



Last Gasp

The coal companies making Europe sick

November 2018

About this report

This report is an initiative of the Europe Beyond Coal campaign, under the responsibility of Climate Action Network Europe.

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This report is endorsed by the following organisations:



The health impact methodology used in this report is guided by recommendations from the World Health Organization Europe's 'Health risks of air pollution in Europe' (HRAPIE) project on health impact assessments for air pollution. It includes atmospheric modelling with the European Monitoring and Evaluation Programme Meteorological Synthesizing Centre - West (EMEP MSC-W) computer model, which is also used by the European Environment Agency for European Commission assessments of health impacts from air pollution in Europe. They are based on publicly available, relevant data known of by the authors; this data may not be exhaustive and there may exist further or updated information they were not aware of at the time of writing. This report does not attempt to quantify actual health occurrences nor their actual costs.

The methodology and calculations have been peer reviewed by Dr Mike Holland, Ecometrics Research and Consulting.

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Executive Summary

Coal-fired electricity in Europe is in terminal decline. Wind and solar are taking over and making coal plants redundant, but the speed of change remains important. A rapid coal phase-out is essential to clean up our air and minimise climate breakdown. Many companies still have no plans to retire their coal plants, instead they are clinging on to them, polluting our air and making us sick.

There are 103 companies that still operate coal power plants in the EU. For the first time, this report models every company's impact from those plants on the air we breathe, and how that adversely impacts our health.

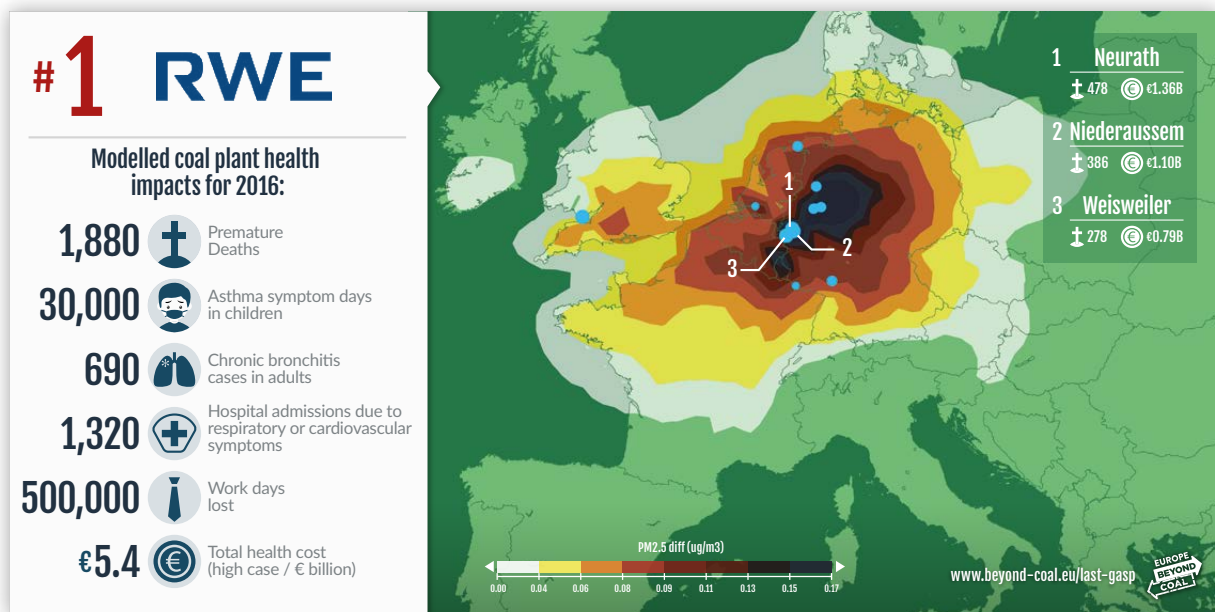
This report finds that just ten companies were responsible for an estimated two-thirds of the health damage caused by coal power plants in 2016. These companies caused a modelled 7,600 premature deaths, 3,320 new cases of chronic bronchitis and 137,000 asthma symptom days in children. This leads to an estimated 5,820 hospital admissions and over two million lost working days.

Four of the ten most toxic companies have their main coal plants in Germany: RWE, EPH, Uniper and STEAG. This is no coincidence: Germany burns more coal than any other country in Europe, and has done little to reduce air pollution from its coal plants in the last decade. Three of the 'toxic ten' are in Poland: PGE, ENEA and ZE PAK. The final three are: ČEZ in the Czech Republic, Endesa in Spain, and Bulgarian Energy Holding in Bulgaria.

Table 1 2016 model results for top ten coal companies

Rank	Company	Main country of coal	Premature Deaths	Asthma symptom days in children	Chronic bronchitis in adults	Hospital admissions due to respiratory or cardiovascular symptoms	Work days lost, working age population	Total Cost High Case [€M]	Total Cost Median Case [€M]	Health cost rate (€/MWh)
1	RWE		1880	30000	690	1320	500000	€5,400	€2,800	€48
2	EPH		1460	27000	680	1150	520000	€4,200	€2,200	€62
3	PGE		1180	20000	510	960	370000	€3,400	€1,800	€53
4	CEZ		730	13000	330	590	260000	€2,100	€1,100	€70
5	Uniper		520	9000	210	370	150000	€1,500	€800	€42
6	Endesa		410	14000	300	340	150000	€1,200	€700	€52
7	ENEA		410	6000	160	330	110000	€1,200	€600	€54
8	STEAG		370	6000	140	260	110000	€1,100	€500	€55
9	ZE PAK		340	6000	150	260	100000	€1,000	€500	€106
10	BEH		310	7000	150	240	80000	€900	€500	€93
Top 10			7600	137000	3320	5820	2350000	€22,000	€11,500	€56

RWE overall was, according to the modelling, the most harmful to health - with the citizens of west Germany, Belgium and the Netherlands suffering the most. We estimate that ~ 65% of the damage is caused by RWE's four large lignite plants in North Rhein-Westphalia alone. Over 46 million people live within 200km of these plants, all of whom will experience lower air quality as a result.



According to the modelling, the health costs these companies burden society with are a similar magnitude to the revenues that they get for selling their coal-fired electricity. The modelled health costs imposed upon society for RWE are €48 for every MWh of electricity it generated from coal, similar to the wholesale electricity price that RWE receives for selling its electricity. CEZ's plants have even higher modelled health costs of €70/MWh. Three state-owned Romanian companies have health costs over €200/MWh. These health costs, picked up by society, are a hidden subsidy that companies do not have to pay.

The report makes recommendations for companies and governments.

Companies must:

- **Stop all investment into hard coal and lignite with immediate effect.** This includes not only new plants, but also means ceasing investments into existing plants. It also includes stopping all investments in new and existing mines - to put an end to destruction of forests and villages, and forced relocations.
- **Commit to the closure of all hard coal and lignite plants by 2030 or earlier.** Companies should not sell their coal plants but rather take responsibility for closing them, and closure dates should be announced to plan for a just transition.
- **Stop lobbying for coal;** especially to weaken and seek derogation from "BREF" air pollution limits and campaign for capacity mechanisms.
- **Work proactively with stakeholders** to speed a just transition away from coal to minimise the societal and economic impacts of coal closures.
- **Adopt business plans** that ensure the company genuinely contributes towards compliance with the Paris Climate Agreement aim of temperature rises not exceeding 1.5°C.

Governments must adopt policies to ensure companies retire their coal plants by 2030. This should include:

- **Transition to 100% renewables:** Commit, including in the 2030 national energy and climate plans, to a rapid-build programme of renewable generation, as well as storage, demand-response, interconnectors and investment in energy efficiency.
- **Policies to make coal pay its way:** tighter air pollution limits, higher carbon pricing, and a cessation of subsidies to coal including capacity mechanisms.
- **A legally-binding coal phase-out date and a just transition for affected communities and workers.**

Chapter 1

Europe's slow march away from coal

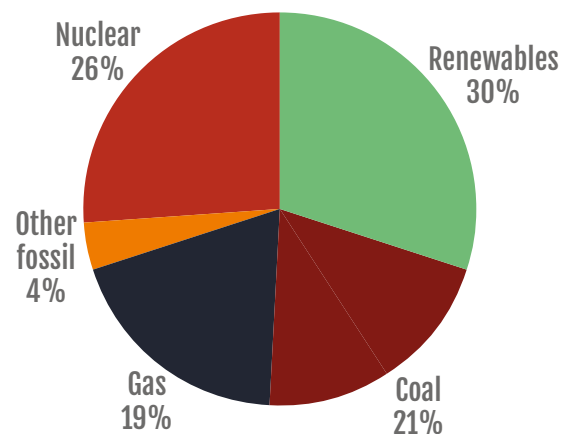
Since the start of 2016, 23 of the EU's coal-fired power plants have been retired; another 22 have announced retirement dates. The transition beyond coal to a cleaner, greener and fairer energy future is gathering pace, and it is as unstoppable as it is inevitable.

The coal phase-out in the EU is being directed by a range of national and EU policies designed to clean our air and reduce climate change. These include tighter air pollution targets on ageing coal plants, carbon pricing, the elimination of coal subsidies, and the rise of renewables. All these adversely impact the economics of coal plants, assuring their eventual closure.

Yet despite this accelerated progress away from coal, 250 coal power plants are still operating today in the EU, polluting the air we breathe. While renewable sources supplied 30% of the EU's electricity needs last year, a fifth of our power still came from coal (**see figure 1**). This coal generation is roughly evenly split between hard coal (11%) and lignite (10%). The vast majority of these plants have as of yet no announced closure dates.

Fig 1.

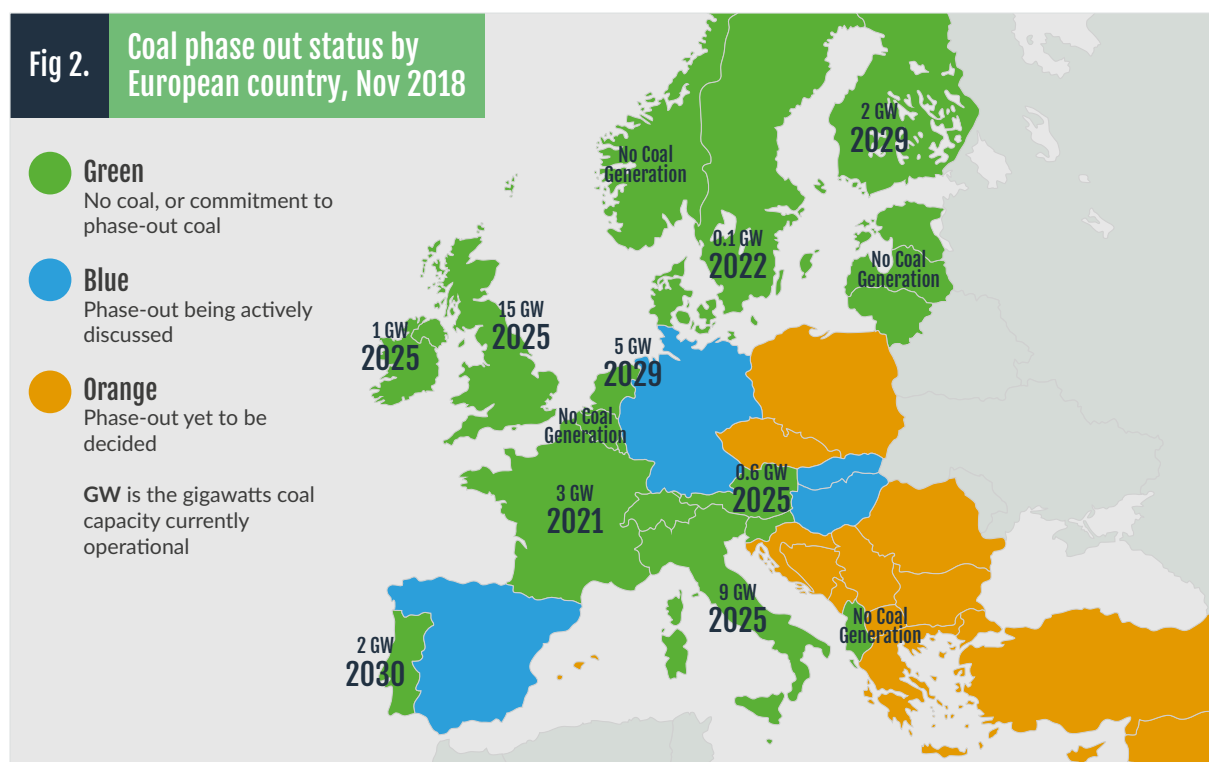
EU electricity mix in 2017 (Source: "The European Power Sector in 2017"¹)



¹ <https://sandbag.org.uk/project/european-energy-transition-power-sector-2017>

Air pollution from coal plants impacts our health in a variety of ways - this is described in detail on the following page. Coal's contribution to climate breakdown is also indisputable: the coal power plants in the EU pumped 659 million tonnes of CO₂ into the atmosphere in 2017. This was equal to 66% of the power sector's CO₂ emissions. Retiring coal plants is therefore widely seen as a "quick win" for cutting carbon emissions.

Several governments have recognised the double climate and air pollution benefits of moving beyond coal, and have already agreed on a phase-out plan for coal (**see Figure 2**). In Germany and Spain, coal phase-outs are currently under discussion. Although other governments do not yet have a plan to get out of coal, many governments now accept coal needs to be phased out, and are developing their strategy on how to do this.



Most coal-burning companies, however, are failing to grasp the gravity of change that is already upon them, and are not retiring coal plants quickly enough. Rather than engage constructively with governments to help speed up the just transition away from coal, companies are clinging to coal and keeping their plants open, despite them being increasingly uneconomic to operate.

There are 103 companies that still own coal plants in the EU. Their business belongs in the past, yet they continue to operate with a disregard for our wellbeing today, and our climate tomorrow.

This report assesses the consequences of air pollution, its health burden and the associated health costs of the EU's coal plants. For the first time, this report models the impacts and costs by company.

Air pollution from coal

The World Health Organization (WHO) says that no level of air pollution can be considered 'safe'² and the link between air pollution and respiratory and cardiovascular diseases is well-established^{3,4,5}. Breathing in particulate matter, even at low levels, can lead to physiological changes in the body that damage health. The biggest impact of particulate matter on health is from long-term exposure, which increases the risk of **premature death**, particularly from conditions affecting the heart and blood vessels. However, poor air quality is also linked to chronic and acute respiratory diseases, which significantly degrade quality of life, such as **bronchitis** and the aggravation of **asthma**.

Scientists continue to identify new ways that air pollution can harm our health, for example, there is increasing evidence linking air pollution to dementia⁶ and new evidence has shown that particles of air pollution travel through pregnant women's lungs and lodge in their placentas, harming babies before they are born.⁷

Around 80% of premature deaths associated with the emissions from coal-fired power plants in Europe were caused by exposure to PM_{2.5}. Coal plants contribute substantially to the formation of PM_{2.5} via their emissions of sulphur dioxide (SO₂) and nitrous oxides (NO_x), which react with ammonia to form PM_{2.5} in the atmosphere; but also, less so, via direct emissions into the air. Coal power plants were responsible for 26% of all SO₂ emissions and 8% of all NO_x emissions across Europe in 2016⁸.

2 See page 1 of http://www.euro.who.int/__data/assets/pdf_file/0004/193108/REVIHAAP-Final-technical-report-final-version.pdf

3 WHO/Europe. Review of evidence on health aspects of air pollution – REVIHAAP Project. <http://www.euro.who.int/en/health-topics/environment-and-health/air-quality/publications/2013/review-of-evidence-on-health-aspects-of-air-pollution-revihaap-project-final-technical-report>

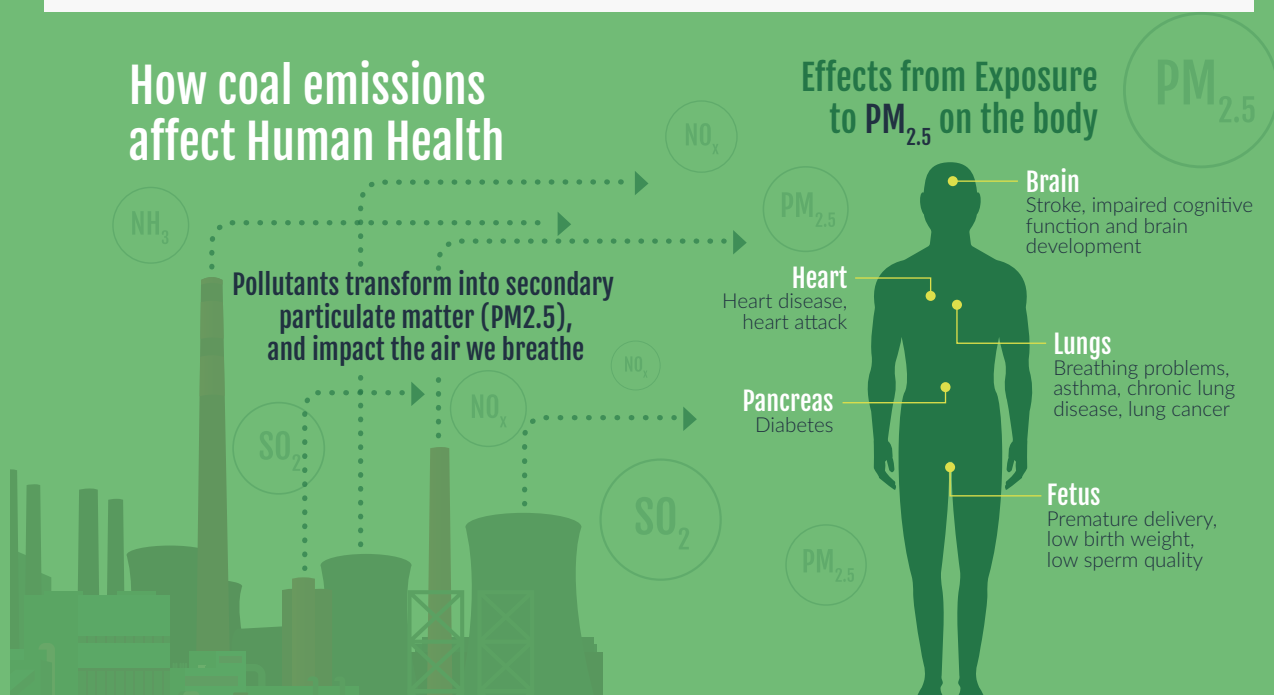
4 Royal College of Physicians - Every breath we take: the lifelong impact of air pollution. <https://www.rcplondon.ac.uk/projects/outputs/every-breath-we-take-lifelong-impact-air-pollution>

5 The European Respiratory Society/The European Lung Foundation. The European Lung White Book. <https://www.erswhitebook.org/chapters/outdoor-environment/>

6 <https://blogs.bmj.com/bmjopen/2018/09/18/air-pollution-may-be-linked-to-heightened-dementia-risk/>

7 <https://www.theguardian.com/environment/2018/sep/16/air-pollution-particles-found-in-mothers-placentas>

8 The coal plants had emissions of 617,000t SO₂ and 612,000t NO_x, compared to economy-wide emissions of 2.4mt and 7.6mt respectively, according to EUROSTAT (all 2016 figures).



Chapter 2

Results: Which companies are making us sick?

Methodology

This report uses pollution data from the EU's coal power plants to calculate their impact on the air we breathe and subsequently on our health. Here are the steps that were taken to do this; a full description is available in the Annex.

- 1 Identify coal power plants operating in the EU in 2016, and their respective owners from the Europe Beyond Coal database.
- 2 Retrieve the latest data for 2016 coal power plant air emissions from the European Environment Agency Large Combustion Plant (LCP) database.
- 3 Use a European Commission approved atmospheric model to estimate how coal power plant emissions impact pollution levels in the air we breathe.
- 4 Calculate how the additional pollution in the air impacts our health using figures recommended by experts convened by the World Health Organisation. Calculate the economic cost of these health impacts using the same approach as the European Commission.
- 5 Estimate each power station's individual contribution to the total health impact. Calculate each energy company's total impact by summing up the values from each power station in their portfolio.

This report models the health impacts caused by the emissions of three air pollutants: SO₂, NO_x and PM₁₀, including their secondary impacts on the formation of PM_{2.5} and ozone. The report will underestimate the total health impact since other significant negative impacts of the coal power plants are not modelled. This includes the impacts of mercury (burning coal is the largest source of mercury emissions in Europe⁹), other toxic heavy metals, ash disposal, mining and water disposal. It also doesn't analyse the climate change impacts from CO₂ emissions.

⁹ <https://www.eea.europa.eu/publications/mercury-in-europe-s-environment>

Results

This report finds that just ten companies were responsible for an estimated two-thirds of the health impacts from coal power plants in 2016 (see figure 3). These ten companies were responsible for 7,600 premature deaths, 3,320 new cases of chronic bronchitis and 137,000 asthma symptom days in children, according to our modelling, based on 2016 data. The ill health they caused contributed to an estimated 5,820 hospital admissions and over 2 million lost working days.

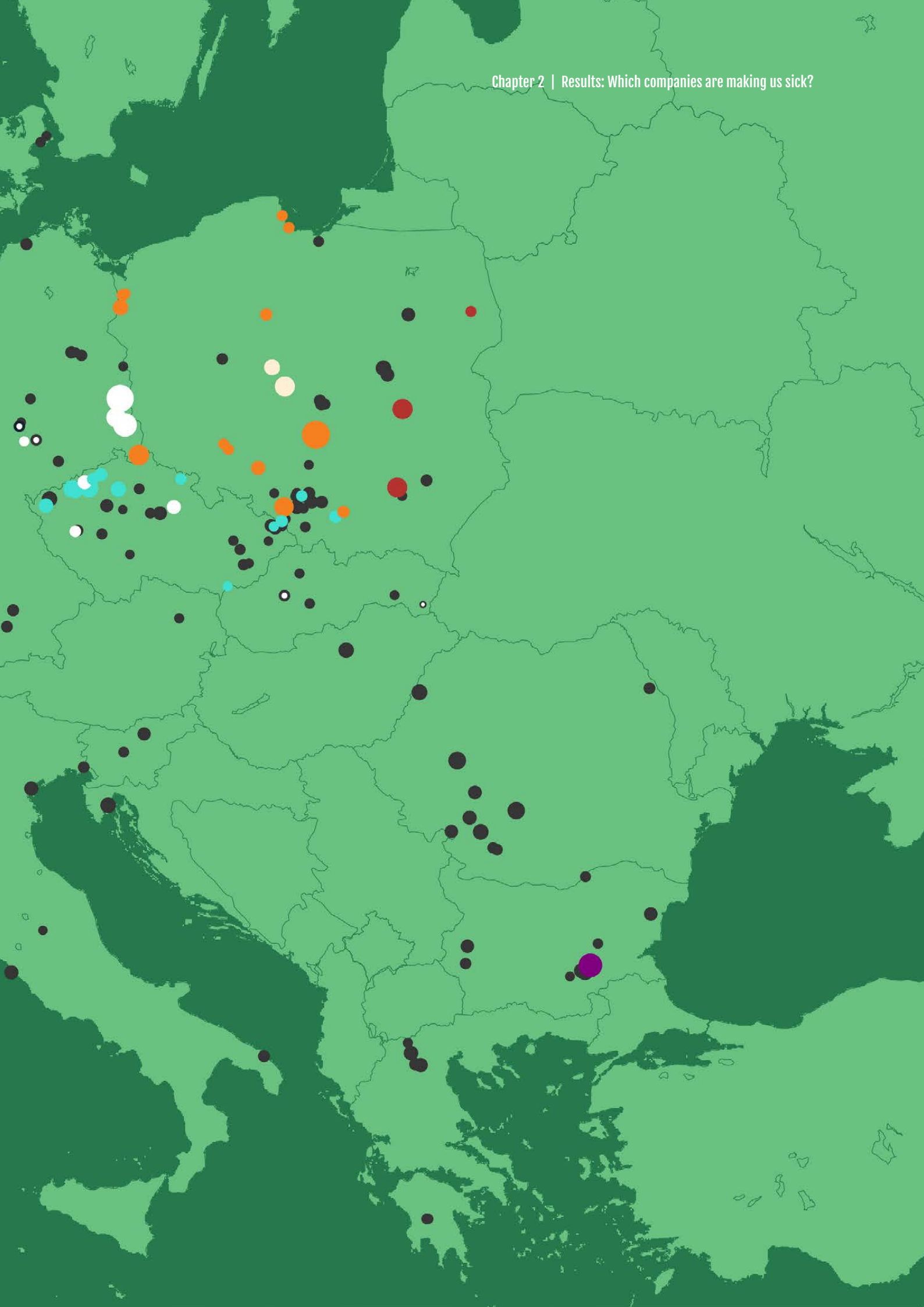
Fig 3.

The 30 most toxic coal companies (2016 model results)

Rank	Company	Main country of coal	Premature Deaths	Asthma symptom days in children	Chronic bronchitis in adults	Hospital admissions due to respiratory or cardiovascular symptoms	Work days lost, working age population	Total Cost High Case [€M]	Total Cost Median Case [€M]	Health cost rate (€/MWh)
1	RWE		1880	30000	690	1320	500000	€5,400	€2,800	€48
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6	Endesa		410	14000	300	340	150000	€1,200	€700	€52
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10	BEH		310	7000	150	240	80000	€900	€500	€93
Top 10			7600	137000	3320	5820	2350000	€22,000	€11,500	€56
11	EnBW	DE	280	5000	120	210	90000	€800	€400	€46
12	Tauron	PL	260	4000	110	210	70000	€700	€400	€46
13	Enel	IT	240	6000	140	180	80000	€700	€400	€24
14	Drax Power plc	GB	230	5000	110	160	50000	€700	€300	€68
15	Veolia	PL	230	4000	100	180	70000	€700	€300	€99
16	CE Oltenia SA	RO	190	4000	90	140	40000	€500	€300	€40
17	CE Hunedoara SA	RO	180	4000	90	140	50000	€500	€300	€386
18	PPC	GR	180	7000	120	160	60000	€500	€300	€22
19	Naturgy	ES	180	6000	140	150	60000	€500	€300	€82
20	Vattenfall	DE	160	3000	60	120	50000	€500	€200	€28
21	PGNiG	PL	140	2000	60	110	40000	€400	€200	€64
22	Valcea County Council	RO	130	3000	60	100	30000	€400	€200	€289
23	ContourGlobal	BG	120	3000	60	90	30000	€300	€200	€64
24	EDF	GB	120	3000	50	80	30000	€300	€200	€41
25	AES	BG	100	2000	50	80	30000	€300	€200	€48
26	Engie	DE	100	2000	40	70	30000	€300	€200	€28
27	Iberdrola	GB	100	3000	60	70	30000	€300	€100	€78
28	City of Oradea	RO	90	2000	50	70	30000	€300	€100	€704
29	HEP d.d.	HR	90	2000	50	60	30000	€300	€100	€113
30	Sokolovská Uhelná AS	CZ	80	2000	40	70	30000	€200	€100	€45

Fig 4. Where do Europe's most harmful coal companies operate?

-
- 1. RWE
 - 2. EPH
 - 3. PGE
 - 4. CEZ
 - 5. Uniper
 - 6. Endesa
 - 7. ENEA
 - 8. STEAG
 - 9. ZE PAK
 - 10. BEH



Four of the ten most damaging companies are in Germany. RWE is in first place by a wide margin. In second place is EPH - which owns the non-RWE half of Germany's lignite power plants. German companies Uniper and STEAG are in fifth and eighth place respectively. The combined health damage of these four German companies equates to a modelled 4,220 premature deaths, 72,000 asthma symptom days in asthmatic children, and over one million lost working days - costing society up to €12 billion, just for one year of business operation.

German coal companies dominate the list for three reasons. First, Germany burns a lot of coal: it alone is responsible for 36% of all coal-based electricity generation in the EU¹⁰. Second, German plants are near a lot of people, so although German air isn't as polluted as other parts of Europe, its coal plants cause more overall health impacts. For example, there are 46 million people that live within 200km of RWE's lignite plants, compared to just 7 million people living in the whole of Bulgaria. Third, progress on air pollution limits has stalled: German power stations were historically less polluting than their neighbours, however, whilst others have improved, German air pollution limits for coal plants have remained broadly unchanged since 2009, and are now similar to Poland or the Czech Republic¹¹.

The remaining six of the ten most damaging companies are three companies from Poland (PGE, ENEA and ZE PAK), and one each from Spain (Endesa), Czech Republic (ČEZ) and Bulgaria (Bulgarian Energy Holding).

Four Romanian utilities also featured in the top 30 list - CE Oltenia (16th), CE Hunedoara (17th), Valcea City (22nd) and City of Oradea (28th). These are all owned by the Romanian government (either centrally or the local councils), and if combined would be the fifth most toxic company.

Figure 4 shows the location of all the power plants owned by these ten toxic coal companies.

Europe is a highly-populated region and a coal plant in any one country threatens the health of people all over Europe. For example, the pollution from RWE's German plants is often carried across into the Netherlands, Belgium and France, and the pollution from PGE's Polish plants is blown over Germany and the Czech Republic.

The health impacts from coal take a huge financial toll on society. **Figure 5** below shows the high case modelled health costs created by the company. The modelled health costs mirror the approach used by the European Commission as well as the World Health Organization (more details are in the annex). The approach involves quoting a median and high case; this is displayed in **Figure 3** above, but throughout the rest of this document only the "high" case is quoted.

These costs are not covered by the companies, but rather by society in the form of increased national healthcare budgets, personal costs for individual treatment and economic losses caused by reduced productivity.

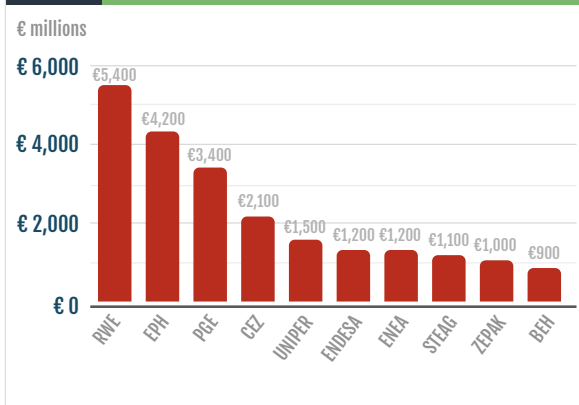
RWE accounts for the largest health costs, causing €5.4 billion of modelled health costs in 2016. RWE says it has 16.1 million customers, so this works to €335 of health costs per customer that it serves.

There are eight coal companies that cause modelled health costs of over one billion Euros each.

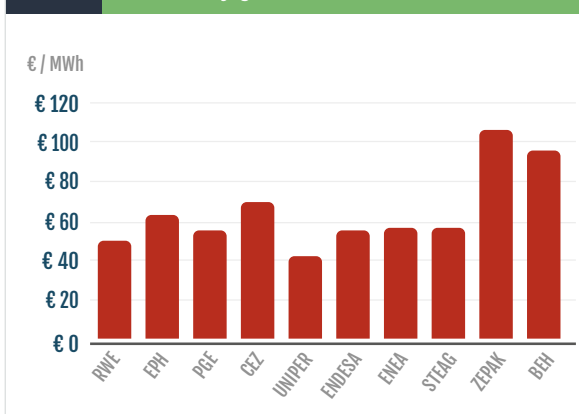
The modelled health costs inflicted upon society are similar to the revenues that the companies receive from selling their electricity (**see figure 6**). For example, RWE caused €48 of modelled health costs for every MWh of electricity it generated from coal¹². The German wholesale electricity price that RWE receives for selling its electricity is around the same level - just over €50 per MWh.

¹⁰ From <https://sandbag.org.uk/project/european-energy-transition-power-sector-2017/>

¹¹ In 2009, the German government substantially changed the emissions limits for coal plants. This was reviewed in 2013, following IED transposition, but the 2013 updates were relatively small.
https://www.bmu.de/fileadmin/Daten_BMU/Download_PDF/Luft/blmschv_13_en_bf.pdf
https://www.gesetze-im-internet.de/bimschv_13_2013/
BJNR102300013.html

Fig 5. Modelled health costs by company (2016)

Lignite generally has a higher impact than hard coal. Because of its older, even more polluting lignite plants, ČEZ has substantially higher associated health costs - at €71 per MWh, which is above the price of the electricity it sells. Bulgarian Energy Holdings and Ze Pak are even higher at around €100 per MWh. The Romanian companies have the most polluting electricity: three out of the four top four Romanian companies, which are all state-owned, have modelled health costs of over €200 per MWh of electricity generated.

Fig 6. Modelled health costs per unit of electricity generated from coal (2016)

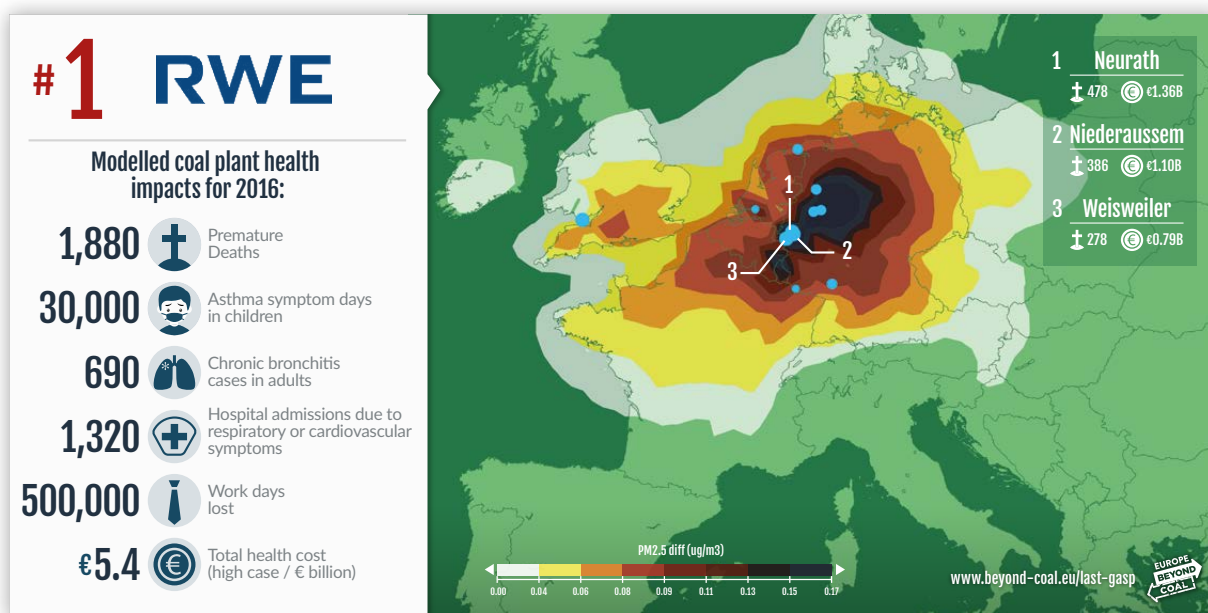
12 This is calculated at a plant level for every plant by taking the modelled health cost and dividing it by the MWh generation as reported in ENTSO-E transparency platform.

Chapter 3

The ten most toxic companies

There are ten coal companies that impact our health more than any others. This section presents the model results on a company-by-company basis, to isolate how and where pollution impacts our health from individual companies. The pollution maps show an average of the particulate matter for all the hours across 2016.

1. RWE
2. EPH
3. PGE
4. CEZ
5. Uniper
6. Endesa
7. ENEA
8. STEAG
9. ZE PAK
10. BEH



1. RWE.

Four RWE lignite plants in North Rhine-Westphalia (Neurath, Niederaußem, Weisweiler & Frimmersdorf) were responsible for 65% of the company's modelled health impacts - including 1,200 premature deaths and €3.4 billion of health costs, for the year 2016. These giant power plants are located close to densely populated areas: there are 46 million people living within 200km of these four plants¹³, meaning a lot of people are impacted by them¹⁴. The modelling shows that the impact of these plants stretches not only across the whole of Germany, but also west, into northern France, Belgium and the Netherlands.

RWE has made no public announcements to retire all its plants; its current plan is to continue its coal business until 2045¹⁵. Instead RWE's CEO Rolf Martin Schmitz has demanded compensation for closing plants early¹⁶. It is clearly questionable that RWE should receive compensation for early retirement when its coal plants are responsible for such a huge impact on our health.

In the UK and the Netherlands, RWE also has yet to announce dates to close its plants. However, following government announcements, RWE will retire its UK and Dutch plants by 2025 and 2029 respectively.



Cologne Paediatrician Christian Doering is one of those exposed to the pollution from these plants, as are many of his patients

¹³ Sourced from <https://www.freemaptools.com/find-population.htm>

¹⁴ New satellite data analysed by Greenpeace actually shows the highest NOx levels over Europe sit above these four lignite plants: <https://energydesk.carto.com/builder/4c2e-ce4f-3367-4432-a418-8ce61ca01801/embed>

¹⁵ See <https://www.wiwo.de/my/unternehmen/energie/rwe-chef-schmitz-das-fossile-zeitalter-geht-zu-ende/23226152.html>

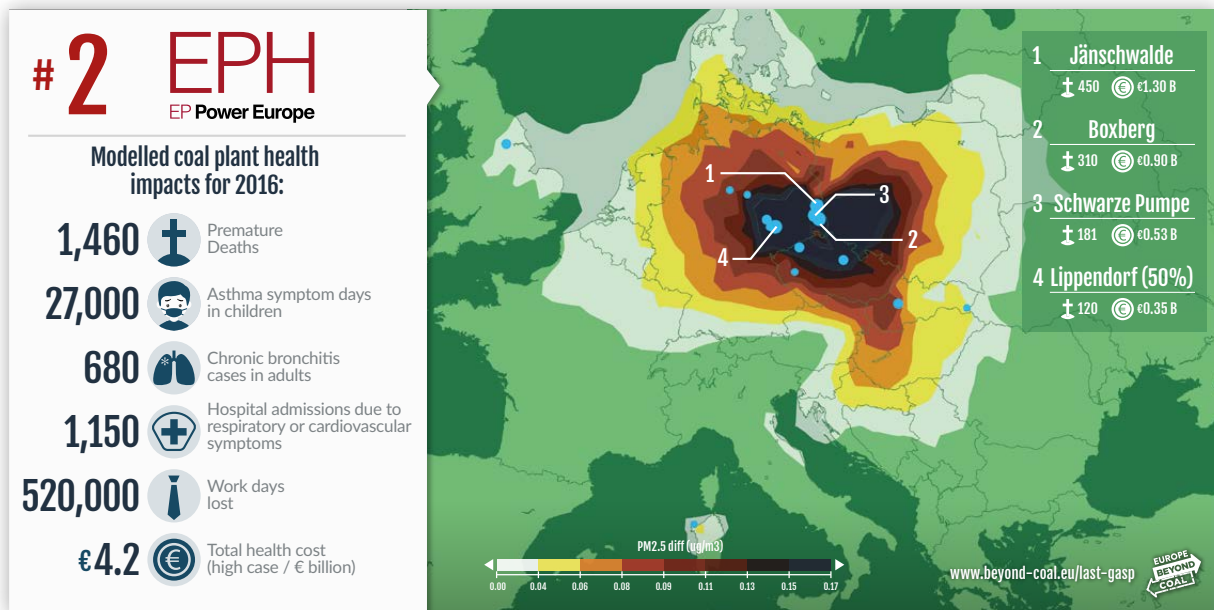
¹⁶ <https://af.reuters.com/article/commoditiesNews/idAFL8N1PI39X>

"The worrying thing is that the problem starts before we see the children. During pregnancy, even three months before pregnancy, the pollutants inhaled by the mother are decisive, and the newborn baby carries a burden of disease throughout its life. As a paediatrician, when I start to work, I'm already at the bottom of the well."

"Children who live in Hellental in the Eifel - which has the cleanest air in the Federal Republic of Germany - would need to smoke more than 1.8 cigarettes a day to have the same health burden as the children of Cologne do, due to air pollution."

"Coal soot particles are one of the most poisonous substances that can be found in the air. These ultra-fine particles that penetrate deeply into the body, even during pregnancy, transporting polycyclic aromatic hydrocarbons (PAHs), dioxin-like chemicals, even to the DNA level. They are the stuff paediatricians' nightmares are made of"





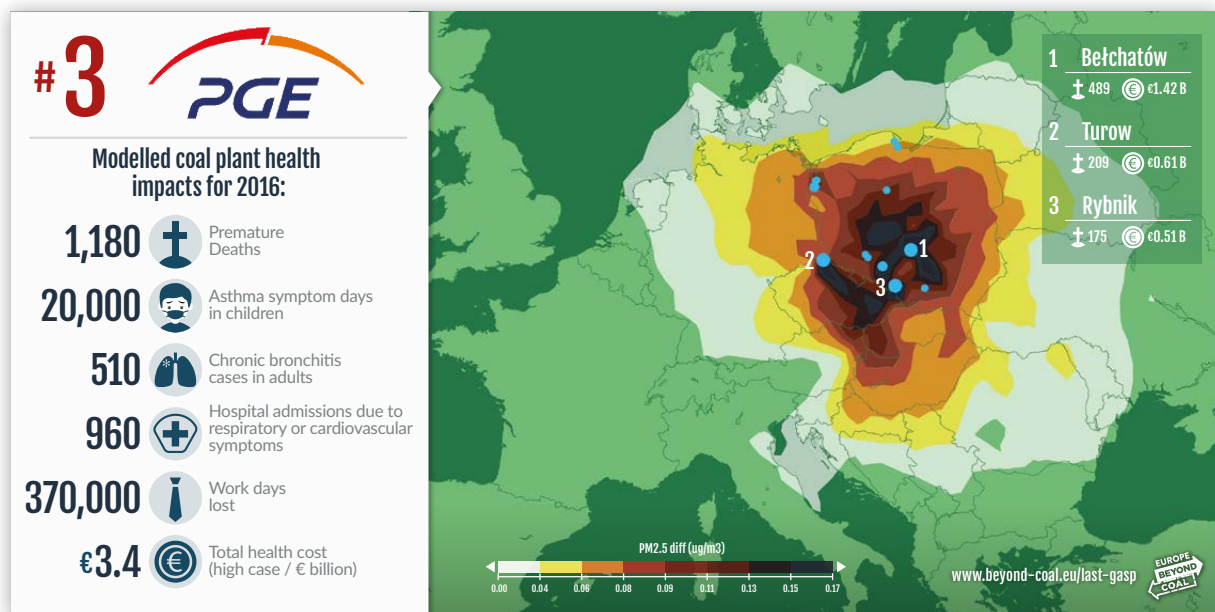
2. EPH.

EPH has grown from a small Czech business to a European-wide company, with coal plants in seven countries, making it Europe's second most harmful generator. It purchased old polluting power plants that progressive utilities no longer wanted to assume responsibility for, including the German lignite plants from Vattenfall.

Over two thirds of EPH's health impacts come from these four giant lignite plants in eastern Germany: Jänschwalde, Boxberg, Schwarze Pumpe and their 50% stake in Lippendorf. The pollution stretches west across the whole of Germany, and also significantly impacts the air quality in the Czech Republic and south-western Poland. In 2016, these four plants alone were responsible for modelled health impacts including more than 19,000 days of children suffering asthma symptoms, 500 new cases of chronic bronchitis in adults, and 1,100 premature deaths. These health impacts add up to over €3 billion for that year.

EPH has closed the UK's Eggborough plant this year, and also is being generously paid to retire three lignite units in Germany through the lignite

reserve, but besides that has announced no plans to close its remaining plants. EPH holding is privately-owned by Czech billionaire Daniel Křetínský, which is registered through a shell company in low-tax Luxembourg.



3. PGE.

The Polish company, which is majority owned by the Polish state, owns the EU's most polluting power plant: Bełchatów. Bełchatów in 2016 alone was responsible for 489 premature deaths, 140,000 lost working days and 205 cases of chronic bronchitis in adults, culminating in over a billion Euros in health costs, according to the modelling. Its pollution reaches across all of Poland. PGE has announced one unit will close in 2019, but that still leaves 93% of Bełchatów's capacity with no public plans to close. PGE's Turów power station is the company's second most harmful plant, located right on the border with Germany and the Czech Republic.

PGE is currently seeking to expand its mines, and if successful the health toll may continue for many years to come.



Joanna Rostek is a retired designer from Rybnik, home of PGE's third most polluting plant. She's a native of Silesia where her family has lived for generations. As soon as the heating season starts, and low stack emissions add to the air pollution, she says her family starts suffering from coughs, dyspnoea, and conjunctivitis. Her grandchildren have chronic runny noses and bronchitis. There were years when she would take them to the seaside in November because they could not breathe and no antibiotics would help them.

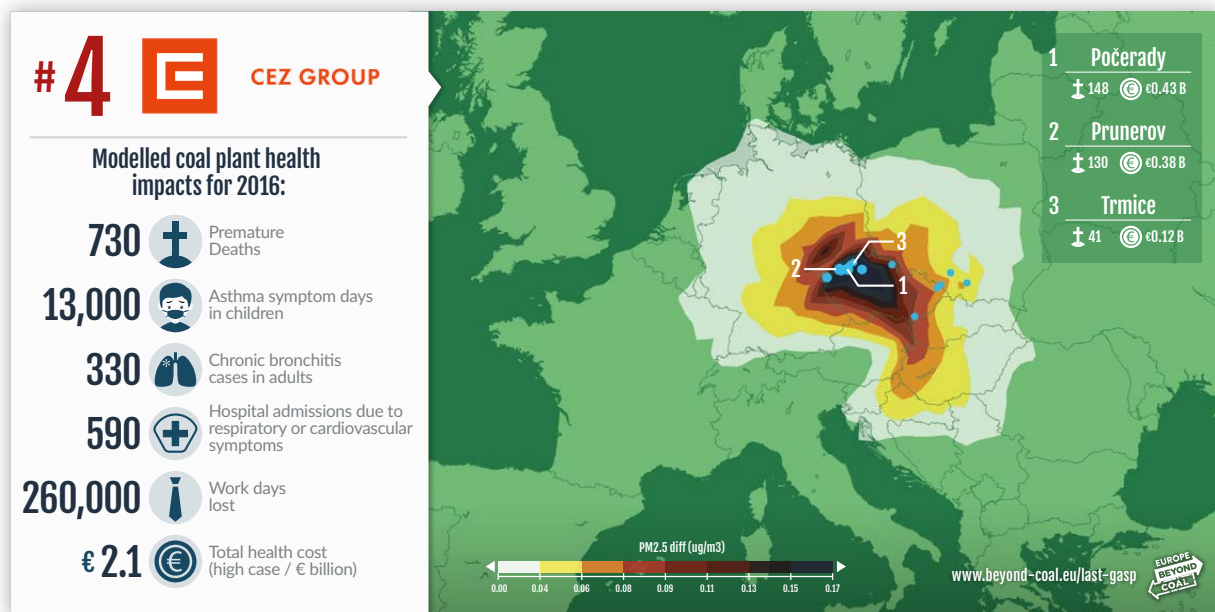
"I was born here and I feel deeply sorry that my Silesia is so polluted. I want to stay here. I want my children and grandchildren to live here but in humane conditions. For the time being we resort to air cleaners so that we could feel safe at least in our homes."

"People who are not miners are anxious about the future of this region, that the economy will collapse, because of mining. We can't attract investment due to pollution. Young people don't want to live here. They say: why would we?"

"There should be no such thing as a choice between jobs and health. We should choose a healthy society. I think that we can create other jobs."

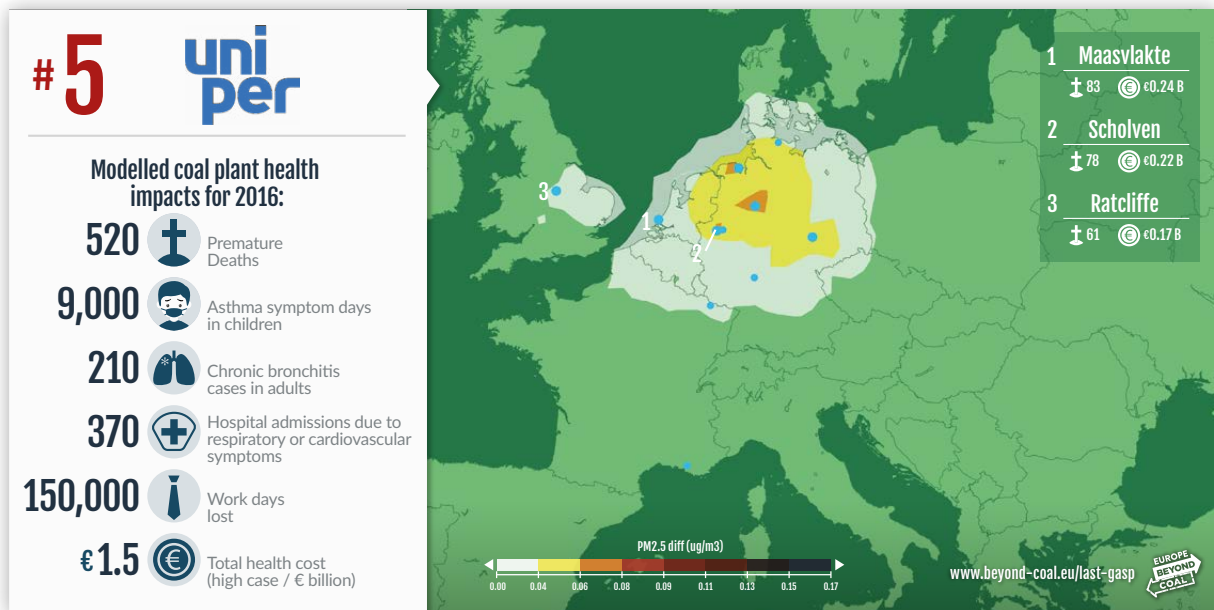
"I would like Rybnik to be a green place, as people told me it used to be. Like the place I remember from my childhood. We're not a nomadic family. We've lived here for generations, have a home here. I would like my children to see their future here but for now it doesn't look so bright."





4. ČEZ.

90% of ČEZ's health impact comes from burning lignite in the Czech Republic, predominantly in the north-east of the country. Pollution from ČEZ's plants spreads a toxic cloud across the region and its most populated city of Prague. ČEZ's most damaging plant is Počerady, situated just 65 km from the city centres of Prague and Dresden. ČEZ power plants cause some of the highest harm per unit of electricity generated. For example, Trmice creates €289 of modelled health costs for every MWh it generates, over five times as much as the revenue it receives from selling its electricity.

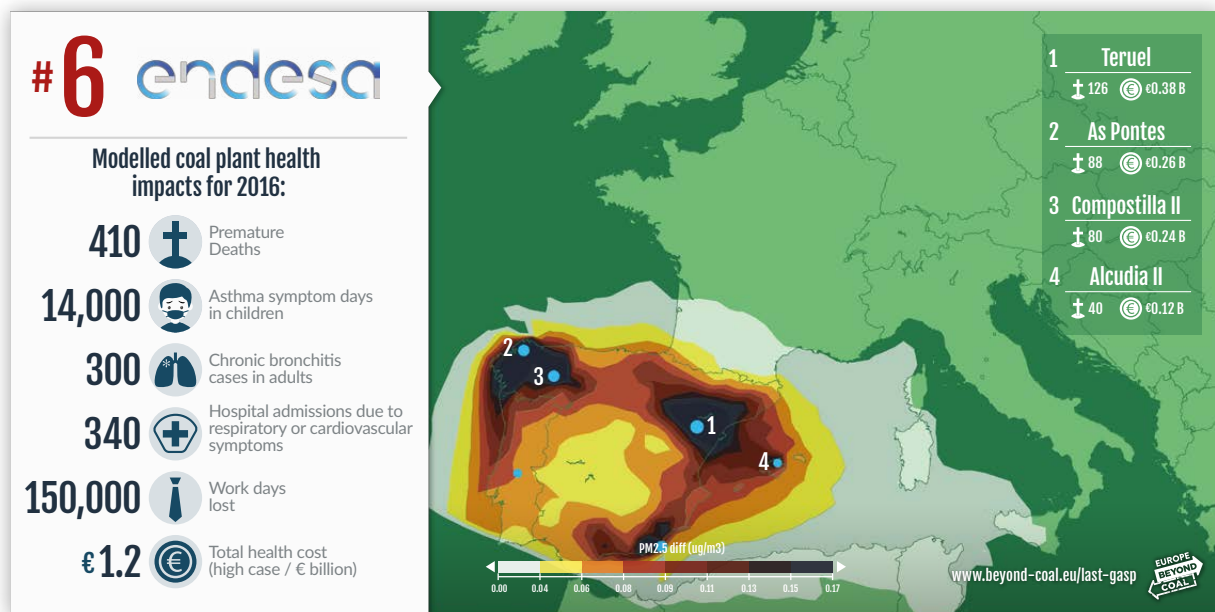


5. Uniper.

Coal plants in the UK, Netherlands and France account for around half of Uniper's pollution impacts; national government coal phase-out plans mean these plants will retire soon.

Uniper's remaining coal plants are scattered throughout western Germany, but Uniper has announced no plans to close any of these. Uniper's German plants are responsible for modelled health impacts of up to €1.5 billion, including 5,000 asthma symptom days in children, 288 premature deaths, and 80,000 lost working days.

Uniper's largest shareholder is the Finnish energy company Fortum. Fortum's coal plants are responsible for a modelled 57 premature deaths from its own Finnish plants; can Fortum lead itself and Uniper to phase-out coal?



6. Endesa.

The modelling shows the extensive scale of pollution from Endesa's coal plants throughout Spain's northern coastal region, all the way down the eastern coast, and the island of Majorca. The modelled health impacts topped over one billion Euros, including more than 400 premature deaths in 2016.

Endesa is discussing retiring two of its dirtiest plants by 2020 - Andorra and Compostilla - which, if done, would result in significantly cleaner air in Aragon and north-western Spain respectively. Still though, Endesa is pouring new money into old coal plants: its strategy outlines investments of €300m being made at Litoral and As Pontes¹⁷.

Endesa is majority owned by the Italian company Enel. While Enel is making some steps toward moving beyond coal in Italy, the company has still failed to set closure dates and plans for some of its Italian plants. Both Endesa and Enel have work to do phase out coal.



Josep Vich knows this reality all too well. He grew up on the holiday island of Majorca in Alcudia, and believes the sinus and asthma problems he has suffered throughout his life relate to air pollution from the plant and dust from the coal that feeds it.

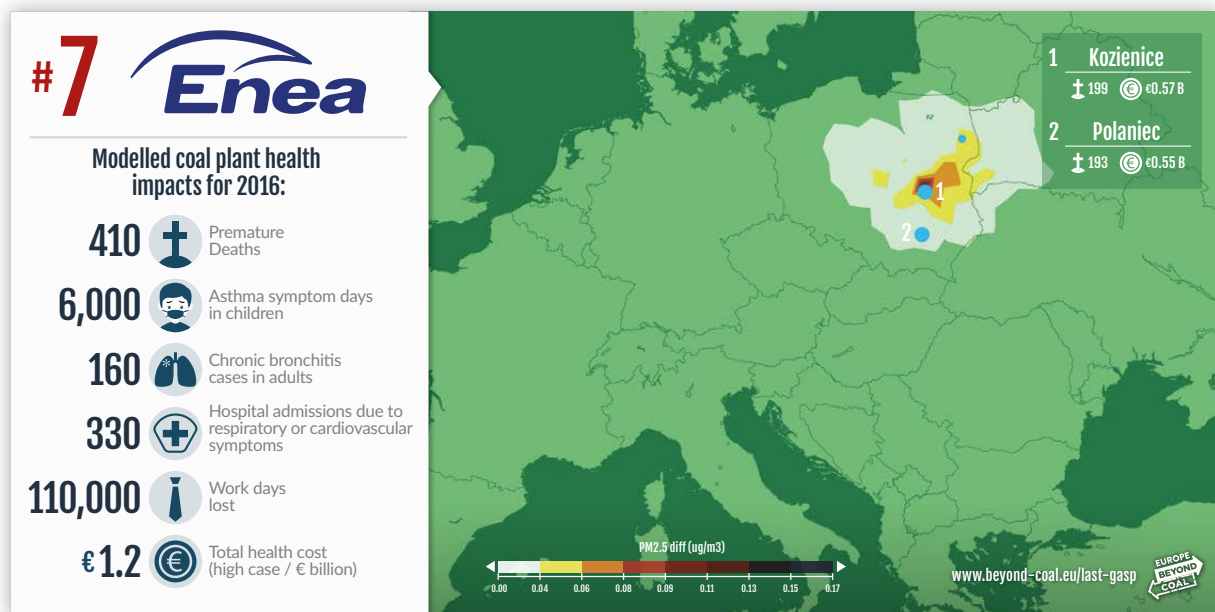
¹⁷ See Endesa "Strategy Plan 2018-2020", November 2017.
https://www.endesa.com/content/dam/enel-es/endesa-en/home/sobreendesa/nuestraestrategia/estrategia/documentos/Endesa_2018-20_Strategic_Plan.pdf

"We lived in the port of Alcudia, and had a house on the foreshore. All the coal trucks circulated in front of the house. Even when I was a child, I remember people repeatedly complained that when someone sneezed in a tissue, black matter came out. This was the coal dust we were inhaling. It was obviously damaging to health."

"I have a six-year old daughter, and all I want for her is that in 20 or 30 years she can have enjoyed her childhood like I enjoyed mine, without having suffered like we have."

Unfortunately, despite the complaints of families like Josep's, Endesa continues to keep the plant running, and it's yet to see whether it will receive support from the national government and grid operator, which may also decide to pump state aid into a retrofit for the plant that will see its lifetime expanded for another five years.





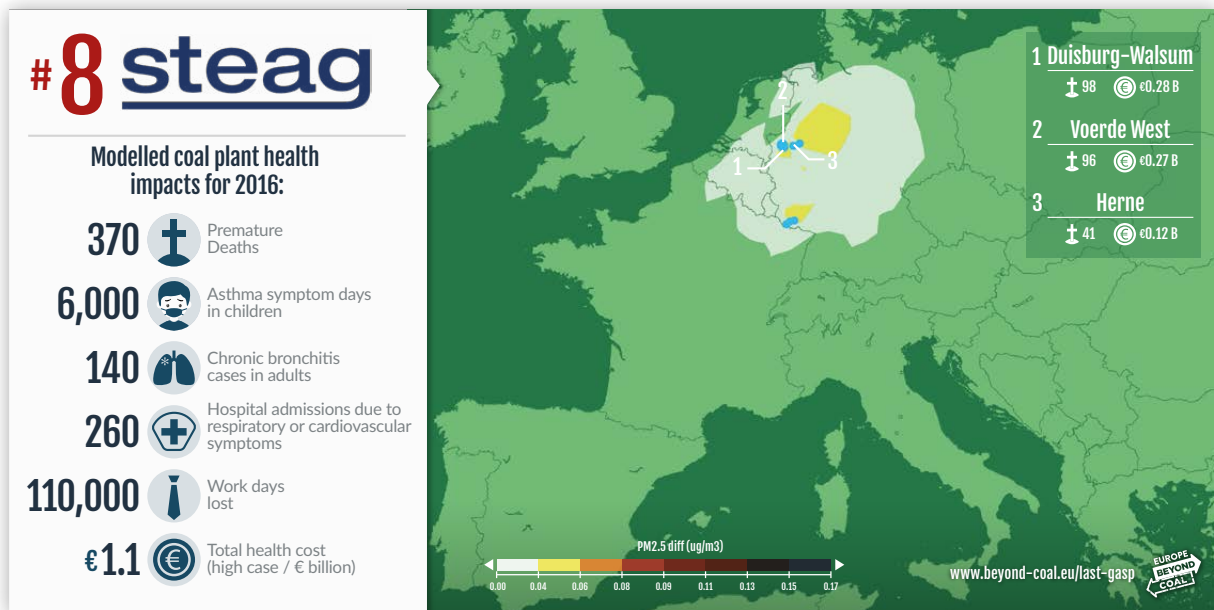
7. ENEA.

The majority state-owned Polish company, ENEA, causes modelled health impacts costing society up to €1.1 billion with 400 premature deaths from just two hard coal plants at Kozienice and Polaniec. Kozienice, the biggest emitter is only 90km from Warsaw, and the modelling clearly shows the pollution impacting Warsaw. What's more, since 2016, a new unit has been commissioned, adding a third extra capacity at Kozienice.

ENEA's plans to expand further. Firstly, to grow the Bogdanka mine that supplies Polaniec¹⁸. Secondly, ENEA is even planning to invest in a new coal power plant Ostrołęka C; independent analysis suggests this could be a massive financial mistake¹⁹.

¹⁸ https://investors.enea.pl/file/attachment/1250571/8b/report_of_the_management_board_on_the_operations_of_enea_sa_and_enea_group_in_2017.pdf

¹⁹ <https://www.carbontracker.org/ostroleka-c-burning-through-more-money-than-coal/>



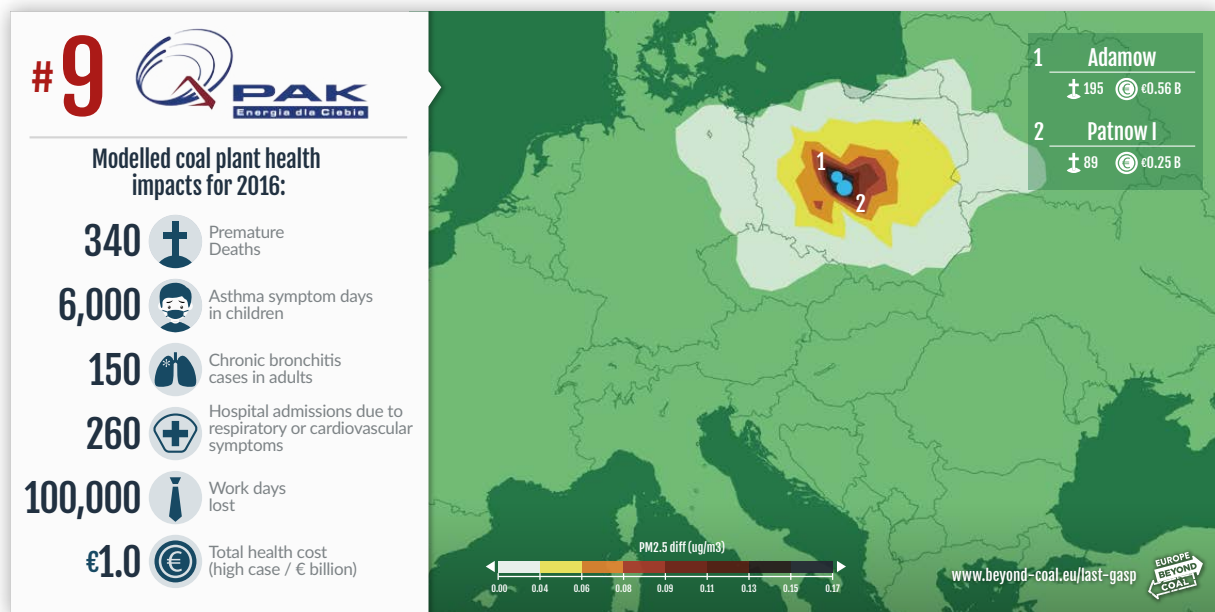
8. STEAG.

All of STEAG's plants are hard coal and located in Germany.

Since 2016, STEAG, a utility owned by several municipalities, has closed 2.5GW of coal capacity across Voerde, Voerde West and Herne. This will have cut STEAG's modelled impact by over a third, saving 150 premature deaths per year, and improving air quality right across north-western Germany. Their Luenen coal plant will also close at the end of 2018²⁰.

However, their most toxic plant is Duisburg-Walsum and is still operational. Even with the new unit built in 2013, expressed per unit of generation, the modelled health costs of Duisburg-Walsum are still only in line with the EU average of €52/MWh.

²⁰ <https://www.energate-messenger.de/news/185744>



9. ZE PAK.

ZE PAK owns four Polish lignite plants all located near each other in central Poland. The most toxic of them, Adamow, closed beginning of 2017. This will lead to cleaner air across Poland, especially in the triangle between Poznań, Łódź and Warsaw.

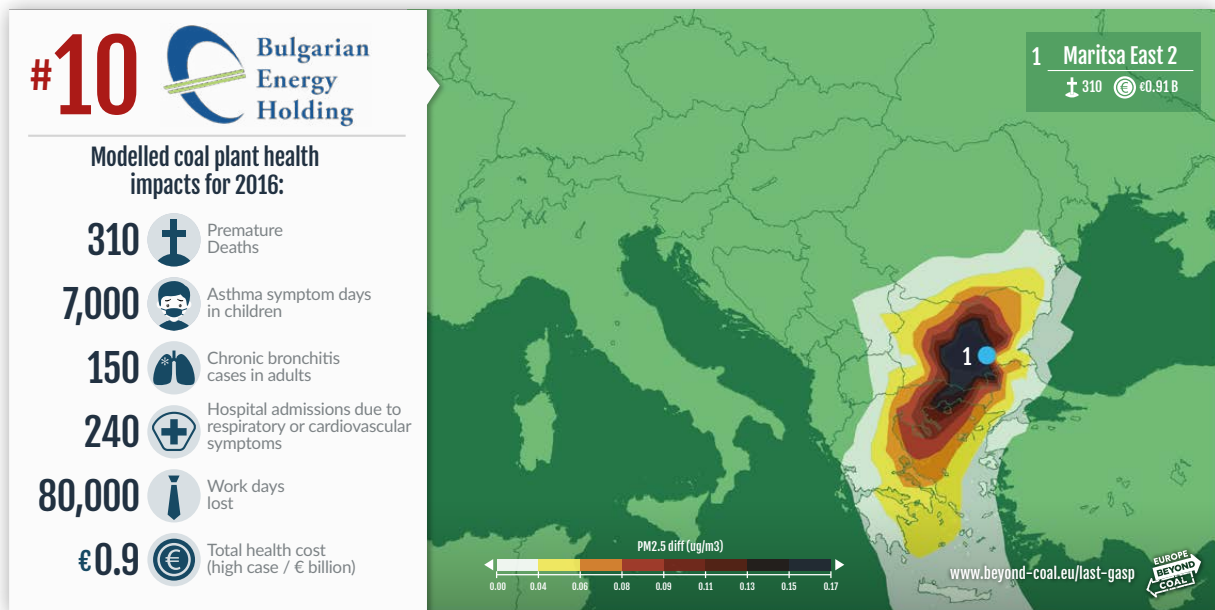
However, three lignite plants remain open, and ZE PAK is planning to extend its open cast lignite mine at Tomislawice, and to construct an entirely new open cast lignite mine¹⁹. Ościslów to fuel its power plants.

Both projects have been significantly delayed so far due to extensive protests of local communities suffering from the health and environmental impacts, including loss of groundwater that affects farming and the protected Natura2000 areas.

The EU Commission has been investigating whether there has been a breach of the EU environmental legislation by the Tomislawice lignite mine²¹.

Moreover, due to assessed environmental impacts exposed in the legal and administrative challenges the Ościslów lignite mine was not granted the environmental permit and the project's future is uncertain.

²¹ For more detail, see here: <http://www.europarl.europa.eu/sides/get-Doc.do?type=COMPARL&reference=PE-454.598&format=PDF&language=EN&secondRef=08>



10. Bulgarian Energy Holding.

This state-owned company makes it into the EU's ten most toxic despite owning just a single plant: Maritsa East 2. The modelling shows how the plant causes high levels of pollution across central Bulgaria and into northern Greece.

The plant causes almost twice as much health damage as the average EU plant per unit of electricity generated (€93/MWh, compared to €52/MWh average). Despite this damage, the plant is the first to be given a derogation from the new EU BREF pollution limits.

According to their statements they have coal reserves for 60-70 years more. Coal has been burnt on this site since the late 1960s, which is also home to Bulgaria's second most toxic plant: Contour Global's Maritsa East.

Chapter 4

How companies are still clinging to coal

All too often, companies have a strong history in coal, which leads them to assume that their coal plants will continue to be economic into the future. For example, companies assume that carbon prices will not be high, that coal plants will be required to run every day, that pollution limits are unlikely to tighten further, and that they will be able to successfully lobby government to support their toxic business. But the tide is turning and coal will not get the easy ride that it has in the past.

This chapter highlights seven ways that companies in Europe are still fighting the tide, clinging to coal.

1. Failing to plan for retirement

Leaving retirement decisions to the last minute risks the security of supply, crowds out investment into replacement capacity, and gives no notice to employees. The commitments set in the Paris Agreement to stay below 1.5 mean that coal generation in EU needs to reduce almost entirely by 2030, according to analysis by both Climate Analytics and the IEA²². The health impacts of coal companies revealed in this report make the need for action even more urgent.

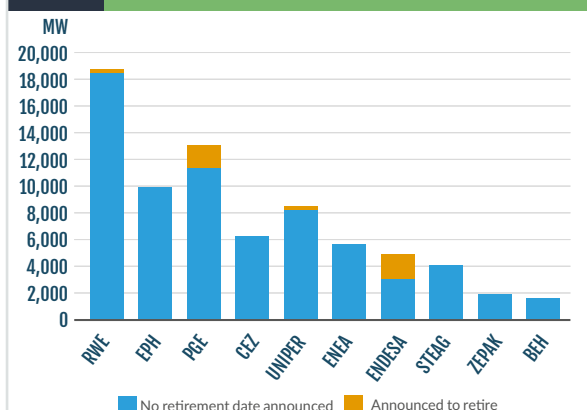
The Europe Beyond Coal campaign tracks announced retirements. Only 4% of the operational plants belonging to the ten most polluting companies have announced a date for retirement. Notably, the four companies with their biggest pollution in Germany - RWE, EPH, Uniper and Steag - have announced almost no closures of their capacity. This leaves a huge job for Germany's Coal Commission to decide how to phase-out coal, with little help from the companies themselves.

In the interests of environmental protection, human health, climate, security and affected communities, companies must set decisive and swift deadlines to retire their coal plants. There should be a fixed date for the end of operations, plus a plan to take care of the workers impacted, and safely decommission the site.

²² Climate Analytics report, "EU Coal Phase-out" says a full EU phase-out by end-2030 is needed. The IEA's ETP 2017 shows that EU unabated coal generation needs to be near-zero (3TWh) by 2030. Climate Analytics: <https://climateanalytics.org/briefings/eu-coal-phase-out/>
IEA: <https://www.iea.org/etp/>

Fig 7.

How much operational capacity is scheduled to close?
(source: Europe Beyond Coal, 17-Sept 2018, with additional updates)



2. Investing more money into old coal plants

European coal plants are old and demand constant investment. They require extended maintenance every four years, life extension upgrades as they approach 40 years old, and 'abatement' equipment to cut pollution when limits are tightened.

Unfortunately, many companies think it makes more sense to keep pouring money into old coal plants, even when their economic outlook is poor. Over half of European coal plants are already losing money, and almost all are projected to do so by 2030, according to a report by Carbon Tracker²³. Have these companies updated their profit assumptions with the latest carbon prices, the latest pollution limits, and the erosion of market share from wind, solar and batteries coming online?

Companies are currently making "invest or close" decisions to comply with new EU 'BREF' pollution limits that must be complied with by 2021 at the latest. Disappointingly, the Polish coal company **PGE** alone has already invested €475 million in meeting newer air pollution limits beyond 2021,

doubling-down on toxic coal investments²⁴. Any proposed investment in a coal plant should be weighed against the option to retire the plant with the presumption resting on 'close' in any "invest or close" decision.

3. Investing in new coal-fired power plants and digging new mines

Despite greater awareness of the impact of air pollution on our health, and the urgency of curbing CO₂ emissions, some companies are still building, or planning to build, new coal-fired power plants, or are opening new mines to fuel their existing ageing plants.

Five of the ten most toxic companies are, in 2018, still planning to build new plants:

- **RWE** still hopes to clear a 12,000 year-old forest for the Hambach mine in Germany, as well as to demolish a number of villages to make way for the neighbouring Garzweiler II lignite mine²⁵. It has also yet to officially cancel its plans for a new 1100MW lignite plant at Niederaussem, even though it is unlikely construction will ever begin.
- **PGE** is currently building two new coal plants in Poland with a combined capacity of 2260MW. A new unit at the Turów plant and two new units at Opole costing €2.7 billion. PGE has delayed a 3000MW mega coal plant at Gubin in Poland, but it is not yet officially cancelled. PGE are also applying for permits to build a large new mine to feed Poland - and Europe's - most-polluting coal plant: Bełchatów. The Żłoczew mine could displace 3,000 people and lead to large dust emissions, making air pollution even worse²⁶.
- **ČEZ** is planning to build a new lignite heating plant at Melník I, as well as putting their new 660MW lignite plant at Ledvice into full operation. ČEZ is

23 Carbon Tracker's "Lignite of the Living Dead" report <https://www.carbontracker.org/reports/lignite-living-dead/>

24 See IEEFA's "Decision Time at PGE", June 2018: http://ieefa.org/wp-content/uploads/2018/06/Decision-Time-at-Polands-PGE_June-2018.pdf

25 IEEFA analysed the impact for RWE if Hambach mine were not extended in this document.

26 http://eko-unia.org.pl/raport/raport_international.pdf

also currently asking for permission to expand the Bilina coal mine in Northern Bohemia. If it is successful, up to 150 million tonnes of coal will be extracted between from 2019 to 2035²⁷.

- **Uniper** plans to bring online the new 1100MW plant at Datteln in Germany in 2020²⁸.
- **ENEA** announced in October 2018 the approval of a new 1000 MW coal power plant - Ostrołęka C in Poland. If constructed the plant would be producing 5 million tonnes CO₂ annually for another 40 years²⁹; independent analysis suggests this could be a massive financial mistake³⁰. ENEA also plans to expand the Bogdanka mine that supplies Polaniec³¹.

With the extent of the health costs of coal revealed by the report, and the need for urgent and unprecedented action to prevent catastrophic climate breakdown, it should go without saying that new coal projects should be a thing of the past.

4. Fighting pollution limits

Stricter industrial air pollution limits came into force in the EU in 2016³². But companies managed to negotiate exceptions for more than half of all coal-fired power stations³³. These exemptions mean plants can pollute at much higher levels for many more years.

Industry lobbying against stronger emissions controls has been fierce. Unhappy that European governments signed-off on new 'BREF' air pollution limits last year, lignite-burning companies (as well as the

government of Poland and Bulgaria) are trying to sue to the European Union to reverse this legislation. Companies named in this report - including RWE, PGE and STEAG - hide behind their European-level lobbying group 'Euracoal'. Environmental groups have joined the legal fight to defend the new rules in a case which is ongoing at the time of writing³⁴.

5. Demanding 'compensation' from governments

Some companies are deliberately holding onto loss-making plants so they can demand government handouts when the state steps in to force plants to retire.

The German government has already promised companies €1.6 billion to close some of the oldest lignite units in the so-called "lignite reserve"³⁵. This August, the **Uniper** CEO Klaus Schaefer appealed for another €2 billion of public money to be handed over to energy companies to expand the scheme to more coal plants³⁶. **RWE's** CEO Rolf Martin Schmitz said his company would only rapidly retire coal units if it is effectively compensated³⁷. RWE is also threatening legal action against the Netherlands, where the government has plans for an ambitious coal phase-out³⁸.

Society is already suffering from the health and climate costs of these coal plants - RWE's unpaid health bill is up to €5.4 billion per year, based on the model findings. So when early retirement of plants is politically decided, instruments should be introduced to ensure compensation payments are unnecessary.

27 As published in their Environmental Impact Assessment: https://portal.cenia.cz/eiasea/download/RUIBX01aUDQ3MV9kb2t-1bVVudGFjZURPQ18xOTEyNzY3MDQxOTY0NzU3NTY2LnBkZg/MZP471_dokumentace.pdf

28 According to Uniper update: <https://ir.uniper.energy/websites/uniper/English/5100/news-details.html?newsID=1694527>

29 <http://biznesalert.pl/tchorzewski-koszty-emisji-co2-ostrolece-wynios-a-blisko-05-mln-zl/>

30 <https://www.carbontracker.org/ostroleka-c-burning-through-more-money-than-coal/>

31 https://investors.enea.pl/file/attachment/1250571/8b/report_of_the_management_board_on_the_operations_of_enea_sa_and_enea_group_in_2017.pdf

32 Contained in Directive 2010/75/EU of the European Parliament and the Council on industrial emissions (the Industrial Emissions Directive or IED)

33 See table 4 of "Lifting the Dark Cloud" 2016 report: https://sandbag.org.uk/wp-content/uploads/2016/10/10_EEB_dark_cloud_report_v2_hr.pdf

34 Environmental groups take legal action to defend EU rules from coal industry attack, EEB Press Release, 28 February 2018: <https://eeb.org/environmental-groups-take-legal-action-to-defend-new-eu-rules-from-coal-industry-attack/>

35 See http://europa.eu/rapid/press-release_IP-16-1911_en.htm

36 <https://www.spglobal.com/platts/en/market-insights/latest-news/coal/081718-hot-summer-turns-up-heat-on-germanys-coal-phase-out-commission>

37 <https://af.reuters.com/article/commoditiesNews/idAFL8N1PI39X>

38 <https://uk.reuters.com/article/uk-netherlands-energy-coal/netherlands-to-ban-coal-fired-power-plants-in-blow-to-rwe-idUKKCN11-11PG>

6. Pushing for new coal subsidies

Coal-burning companies are lobbying governments across Europe for millions of Euros of public money in the form of 'capacity mechanisms'. These payments are presented as means to ensure security of supply, but they distort the market and are often abused to subsidise otherwise unprofitable fossil fuels, coal in particular.

The Greenpeace European Unit recently revealed that governments in the EU have paid or allocated €58 billion through capacity mechanisms³⁹ to coal, gas and nuclear. 98% of the subsidies goes to fossil fuels and nuclear energy and two thirds of the total amount goes to coal plants.

Old and polluting plants are being paid to stay online while much of Europe has more capacity than required. For example, Spain suffers from 30% overcapacity⁴⁰, with only 16.7% of its gas capacity being used⁴¹. However, Spanish utilities are receiving €17.9 billion in capacity mechanisms, making Spain the biggest beneficiary of capacity mechanisms in Europe.

A new capacity mechanism will begin in Poland this year, where consumers are expected to pay €14.4 billion in capacity mechanisms between 2016 and 2030. The vast majority of this is expected to go to coal plants, according to the Greenpeace report mentioned above. It may even subsidise the construction of **ENEA's** new 1GW hard coal plant at Ostrołęka⁴², which would be expected to lose €1.7 billion over its lifetime if it didn't get capacity payments⁴³.

This autumn, national governments and the European Parliament will decide whether or not capacity mechanisms will be restricted by EU law. The Commission proposal for the Electricity

Market Regulation, supported by the European Parliament, would prevent governments from subsidising coal plants with capacity payments. The proposal would require governments to properly assess and prove the need for subsidies in the form of the capacity mechanisms and set a carbon intensity criterion of 550g CO₂/kWh that would effectively exclude coal plants and the most polluting gas plants from subsidies. However some governments and utilities heavily oppose it and seek to prolong subsidies for coal for as long as possible.

7. Selling up instead of closing down

Even when companies want to get rid of their coal plants, they don't do the right thing. While some companies have been selling coal plants to get themselves out of the coal business, selling plants to another company, who will continue to operate them, is not improving our health or the climate. It is simply passing the problem onto others who are even less likely to close the plants.

EPH has become the second most polluting coal company in Europe by buying old coal plants from companies exiting coal. Its biggest acquisition was the German lignite plants and mines from **Vattenfall**. A second Czech billionaire, Pavel Tykač, is looking to follow EPH owner Kretinsky's lead with a billion euros at his disposal for his company **Seven Energy**⁴⁴.

EPH and Seven Energy are leading bidders for plants being sold by **Engie** and **PPC**. Other companies' plants have been linked with potential sales. **Uniper** could sell coal plants if its new parent company **Fortum** decides to do so, while **ČEZ's** Počerady plant has been linked to Seven Energy, and reports have suggested that the coal fleets of **Steag** and **ENBW** could also be up for sale.

39 <https://www.greenpeace.org/eu-unit/issues/climate-energy/1519/exposed-e58-billion-in-hidden-subsidies-for-coal-gas-and-nuclear/>

40 https://docstore.entsoe.eu/Documents/SDC%20documents/SOAF/150630_SOAF_2015_publication_wcover.pdf

41 <http://www.ree.es/en/statistical-data-of-spanish-electrical-system/annual-report/spanish-electricity-system-2017-report>

42 <http://elektrowniaostroleka.com/news/5-energa-avoids-answering-inconvenient-questions/lang:en>

43 <https://www.carbontracker.org/ostroleka-c-burning-through-more-money-than-coal/>

44 <https://www.reuters.com/article/czech-sevenenergy/new-czech-firm-to-invest-1-billion-euros-in-european-power-idUSL8N1QC6F3>

Companies are also converting coal plants to run on biomass, which does not solve the problem. Biomass procured for power stations is often not of a high sustainability criteria⁴⁵, and while less polluting than coal, biomass power plants are still a significant source of air pollution - and converted coal plants are much more harmful per unit of electricity generated than purpose built biomass installations⁴⁶.

45 "Carbon impacts of biomass consumed in the EU":
<https://europeanclimate.org/new-report-carbon-impacts-of-biomass-consumed-in-the-eu/>

46 "Burning biomass: the impact on European health":
<https://fern.org/sites/default/files/news-pdf/briefingnote%20burning%20biomass.pdf>

Chapter 5

Recommendations

Coal companies in Europe are still making us sick. And two thirds of the impact is traced to just ten of the most toxic companies.

While energy companies profit, society picks up coal's unpaid health bill: we all deserve better. Workers and affected communities deserve certainty about their future and access to the green jobs of tomorrow. Governments must meet their commitment to keep temperature rise to 1.5 degrees. While a Europe beyond coal is a question of when, not if.

Companies must:

- **Stop all investment into hard coal and lignite with immediate effect.** This includes not only new plants, but also means ceasing investments into existing plants. It also includes stopping all investments in new and existing mines - to put an end to destruction of forests and villages, and forced relocations.
- **Commit to the closure of all hard coal and lignite plants by 2030 or earlier.** Companies should not sell their coal plants but rather take responsibility for closing them, and closure dates should be announced to plan for a just transition.
- **Stop lobbying for coal;** especially to weaken and seek derogation from "BREF" air pollution limits and campaign for capacity mechanisms.
- **Work proactively with stakeholders** to speed a just transition away from coal to minimise the societal and economic impacts of coal closures.
- **Adopt business plans** that ensure the company genuinely contributes towards compliance with the Paris Climate Agreement aim of temperature rises not exceeding 1.5°C.

Governments must adopt policies to ensure companies retire their coal plants by 2030. This should include:

- **Transition to 100% renewables:** Commit, including in the 2030 national energy and climate plans (NECPs), to a rapid-build programme of renewable generation, as well as storage, demand-response, interconnectors and investment in energy efficiency.
- **Policies to make coal pay its way:** tighter air pollution limits, higher carbon pricing, and a cessation of subsidies to coal including capacity payments.
- **A legally-binding coal phase-out date and a just transition for affected communities and workers.**



ANNEX:

Methodology & Sources

This methodology details the health modelling used in this report.

There are a series of discrete steps:

1. Identify coal power plants operating in the EU in 2016.
2. Source 2016 coal power plant emissions data.
3. Model the pollutant exposure resulting from the emissions from all EU coal power plants.
4. Calculate the health impacts associated with modelled pollutant exposures.
5. Attribute the health impacts to individual coal power plants.
6. Calculate the cost of the health impacts.
7. Create pollution maps for the ten most polluting companies.

1. Identify coal power plants operating in the EU in 2016.

Europe Beyond Coal maintains a database of information on coal power plants⁴⁷. From this, we identified the 265 coal plants operational in the EU in 2016 and the company or companies that owned these plants.

2. Source 2016 coal power plant emissions data.

In the modelling, SO₂ and NO_x emissions as well as fine (PM_{2.5}) and coarse (PM_{2.5-10}) particle emissions from all facilities are accounted for. Every coal plant must report its emissions and they are published by the European Environment Agency in two separate databases: the Large Combustion Plant database (LCP)⁴⁸ and the European Pollutant Release and Transfer Register (E-PRTR)⁴⁹. We have worked with *Europe Beyond Coal* over the years to correctly map their database to each of the LCP

⁴⁷ <https://beyond-coal.eu/data/>

⁴⁸ See <https://www.eea.europa.eu/data-and-maps/data/lcp-6>

⁴⁹ Dataset used for modelling of SO₂, NO_x & dust was EPRTR v13 for 2016 data <https://www.eea.europa.eu/data-and-maps/data/member-states-reporting-art-7-under-the-european-pollutant-release-and-transfer-register-e-prtr-regulation-21>

and E-PRTR databases, and this was updated again for this report. For our modelling, we use the LCP emissions, if they are available, and if they are not, we use the E-PRTR emissions. We also carry out cross-checks with the CO₂ emissions from the EUTL database to add further confidence that the emissions used in the modelling are correct.

Note, the emissions used in the report are for coal power plants, which include some amount of running of gas, oil and biomass, either as co-firing or in separate units within the coal plant; rough analysis estimates this as around 1% of the air pollution across the total EU coal plant fleet, but may be bigger for some companies - for example, Drax's health impact includes a sizable contribution from burning biomass.

3. Model the pollutant exposure resulting from the emissions from all EU coal power plants.

The modelling used the Open Source EMEP/MSC-W chemical transport model⁵⁰ and the associated input datasets developed by European meteorological institutes under the Convention on Transboundary Air Pollution (CLRTAP). Specifically, for this report we rely on input data provided by EMEP/MSC-W, ECMWF and the Norwegian Meteorological Institute.

The EMEP/MSC-W is an advanced chemical-transport model that simulates air quality across Europe using spatial data on emissions from different sectors and sources, along with three-dimensional time series data on meteorological variables, such as wind speed and direction, temperature, humidity and precipitation as well as land use, topographical and other relevant geophysical data. The model is continuously developed and validated yearly by comparing predicted total pollution levels and pollution composition with measurements at dozens of ground stations⁵¹. All datasets used and meteorological data are for the year 2016.

For the first time in this report series, the total air quality and health impacts from all the studied power plants were estimated using the new, high-resolution EMEP grid⁵², using two simulation⁵³ that singled out SO₂ and NO_x emissions as well as fine (PM_{2.5}) and coarse (PM_{2.5-10}) particle emissions from all facilities.

The MSC-W model is a regional-scale model. The local pollutant concentrations at the most affected locations would be much higher than indicated by the value for the whole grid cell, but most of the health impacts are associated with long-range transport of pollution which exposes millions of people to small additional concentrations, leading to an additional burden of disease and mortality.

50 Version 4.17a

51 EMEP MSC-W model performance for acidifying and eutrophying components, photo-oxidants and particulate matter in 2016: http://emep.int/publ/reports/2018/sup_Status_Report_1_2018.pdf

52 A 0.1 x 0.1 degree regular longitude-latitude grid (as opposed to the lower resolution 50 x 50 km polar stereographic grid used in previous years) - this represents an approximately 26 fold increase in model resolution.

53 A simulation with all emissions from all sectors - known as the baseline - and a simulation with the emissions from the coal power stations removed (with all other emissions left unchanged). The difference between the two simulations identifies the impact of coal power stations on air quality.

4. Calculate the health impacts associated with modelled pollutant exposures.

The methodology for estimating mortality and morbidity caused by emissions of coal-fired power plants in this report follows the recommendations of experts from Europe and North America, convened by WHO-Europe for health impact assessment of air pollution in Europe in terms of the health endpoints included (see HRAPIE⁵⁴ recommendations). It applies the same monetary valuations as those used in impact assessments for the EU Clean Air Policy Package in 2014⁵⁵, but updated to reflect 2016 prices. Exposure with primary and secondary particulate matter, ozone and nitrogen dioxide caused by emissions from the studied plants was estimated using the modelling process described earlier.

The health impacts resulting from modelled pollutant concentrations were evaluated by assessing the resulting population exposure, based on high-resolution gridded population data for 2015 from NASA SEDAC Gridded Population of the World v.4⁵⁶ then applying the WHO HRAPIE recommendations for health endpoints and for concentration-response functions for health impact assessment⁵⁷. The extended set of pollutant-outcome pairs recommended for inclusion in total effect (HRAPIE groups A* and B*) was used⁵⁸. Affected fractions of the population were applied evenly to all grid cells. Required baseline health data were obtained from WHO databases⁵⁹ as well as from a technical guidance paper on implementing HRAPIE recommendations⁶⁰.

The health impacts in each grid cell are calculated as:

[number of cases] = [population in grid cell] * [affected population fraction] * [baseline incidence] * [change in pollutant concentration] * [concentration-response factor],

Baseline incidence refers to the incidence or prevalence of the studied impact in the population - excluding the impact of the modelled coal emissions; e.g. new cases of chronic bronchitis per 100,000 people.

Affected population fraction refers to the percent of the total population that the impact estimate is applied to e.g. population at or above 30 years of age for chronic mortality. The fractions were calculated for the total population and applied to all grid cells.

Change in pollutant concentration refers to the change in predicted concentrations between the baseline and the simulations.

Concentration-response factor refers to the percentage increase in cases per increase in pollutant concentration derived from scientific studies, e.g. 6.2% increase in mortality⁶¹ when PM_{2.5} concentrations increase by 10µg/m³ over a long period. These results for each grid cell are then summed over the geographic area for which impacts are being calculated.

54 <http://www.euro.who.int/en/health-topics/environment-and-health/air-quality/publications/2013/health-risks-of-air-pollution-in-europe-hra-pie-project-recommendations-for-concentrationresponse-functions-for-costbenefit-analysis-of-particulate-matter,-ozone-and-nitrogen-dioxide>

55 <http://ec.europa.eu/environment/air/pdf/TSAP%20CBA.pdf>

56 <http://beta.sedac.ciesin.columbia.edu/data/set/gpw-v4-population-density>

57 Health risks of air pollution in Europe – HRAPIE project. Recommendations for concentration–response functions for cost–benefit analysis of particulate matter, ozone and nitrogen dioxide:

<http://www.euro.who.int/en/health-topics/environment-and-health/air-quality/publications/2013/health-risks-of-air-pollution-in-europe-hra-pie-project-recommendations-for-concentrationresponse-functions-for-costbenefit-analysis-of-particulate-matter,-ozone-and-nitrogen-dioxide>

58 Groups A* and B* are recommended by HRAPIE for estimating the total effect as one option for impact analyses, representing the extended set of effects. Groups B* and B come with higher uncertainty than groups A* and A.

59 WHO Global Health Estimates, 2012, http://www.who.int/healthinfo/global_burden_disease/estimates/en/index1.html

60 Holland, M. (2014), Implementation of the HRAPIE Recommendations for European Air Pollution CBA work: <http://ec.europa.eu/environment/air/pdf/CBA%20HRAPIE%20implement.pdf>

61 Natural mortality in the over 30s, eliminating deaths under that age, and any death from accidental and intentional causes (suicides, murders etc.).

Table 2 Concentration-response functions for mortality:

– Increase in risk for a 10µg/m³ increase concentration core mortality functions without infant mortality to be added for total impact with likely overlap of 33% between PM_{2.5} and NO₂ effect, Ozone concentration refers to summer period (April to September) average.

Impact	Subgroup	Pollutant	Central	Low	High
All cause natural mortality from chronic exposure	Over 30 years	PM _{2.5}	6.20 %	4 %	8.30 %
All cause natural mortality from acute exposure	All ages	O ₃	0.29 %	0.14 %	0.43 %
All cause natural mortality from chronic exposure	Over 30 years	NO ₂	5.5 %	3.1 %	8.0 %
Infant mortality (HRAPIE group B*)	1 month to 12 months	PM _{2.5}	4.0 %	2.0 %	7.0 %

Table 3 Concentration response functions and population and morbidity data for non-fatal health impacts:

Pollutant	Effect	Affected population fraction	Incidence rate	Response function	Concentration increase (10µg/m ³)	HRAPIE group
PM ₁₀	Incidence of chronic bronchitis, population aged over 27 years	67.6 %	0.39 %	11.70 %	10	B*
PM ₁₀	Bronchitis in children, ages 6-12 years	7 %	18.6 %	8 %	10	B*
PM ₁₀	Incidence of asthma symptoms in asthmatic children, ages 5-19 years	0.6 %	62	2.8 %	10	B*
PM _{2.5}	Respiratory hospital admissions, all ages	100%	1.165 %	1.9 %	10	A*
PM _{2.5}	Cardiac hospital admissions, all ages	100%	2.256 %	0.91 %	10	A*
PM _{2.5}	Restricted activity days (RADs)	100%	19	4.7 %	10	B*
PM _{2.5}	Work days lost, working age population	42.5 %	9.4	4.6 %	10	B*
Ozone (SOM035)	Minor restricted activity days, all ages	100%	7.8	1.54 %	10	B*
Ozone (SOM035)	Respiratory hospital admissions, ages over 64 years	16.4 %	2.2 %	0.44 %	10	A*
Ozone (SOM035)	Cardiovascular hospital admissions, ages over 64 years	16.4 %	5 %	0.89 %	10	A*
NO ₂	Bronchitis in children, ages 5-14 years	0.5 %	1.52 %	2.1 %	1	B*
NO ₂	Respiratory hospital admissions, all ages	100 %	1.165 %	1.8 %	10	A*

The mortality estimates include the effect of direct NO₂ exposure, in line with WHO recommendations. The central and low estimates of mortality in this report (low range of 95% confidence interval) only include 67% of the NO₂ mortality effect based on a single-pollutant risk model because of possible overlap with PM_{2.5} health impacts identified by the WHO (HRAPIE project report). Similarly, in line with the HRAPIE project guidance, only grid cells for which background concentrations of NO₂ above 20 µg per m³ had been reported in the AQ e-Reporting dataset⁶² from European monitoring stations, as well as grid cells for which the MSC-W simulations yielded concentrations above 20 µg per m³ were included to calculate NO₂ mortality.

Our analysis, based on WHO-Europe's latest recommendations from 2013, suggests that ~ **21%** of the damage caused power coal power stations in the EU is linked to exposure to NO₂. Compared to the literature on fine particle effects, there is, even now, much less research available on NO₂ and so this part of the results should be regarded as having higher uncertainty. A more recent review has been provided by COMEAP (2018)⁶³ on behalf of the UK's Department for Health and Social Care and provides a detailed account of the uncertainties involved in the NO₂ assessment.

5. Attribute the health impacts to individual coal power plants.

For the purpose of further simulations, the power plants were grouped into ten geographical clusters and a simulation was carried out separately for the SO₂ and NO₂ emissions from each cluster. Due to limitations on computational availability, these additional simulations were carried on the lower resolution 50 x 50 km polar stereographic grid. This provided a total of 22 simulations, including two baseline simulations with all clusters and without all clusters. The pollution exposure and health impacts resulting from one unit of emissions of SO₂ and one unit of NO₂ from each cluster were then calculated and applied to the emissions from each facility in the cluster. This assigned the estimated health impacts caused by SO₂ and NO₂ to each facility.

To assign the primary PM_{2.5} and PM₁₀ emissions impact, we used the existing country-by-country emissions-to-exposure values from the CAFE CBA methodology. Primary PM emissions are responsible for a small share of the total health impacts - therefore we did not do an additional set of cluster runs for them - we believe the added value would have been negligible.

This approach is similar to that used in the European Commission's 'Clean Air For Europe (CAFE) Cost Benefit Analysis' methodology⁶⁴ as well as the EEA's 'Revealing the costs of air pollution from industrial facilities in Europe' report, improving upon it in some respects:

- Atmospheric modelling is carried out specifically for the studied coal-fired power plants. Earlier approaches to plant-level health impact estimates relied on modelling results, including emissions from all sectors, using sectoral adjustment factors to make the estimates more appropriate for power plants.

62 European Environment Agency, Air Quality e-Reporting (AQ e-Reporting). The European air quality database. <https://www.eea.europa.eu/data-and-maps/data/aqereporting-8>

63 <https://www.gov.uk/government/publications/nitrogen-dioxide-effects-on-mortality>

64 AEA Technology Environment (2005), Methodology for the cost-benefit-analysis for CAFE. Volume 2: Health Impact Assessment: http://ec.europa.eu/environment/archives/cafe/pdf/cba_methodology_vol2.pdf

- PM₁₀ concentrations were simulated directly, rather than being calculated from PM_{2.5} using a fixed ratio.
- The influence of coal-fired power plants on ambient NO₂ levels is included. Earlier work only looked at the impacts on PM_{2.5} and ozone, but the new WHO recommendations now recognise that NO₂ exposure also has long-term health impacts.

The health impacts by each company were then calculated by summing the combined health impacts of each facility under the company's ownership. Where facilities are jointly owned by two or more companies the health impacts were split by the percentage ownership.

6. Calculate the cost of the health impacts.

The economic valuation of human health impacts is a tool to estimate what would be an acceptable cost for avoiding those impacts. The approach used by the European Commission and the European Environment Agency⁶⁵ as well as the World Health Organization⁶⁶ and adopted in this paper includes both direct costs, such as health care costs and lost economic output due to absence from work, as well as a measure of people's willingness to pay to avoid the risk of death or disease. The premise is that since health risks from air pollution affect all European citizens and individual people do not have the choice of spending money to significantly reduce toxic power plant emissions, a government's willingness to direct resources to reduce health impacts from air pollution should be the same as the willingness of the people it governs.

The costs associated with the health impacts of EU coal-fired power plants are estimated based on the cost values used in 2014 impact assessments for the EU Clean Air Policy Package⁶⁷. They were updated from 2005 prices to 2016 prices to reflect the substantial changes in prices⁶⁸. Similar to the work for the EU Clean Air Policy Package, in this assessment EU averages were applied for all monetary valuations of the impacts, as the health impacts are transboundary in nature.

Table 3A Monetary values applied to mortality and morbidity endpoints

Health Impact	Median monetary value, EU-28 average Euro 2016 prices	High monetary value, EU-28 average Euro 2016 prices
Mortality from Chronic or Acute Exposure, VSL	1,335,915	2,720,854
Infant Mortality (1-12 months)	1,960,976	4,044,512
Hospital admissions due to respiratory or cardiovascular symptoms	2,721	
Chronic bronchitis in adults	65,693	
Work days lost, working age population	159	
Restricted activity days	113	
Minor restricted activity days	51	
Bronchitis in children	721	
Asthma symptom days in asthmatic children	51	

65 AEA Technology Environment 2005: Damages per tonne emission of PM_{2.5}, NH₃, SO₂, NO_x and VOCs from each EU25 Member State (excluding Cyprus) and surrounding seas. Tables 4 and 5. http://ec.europa.eu/environment/archives/cafe/activities/pdf/cafe_cba_externalities.pdf

66 WHO European Region (2015), Economic cost of the health impact of air pollution in Europe: Clean air, health and wealth. <http://www.euro.who.int/en/health-topics/environment-and-health/air-quality/publications/2015/economic-cost-of-the-health-impact-of-air-pollution-in-europe>

67 Amann, M. (ed.) (2014), The Final Policy Scenarios of the EU Clean Air Policy Package. International Institute for Applied Systems Analysis IIASA: <http://ec.europa.eu/environment/air/pdf/TSAP.pdf> as well as Holland, M. (2014), Cost benefit Analysis of Final Policy Scenarios for the EU Clean Air Package. <http://ec.europa.eu/environment/air/pdf/TSAP%20CBA.pdf>

68 Price development as reflected in Eurostat indicator "Purchasing power parities (PPPs), price level indices and real expenditures for ESA 2010 aggregates [prc_ppp_ind]" for Actual Individual Consumption, real expenditure per capita (EU-28). <http://ec.europa.eu/eurostat/data/database>

7. Create pollution maps for the ten biggest polluters.

In chapter 3, we show pollution maps for the ten most polluting companies. The data underpinning these were generated by re-running the Open Source EMEP/MSC-W chemical transport model (on the lower resolution 50 x 50 km polar stereographic grid) with just the emissions from each highlighted company, resulting in a further ten individual simulations.



