreting the impacts to human health of selected coal fired power plants in Europe. The assessment comprises health impacts of air pollution due to stack emissions.

# 2 Starting Point: Preparatory Work by GREENPEACE

GP has collected data (especially operation phase) for about 80 coal fired power plants in Europe and has entered it into the EcoSenseWeb (ESW) tool. The data needs for ESW were explained by IER.

In addition GP has collected emission data for other coal fired power plants in Europe and delivered it in an Excel spread sheet. These data have been evaluated by IER by a simplified approach. In order to calculate average health impacts unit damage factors, i.e. YOLL per tonne for each of the considered pollutants have been applied.

# 3 Description of Methodology

In the following the underlying approach and the main assumptions for the evaluation of environmental and health impacts are described.

In addition to the presentation of results, that is generated automatically by EcoSenseWeb, further maps regarding the distribution of PM concentrations and the corresponding impacts are generated.

## 3.1 Description of Impact Pathway Approach

The impact pathway approach was developed within the ExternE project series and represents its basic approach. Impact pathway assessment is a bottom-up-approach in which environmental benefits and costs are estimated by following the pathway from source of emissions via quality changes of air, soil and water to physical impacts. These can then be expressed in monetary benefits and costs. An illustration of the main steps of the impact pathway methodology applied to the pollutant emissions is shown in the following diagram.

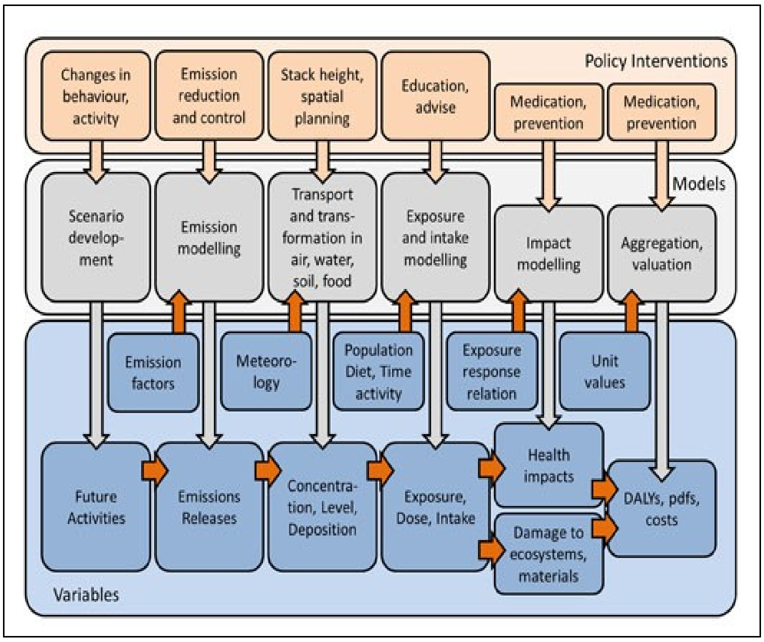

Figure 1: Illustration of the Impact Pathway Approach (www.ExternE.info)

In order to allocate impacts to certain sources two emission scenarios are needed for each calculation, one reference scenario and one case scenario. The background concentration of pollutants in the reference scenario is a significant factor for pollutants with non-linear chemistry or non-linear dose-response functions. The estimated difference in the simulated air quality situation between the case and the reference situation is combined with concentration response functions to derive differences in physical impacts on public health, crops, biodiversity and building material.

It is important to note, that not only local damages have to be considered - air pollutants are transformed and transported and cause considerable damage hundreds of kilometres away from the source. So local, European wide and hemispheric modelling is required. As a next step within the IPA, concentration-response models are used to derive physical impacts on the basis of the population data and concentration levels of air pollutants. The concentration -response models have been compiled and critically reviewed in ExternE by expert groups (Torfs et al. 2007).

## 3.2 Description of the Source-Receptor-Matrix Approach

The EMEP model (Unified EMEP Model 2003) is capable of performing calculations for a change of emissions in a single source grid cell. However, in order to provide regional specific average CFs so called “Source-Receptor-Matrices” (SRM) have been derived. Regarding the EMEP model these are the EMEP_N-Hem_SR and the EMEP_EU_SRM, which are both implemented in the online tool (EcoSenseWeb).

It is evident that the models differ in their completeness of substances coverage, the sophistication regarding air pollution chemistry and degree of resolution of meteorological conditions, their degree of source-region resolution and their degree of receptor grid and receptor characteristics resolution, and finally, in the degree of complete coverage of the whole global area as source and receptor region. For the purpose of regional assessment of primary and secondary air pollutants therefore, the EMEP_EU_SRM is quite appropriate. The EMEP_EU_SR model for Europe distinguishes between release height, smaller sub-regions within Europe, different background emission scenarios and meteorological years. In the following, the EMEP_EU_SR for Europe will be described.

## 3.3 "Source-Receptor-Matrices" derived with EMEP model for NEEDS project

Within the EMEP model for Europe the grid cells have a size of 0.5 * 0.5 degree, i.e. ca. 50*50 km² and hence, the European receptor area consists of 132*111, i.e. 14652 grid cells. The EMEP50 grid is depicted in Figure 2.

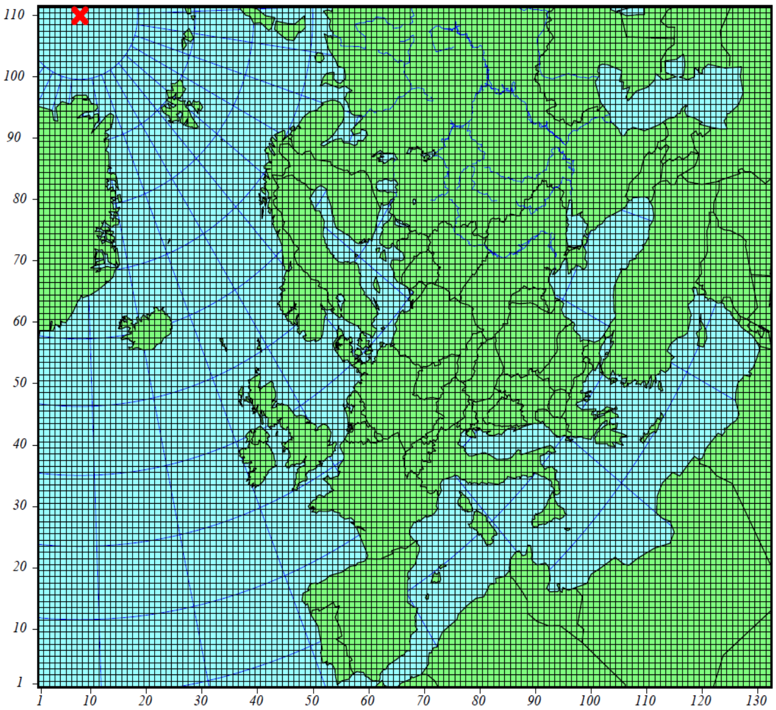

Figure 2: EMEP50 grid (used 1997 till 2008), (EMEP 2008)

In order to obtain the source-receptor relations for different regions, several model runs are performed with the atmospheric chemical transport model (CTM) (Unified EMEP Model 2003) for each source region depicted in Figure 3 and each pollutant.

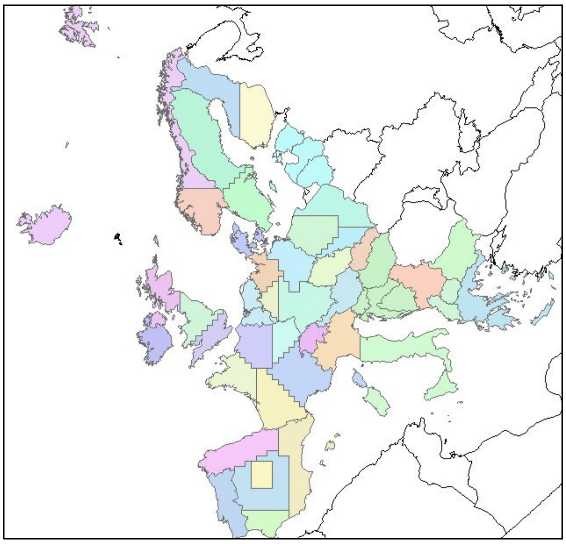

Figure 3: Source regions (countries and sub-regions) for which EMEP_EU_SRM source-receptor relations have been derived

For example, emissions of $SO_2$ in a certain region are reduced by 15% compared to the base emission inventory (accounting also for the underlying spatial and temporal distribution of the activities). This 15% change leads to a concentration change in each grid cell of different pollutants, in particular of sulphates. “Sulphates” represent the sum of $(NH_4)_2SO_4$, $(NH_4)_2SO_4$ and $H_2SO_4$.

Figure 4 and Figure 5 display the change of accumulated exposure (concentration increment time people living in the corresponding grid cell) due to emission of one additional tonne of pollutant in one of four sub-regions of Germany (DE_3).

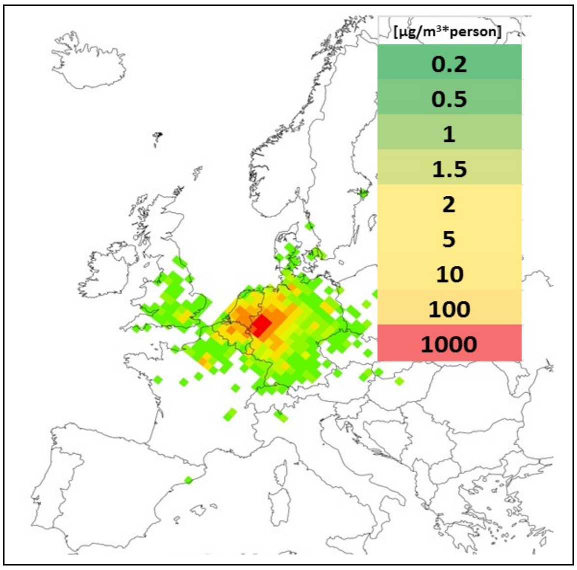

Figure 4: Change of accumulated concentration of PM2.5 per tonne of PPM2.5 released of a coal fired power plant in German sub-region DE3 (all sectors, year 2010, average meteorology)

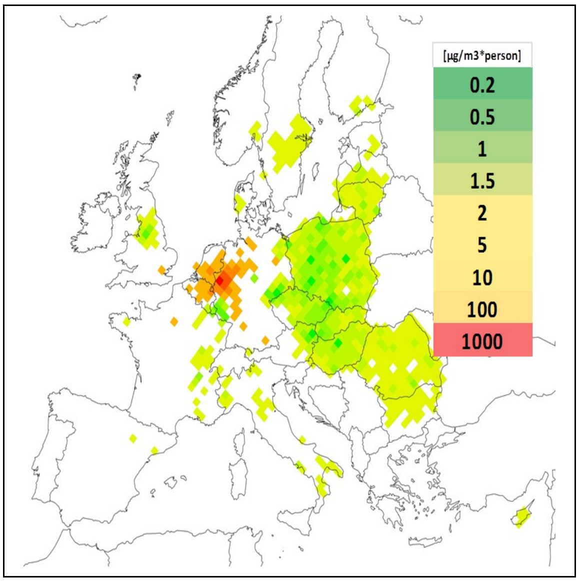

Figure 5: Change of accumulated concentration of SIA per tonne of $NO_x$ released of a coal fired power plant in German sub-region DE3 (all sectors, year 2010, average meteorology)

This procedure is conducted for each sub-region, each pollutant, different background emission scenarios and different meteorological years. The 15% change of emission are chosen for practical reasons, i.e. to represent a realistic "quasi-marginal" change of emissions which still allows to assume sufficient linearity and allows to downscale the change of impacts to a unit of emission change. More explanation is provided by (Tarrasón 2009) : "The justification of the 15% reduction is that the reduction of individual emission is then small enough to approximate a mathematical derivative, but is sufficiently large to give a clear signal in the pollution changes."

Finally, this results in a matrix covering the resulting concentration of different pollutants in each of the 50 x 50 km$^2$ grid cell of the EMEP grid. This matrix contains the results in terms of concentrations of primary air pollutants ($NO_x$, primary PM, e.g. black and organic carbon) and secondary air pollutants (nitrates and ozone, sulphates, etc.) on the grid. The chemical reactions and interactions are quite complex (described, e.g. in (UNECE 2010) and in SI, Chapter 7.3). For example, a reduction of $SO_2$ emissions in regions where also $NH_3$ is emitted as well will decrease $SO_4$ in SIA, but the ammonium sulfate will be partly replaced by ammonium nitrate (if $HNO_3$ is available, from $NO_x$ oxidation). If ammonium nitrate is limited by the availability of $NH_3$, a reduction of $NH_3$ emissions will have a more than linear effect because, by lack of the neutralizing $NH_4$ ion in the presence of $SO_4$, also $HNO_3$ will be driven out of the particles. If excess ammonium is available (more than needed to neutralize $SO_4$ and $NO_3$), a reduction of $NH_3$ emissions will have no effect on SIA concentration until the excess in the gas phase has been cancelled.

Additional free $NH_3$ and $SO_2$ increases the concentration of sulphates at certain locations, downwind.

Table 1 shows some of the primary and secondary pollutants provided by the EMEP dispersion model.

Table : Primary and secondary airborne pollutants in EMEP dispersion model

| **Shortcut** | **Comment** | **Unit** |
|---|---|---|
| $NH_4$ | Particulate ammonium | µgN/m$^3$ |
| $aNO_3$ | Particulate nitrate with diameter below 2.5µm | µgN/m$^3$ |
| $pNO_3$ | Particulate nitrate in the coarse fraction (with diameter between 2.5 and 10 µm) | µgN/m$^3$ |
| SIA | secondary inorganic aerosols (coarse + fine) | µg/m$^3$ |
| $SO_4$ | Particulate sulphate, includes also ammonium sulphate (assumed to refer to the <2.5µm fraction) | µgS/m$^3$ |
| $tNO_3$ | total coarse and fine nitrate aerosols | µgN/m$^3$ |
| $PPM_{25}$ | primary particles with diameter below 2.5 µm | µg/m$^3$ |

| Shortcut | Comment | Unit |
|---|---|---|
| | | |
| $PPM_{co}$ | primary particles with diameter between 2.5 and 10 µm | µg/m$^3$ |
| $NO_x$ | Gas phase $NO_x = NO_2 + NO$ | µgN/m$^3$ |
| $SOMO_{35}$ | sum of hourly mean ozone concentrations higher than 35 ppbV | ppb day |

SIA includes all secondary inorganic particles with an aerodynamic diameter < 10µm. It consists mainly of ammonium nitrates and sulphates. However, sulphates are mainly smaller than 2.5 µm. Different concentration response functions (CRF) regarding impacts to human health are available for PM2.5 and for PM10. Therefore, for the results from EMEP_EU_SRM , $SIA_{2.5}$ and $SIA_{coarse}$ were derived for Europe to be able to apply the different concentration response functions (CRF) accordingly.

Model runs have been performed to take into account all sources and all emission data, as well as to reflect the emissions and corresponding impacts of only one SNAP (Selected Nomenclature for Air Pollution) category, i.e. SNAP Sector 1 “Combustion in energy and transformation industry”. This corresponds to sources with very high stacks, i.e. above 100 meter. Moreover, because of inter-annual variability in the meteorology, different meteorological data are included.

Europe is divided into 65 regions, i.e. some larger countries are subdivided into sub-regions.

Based on the meteorological years 1996, 1997, 1998 and 2000, average results have been derived representing typical, average conditions. This exercise has been performed in order to reflect not only one, more or less arbitrary year, but more typical and average conditions of wind speed, wind direction, precipitation, temperature, stability, etc.

The emission and hence, the concentration of $NH_3$, NMVOC, $NO_x$ and $SO_2$ influences the creation of secondary pollutants (sulphates, nitrates, ozone). In order to assess the significance of the differences between current and future emission scenarios two sets of SRM have been made available. One corresponds to an emission scenario in 2010 and the second corresponds to an emission scenario anticipated in 2020. For most countries the emissions in 2020 are lower than in 2010. Because of non-linearity of the air pollution chemistry the creation of secondary pollutants and hence, the CFs differ between the two scenarios. According to (Tarrasón 2009) “The emission data set for 2010 corresponds to the baseline Current Legislation (CLE) scenario and the 2020 emission scenario is an scenario more demanding than the current legislation scenario (2020_CLE) but less than the maximum technically feasible reduction (2020_MFTR)”.

Both scenarios were developed by IIASA for the development of the Thematic Strategy on Air and are documented in (Amann et al. 2007).

The SRMs have been derived by simulation of 15% emission reduction in each sub-region. This has been done in two ways, providing two sets of SRM, i.e.:

- for pollutants from all sources, i.e. all SNAP sectors (Selected Nomenclature for reporting of Air Pollutants) (i.e., including transport, industry, domestic firing systems, but also combustion plants), and
- for pollutants (primary particles, $SO_2$ and $NO_x$) from for SNAP sector 1 (combustion in power plants) only.

Since the first SRM set provide an average value for all emissions, these values can be used if the release height is unknown. The second SRM correspond to releases above 100 meters.

## 3.4 Description of Impact Assessment Human Health

### 3.4.1 Concentration response functions & monetary values

In Table an overview over the different health endpoints and the corresponding CRFs for particulate matter (PM) and ozone is given. These are the most important and updated CRF for Europe, as provided by (Torfs et al. 2007). Furthermore, the monetary values per health impact are shown.

The impacts due to classical pollutants are caused by the (yearly average) concentration increment in the same year as the (yearly average) release of the pollutants takes place. Therefore, also most impacts occur in the same year. In case of chronic mortality, however, the reduction of life time at the end of the life is evaluated with the VOLY (value of a life year lost) of a chronic YOLL, i.e. 40,000 $Euro_{2000}$ if the emission takes place in the year 2000. This chronic YOLL value takes into account a certain implicit discounting of the willingness to pay (WTP) to avoid this future impact. Hence, the corresponding value for an acute mortality is estimated to be 60,000 $Euro_{2000}$.

The monetary values per health impact in (European Commission 2005), Table 7.6 are expressed as $Euro_{2000}$, i.e. price in the year 2000 for impacts triggered in 2000 due to the emission of the pollutants in 2000.

The percentages of different risk group and age group fractions are already accounted for in the factors in the last column of Table 2. Hence, they can be applied to the total population. The reduced life time expectancy (YOLL, Years of Lost Lifetime) is the most important endpoint with regard to the share of external costs of air pollutants. All impacts can be aggregated to total external costs due to weighting by monetary valuation of the disease.

Table 2: Overview of the CRF for particulate matter (PM) and ozone and corresponding monetary values based on (Torfs et al. 2007) and (Preiss 2008)

| **Pollutant and corresponding endpoint** | **Physical impact per person per µg per m³ [x/ (µg/m3)]** | **Unit** | **Monet value per impact, e.g. per case or per YOLL [Euro]** | **External costs per person per µg per m³ [Euro/ (µg/m³)]** |
|---|---|---|---|---|
| Primary Particle and SIA < 2.5 µm, i.e. PM2.5 [µg/m³] | | | | |
| Life expectancy reduction - YOLLchronic | 6.51E-04 | year | 40,000 | 26.0 |
| net Restricted activity days | 9.59E-03 | days | 130 | 1.3 |
| Work loss days (WLD) | 1.39E-02 | days | 295 | 4.1 |
| Minor restricted activity days (MRAD) | 3.69E-02 | days | 38 | 1.4 |
| Primary Particle and SIA < 10 µm, i.e. PM10 [µg/m³] | | | | |
| Increased mortality risk (infants) | 6.84E-08 | cases | 3,000,000 | 0.2 |
| New cases of chronic bronchitis | 1.86E-05 | cases | 200,000 | 3.7 |
| Respiratory hospital admissions | 7.03E-06 | cases | 2,000 | 1.41E-02 |
| Cardiac hospital admissions | 4.34E-06 | cases | 2,000 | 8.68E-03 |
| Medication use / bronchodilator use | 4.03E-04 | cases | 1 | 4.03E-04 |
| Medication use / bronchodilator use | 3.27E-03 | cases | 1 | 3.27E-03 |
| Lower respiratory symptoms (adult) | 3.24E-02 | days | 38 | 1.2 |
| Lower respiratory symptoms (child) | 2.08E-02 | days | 38 | 0.8 |
| Ozone [µg/m³] - from SOMO35 by multiplication by *1/365 | | | | |
| Increased mortality risk | 2.23E-06 | year | 60,000 | 0.1 |
| Respiratory hospital admissions | 1.98E-06 | cases | 2,000 | 3.95E-03 |
| MRAD | 7.36E-03 | days | 38 | 0.3 |
| Medication use / bronchodilator use | 2.62E-03 | cases | 1 | 2.62E-03 |

|  |  |  |  |  |
|---|---|---|---|---|
| LRS excluding cough | 1.79E-03 | days | 38 | 6.81E-02 |
| Cough days | 1.04E-02 | days | 38 | 0.4 |

Whereas:
CRF: concentration-response function
YOLL: years of life lost
RAD: Restricted activity days
WLD: Work loss days
MRAD: Minor restricted activity days
LRS: lower respiratory symptoms.

Within {Torfs, 2007 #420} the scientific basis for the recommended set of concentration-response-functions regarding ambient air pollution of the air pollutants particulate matter and ozone in Europe (i.e. in the EU-27) is provided. The set of CRFs and associated background rates were needed to update previous work in the field of external cost assessments for the NEEDS-project {NEEDS, 2004-2009 #526}, which extends work previously carried out for the European Commission under the various projects of the ExternE programme.  A detailed literature review, and the associated recommendations for CRFs and for background rates is reported in {European Commission - CAFE, 2005 #569}.

The view of many individual air pollution researchers, and of established working groups

The toxicity of different kinds of particles (due to difference in shape, composition, etc) may vary per unit mass PM2.5 taken in. However, e.g. the World Health Organisation states that based on current evidence, it is not possible to quantify reliably this difference, e.g. between secondary inorganic aerosols (sulfates and nitrates) and primary particalte matter (black carbon or ash). Hence, the only distinction made here is betwenn very fine particulated PM2.5 and PMcoarse (i.e. the fraction pariticales with a size between 2.5µm and 10µm aerodynamic diameter).

The CRFs are based on epidemiological studies. Most important is chronic mortality from particulates. This is derived from the so called In the "ACS study" {Pope, 2002 #294}  PM2.5 was measured in very different metropolitan areas across the US, with varying PM2.5 concentrations and composition. It is therefore unlikely that a different composition of PM2.5 in Europe will affect the CRF derived from the ACS study.

Detailed analyses of the ACS study have shown that the relative risks of mortality from long-term exposure to ambient PM2.5 are robust to a range of population characteristics.

Chronic mortality Life expectancy reduction PM2.5

Age group > 29 years → CRF (95% CI) 651 (127 – 1194) YOLL per 10 µg/m³ per 100 000 people.

# 4 Results

In the following the results for the different power plants are presented.

In Chapter 5.1 are the results for the Dutch case study power plants (the ones under construction) which were calculated with EcoSenseWeb.

In Chapter 5.2 the total YOLL are listed for all considered power plants. Here also the actual status is indicated.

In Chapter 5.3 the total WLD are listed for all considered power plants. Here also the actual status is indicated.

## 4.1 Results calculated with EcoSenseWeb for selected power plants (air pollutants without greenhouse gases)

### 4.1.1 GPNL0001 - E.ON Maasvlakte Port (under construction)

| | | |
|---|---|---:|
| 'chronic' YOLL | [years] per [year] | 290.24 |
| | | |
| Work loss days | [days] per [year] | 6203.10 |
| | | |
| Lower respiratory symptoms | [days] per [year] | 27369.20 |
| | | |
| Bronchodilator usage | [cases] per [year] | 564.83 |
| Chronic bronchitis | [cases] per [year] | 9.47 |
| | | |
| Cardiac hospital admissions | [cases] per [year] | 2.22 |
| Respiratory hospital admission | [cases] per [year] | 2.60 |

### 4.1.2 GPNL0002 - GDF Suez Maasvlakte Port (under construction)

| | | |
|---|---|---:|
| 'chronic' YOLL | [years] per [year] | 167.10 |
| | | |
| Work loss days | [days] per [year] | 3569.60 |
| | | |
| Lower respiratory symptoms | [days] per [year] | 15702.50 |
| | | |
| Bronchodilator usage | [cases] per [year] | 403.16 |
| Chronic bronchitis | [cases] per [year] | 5.44 |
| | | |
| Cardiac hospital admissions | [cases] per [year] | 1.27 |
| Respiratory hospital admission | [cases] per [year] | 1.55 |

### 4.1.3 GPNL0003 – RWE/Essent Eemshaven (under construction)

| | | |
|---|---|---:|
| 'chronic' YOLL | [years] per [year] | 423.35 |
| | | |
| Work loss days | [days] per [year] | 9045.90 |
| | | |
| Lower respiratory symptoms | [days] per [year] | 39733.30 |
| | | |
| Bronchodilator usage | [cases] per [year] | 922.31 |
| Chronic bronchitis | [cases] per [year] | 13.75 |
| | | |
| Cardiac hospital admissions | [cases] per [year] | 3.22 |
| Respiratory hospital admission | [cases] per [year] | 3.85 |

### 4.1.4 GPNL – All plants under construction

| | | |
|---|---|---|
| 'chronic' YOLL | [years] per [year] | 880.69 |
| | | |
| Work loss days | [days] per [year] | 18818.60 |
| | | |
| Lower respiratory symptoms | [days] per [year] | 82805 |
| | | |
| Bronchodilator usage | [cases] per [year] | 1890.3 |
| Chronic bronchitis | [cases] per [year] | 28.66 |
| | | |
| Cardiac hospital admissions | [cases] per [year] | 6.71 |
| Respiratory hospital admission | [cases] per [year] | 8 |
| | | |

## 4.2 Generic approach for classical air pollutants - all power plants considered – YOLL_total

### 4.2.1 Results for power plants in Netherlands

| FacilityName | Status | Municipality | YOLL | Premature deaths |
|---|---|---|---:|---:|
| E.On Benelux NV (Maasvlakte) | Operation | Rotterdam | 419 | 39 |
| Nuon Power BV (Hemweg) | Operation | Amsterdam | 113 | 10 |
| Essent Energie Productie BV (Amer) | Operation | Geertruidenberg | 453 | 42 |
| EPZ NV Borssele | Operation | Borssele | 201 | 19 |
| Nuon Power Generation BV (Buggenum) | Operation | Haelen | 47 | 4 |
| Electrabel NV (Gelderland) | Operation | Nijmegen | 243 | 23 |
| **Total operated in 2010** | | | **1476** | **137** |
| E.ON Maasvlakte Port | Construction | Rotterdam | 290 | 27 |

| | | | | |
|---|---|---|---|---|
| | | | | |
| GDF Suez Maasvlakte Port | Construction | Rotterdam | 167 | 16 |
| RWE/Essent Eemshaven | construction | Eemsmond | 423 | 40 |
| **Total under construction** | | | **880** | **83** |
| | | | | |
| **Sum of YOLLs** | | | **2356** | **220** |

## 4.3 Generic approach for classical air pollutants - all power plants considered – Work loss days (WLD)

### 4.3.1 Results for power plants in Netherlands

| **FacilityName** | **Status** | **Municipality** | **WLD** |
|---|---|---|---|
| E.On Benelux NV (Maasvlakte) | Operation | Maasvlakte Rotterdam | 8892 |
| Nuon Power Generation BV (Hemweg) | Operation | Amsterdam | 2391 |
| Essent Energie Productie BV (Amer) | Operation | Geertruidenberg | 9629 |
| EPZ NV Borssele | Operation | Borssele | 4263 |
| Nuon Power Generation BV (Buggenum) | Operation | Haelen | 1008 |
| Electrabel Nederland NV (Gelderland) | Operation | Nijmegen | 5154 |
| **Total operated in 2010** | | | **31337** |
| E.ON Maasvlakte Port | Construction | | 6203 |
| GDF Suez Maasvlakte Port | Construction | | 3570 |
| RWE/Essent Eemshaven | Construction | | 9046 |
| **Total under construction** | | | **18819** |
| | | | |
| **Sum of WLDs** | | | **50156** |

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# B. Explanatory Notes by Greenpeace

## How coal power plants can make you sick

| | **Microscopic particles (PM2.5)** | **Toxic metals** | **Ozone** |
|---|---|---|---|
| Emissions from coal-fired power plants | soot and dust<br>sulphur dioxide (SO2)<br>nitrogen oxides (NOx) | mercury, arsenic, lead, chromium, nickel, cadmium | sulphur dioxide (SO2)<br>nitrogen oxides (NOx) |
| Pollution in the environment | microscopic particles (from soot, dust, SO2 and NOx) | mercury in food<br>other toxic metals in the air | ozone (smog) |
| Impacts on the body | • Particles smaller than 2.5 micrometers (one 20th of the thickness of human hair) are small enough to penetrate deep into the lungs<br>• Soluble particles are absorbed to the bloodstream, harming the heart, and the blood vessels and carrying toxic components to tissues.<br>• Insoluble particles are accumulated in the lung, impairing lung function and damaging lung tissue | Mercury and lead enter the bloodstream and affect the brain and other organs; other metals are toxic to the lung | irritation and tissue damage in the throat and lungs |
| Health damages | • death from cancer, heart disease and lung disease<br>• heart attack<br>• asthma attacks<br>• respiratory infections and symptoms<br>• cough | • Mercury: Damage to childrens' brain development.<br>• Lead: Impaired mental and physical development in children. Damage to kidney, blood cells, and reproductive systems<br>• Arsenic, chromium, nickel, cadmium: lung cancer | • chest pain<br>• coughing<br>• congestion<br>• asthma attacks |

# Emissions coal power plants under construction in the Netherlands[1]

| **Company** | **RWE/Essent** | **E.ON** | **GDF SUEZ/ Electrabel** |
|---|---|---|---|
| Site plant | Eemshaven, Groningen, next to the Waddensea | Maasvlakte, Rotterdam | Maasvlakte, Rotterdam |
| Coordinates | 53°26'56.01"N<br>6°51'28.02"E | 51°57'19.78"N<br>4° 1'18.92"E | 51°56'32.60"N<br>4° 2'31.47"E |
| | | | |
| Capacity (Net) | 2 x 780 MWe | 2 x 535 MWe | 750 MWe |
| | | | |
| CO2-emissions | 8.1 million tons | 5.6 million tons | 3.9 million tons |
| Comparable to …. cars | 3.3 million | 2.3 million | 1.6 million |
| | | | |
| **Emissions** | **Tonnes/year** | **Tonnes/year** | **Tonnes/year** |
| Nitrogen oxides (NOX) | 2,060 | 1,535 | 730 |
| Sulphur dioxide (SO2) | 1,454 | 923 | 580 |
| Carbon monoxide (CO) | 1,750 | ?? | 435 |
| Particulate matter (PM10) | 103 | 71 | 45 |
| Hydrogen chloride (HCl) | 43 | 72 | 30 |
| Hydrogen fluoride (HF) | 17 | 10.4 | 4.5 |
| Total hydrocarbons (CXHY) | 10 | 10 | ?? |
| | **Kilograms/year** | **Kilograms/year** | **Kilograms/year** |
| Cadmium (Cd) and thallium (Tl) | 3 | 1.7 | 8 |
| Mercury (Hg) | 95 | 56 | 15 |
| Other heavy metals (Sb, As, Pb, Co, Cu, Mn, Ni, V) | 472 | 114 | 300 |
| | **mg/year** | **mg/year** | **mg/year** |
| Dioxins / furans (PCDD / PCDF) | 89 | ?? | ?? |

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[1] According to environmental licenses.

## Ratio of YOLL to deaths

The ratio of YOLL to deaths is based on risk factors of the European Environment Agency (EEA).[2] According to NEEDS/Stuttgart 1 ug/m3/a/person increase in PM2.5 causes 6.51E-04 YOLL. EEA uses this number, but they also say that it causes 6.066E-05 deaths (calculated from table on page 49). So firstly, we calculated backwards from YOLL to population exposure according to Stuttgart. Secondly, we used the EEA factor to calculate deaths resulting from that population exposure. 6.51E-04/6.066E-05 = 10.73.

So by dividing YOLL with 10.73, the amount of premature deaths per year are calculated. On average, these people die ten years earlier, compared to a situation without the coal power plant.

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[2] European Environment Agency, “Revealing the costs of air pollution from industrial facilities in Europe“, November 2011, <http://www.eea.europa.eu/publications/cost-of-air-pollution>