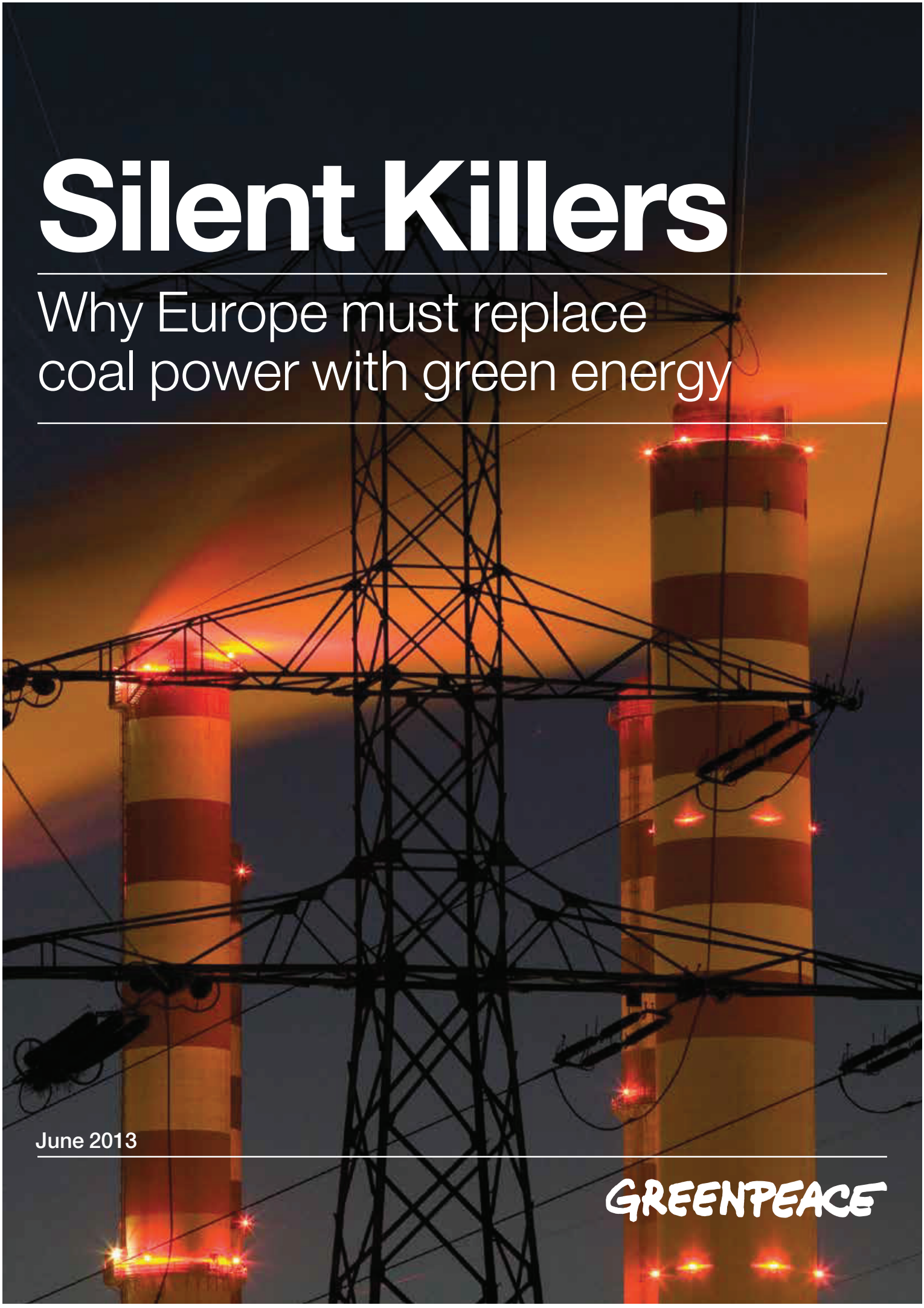

Silent Killers

Why Europe must replace coal power with green energy

June 2013

GREENPEACE

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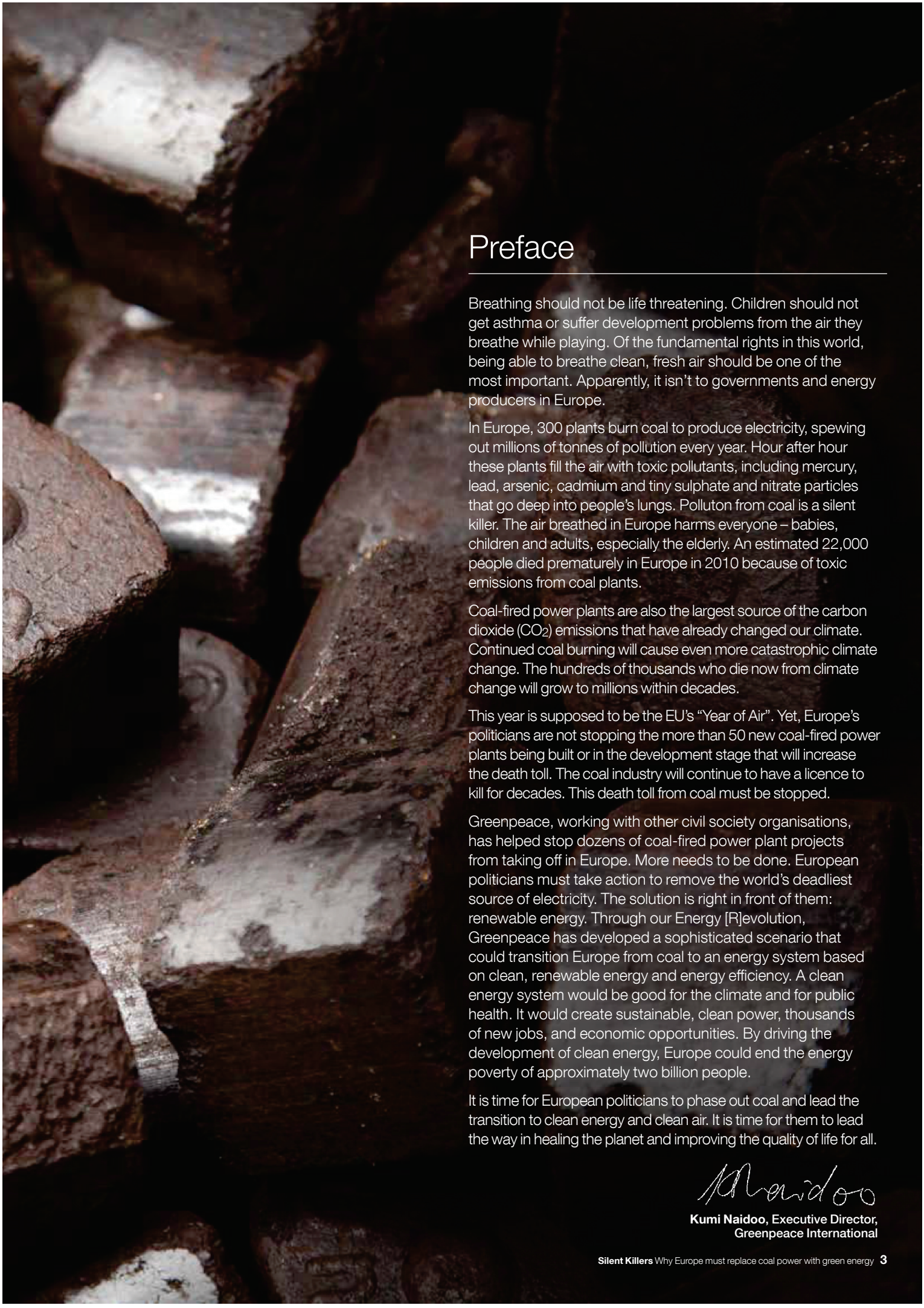


Preface

Breathing should not be life threatening. Children should not get asthma or suffer development problems from the air they breathe while playing. Of the fundamental rights in this world, being able to breathe clean, fresh air should be one of the most important. Apparently, it isn't to governments and energy producers in Europe.

In Europe, 300 plants burn coal to produce electricity, spewing out millions of tonnes of pollution every year. Hour after hour these plants fill the air with toxic pollutants, including mercury, lead, arsenic, cadmium and tiny sulphate and nitrate particles that go deep into people's lungs. Polluton from coal is a silent killer. The air breathed in Europe harms everyone – babies, children and adults, especially the elderly. An estimated 22,000 people died prematurely in Europe in 2010 because of toxic emissions from coal plants.

Coal-fired power plants are also the largest source of the carbon dioxide (CO_2) emissions that have already changed our climate. Continued coal burning will cause even more catastrophic climate change. The hundreds of thousands who die now from climate change will grow to millions within decades.

This year is supposed to be the EU's "Year of Air". Yet, Europe's politicians are not stopping the more than 50 new coal-fired power plants being built or in the development stage that will increase the death toll. The coal industry will continue to have a licence to kill for decades. This death toll from coal must be stopped.

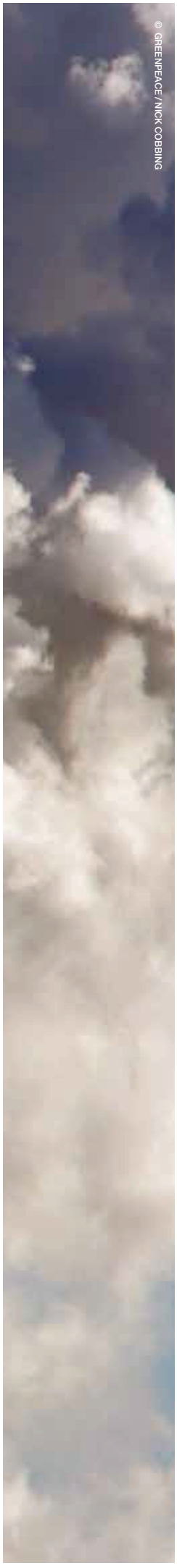
Greenpeace, working with other civil society organisations, has helped stop dozens of coal-fired power plant projects from taking off in Europe. More needs to be done. European politicians must take action to remove the world's deadliest source of electricity. The solution is right in front of them: renewable energy. Through our Energy [R]evolution, Greenpeace has developed a sophisticated scenario that could transition Europe from coal to an energy system based on clean, renewable energy and energy efficiency. A clean energy system would be good for the climate and for public health. It would create sustainable, clean power, thousands of new jobs, and economic opportunities. By driving the development of clean energy, Europe could end the energy poverty of approximately two billion people.

It is time for European politicians to phase out coal and lead the transition to clean energy and clean air. It is time for them to lead the way in healing the planet and improving the quality of life for all.

Kumi Naidoo, Executive Director,
Greenpeace International

32,000 life years would be robbed every year if the coal-fired power plants currently under construction or in planning go into operation. This loss of life is entirely unnecessary, as renewable energy and the latest cutting-edge energy-efficient solutions enable us to keep Europe's lights on.

Image Poland is dependent on coal for 93% of its power generation. Coal-burning exacts a heavy toll on health: a single lignite-fired power plant, the Patnów plant near Konin in western Poland, is estimated to cause the loss of 1,100 life years from premature deaths in 2010, and the loss of 23,000 working days due to sickness.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Executive summary

Coal-fired power plants are among the worst sources of toxic air pollutants in the EU and globally. Acid gas, soot, and dust emissions from coal are the biggest industrial contributors to microscopic particulate pollution that penetrates deep into the lungs and into the bloodstream. The pollution harms the health of babies, children and adults, causing heart attacks and lung cancer, as well as increasing asthma attacks and other respiratory problems[1]. Tens of thousands of kilograms of toxic metals such as mercury, lead, arsenic and cadmium are spewed out of the stacks[2], contributing to cancer risk and harming children's development. Despite these health risks, European governments have failed to steer clear of the dirty old-fashioned energy source, with coal burning increasing in Europe each year from 2009 to 2012, and with more than 50 new dirty power plants in development.

To shed light on the health impacts of coal-burning power plants in Europe, a report was commissioned from the Stuttgart University. The report, which is the basis for this Greenpeace International publication, investigates the health impacts of each of the 300 operating large power plants in the EU, as well as the predicted impact of the 50 new projects if they come online. Using a sophisticated health impact assessment model, the report estimates that pollution from coal-fired power plants in the EU resulted in thousands of premature deaths, shortening the lives of Europeans by an estimated total of **240,000 lost life years in 2010**. In countries with heavy coal use, the results indicate that more people are killed by coal than in traffic accidents[3]. The research estimates that a total of approximately 5 million working days were lost in 2010 due to illnesses and disability associated with pollution from coal-fired power plants.[4] The estimated negative health impacts from coal power plant pollution in Europe in 2010 – measured in decreased life expectancy – was equivalent to the damage to health from the smoking of 22 million cigarettes by European citizens every day of that year[5]. The 11% increase in coal burning in Europe from 2009 to 2012[6] will have caused a similar increase in the negative impacts on the population's health, amounting to a potential increase of more than a thousand deaths throughout the EU[7].

This pollution crosses borders and affects everyone in Europe, even in those countries with little or no domestic coal burning. As such, all EU countries have an interest to act to stem these emissions.

To add insult to injury, the coal industry is building or planning more than 50 new power plants in Europe. According to the modelling results, another **32,000 life years** would be robbed every year if the power plants currently under construction or in planning go into operation – a total of 1.3 million lost life years if the power plants operate for a full lifetime of 40 years.

The research found that the worst offenders among EU countries are Poland, Germany, Romania, Bulgaria, and the UK. The utilities with the worst estimated health impacts are PGE (Poland), RWE (Germany), PPC (Greece), Vattenfall (Sweden) and ČEZ (Czech Republic).

This loss of life is entirely unnecessary, as renewable energy and the latest cutting-edge energy-efficiency solutions enable us to keep Europe's lights on without a single new coal-fired power plant, and to start phasing out all existing coal in Europe's power generation. Coal burning also needs to be reduced rapidly, to stem the catastrophic impacts of climate change. In order to achieve this, European governments need to set targets for green energy that ensure coal can be phased out.

What is a "lost life year"?

The Stuttgart University report converts the estimate of deaths attributed to air pollution into the amount of life years that were lost because of premature deaths. Each European whose death is attributable to the exposure to particulate pollution has his or her life shortened by an estimated 11 years, and each death attributable to ozone exposure loses nine months of life. The Stuttgart University results indicate that in 2010 approximately **22,000 deaths** were attributable to pollution from coal-fired power plants, and the researchers estimate that their lives were shortened by a total of **240,000 years**. The increased risk of death due to air pollution has been estimated in a study that followed 500,000 adults in 50 US states with different air pollution levels between 1982 and 1999.

What is a "lost working day"?

Air pollution increases the risk of several diseases and health problems that can force people to take additional sick leave. This ranges from minor respiratory infections and coughs to recovery from heart attacks. The increase in sick leave days as a result of air pollution has been estimated from data collected in the US National Health Interview Survey. (See the Annex for details on how the health impacts of coal-fired power plants were estimated.)

Greenpeace demands

Europe needs to rein in coal pollution:

EU countries urgently need to put a stop to the construction of new coal-fired power plants, and start shutting down the existing ones. National governments should not permit new coal-fired power plants anywhere in the EU.

All coal-fired power plants must be required to be fitted with Best Available Control Technology, not just technology that meets the minimum regulatory standard. The dirtiest power plants, estimated to cause hundreds of deaths a year, must be closed down.

The European Commission must not allow the implementation of the Industrial Emissions Directive, which sets new air pollution standards in EU countries, to be delayed by years with weak "transitional" plans.

The European Commission and progressive governments must take immediate action to end public subsidies to the coal sector, particularly in Spain, Germany, Poland and Romania.

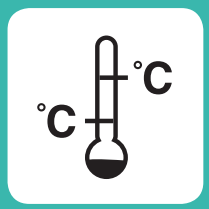
The EU Emissions Trading Scheme (ETS) is not currently working, due to an over-supply of emission allowances. EU governments and the European Parliament must, in the short term, curb the over-supply by postponing ETS emission allowances auctions. The short-term fix must be followed by permanent cancellation of allowances and stricter annual emission reductions.

...and to speed up the Energy [R]evolution:

The EU should set legally binding targets that add up to a 45% share of renewables across Europe in 2030, and set a binding greenhouse gas reductions and energy savings targets for 2030. These targets should be in line with phasing out coal in power generation by 2040 at the latest.

National governments should implement effective policies for a sustainable energy economy, including a commitment to fully implement the 2020 renewable energy targets and supporting policies and schemes.

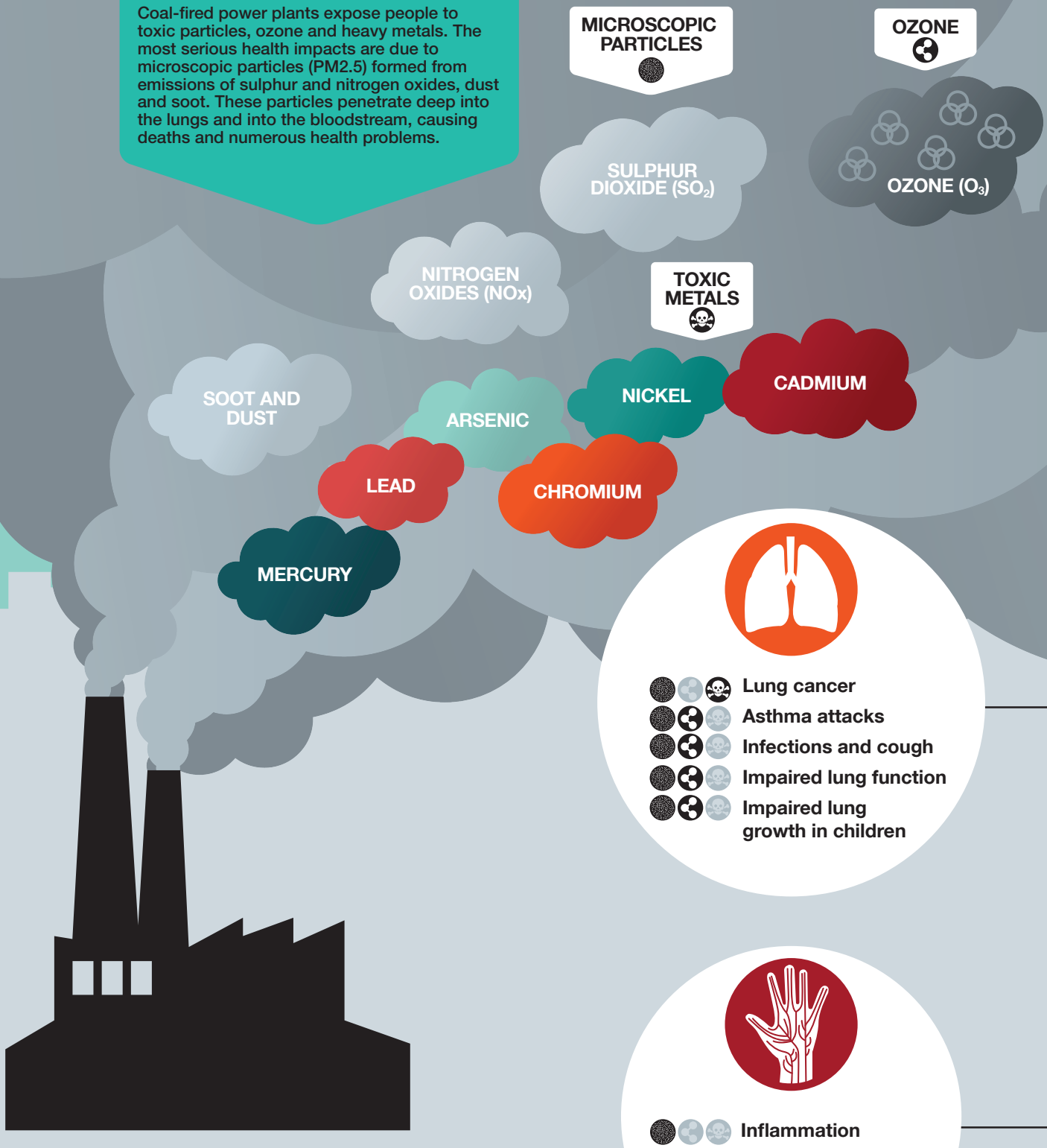
Investments in electric grids are central to enabling a near 100% renewable power system in Europe. All new investments should be planned with a view to rapidly increasing renewable generation, rather than built around dirty, centralised 20th century power plants.



To contribute to limiting global temperature increase below 2°C, the EU should reduce its greenhouse gas emissions domestically by at least 30% by 2020 compared to 1990 levels.

How coal-fired power plants can make you sick

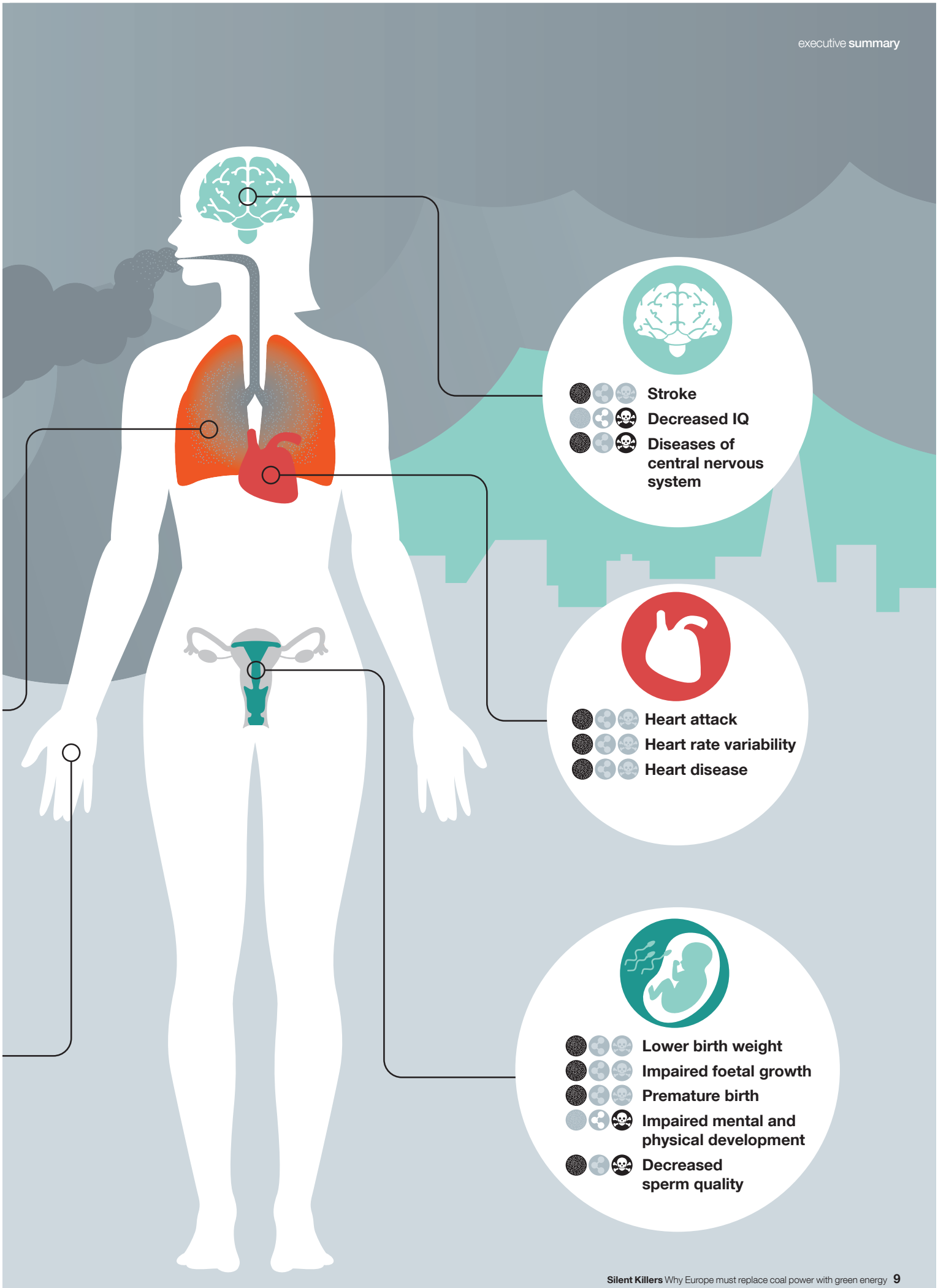
Coal-fired power plants expose people to toxic particles, ozone and heavy metals. The most serious health impacts are due to microscopic particles (PM2.5) formed from emissions of sulphur and nitrogen oxides, dust and soot. These particles penetrate deep into the lungs and into the bloodstream, causing deaths and numerous health problems.



KEY

- Particle pollution
- Ozone
- Toxic metals

Source: Rückerl R et al (2011). Health effects of particulate air pollution: A review of epidemiological evidence. Inhalation Toxicology 23(10): 555–592; Pope III CA & Dockery DW (2006). Health Effects of Fine Particulate Air Pollution: Lines that Connect. J Air & Waste Manage. Assoc. 56:709 –742; US EPA: Six Common Air Pollutants. www.epa.gov/airquality/urbanair; US EPA: Integrated Risk Information System (IRIS). www.epa.gov/IRIS


Stroke
Decreased IQ
Diseases of central nervous system
Heart attack
Heart rate variability
Heart disease
Lower birth weight
Impaired foetal growth
Premature birth
Impaired mental and physical development
Decreased sperm quality

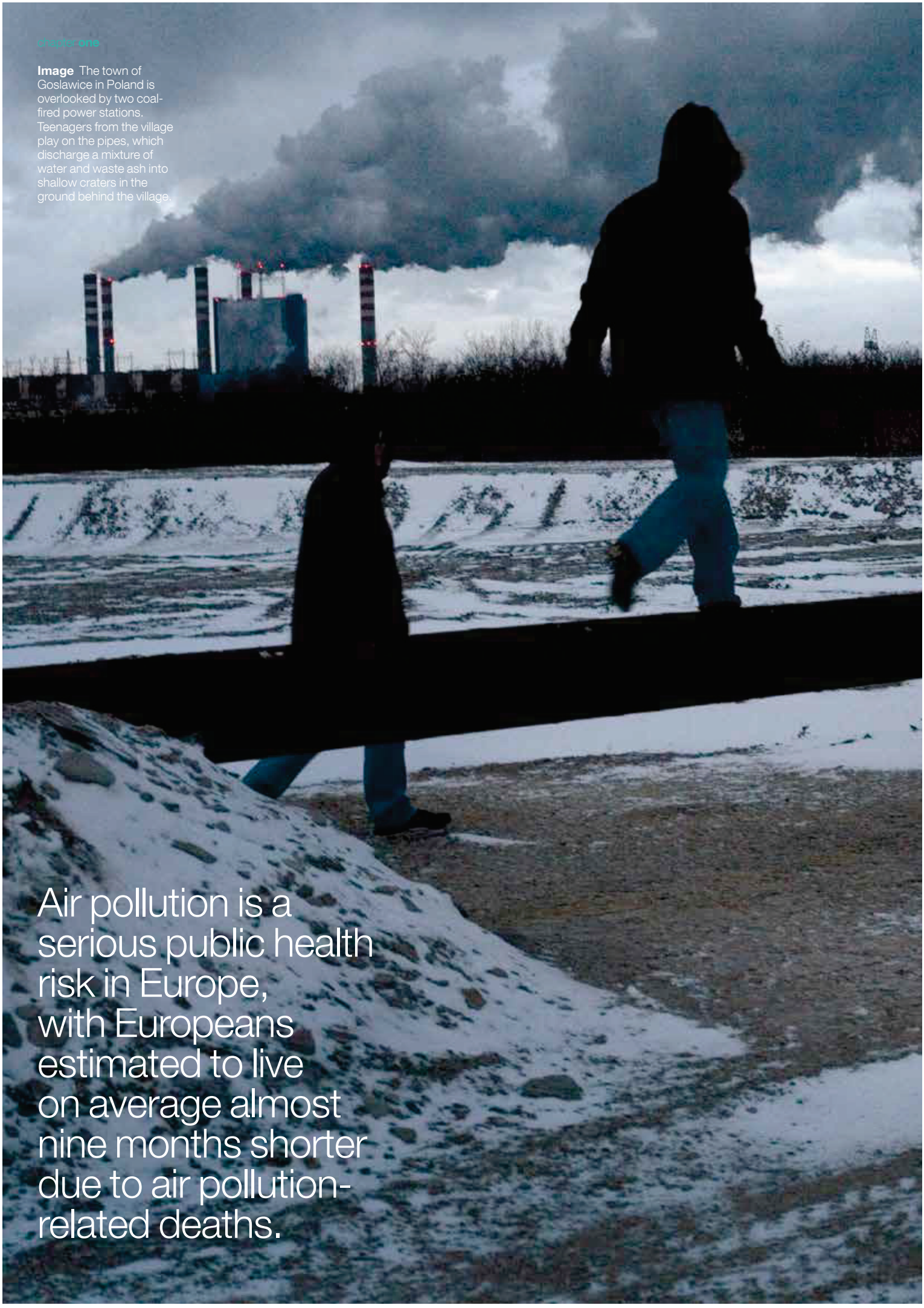


Image The town of Goslawice in Poland is overlooked by two coal-fired power stations. Teenagers from the village play on the pipes, which discharge a mixture of water and waste ash into shallow craters in the ground behind the village.

Air pollution is a serious public health risk in Europe, with Europeans estimated to live on average almost nine months shorter due to air pollution-related deaths.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#1

Introduction
No future for coal

European governments are making major decisions about our energy future. While renewable energy growth continues to break records, more than 50 large coal-fired power plants are also in development in the EU. Targets for renewable energy production, energy efficiency improvements, and CO_2 emissions in 2030 are being agreed. The failure of the European emission trading system has caused coal imports and consumption to escalate[8]. All of this requires immediate action. New air pollution rules have been agreed, but are far from requiring best available technology, and still require strict implementation. This report shows how these decisions affect not only the climate and economy, but how they also directly impact our health and the health of our children.

Europe has a choice. The lack of leadership on energy amidst the economic turmoil would mean locking in decades of coal pollution and stifling innovations on green energy. Conversely, ambitious renewable energy growth and CO_2 reduction policies can render polluting coal power plants obsolete, stimulating the economy and creating hundreds of thousands of more jobs for Europeans[9].

These energy choices are decisions about our health. When people in developed countries think of toxic air pollution, it tends to bring up images of Victorian London's smog, or the hazardous "pea soup" that envelops Beijing during the winter. At concentrations commonly found in Europe, air pollution is not visible, and you cannot feel it while breathing, but the microscopic particles penetrate deep into the lungs, and further into the bloodstream, causing inflammation, respiratory problems, coagulation of blood and toxic effects on many internal organs, including the brain. The result is increased risk of death from heart attack, stroke, lung cancer and respiratory diseases. Children, pregnant women, people with pre-existing conditions and the elderly are most affected, but healthy working-age people also experience an increase in sick leave as air pollution levels rise.

The invisible health risk

Air pollution is a serious public health risk in Europe, with Europeans estimated to live on average almost nine months shorter due to air pollution-related deaths[10]. The European Environmental Agency estimates that over 90% of urban population in the EU is exposed to fine particle (PM2.5) and ozone pollution levels above the WHO guidelines, with over 97% of the EU population being exposed to ozone levels above the limit. Almost a third are exposed to more particle pollution than stipulated by the EU's own standard, which allows two-and-a-half times more pollution than the WHO recommendation.[11]

Coal-fired power plants are the largest source of sulphur dioxide emissions, one of the key causes of particulate pollution. They also emit huge quantities of nitrogen oxides, as well as fine ash and soot particles, contribute to smog formation, and are the largest source of arsenic and mercury emissions in Europe.[12]

This is despite significant advances in end-of-pipe pollution controls, such as SO_2 scrubbers and particulate filters. While the coal-fired power plants of today have lower emissions than those of last century, they continue to exact a heavy toll on the health of Europeans. Even so-called "clean coal" – the favourite buzzword of the dirty energy lobby – is unacceptably dirty, as shown by the results in this report. The OECD Environmental Outlook recently warned that air-pollution-related deaths were bound to increase in developed countries, even as pollution controls improve[13]. This is due to several factors that make people more susceptible to pollution, including the elimination of other causes of death, aging of the population and urbanisation. Furthermore, the OECD found that the most affordable way to reduce deaths from air pollution is to invest as much in cleaner energy sources as in end-of-pipe controls.

There is no such thing as clean coal. The only way to eliminate the thousands of deaths associated with coal burning in Europe is to **phase out these dirty power plants** in favour of **clean and modern renewable energy sources**. This report exposes the impacts of dirty energy on Europeans' health and illustrates how **smart decisions by governments and energy companies can eliminate coal pollution in Europe**.

Examples of studies on health problems around coal-fired power plants[14]

In a district of Northern Italy, the risk to women of dying from lung cancer was found to be up to twice as high in an area exposed to air pollution from a coal-fired power plant and other industrial sources[15].

A Spanish study found an elevated risk of lung, throat, and bladder cancer within 50 kilometres of coal-fired power plants, with higher risks associated with living closer to the plant[16].

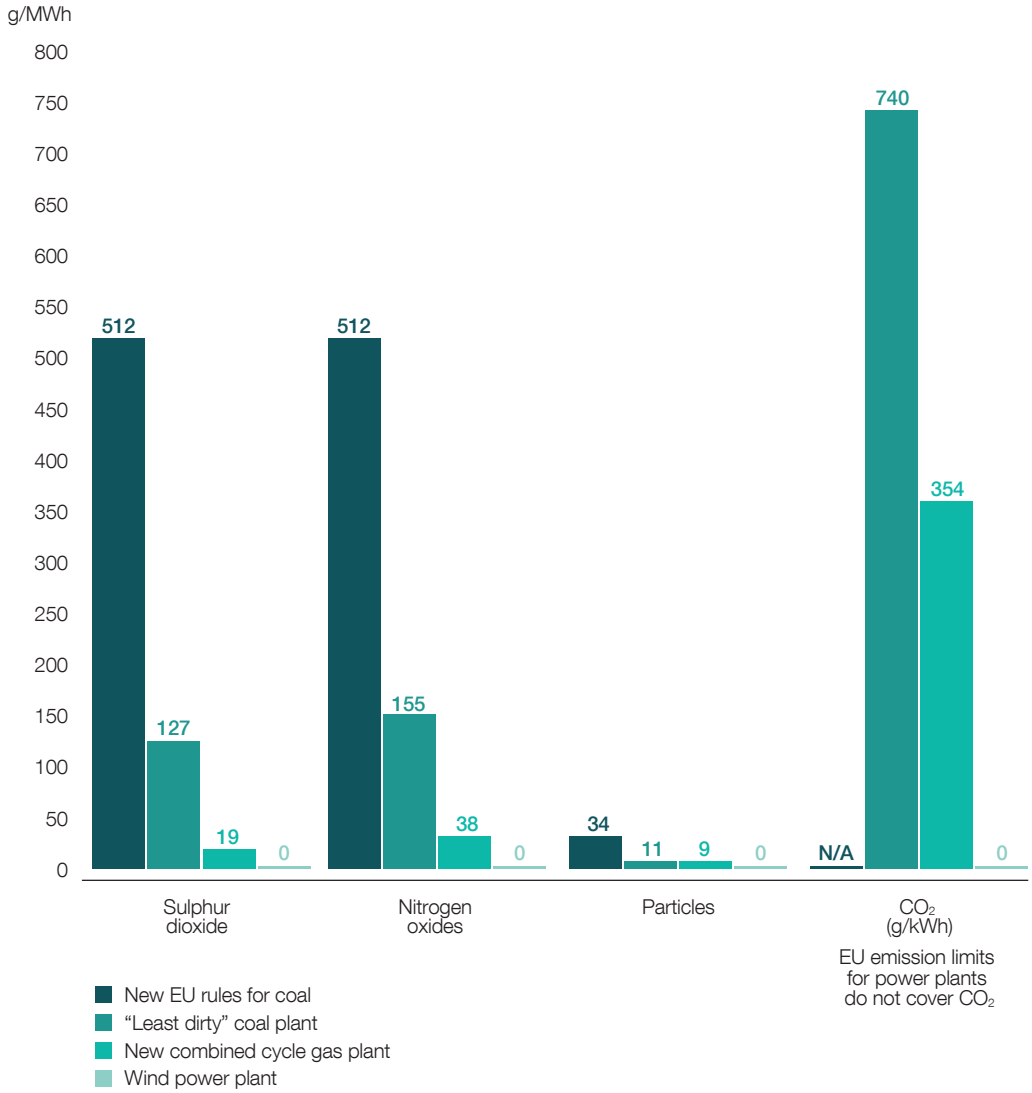
Studies on the Nováky power plant in Slovakia burning high-arsenic coal have found increased arsenic concentrations in hair and urine, hearing loss in children and elevated risks of skin cancer[17].

In the Chongqing province of China, the closure of a coal-fired power plant led to a drop in the levels of organic toxics in the birth cords of newborns, and an improvement in the children's motor and language skills, as well as overall mental development[18].

Figure 1 EU's new air pollution rules for coal-fired power plants allow much higher emissions than can be achieved with best available technology, and more than 10 times higher emissions than a new gas-fired power plant.[19]

Even the "cleanest" coal is too dirty

Emissions from coal, gas and wind compared



There is no such thing as clean coal. The only way to eliminate the thousands of deaths associated with coal burning in Europe is to phase out these dirty power plants in favour of clean and modern renewable energy sources.

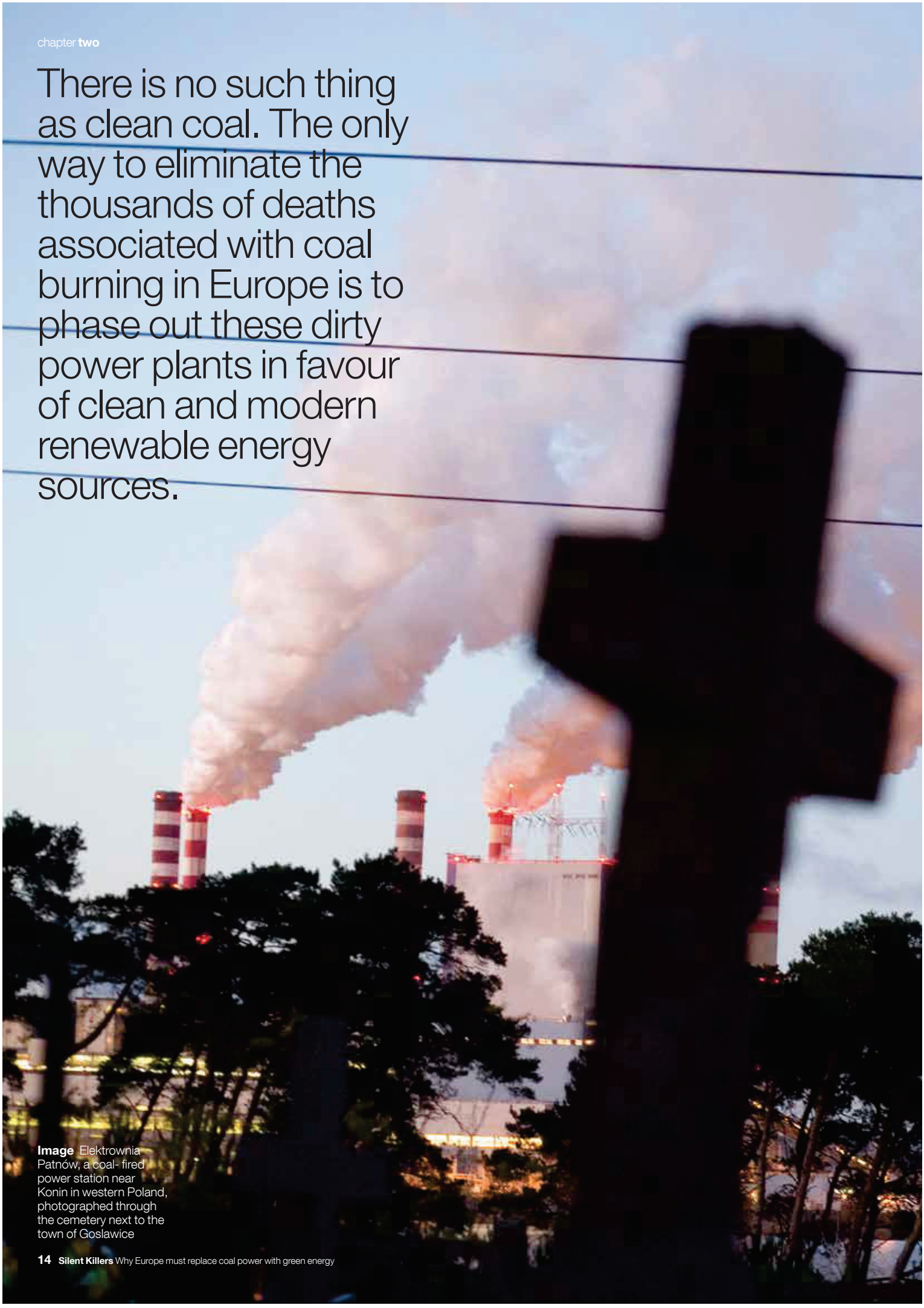


Image Elektrownia Patnów, a coal- fired power station near Konin in western Poland, photographed through the cemetery next to the town of Goslawice

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#2

The current health impacts of coal in Europe

Coal-fired power plants are silent killers. Spread all over Europe, they spew out millions of tonnes of toxic gases and particles[20]. These emissions enter the lungs and the bloodstream of Europeans, associated with causing respiratory diseases, heart attacks, lung cancer, asthma attacks, and other damages to health. Even though you won't find a single death certificate that states "air pollution" as the cause of death, the impact on health is real and significant.

Approximately 300 large coal-fired power plants are in operation in the EU, producing a quarter of all electricity consumed[21]. These power plants are **responsible for over 70% of the EU's sulphur dioxide emissions** and **over 40% of nitrogen oxide emissions from the power sector**. They account for approximately **half of all industrial mercury emissions**, and a **third of industrial arsenic emissions into the air**.[22] These coal-fired power plants are also **responsible for almost a quarter of Europe's CO_2 emissions**[23].

The modelling of health impacts from the coal-fired power plant emissions for this report was commissioned from Stuttgart University Institute for Energy Economics (IER). The IER has developed the EcoSense model, which is the most advanced tool available to assess the individual health impacts of a large number of power plants in Europe. The EcoSense model is based on sophisticated atmospheric modelling carried out by the European Monitoring and Evaluation Programme (EMEP) of the Convention on Long-Range Transboundary Air Pollution. The health impact estimates are based on risk factors derived from the best available scientific studies, in line with the recommendations of another large European research programme, NEEDS. (See *Annex: How the study was carried out* for more details).

In Poland, Romania, Bulgaria and the Czech Republic, it is estimated that more deaths are associated with air pollution from coal-fired power plants than with road traffic accidents.

Image Smoke belching from the Patnów coal plant's chimney.

The results are staggering. In Poland, Romania, Bulgaria and the Czech Republic, it is estimated that **more deaths are associated with air pollution from coal-fired power plants than with road traffic accidents**. In Germany and the UK, coal-fired power stations are associated with **almost as many deaths as road accidents**.[24] Overall, it is estimated that **the deaths of approximately 22,000 people in the EU in 2010 are attributable to pollution from coal-fired power plants**, resulting in a total of 240,000 lost life-years. In the same year, illnesses and health problems from coal plant pollution were associated with an estimated total of 5 million lost working days.

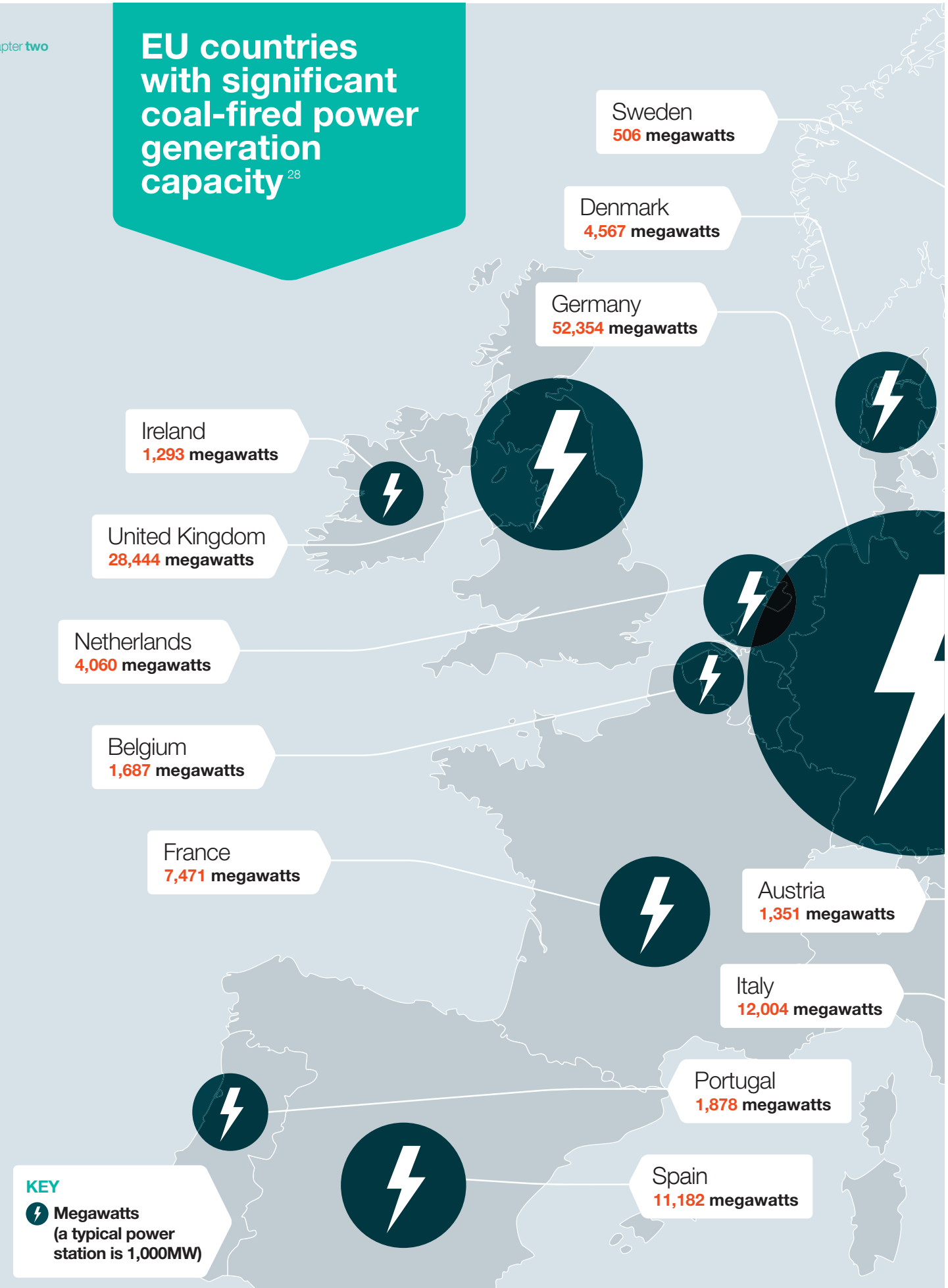
Coal is **always dirty**, even with the best available pollution control technologies. However, matters are made worse by the fact that governments are still allowing the power industry to get away with less effective controls than are available (see Figure 1).

This is particularly true of lignite plants. New EU air pollution rules are entering into force in 2016[25], and national governments are busy working with the industry to craft exceptions from the pollution control requirements – most countries heavily dependent on coal are expected to apply for a "transitional national plan" that could allow them to run the dirty power plants until 2020 without improving pollution controls. The EU and responsible national governments must ensure that no such exceptions are allowed and all plants are required to be fitted with Best Available Control Technology[26], not just technology that meets the minimum regulatory standard.

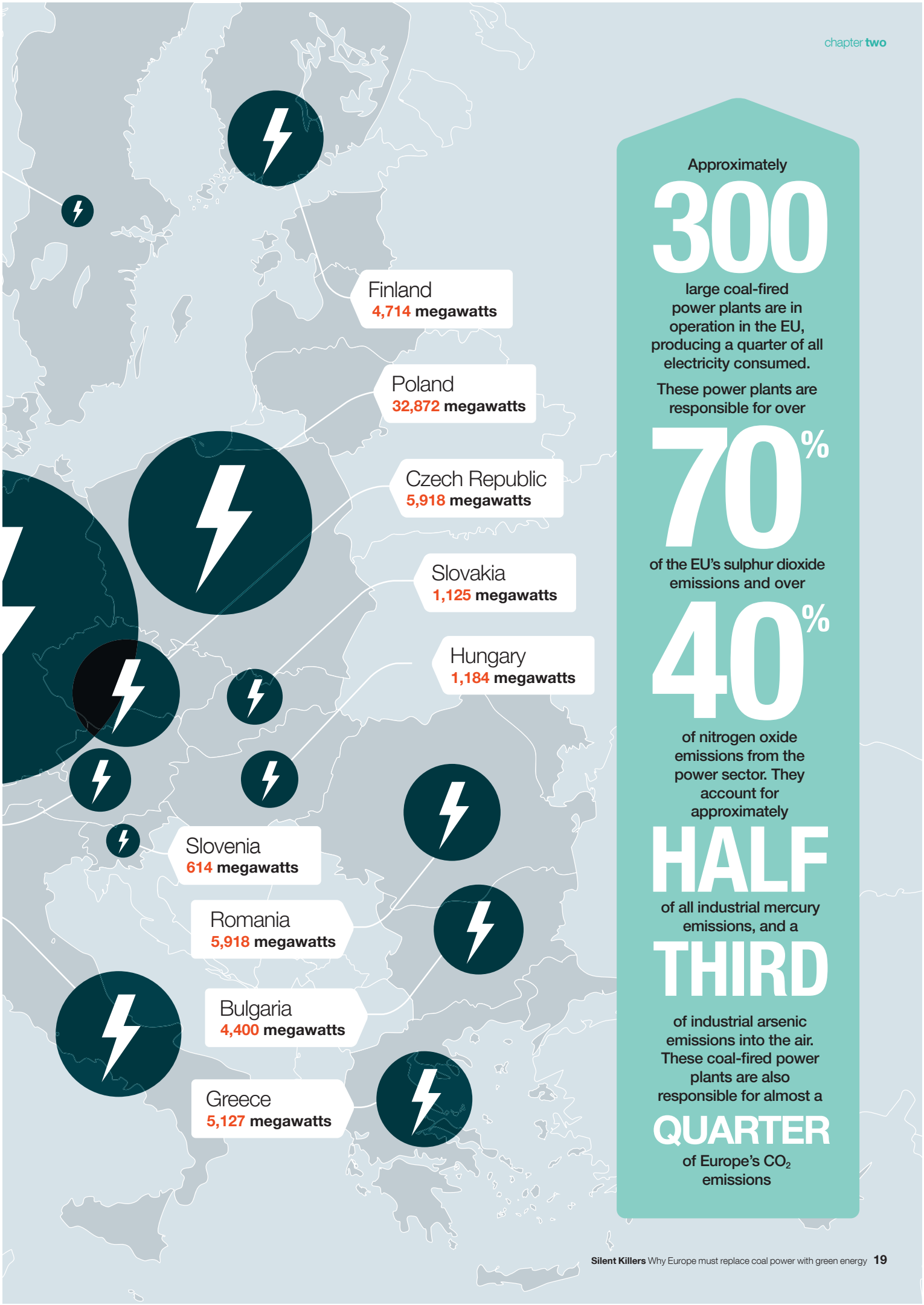
Results

Tens of thousands of deaths in the EU every year are associated with pollution from coal-fired power plants. But which countries and companies are most responsible? The following tables and graphs illustrate the results of the research carried out by Stuttgart University.

EU countries with significant coal-fired power generation capacity[28]



Source: Coal, lignite and peat-fired capacity from Platts World Electric Power Plants Database; except for Romania and Bulgaria, Euracoal Country Profiles. http://www.euracoal.be/. Emissions from E-PRTR database.



Approximately

300

large coal-fired power plants are in operation in the EU, producing a quarter of all electricity consumed.

These power plants are responsible for over

70%

of the EU's sulphur dioxide emissions and over

40%

of nitrogen oxide emissions from the power sector. They account for approximately

HALF

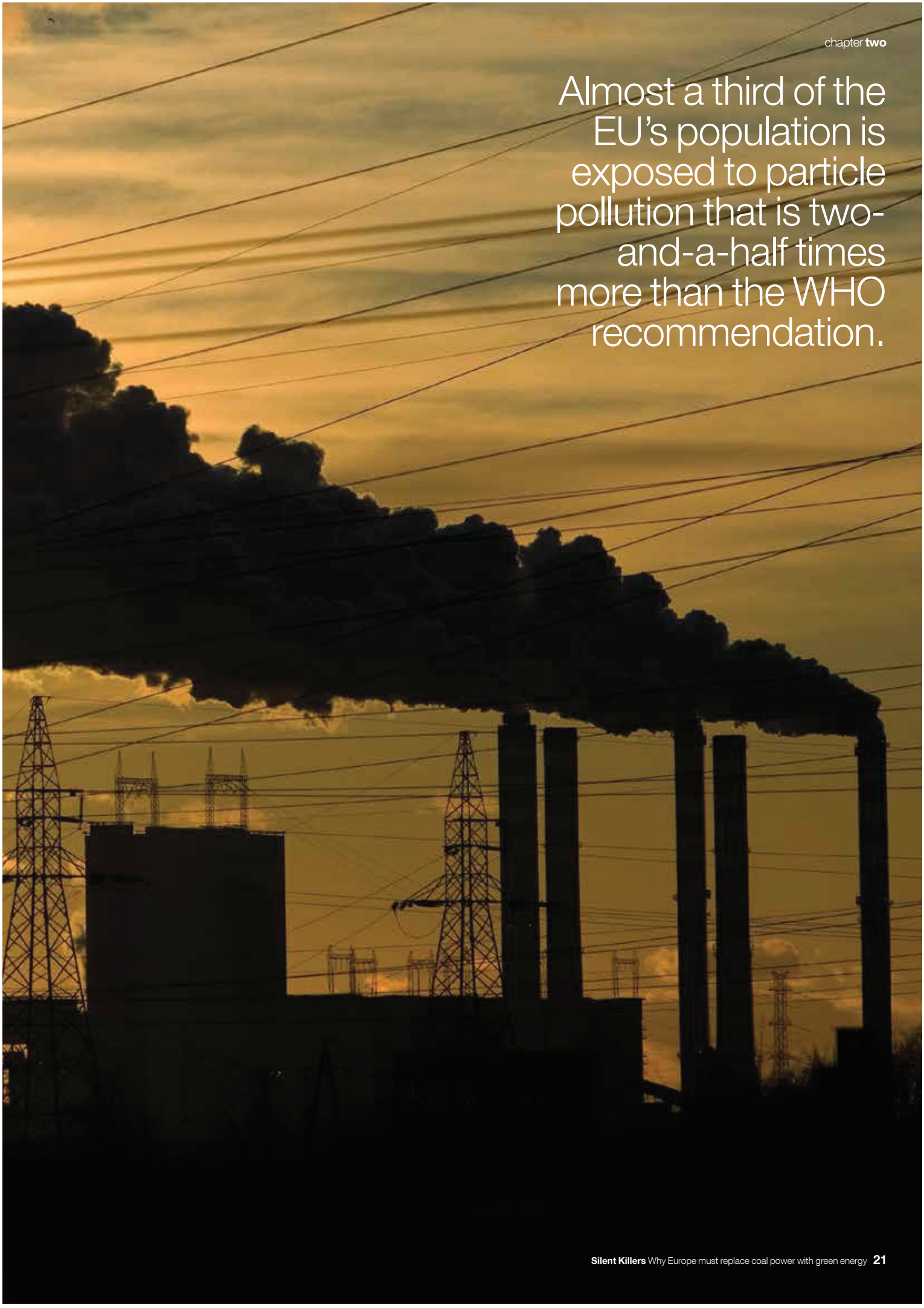
of all industrial mercury emissions, and a

THIRD

of industrial arsenic emissions into the air. These coal-fired power plants are also responsible for almost a

QUARTER

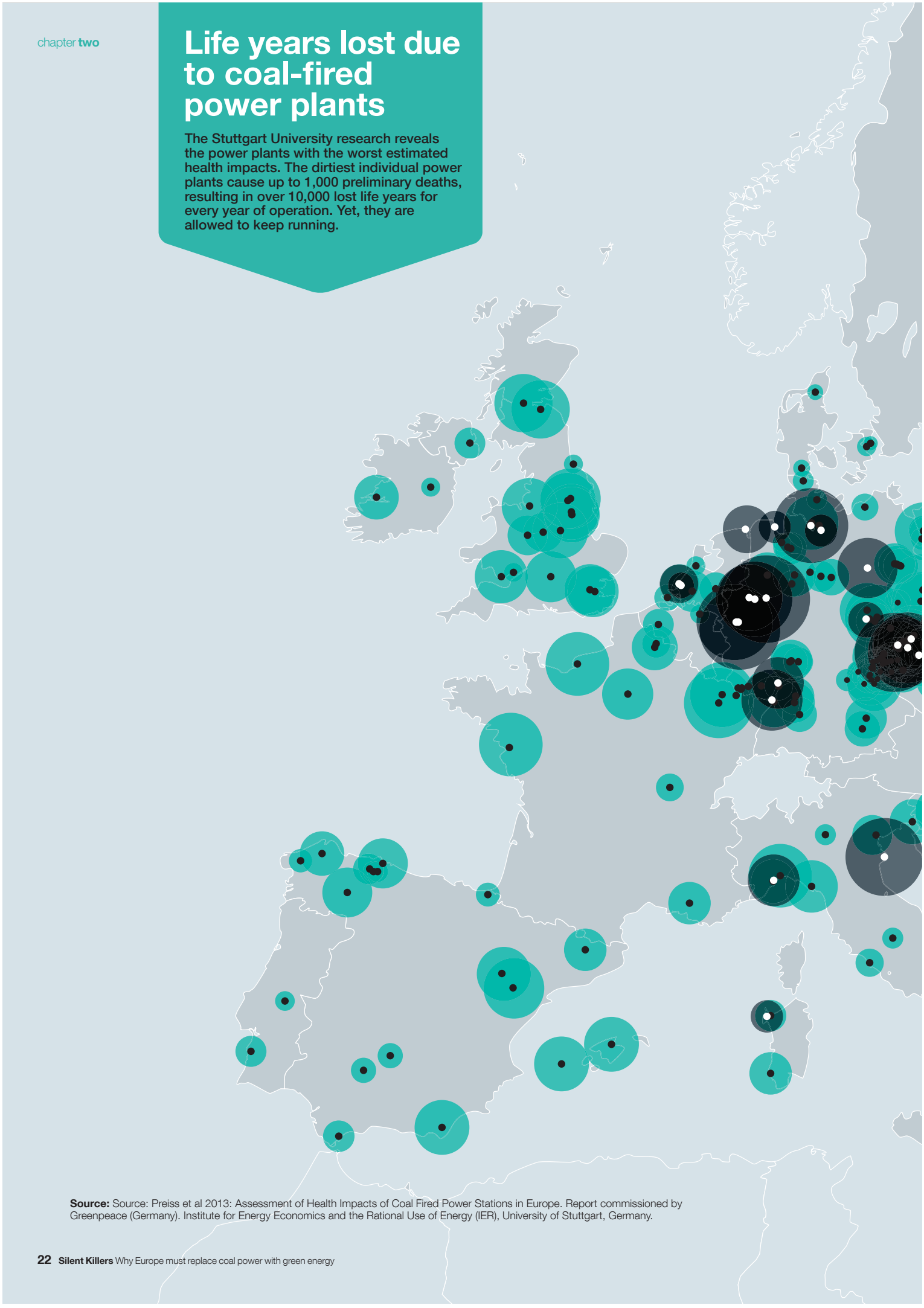
of Europe's CO_2 emissions



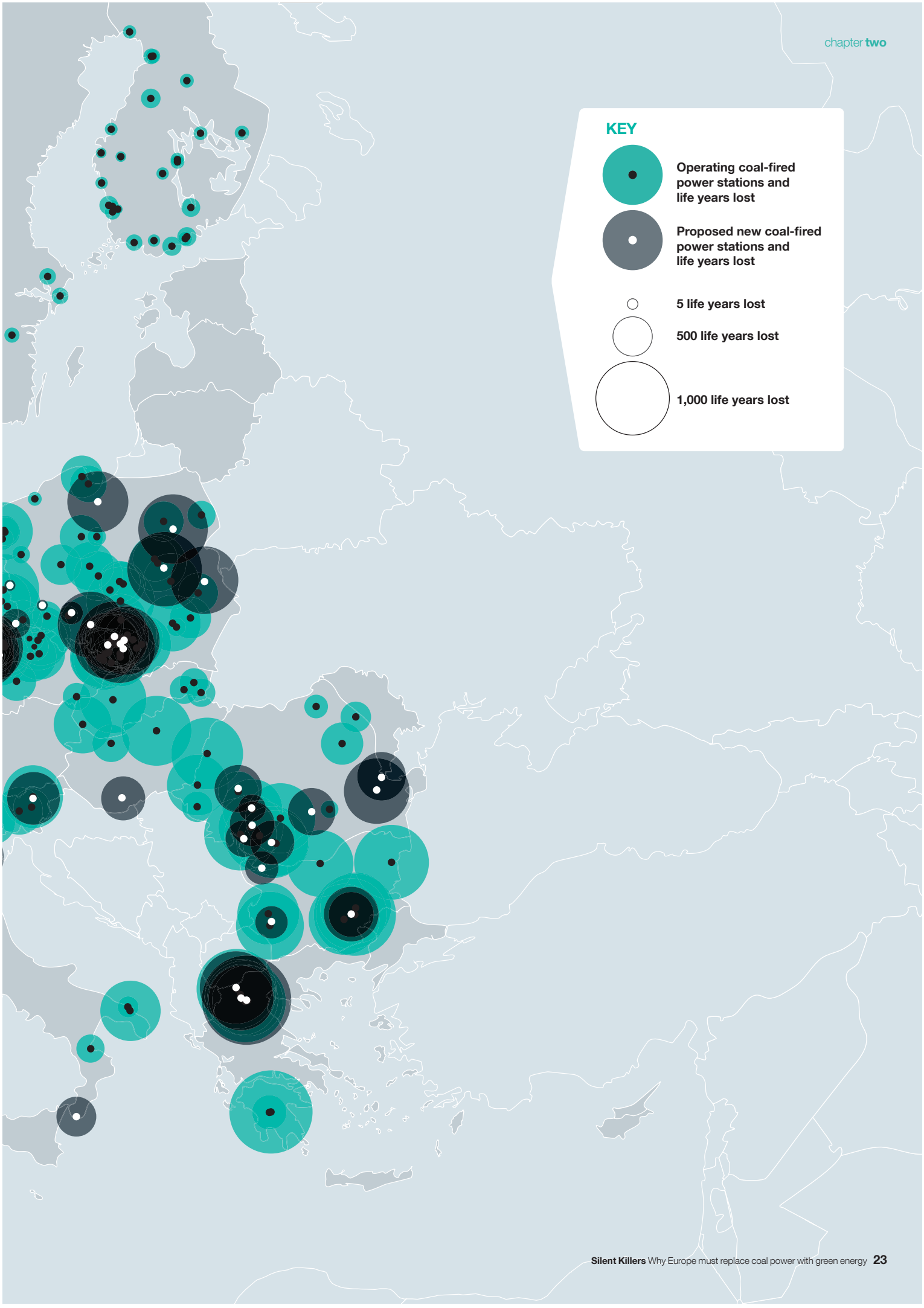
Almost a third of the EU's population is exposed to particle pollution that is two-and-a-half times more than the WHO recommendation.

Life years lost due to coal-fired power plants

The Stuttgart University research reveals the power plants with the worst estimated health impacts. The dirtiest individual power plants cause up to 1,000 preliminary deaths, resulting in over 10,000 lost life years for every year of operation. Yet, they are allowed to keep running.



Source: Source: Preiss et al 2013: Assessment of Health Impacts of Coal Fired Power Stations in Europe. Report commissioned by Greenpeace (Germany). Institute for Energy Economics and the Rational Use of Energy (IER), University of Stuttgart, Germany.


KEY
Operating coal-fired power stations and life years lost
Proposed new coal-fired power stations and life years lost
5 life years lost
500 life years lost
1,000 life years lost

Deaths associated with coal pollution vs road traffic accidents

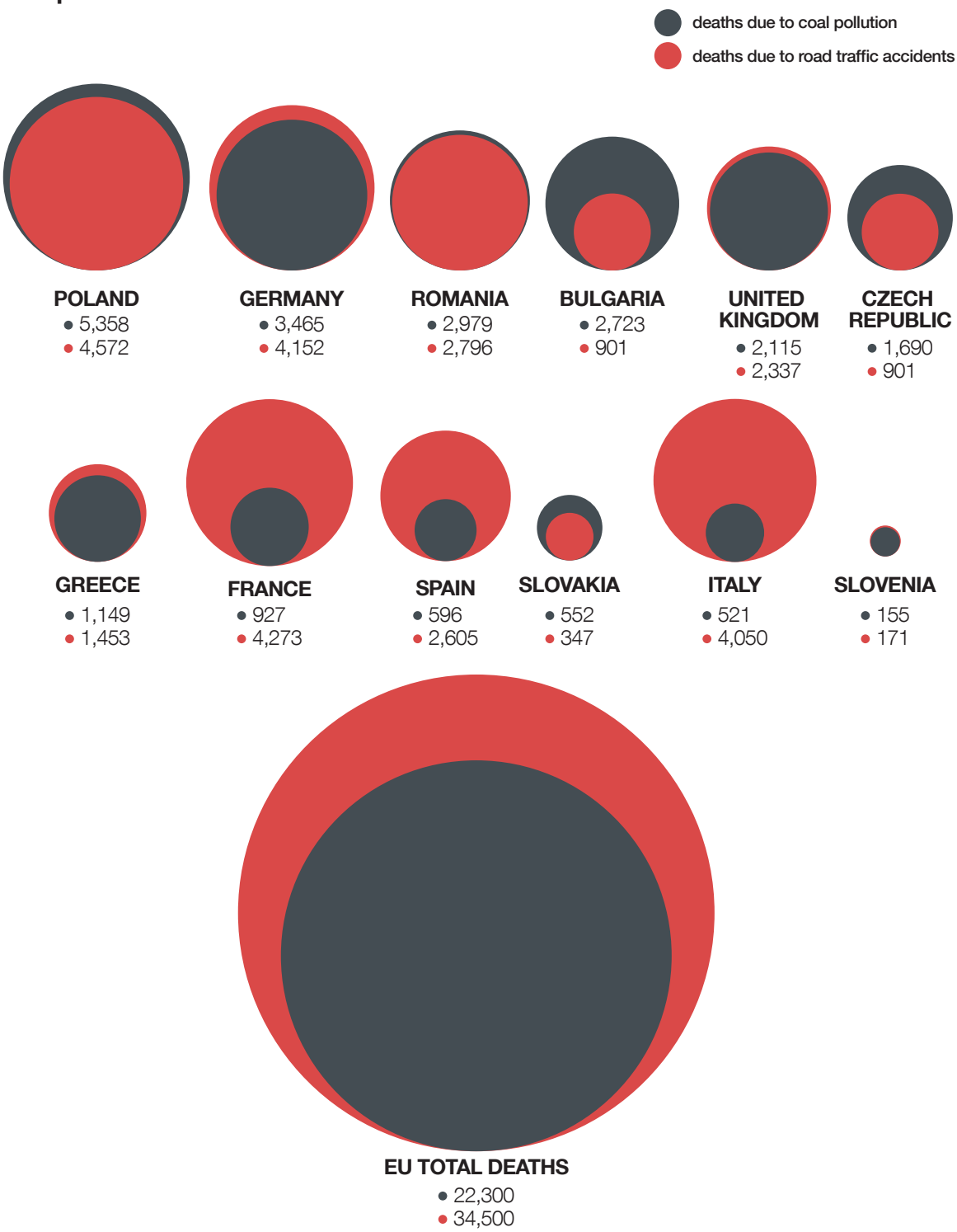
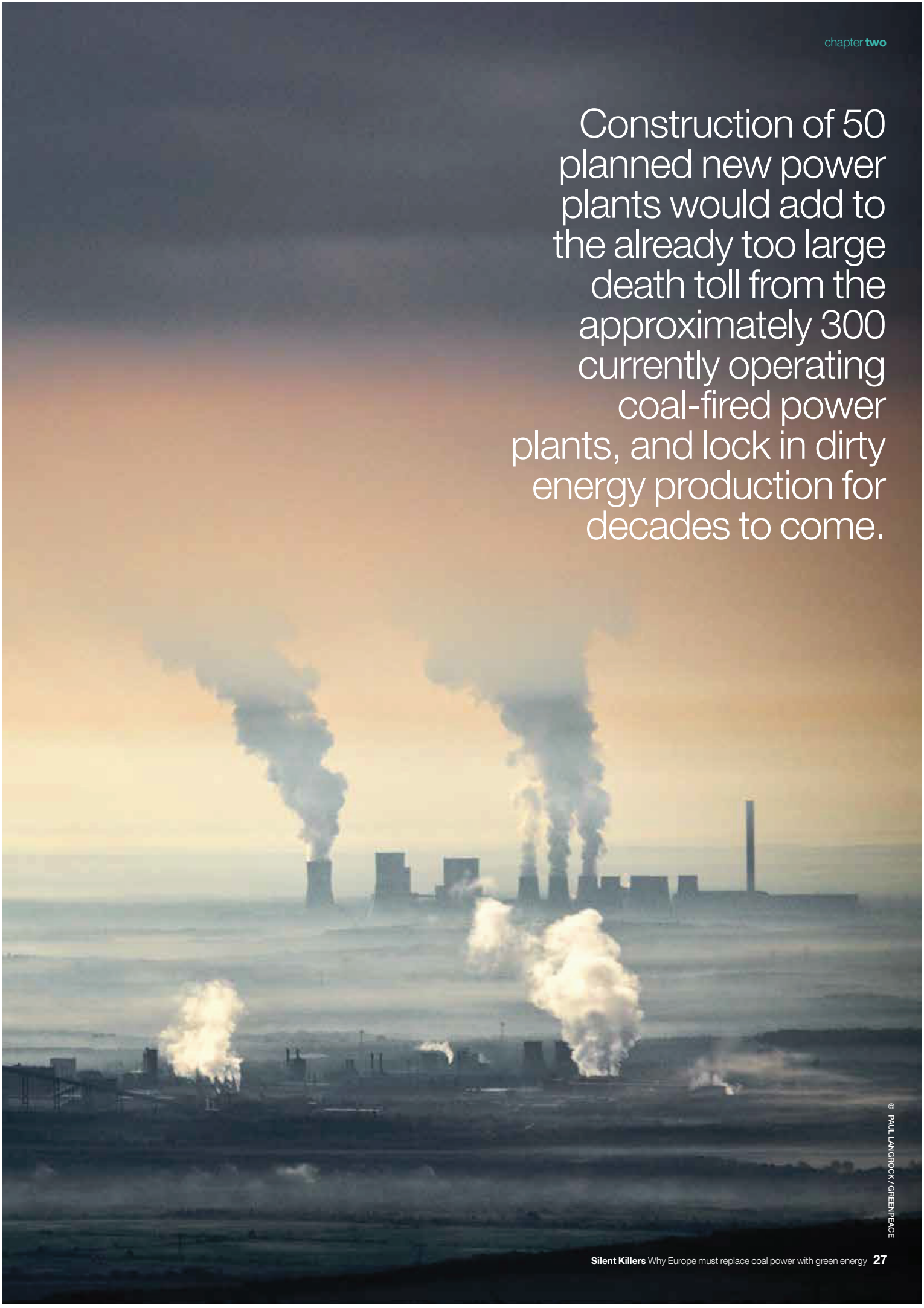


Image Machinery and workings inside the Jozwin II B pit, an open cast mine that is part of the Konin mine complex in Poland, owned by KBW Konin.

The deaths of approximately 22,000 people in the EU in 2010 are attributable to pollution from coal-fired power plants.

Image Aerial view of the Vattenfall brown coal (lignite) power plants Schwarze Pumpe (foreground) and Boxberg (background). These plants are among the worst air polluters in Germany, estimated to cause a combined total of 2,900 lost life years due to premature deaths, and 62,000 lost working days due to various illnesses.

Construction of 50 planned new power plants would add to the already too large death toll from the approximately 300 currently operating coal-fired power plants, and lock in dirty energy production for decades to come.



Countries with the most polluting power plants

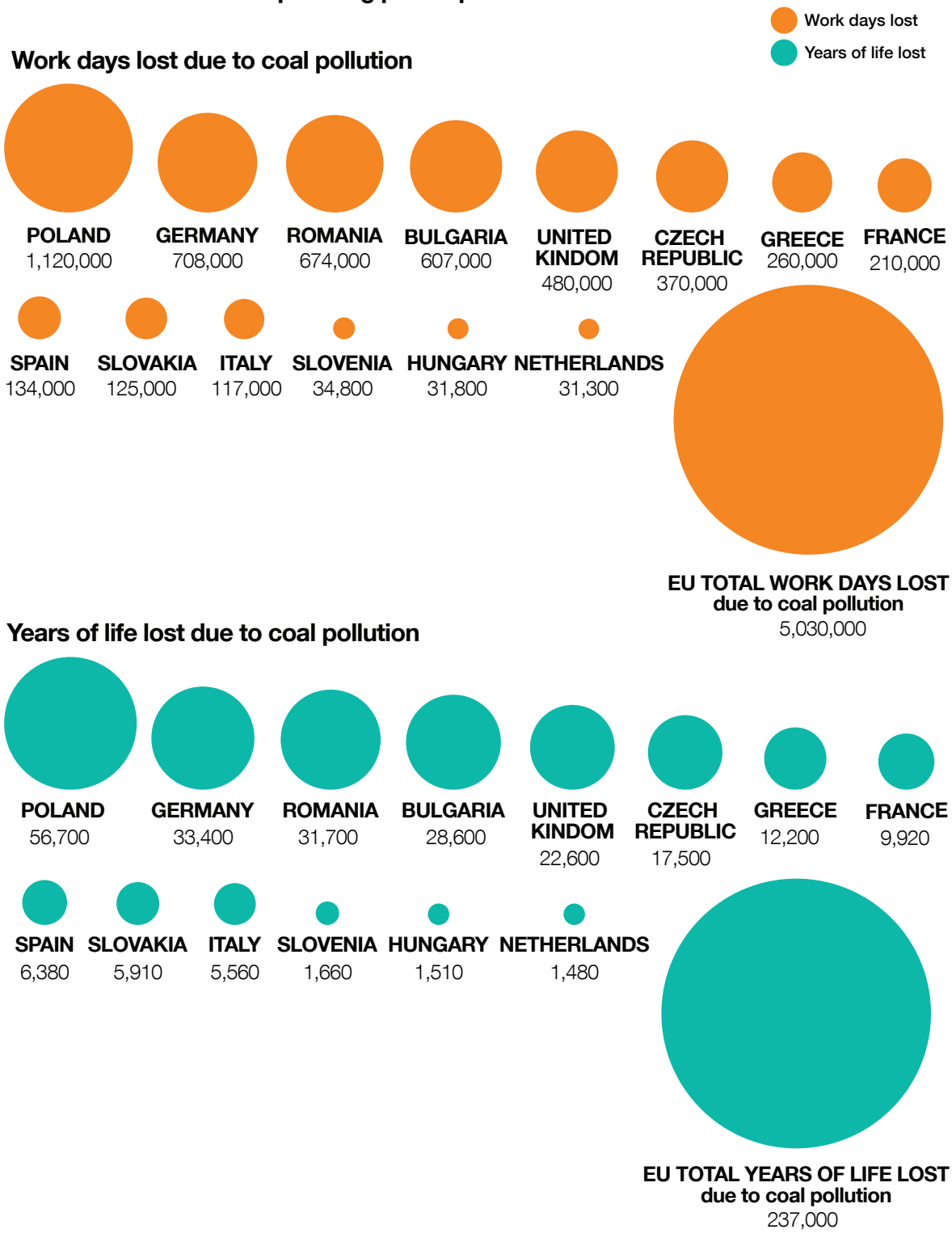
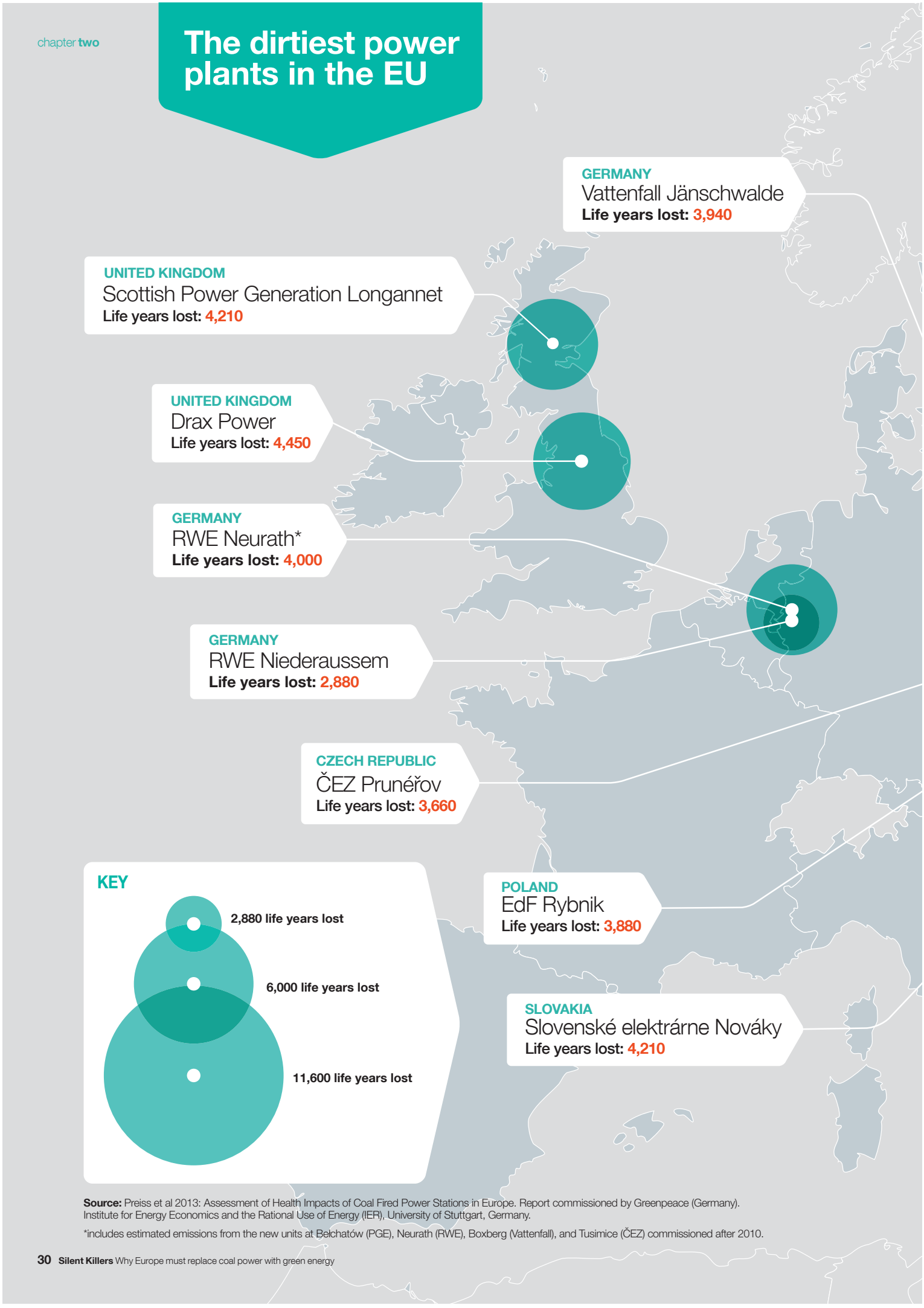


Image Greenpeace activists protesting with a burning CO_2 sign on a lake at the SPD Party Leaders' closed conference site in Potsdam. The banner reads: "Dear SPD, Platzecks brown coal blocks the Energy Revolution".

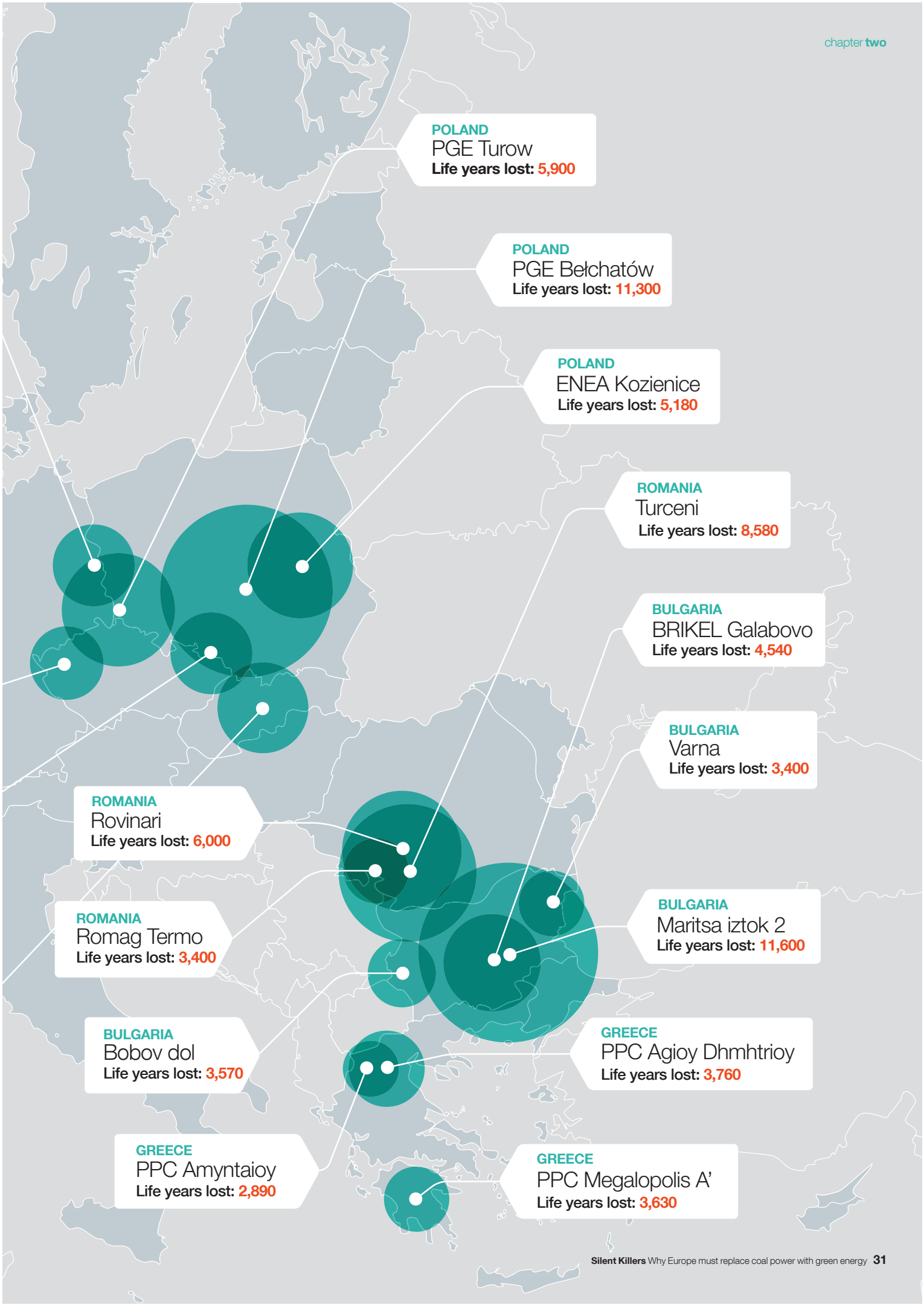
Germany has gone from 8% to 22% renewable electricity in 10 years.

The dirtiest power plants in the EU



Source: Preiss et al 2013: Assessment of Health Impacts of Coal Fired Power Stations in Europe. Report commissioned by Greenpeace (Germany). Institute for Energy Economics and the Rational Use of Energy (IER), University of Stuttgart, Germany.

*includes estimated emissions from the new units at Belchatów (PGE), Neurath (RWE), Boxberg (Vattenfall), and Tusimice (ČEZ) commissioned after 2010.


POLAND
PGE Turow
Life years lost: 5,900
POLAND
PGE Bełchatów
Life years lost: 11,300
POLAND
ENEA Kozienice
Life years lost: 5,180
ROMANIA
Turceni
Life years lost: 8,580
BULGARIA
BRIKEL Galabovo
Life years lost: 4,540
BULGARIA
Varna
Life years lost: 3,400
ROMANIA
Rovinari
Life years lost: 6,000
ROMANIA
Romag Termo
Life years lost: 3,400
BULGARIA
Maritsa iztok 2
Life years lost: 11,600
BULGARIA
Bobov dol
Life years lost: 3,570
GREECE
PPC Agioy Dhmhtrioy
Life years lost: 3,760
GREECE
PPC Amyntaioy
Life years lost: 2,890
GREECE
PPC Megalopolis A'
Life years lost: 3,630

The power companies with the highest modelled impacts in 2010

Company	Countries with coal power plants	Years of life lost	Lost working days
PGE	Poland	21,600	460,000
RWE	Germany, UK	14,900	309,000
Vattenfall	Germany, Poland, Denmark	13,200	279,000
PPC	Greece	12,200	260,000
Bulgarian Energy Holding EAD	Bulgaria	11,600	248,000
ČEZ	Czech Republic, Poland	10,400	220,000
Electricite de France	France, UK, Poland	8,780	186,000
CE Turceni SA	Romania	8,580	183,000
E.ON	Germany, France, Spain, Italy, Netherlands, Belgium	8,330	176,000
ENEL	Italy, Spain, Bulgaria	7,310	155,000
CE Rovinari S.A.	Romania	6,000	128,000
TAURON	Poland	5,600	118,000
ENEA	Poland	5,180	109,000
BRIKEL	Bulgaria	4,540	96,000
Drax Group Plc	UK	4,450	94,400
Slovenské elektrárne a.s.	Slovenia	4,350	92,100
Scottish Power Generation Ltd	UK	4,210	89,100
CE Craiova SA	Romania	3,950	84,300
ZE PAK	Poland	3,540	74,800

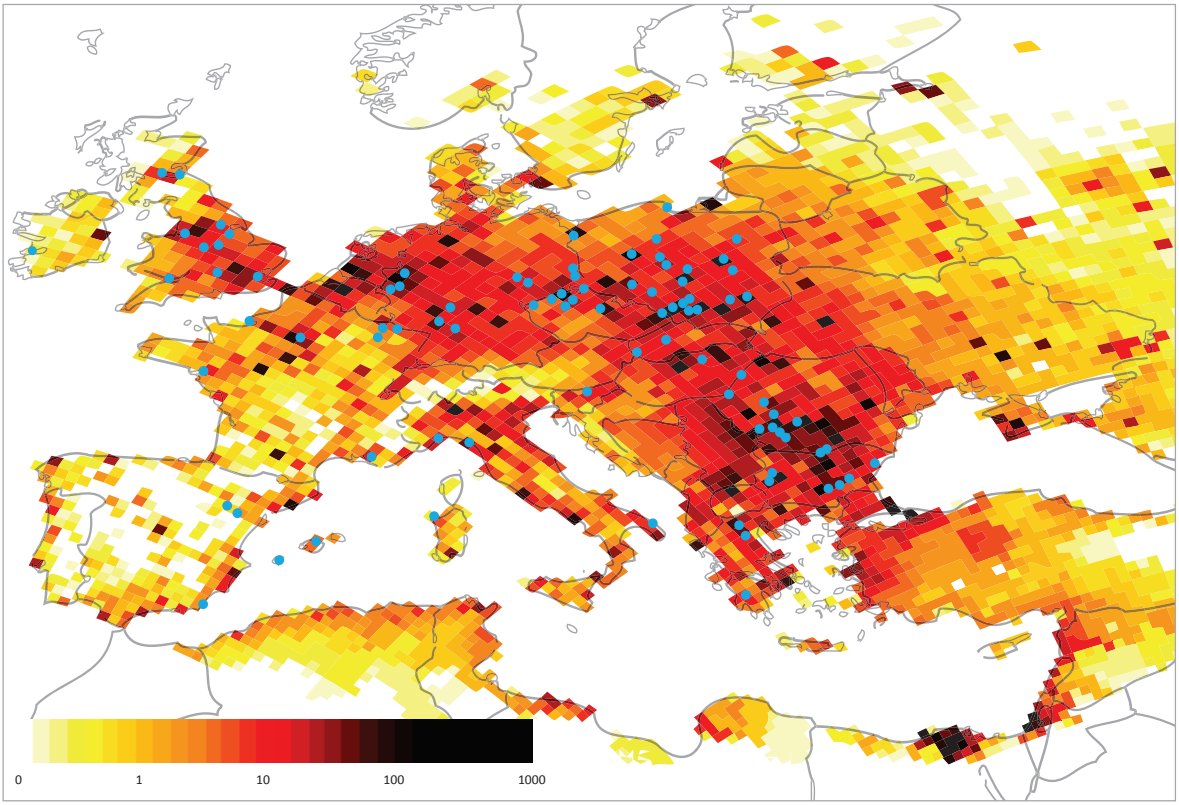
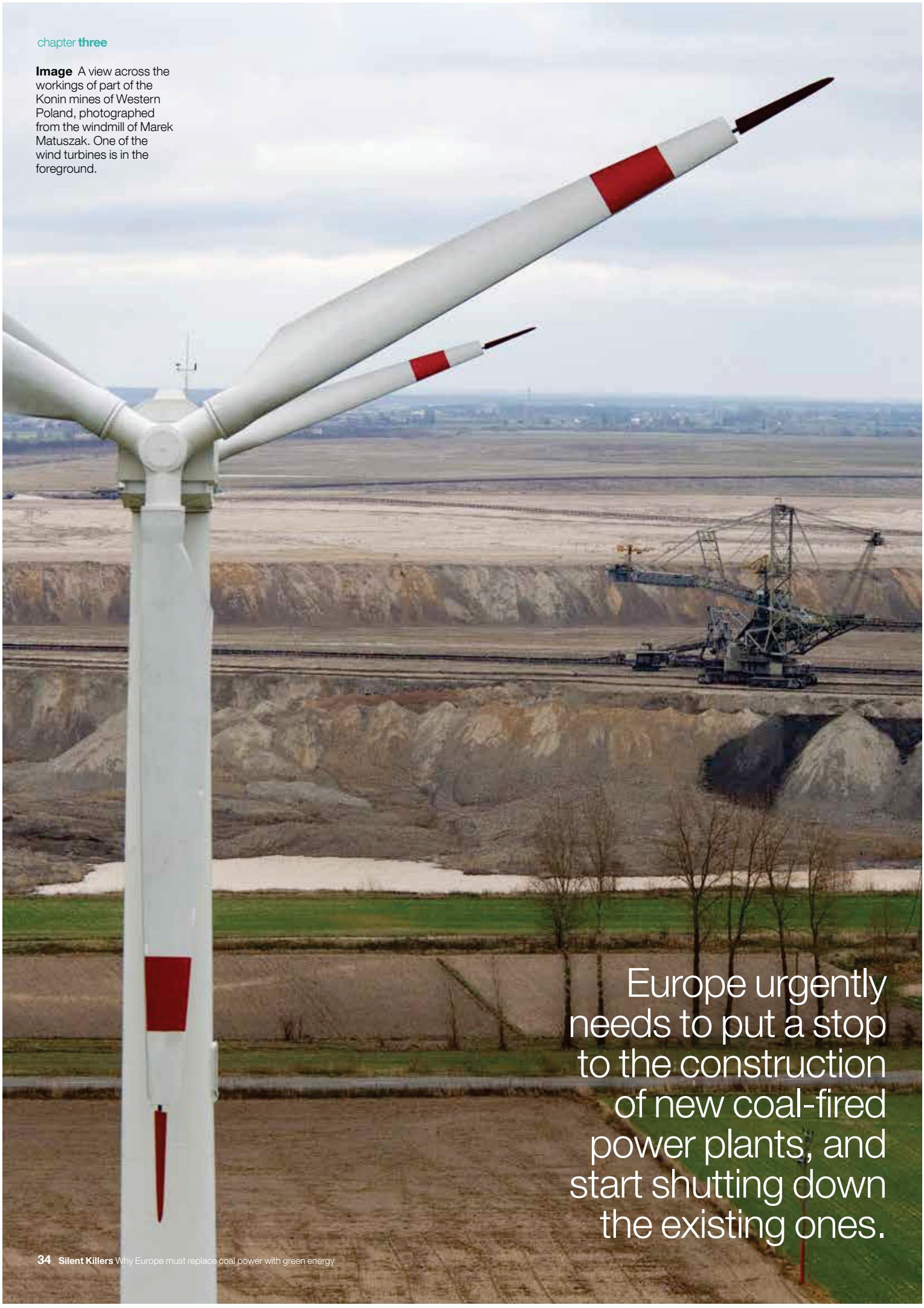


Image: Virtually everyone in Europe is breathing in invisible pollution from coal-fired power plants' smokestacks, resulting in an estimated total of 22,000 deaths in 2010. The colours show the estimated number of deaths in each 50 x 50 km grid tile. The blue dots mark the locations of the 100 most polluting power plants in Europe.

Map source: Greenpeace modelling using the EMEP MSC-W atmospheric chemistry-transport model, input data provided by EMEP and power plant emission data from the E-PRTR database.

Image A view across the workings of part of the Konin mines of Western Poland, photographed from the windmill of Marek Matuszak. One of the wind turbines is in the foreground.



Europe urgently needs to put a stop to the construction of new coal-fired power plants, and start shutting down the existing ones.

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#3

The future: Choosing between polluting and clean energy

Despite the technological advances and the amazing growth of renewable energy in Europe, many power utilities are still stuck in the past. Mapping carried out by Greenpeace International for this report shows that a total of over 50 new coal-fired power plant projects are active, including 15 under construction and 37 in planning[27]. The countries with the largest coal-fired capacity in the pipeline are Poland, Germany, Italy and Romania.

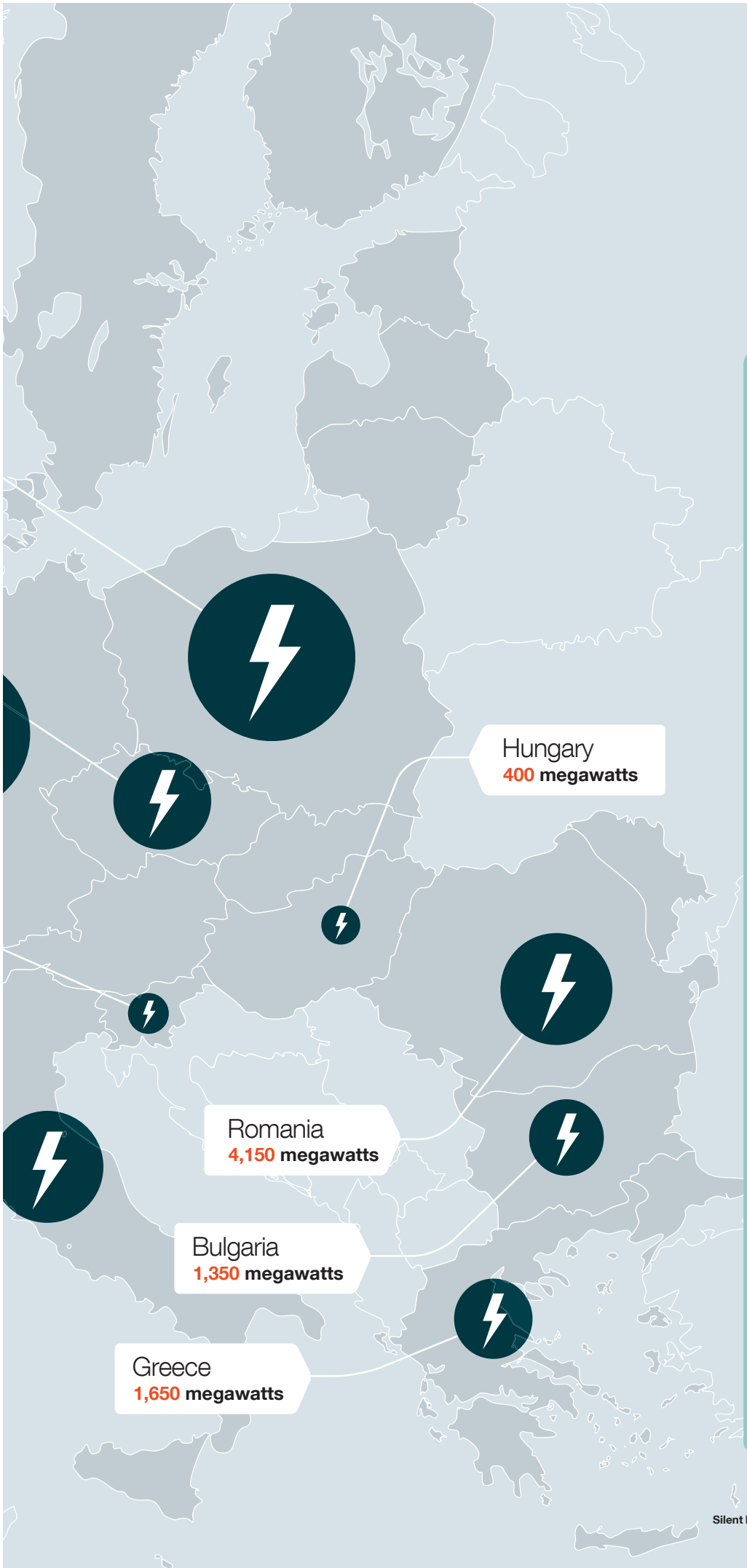
The construction of **new dirty power plants would add to the already too large death toll from currently operating coal-fired power plants**, and lock in dirty energy production for decades to come. The Stuttgart University report projects that if these 50 power plants go into operation, another 32,000 life years would be lost each year[28] – translating to a total of 1.3 million life years over an operating lifetime of 40 years, barring significant increases in pollution control requirements. These power plants would also emit approximately as much CO_2 as Spain, adding 7% to EU's CO_2 emissions.[29] This would make it **much harder to cut CO_2 emissions fast enough to prevent catastrophic climate change**, by at least 30% by 2020.

The large death toll associated with coal-fired power plants is in large part due to a **lack of resolve by European governments to step up and make the power industry clean up its act**. The use of coal in Europe's power generation declined steadily from almost 40% in 1990 to 26% in 2009; unfortunately since then, Europe has experienced a relapse[30]. Generators have switched from using gas-fired power plants to coal-fired power plants, driven by the failure of governments to set a meaningful cap on CO_2 emissions and the influx of relatively affordable coal imported from the US. European coal consumption grew by 11% in just three years from 2009 to 2012[31], which will have caused a similar increase in negative health impacts from coal-related air pollution, amounting to an increase of more than a thousand deaths[32].

Climate targets and implementation measures such as the emission trading scheme, renewable energy targets and energy efficiency targets, need to be toughened up to ensure coal use goes down and not up. Otherwise the social, economic and environmental repercussions illustrated by the University of Stuttgart's research will have an even greater toll on Europe as shown in the graphic below. Europe needs to embrace Smart 21st century energy solutions, and relegate 19th century energy such as coal to the past where it belongs.

New coal-fired power plants under construction or being planned in the European Union

Source: Information compiled by Greenpeace International and European Climate Foundation.



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emit as much CO_2 as Spain adding 7%

to EU's CO_2 emissions. This would make it much harder to cut CO_2 emissions fast enough to prevent catastrophic climate change by at least 30% by 2020.

The Top 10 companies building new dirty power plants

Table: Projected health impacts if new coal-fired power plants go into operation

Company	Countries with new projects	Life years lost	Working days lost	Total sick leave days	Asthma attacks requiring medication	Cough and other respiratory problems, days
RWE	Germany, Poland, Bulgaria, Netherlands	5,113	109,262	471,835	31,111	466,631
PGE	Poland	3,620	77,400	350,000	27,900	362,000
PPC	Greece	2,734	58,428	291,954	30,522	312,190
ENEL	Italy, Romania	1,409	30,117	141,770	12,561	145,411
ČEZ	Czech Republic	1,344	28,706	129,220	10,093	132,145
E.ON	Germany, Netherlands, Italy	1,329	28,404	117,262	6,196	112,765
GDF Suez	Poland, Germany, Netherlands	977	20,868	94,629	7,578	97,089
EdF	Poland	898	19,193	82,463	5,458	83,333

Choosing clean and safe energy

European governments have pampered the coal industry with almost-free CO_2 emission permits and subsidies[33], as well as air pollution norms that allow much higher emissions than other forms of power generation. The exceptions crafted to the current air pollution rules have meant that average power plant emissions are significantly higher than the regulatory limits[34], which in turn are a far cry from best available technology. Despite the large toll on health and on the climate, many European governments are still sponsoring or contemplating the construction of new coal-fired power plants. Even more governments focus on shielding the old coal power plants from new air pollution control requirements.

However, governments and power companies have a choice. The astonishing growth and development of renewable energy means that Europe's power needs can be covered without building a single new coal-fired power plant.

Since 2009, renewable energy, mainly wind and solar, has provided more than half of the additions to EU power generation. In 2011, wind power generated 179 terawatt-hours of electricity – seven times as much as 10 years earlier, and more than the total electricity consumption of Poland. A record 12 gigawatts of new wind capacity was installed in 2012, producing as much power as four large coal-fired power stations. At current growth rates, wind power generation alone is on track to surpass coal and lignite before 2020. Between 2009 and 2012, 50 gigawatts of solar power was installed, providing as much electricity as 10 large coal-fired power stations, roughly equal to the entire power consumption of the Czech Republic or Austria[35].

The Energy [R]evolution energy scenario for EU, published by Greenpeace International and the European Renewable Energy Council (EREC) in 2012, shows how Europe can phase out coal and nuclear power generation, reduce greenhouse gas emissions rapidly, create half a million additional jobs in the energy sector, keep the lights on, and keep energy costs in check[36].

Germany provides an example of how rapidly renewable energy sources can be rolled out. The country has gone from 8% to 22% renewable electricity in 10 years[37], and grown non-hydro renewable power generation five-fold. If the federal states' current development plans for renewables are implemented, Germany will hit over 50% renewable electricity in 2020[38] and can halve power sector coal use while completely phasing out nuclear[39]. Renewable energy employs a total of 380,000 people in Germany, a number that has more than doubled since 2004. Three quarters of the jobs are in the power sector.[40]

Europe urgently needs to put a stop on the construction of new coal-fired power plants, and start shutting down the existing ones. Countries such as the UK, the US and Canada have already introduced standards that prevent the construction of conventional coal-fired power plants[41], and Denmark has made a commitment to shut its coal-fired power plants[42]. The Canadian province of Ontario and the US states of Oregon and Washington are closing down all their coal-fired generation, Ontario already in 2014[43].

In sum, the realisation of the Energy [R]evolution energy model requires sustaining current growth rates of renewable energy sources, investing in the smarter use of energy in buildings, transport and industry, as well as planning future development of the power grids with a view to near 100% renewable generation. By implementing this energy blueprint European governments will foster positive health, economic and environmental impacts.

Europe's transition to clean and safe power generation in the Energy [R]evolution

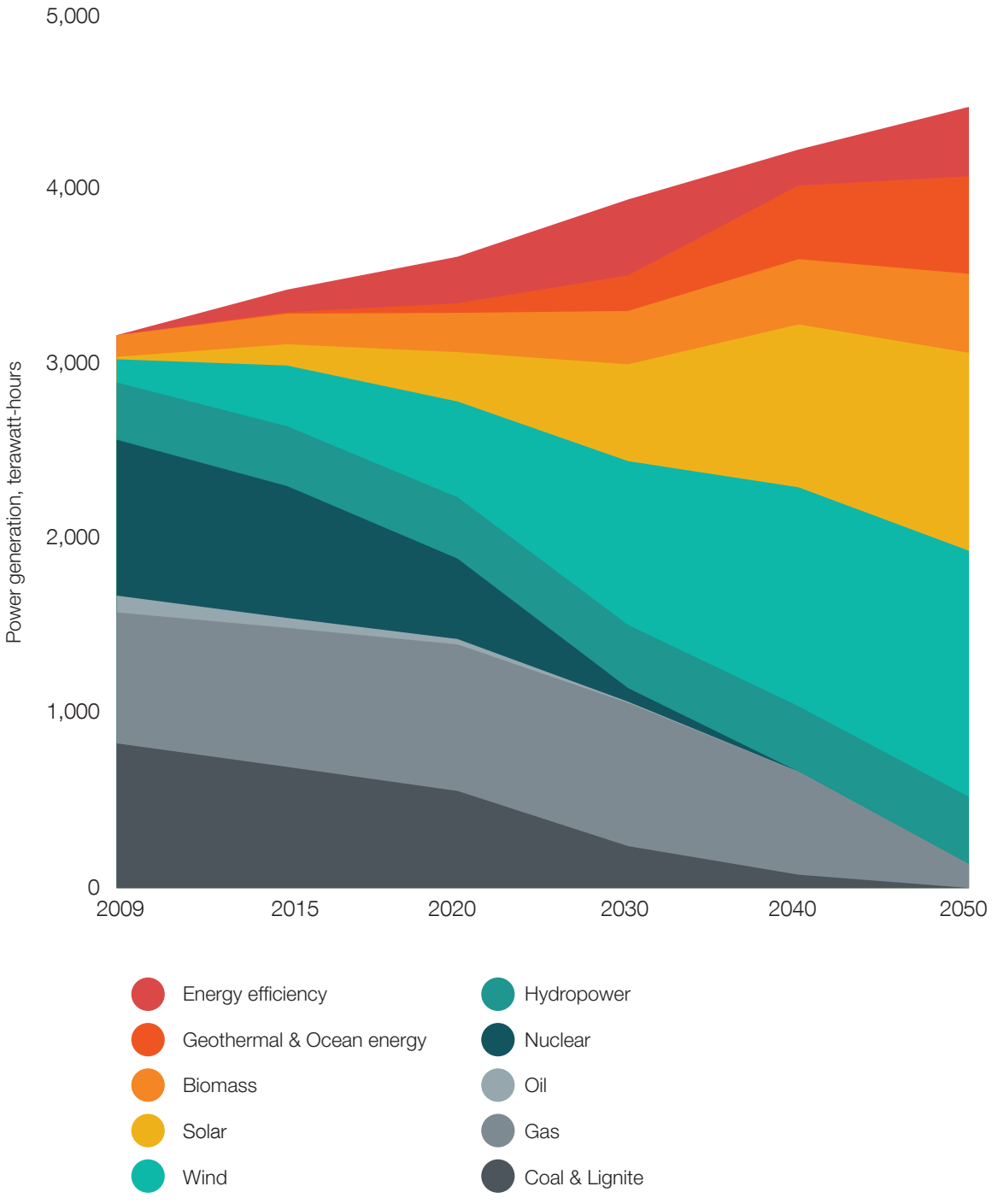
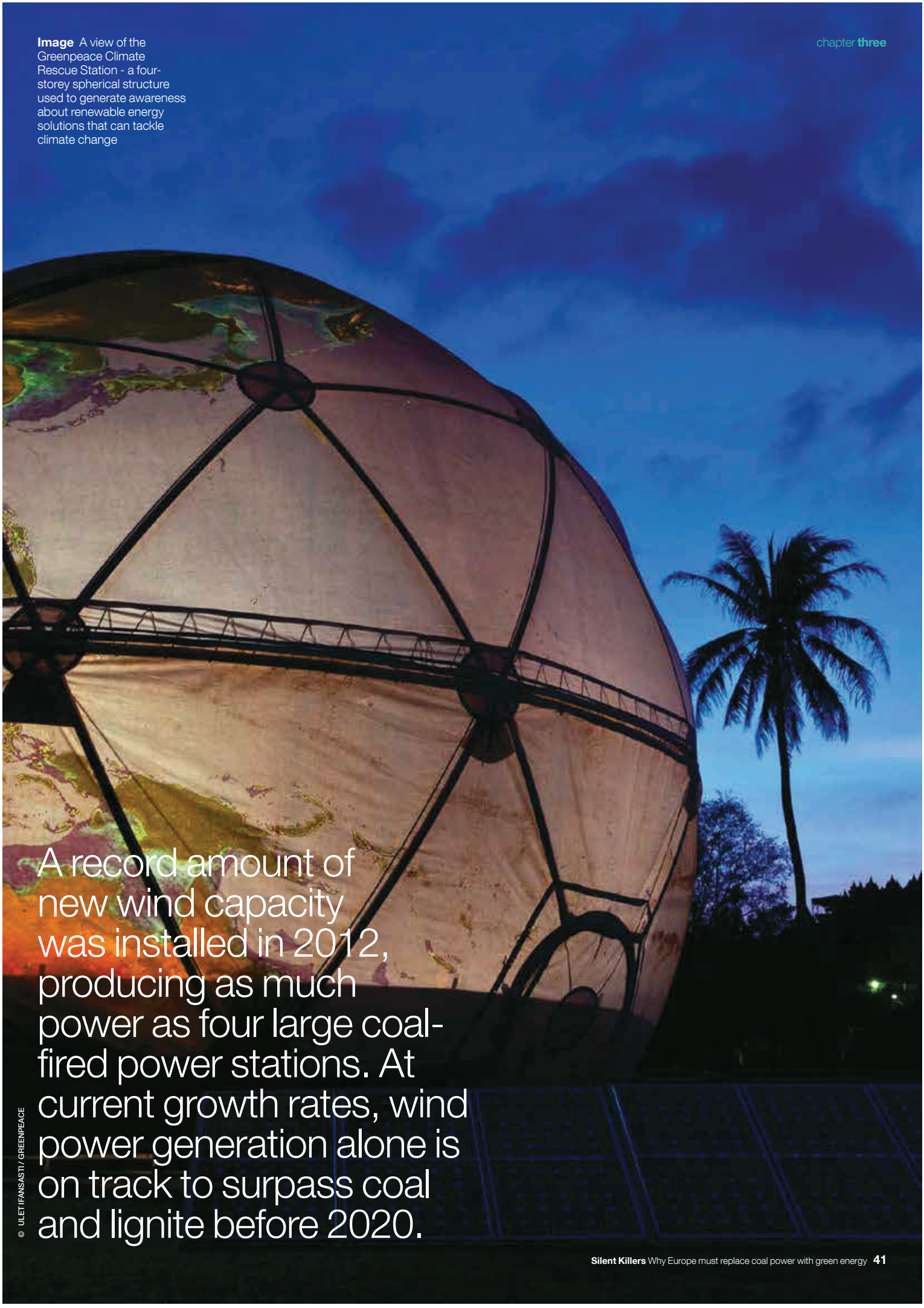


Image A view of the Greenpeace Climate Rescue Station - a four-storey spherical structure used to generate awareness about renewable energy solutions that can tackle climate change



A record amount of new wind capacity was installed in 2012, producing as much power as four large coal-fired power stations. At current growth rates, wind power generation alone is on track to surpass coal and lignite before 2020.

The Energy [R]evolution

Following Greenpeace's Energy [R]evolution would achieve the following:

A PEAK IN **CARBON EMISSIONS**

from the **ENERGY +TRANSPORT** SECTORS IN THE NEXT FEW YEARS, AND A

96%

---CUT BY 2050

44%

of electricity from renewables by 2020 and

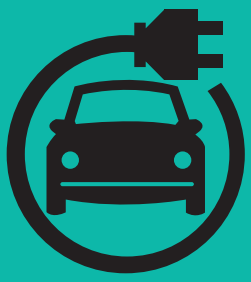
96%

by 2050 when a massive

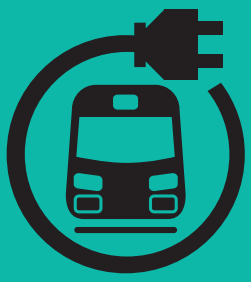
700,000

MEGAWATTS

will be installed, mostly in the form of wind, solar photovoltaic and solar thermal technologies.



LOWER ENERGY DEMAND IN THE TRANSPORT SECTOR, THANKS TO A SHIFT TO SMALLER ELECTRIC CARS AND THE USE OF MORE EFFICIENT MASS TRANSIT METHODS, SUCH AS ELECTRIFIED POWER TRAINS



IN 2030 ELECTRICITY WILL PROVIDE **12%** OF THE TRANSPORT SECTOR'S TOTAL ENERGY DEMAND **50%** IN 2050

€75 BILLION

IN FUEL COST SAVINGS A YEAR:

by switching to renewable energy, investing an additional €39 billion in new power plants every year until 2050 will pay for itself in the long run. The savings are made because – once the infrastructure is built –

THERE IS NO COST

IN HARNESSING RENEWABLE ENERGY, UNLIKE WITH CONVENTIONAL FOSSIL FUELS

MORE JOBS

1.4 MILLION

ENERGY SECTOR JOBS BY 2020

ONLY 0.9 MILLION

IN THE BUSINESS-AS-USUAL SCENARIO

NO EXTRA COST COMPARED TO FOSSIL FUELS:

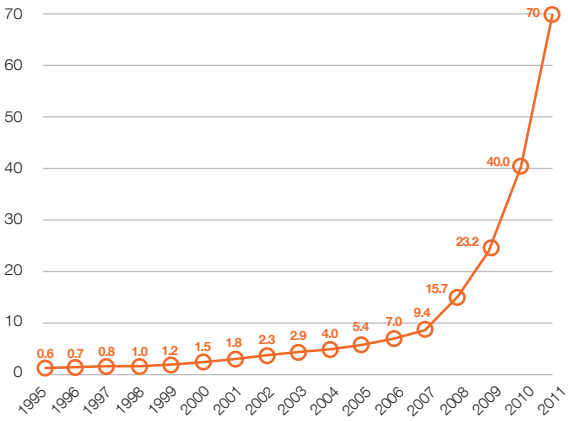
THE INVESTMENT IN RENEWABLE ENERGY COSTS MORE UPFRONT BUT PAYS BACK, AS RENEWABLE ENERGY HAS NO FUEL COSTS

Image: Solar thermal parabolic trough power plant Ain Beni Mathar in Morocco. The plant, run by Abengoa, produces 450MW through natural gas and 20MW through gutter power plant.

Global growth in wind and solar power generation capacity

Solar PV: total world capacity 1995-2011

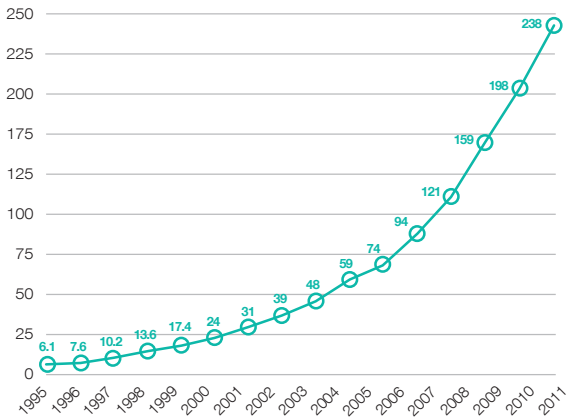
Gigawatts



Source: Renewables capacity graphs: REN21: Renewables 2012. Global Status Report. http://new.ren21.net/Portals/0/documents/activities/gsr/GSR2012_low%20res_FINAL.pdf

Wind power: total world capacity 1995-2011

Gigawatts



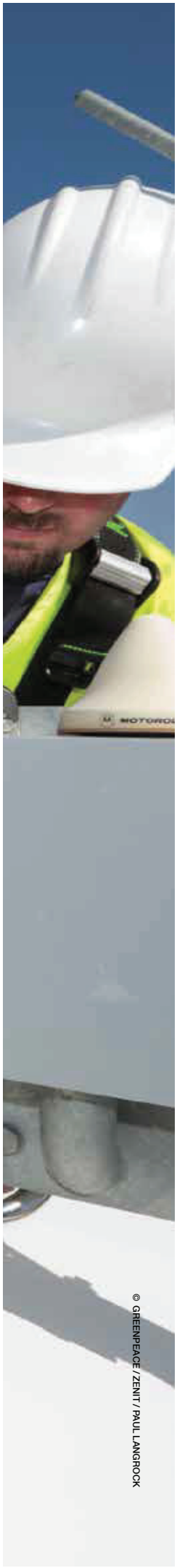
Source: Renewables capacity graphs: REN21: Renewables 2012. Global Status Report. http://new.ren21.net/Portals/0/documents/activities/gsr/GSR2012_low%20res_FINAL.pdf

Image The offshore windpark Baltic One, the first offshore windpark in the Baltic Sea. The wind farm will deliver energy for 50,000 households.

"It is time for European politicians to phase out coal and lead the transition to clean energy and clean air. It is time for them to lead the way in healing the planet and improving the quality of life for all."

- Kumi Naidoo,
Greenpeace International
Executive Director

Image The Forest Creek Wind Farm in Texas, USA, produces 2.3MW with wind turbines made by Siemens.



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#4

Conclusions: What needs to be done

Coal-fired power plants are estimated to have sent thousands of people to the grave prematurely in 2010, shortening the life of Europeans by an estimated total of 240,000 lost life years. Many more lives depend on whether we can stop new coal-fired power plants from being built, and how fast we can close down the old ones. Europe has made amazing progress in building a safe and clean energy system in the past years, but at the same time, lack of political resolve has allowed the polluting power plants to increase coal burning.

Europe has a choice. Setting ambitious targets for renewable energy, energy efficiency and CO_2 at the EU level, and maintaining successful policies to promote strong renewable energy growth at the national level, would see Europe lead the way in transforming its energy system to pollution and CO_2-free sources, while stimulating the economy and slashing the massive fuel import bill. In contrast, losing political leadership and falling back to last century's energy policies amidst the economic turmoil would see Europe's energy revolution hit the wall after an impressive start, locking in decades of pollution, as well as stifling innovation and growing employment in renewable energy.

It is time to stop listening to the polluting companies, who have undermined the health of Europeans for decades, and done their best to slow down progress in cutting CO_2 emissions.

Greenpeace demands

Europe needs to rein in coal pollution:

EU countries urgently need to put a stop to the construction of new coal-fired power plants, and start shutting down the existing ones. National governments should not permit new coal-fired power plants anywhere in the EU.

All coal-fired power plants must be required to be fitted with Best Available Control Technology, not just technology that meets the minimum regulatory standard. The dirtiest power plants, estimated to cause hundreds of deaths a year, must be closed down.

The European Commission must not allow the implementation of the Industrial Emissions Directive, which sets new air pollution standards in EU countries, to be delayed by years with weak "transitional" plans.

The European Commission and progressive governments must take immediate action to end public subsidies to the coal sector, particularly in Spain, Germany, Poland and Romania.

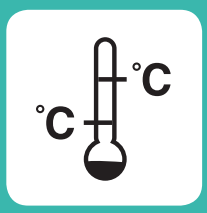
The EU Emissions Trading Scheme (ETS) is not currently working, due to an over-supply of emission allowances. EU governments and the European Parliament must, in the short term, curb the over-supply by postponing ETS emission allowances auctions. The short-term fix must be followed by permanent cancellation of allowances and stricter annual emission reductions.

...and to speed up the Energy [R]evolution:

The EU should set legally binding targets that add up to a 45% share of renewables across Europe in 2030, and set a binding greenhouse gas reductions and energy savings targets for 2030. These targets should be in line with phasing out coal in power generation by 2040 at the latest.

National governments should implement effective policies for a sustainable energy economy, including a commitment to fully implement the 2020 renewable energy targets and supporting policies and schemes.

Investments in electric grids are central to enabling a near 100% renewable power system in Europe. All new investments should be planned with a view to rapidly increasing renewable generation, rather than built around dirty, centralised 20th century power plants.



To contribute to limiting global temperature increase below 2°C, the EU should reduce its greenhouse gas emissions domestically by at least 30% by 2020 compared to 1990 levels.

It is time to stop listening to the polluting companies who have done their best to slow down progress in cutting CO_2 emissions.

© PAUL LANGROCK / GREENPEACE

Image Enercon wind turbines near Straussberg (Brandenburg), Germany, among clouds in the morning.

Annex: How the study was carried out

The modelling for this study was commissioned from Stuttgart University, which has been involved for a long time in developing the European assessment framework for the external impacts of energy. The Institute for Energy Economics (IER) in Stuttgart University has developed the EcoSense model[44] to assess the health and other environmental and economic impacts of power plants. The assessment was based on a coal-fired power plant emission inventory developed by Greenpeace International.

From the power plant to the air: Quantifying emissions

The first step in modelling the health impacts of coal-fired power plants is to find out how much pollution is emitted and where the pollution sources are. Emissions of sulphur dioxide (SO_2), nitrogen oxides (NO_x) and very fine particulates (PM2.5), as well as toxic metals and CO_2, were included in the study. The emission data for all operating power plants in the EU is available from the European Pollutant Release and Transfer Register (E-PRTR)[45] maintained by the European Environmental Agency. However, the database does not include information on which power plants use coal, so the coal-fired power plants were identified using the Platts World Electric Power Plants database, the EEA Large Combustion Plant emission data[46], and the companies' annual reports and websites.

The latest emission data is for the year 2010, which was a year with very low coal-fired power generation. Europe's total coal consumption increased approximately 11% from 2010 to 2012, which will have resulted in increased numbers of deaths and negative health impacts.

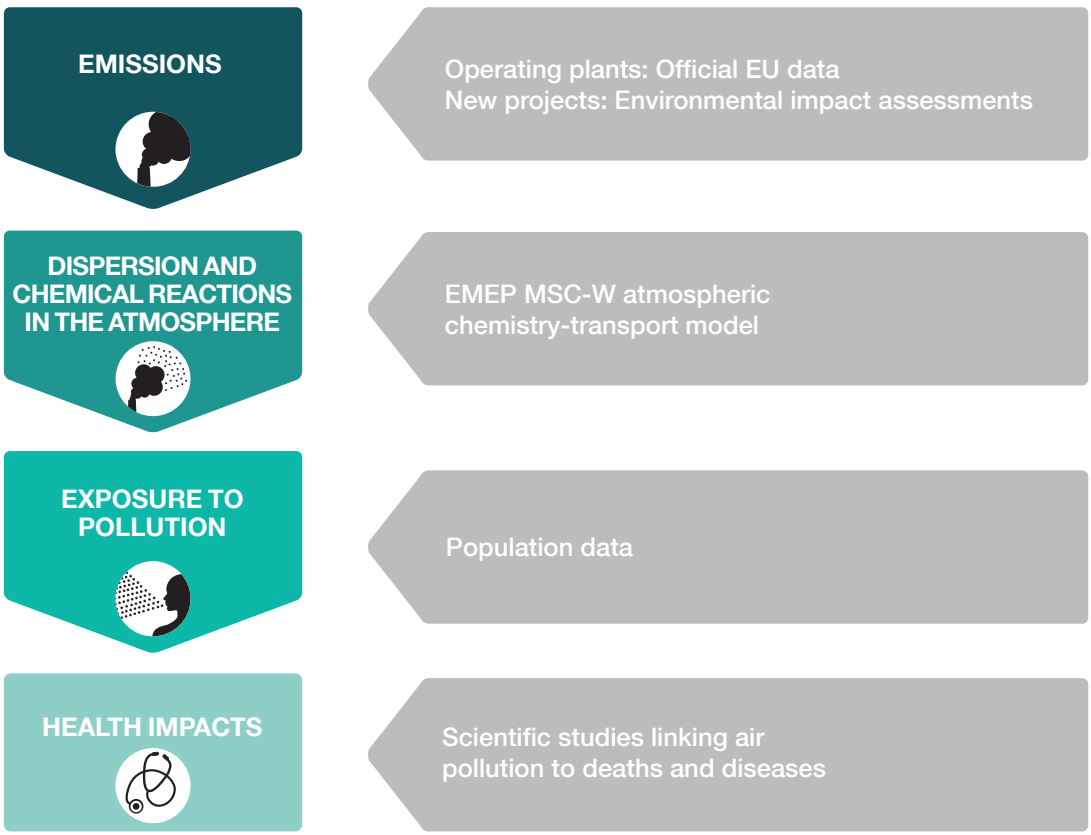


Image: A simplified flow-chart of the health impact assessment methodology

Data on power plants under construction or in planning was compiled by Greenpeace national and regional organisations, based on a project listing provided by European Climate Foundation in October 2012. The coordinates of these power plant sites were obtained from the E-PRTR and CARMA[47] databases and using Google Maps. For the purposes of calculating total health impacts by company, the health impacts of each power plant are fully attributed to the largest owner of the plant.

Air pollutant emissions from new power plants were taken from environmental impact assessments and environmental permits when possible. When these were not available, emissions were estimated based on nationally applicable or EU-level emission limit values. The calculation requires information on thermal efficiency, load factor and specific flue gas volume. Plant-specific values were used when possible, and typical values for new power plants were used as a secondary option.

The plant-level emission data for operating power plants is mainly based on continuous emission measurements from power plant stacks, and hence the uncertainty is very small, barring manipulation of data by companies or authorities. The main sources of error are the E-PRTR reporting thresholds, which allow many large power plants not to report all of their emissions. Out of the three main pollutants, SO_2, NO_x and particulates, the particulate emission inventory is most affected. Greenpeace has examined the distribution of the reported particulate emission data and found out that approximately 10% of total particulate emissions from coal power plants are unreported. Furthermore, less than half of the total particulate emission inventory is based on measurements; the rest is calculated assuming pollution controls operate as required. While this could possibly cause significant errors on the facility level, the impact on the total inventory is likely to be small.

For new power plant projects, there is naturally no emission data based on actual performance. The required emission limit values could change from those in environmental impact assessments, or load factors could be different from those assumed, or the entire project could be cancelled or modified. For new power plants, the report is a what-if assessment, looking at the impacts of power plants being built and commissioned as currently planned by the coal industry.

The emission data was prepared by Greenpeace International, and was used as an input to the next two steps in the assessment, carried out by Stuttgart University.

From the air into the lungs: Atmospheric transport and chemistry

The second step is to determine the additional pollution exposure caused by the pollutant emissions. The pollution from coal-fired power plants spreads over very large areas. The health impacts of a single power plant result from a very large number of people being exposed to small additional doses of air pollution, and conversely, the air pollution levels anywhere in Europe are affected by dozens or even hundreds of coal-fired power plants. A sophisticated model is required to assess the impacts of power plant emissions.

The EcoSense model used by Stuttgart University contains information on a large number of modelling runs carried out with the state-of-the-art MSC-W chemistry-transport model. The model uses data on winds, moisture, rain and other meteorological conditions from satellites and ground stations to compute the dispersion of pollution from different sources and the chemical reactions that change the composition of the pollution.

The information from the model runs is used to calculate the increase in pollutant concentrations caused by the modelled power plant emissions in thousands of different locations in Europe. These increases in concentrations are combined with population data to find out how many people are exposed to the elevated concentrations. Summing up the additional exposure from the different locations gives the total additional pollution exposure caused by the modelled power plant emissions. The emissions-to-population-exposure factors used in the EcoSense model are averaged over five years of meteorological data, to make the results representative of typical weather conditions.

Typically, it is found that for each 1,000 tonnes of a pollutant emitted by a power plant, between 200 grams and 5 kilograms of toxic particles are inhaled by the public[48]. This number will vary for different power plant locations, pollutants and atmospheric conditions.

The accuracy of the air pollutant concentrations predicted by the EMEP MSC-W model is evaluated annually against real-world measurement data.[49] The correlations between predicted and observed annual average concentrations are 90% and 88%, and model bias is -20% and 8%, respectively, for sulphate and nitrate particulate pollution[50], the main pollutants responsible for the health impacts quantified in this report. While this validation data cannot be used to quantify the confidence intervals for the emissions-to-concentrations relationships derived from the model, the good agreement between the model and reality provides confidence in the results. The negative bias for sulphate, the pollutant responsible for most of the negative health impacts, indicates the results could be conservative.

The toll on health

Once the total pollution exposure caused by the power plant emissions is calculated, the final step is to put numbers on the deaths and different diseases associated with the exposure. This is done by applying results from studies that have established relationships between pollutant levels and death and other health problems. The exposure-response factors used in the Stuttgart Ecosense model to calculate the health impacts are based on the recommendations of the NEEDS project funded by the European Commission[51] and adapted for example by the European Environmental Agency, for similar studies.

In the largest and most well known study on particulate air pollution and risk of death, 500,000 adults in 50 US states with different air pollution levels were followed between 1982 and 1998. The study has shown that people living in more polluted environments have a significantly higher risk of fatal heart and lung disease and lung cancer.[52]

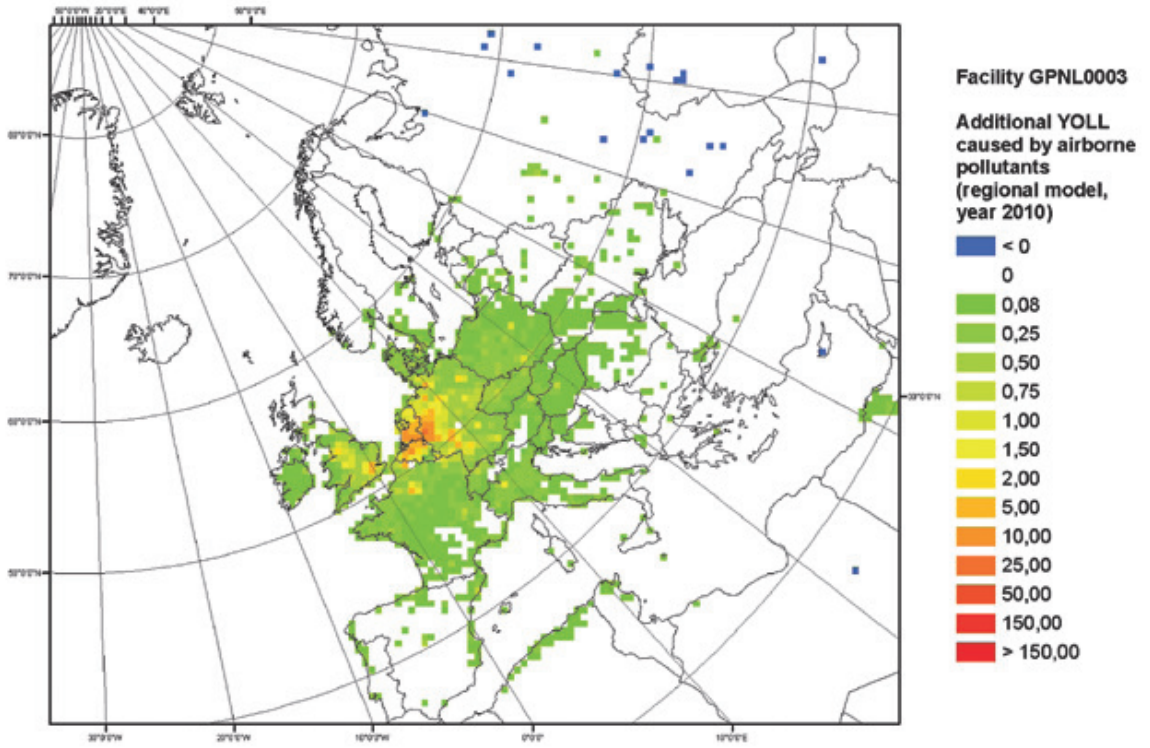


Image: An example of modelling results for a power plant in the Netherlands (the Eemshaven power plant under construction).

The risk factor for deaths from air pollution is based on the findings of this study, adjusted for the age structure death rate of the European population.

Work loss days resulting from air pollution are estimated using data from the US National Health Interview Survey[53], in which data on tens of thousands of households has been collected continuously since 1957. The survey maps the number of days that the interviewees have been disabled in bed, have had to stay away from work, or have been experiencing less severe health problems. The analysis of this data shows that all kinds of sickness days increase as a result of air pollution and provides risk factors that can be used to calculate the impacts[54].

Air pollution is associated with asthma attacks in children and adults with an existing asthma. This is measured as the amount of asthma symptoms requiring medication. The risk factor for asthma symptoms is taken from a World Health Organisation analysis[55] using data from several studies, mainly from Europe.

The number of people hospitalised due to an increase in air pollution levels was estimated in a 2005 study[56] covering seven European cities, plus the Netherlands. The data showed that increases in air pollution levels caused more people to be hospitalised due to heart attacks and symptoms, as well as respiratory symptoms.

The Stuttgart University EcoSense model uses "life years lost" as the indicator of the deaths associated with air pollution. This enables the use of one number to present deaths from ozone, and from acute and chronic effects of particulate pollution. The EU-sponsored project to assess the costs and benefits of the Clean Air For Europe programme (CAFE CBA) has also established a risk factor for the number of deaths from particulate air pollution, based on the same Pope et al 2002 study as the risk factors in the EcoSense model.[57] Greenpeace International has used this risk factor to calculate the number of deaths associated with the population exposure estimated in the Stuttgart University report. On average, each death from PM2.5 is estimated to cause the loss of 10.7 life years, and each death from ozone is associated with the loss of nine months of life.

The risk factors estimated from large statistical studies include uncertainty ranges. The 95% confidence interval for deaths is 127 to 1,194 years of life lost for every 100,000 people for each 10 µg/m3 increase in annual average PM2.5 level, with a central value of 651. This implies that the loss of life associated with emissions from operating power plants estimated in this report, 237,000, has a 95% confidence interval of 46,300 to 436,000. Similarly, the confidence interval for lost working days, 5.03 million, has a 95% confidence interval of 4.28 to 5.06 million.[58]

Endnotes

1 Rückerl R et al (2011). Health effects of particulate air pollution: A review of epidemiological evidence. Inhalation Toxicology 23(10): 555–592.

Pope III CA & Dockery DW (2006). Health Effects of Fine Particulate Air Pollution: Lines that Connect. J Air & Waste Manage. Assoc. 56:709 –742.

2 EEA (2012). The European Pollutant Release and Transfer Register. http://prtr.ec.europa.eu/FacilityLevels.aspx

Coal-fired power plants were identified from the database for the purposes of this study, as described in the Annex.

3 See footnote 24.

4 Preiss P, Roos J & Friedrich R (2013). Assessment of Health Impacts of Coal Fired Power Stations in Europe. Report commissioned by Greenpeace Germany. Institute for Energy Economics and the Rational Use of Energy (IER), University of Stuttgart, Germany.

5 Calculated using the life expectancy loss per cigarette estimated by: Spiegelhalter D (2012). Using speed of ageing and "microlives" to communicate the effects of lifetime habits and environment. British Medical Journal 345. http://dx.doi.org/10.1136/bmj.e8223

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2012 consumption estimated by calculating year-on-year growth rates from 8-11 months of data depending on country, and extrapolating into full year consumption. Hard coal and lignite data aggregated using Eurostat calorific values.

7 Assuming that the health impacts per tonne of coal burned of the power plants in which the increase occurred are the same as EU average, an 8% increase in generation implies 19,000 more years of life lost or approximately 1,800 more deaths.

8 See for example:
Buckens M-M (2013). Coal surge in Europe temporary, says consultant, Europolitics, Brussels, Belgium. http://www.europolitics.info/sectorial-policies/coal-surge-in-europe-temporary-says-consultant-art348203-14.html

9 Greenpeace International (2012). Energy Revolution: A Sustainable World Energy Outlook.
http://www.greenpeace.org/international/en/publications/Campaign-reports/Climate-Reports/Energy-Revolution-2012/

10 European Environment Agency (EEA) (2012a). Air quality in Europe — 2012 report. Copenhagen. p24
http://www.eea.europa.eu/publications/air-quality-in-europe-2012/at_download/file

11 EEA (2012a) op cit, p8

12 EEA (2012b). The European Pollutant Release and Transfer Register. http://prtr.ec.europa.eu/FacilityLevels.aspx
See Annex in this report as to how coal-fired power plants were identified from the database.

13 OECD (2012). OECD Environmental Outlook to 2050: The Consequences of Inaction, p287.
http://www.oecd.org/environment/indicators-modelling-outlooks/oecdenvironmentaloutlookto2050theconsequencesofinaction.htm

14 Disentangling pollution from coal-fired power plants from all other sources of pollution, and controlling for other risk factors in studies like these is very hard. Accordingly, it is impossible to fully attribute the observed effects in these studies solely to impacts of coal fired power plants, but the results are indicative of significant epidemiological impacts.

15 Parodi S (2004). Lung cancer mortality in a district of La Spezia (Italy) exposed to air pollution from industrial plants. Tumori. 90(2):181-5. http://www.ncbi.nlm.nih.gov/pubmed/15237579

16 Garcia-Perez J et al (2009). Mortality due to lung, laryngeal and bladder cancer in towns lying in the vicinity of combustion installations. Science of the Total Environment 407:2593–2602.

17 Ranft U et al (2003). Association between arsenic exposure from a coal-burning power plant and urinary arsenic concentrations in Prievidza District, Slovakia. Environ Health Perspect. 111(7): 889–894.
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Bencko V (2009). Ecological and human health risk aspects of burning arsenic-rich coal. Environmental Geochemistry and Health 31(1): 239-243.
http://www.springerlink.com/content/x7m351017h665118/

18 Tang et al (2008). Effects of Prenatal Exposure to Coal-Burning Pollutants on Children's Development in China.
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Perera et al (2008). Benefits of Reducing Prenatal Exposure to Coal-Burning Pollutants to Children's Neurodevelopment in China.
http://dx.doi.org/10.1289/ehp.11480

19 "New EU rules for coal" calculated based on 38% average coal power plant efficiency (LHV basis) and Industrial Emission Directive norms for coal; "Least dirty" coal based on most stringent values reported for new power plant projects covered in the report (45/55/4 mg/Nm3 stack concentrations for SO_2/NO_X/TSP and 46% efficiency); and "New gas" based on Industrial Emission Directive norms for gas and 56% efficiency.

20 The large coal-fired power plants included in this report emitted 1.8 million tonnes of SO_2, 1.0 million tonnes of of NO_X and 65 kilotonnes of primary particles in 2010. EEA (2012b) op cit.:

21 Eurostat energy statistics.
http://epp.eurostat.ec.europa.eu/portal/page/portal/energy/data/database

22 EEA (2012b) op cit

23 The emissions from the operating power plants included in this study were 850 million tonnes, according to the E-PRTR database. The total CO_2 emissions of EU27 were 3660 million tonnes in 2011, according to IEA (2012). CO_2 Emissions from Fuel Combustion 2012.

24 The years of life lost were converted to number of attributable deaths using the ratio of 10.7 years of life lost per PM2.5-related death, based on EEA (2011). Revealing the costs of air pollution from industrial facilities in Europe.
http://www.eea.europa.eu/publications/cost-of-air-pollution.

Number of people killed in road accidents from Eurostat transport statistics for 2009.
http://epp.eurostat.ec.europa.eu/portal/page/portal/transport/data/main_tables

25 Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control).
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:334:0017:0119:EN:PDF

26 For example, US EPA new regulation defines Maximum Achievable Control Technology as emission levels for SO_2 that are approximately one third of the new EU standard, and particulate matter emission levels that are a tenth of what the EU allows.

US EPA (2012). National Emission Standards for Hazardous Air Pollutants from Coal and Oil-Fired Electric Utility Steam Generating Units and Standards of Performance for Fossil-Fuel-Fired Electric Utility, Industrial-Commercial-Institutional, and Small Industrial-Commercial-Institutional Steam Generating

Units. 9304 Federal Register / Vol. 77, No. 32 / February 16, 2012 / Rules and Regulations.

27 Preiss P et al (2013), op cit.

28 The results for new projects reported in this report have been corrected for the abandonment of the Staudinger project in Germany, and for the increased capacity of the Gubin project in Poland.

29 The new power plant projects included in this report would emit approximately 260 million tonnes of CO_2 a year, while Spain's CO_2 emissions were 268 million tonnes in 2011, according to IEA (2012) op cit.

30 Eurostat monthly energy statistics.
http://epp.eurostat.ec.europa.eu/portal/page/portal/energy/introduction

31 Eurostat monthly statistics for solid fuels.
http://epp.eurostat.ec.europa.eu/portal/page/portal/energy/data/database

2012 consumption estimated by calculating year-on-year growth rates from 8-11 months of data depending on country, and extrapolating into full year consumption. Hard coal and lignite data aggregated using Eurostat calorific values.

32 Assuming that the health impacts per tonne of coal burned of the power plants in which the increase occurred are the same as EU average, an 8% increase in generation implies 19,000 more years of life lost or approximately 1,800 more deaths.

33 Reuters (2010a). EU coal nations win fight for subsidies to 2018. 10 December.

34 Calculated from the E-PRTR database using flue gas volume factors in EEA (2008). Air pollution from electricity-generating large combustion plants.
http://www.eea.europa.eu/publications/technical_report_2008_4.

For example, the total SO_2 emissions from the 300 power plants included in this report were 1.75Mt in 2010, and CO_2 emissions 825Mt, which gives an estimated total flue gas volume of 2.94x1015Nm3 and further estimated average SO_2 stack concentration of 596 mg/Nm3, whereas the regulatory norm for large power plants is 400 mg/Nm3.

35 Renewable energy installation data from EWEA (2013). Wind in power. 2012 European statistics. http://www.ewea.org/fileadmin/files/library/publications/statistics/Wind_in_power_annual_statistics_2012.pdf

Comparisons to coal assuming 1 GW coal units, 17% load factor for PV, 25% for wind and 80% for coal. Country electricity consumption from Eurostat http://epp.eurostat.ec.europa.eu/.

36 Greenpeace International (2012) op cit. http://www.greenpeace.org/international/en/publications/Campaign-reports/Climate-Reports/Energy-Revolution-2012/

37 AGEB (2013). Tabelle zur Stromerzeugung nach Energieträgern 1990–2012.
http://www.ag-energiebilanzen.de/viewpage.php?idpage=1

38 Bundesnetzagentur: Szenariorahmen für den Netzentwicklungsplan Strom (2013).
http://www.netzausbau.de/cln_1931/DE/Bedarfsermittlung/Szenariorahmen%20zum%20NEP%202013/szenarios_nep2013_node.html;jsessionid=D4730BEF253B8049B18C005F79289112.

39 Calculated based on the capacity projections in Bundesnetzagentur's Szenariorahmen, assuming current load factors for renewable energy and gas.

40 German Federal Environment Ministry (2012). Gross employment from renewable energy in Germany in 2011.
http://www.erneuerbare-energien.de/files/english/pdf/application/pdf/ee_bruttobeschaeftigung_en_bf.pdf

41 Hanly D (2012). Emission performance standards - Old option, new incentive for CCS. Global CCS Institute, Canberra, Australia.
http://www.globalccsinstitute.com/insights/authors/davidhanly/2012/12/04/emission-performance-standards-old-option-new-incentive-ccs

42 Danish Ministry of Climate, Energy and Buildings (2011). Our Future Energy.
http://www.ens.dk/Documents/Netboghandel%20-%20publikationer/2011/our_future_energy_%20web.pdf

43 Scientific American (2013). Ontario Phases Out Coal-Fired Power. 11 January.
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Sierra Club (2011). Historic agreement reached to phase out coal-burning in Washington. Press release, 5 March.

Reuters (2010b). PGE to stop burning coal at Oregon power plant in 2020. 22 November.
http://www.reuters.com/article/2010/11/22/pge-boardman-idUSN2218964620101122

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http://www.needs-project.org/RS1b/NEEDS_Rs1b_TP7.4.pdf

45 EEA (2012b) The European Pollutant Release and Transfer Register.
http://prtr.ec.europa.eu/FacilityLevels.aspx

46 EEA (2012c). Plant-by-plant emissions of SO_2, NO_X and dust and energy input of large combustion plants covered by Directive 2001/80/EC.

47 Carbon Monitoring for Action.
http://carma.org/

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http://www.emep.int/mscw/sr_main.html

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50 Ibid.

51 Torfs R, Hurley F, Miller B & Rabl A (2007). A set of concentration-response functions. New Energy Externalities Developments for Sustainability. http://www.needs-project.org/RS1b/NEEDS_Rs1b_D3.7.pdf

52 Pope et al (2002). Lung cancer, cardiopulmonary mortality, and long-term exposure to fine particulate air pollution. The Journal of the Americal Medical Association.
http://www.ncbi.nlm.nih.gov/pubmed/11879110

53 Centers for Disease Control and Prevention, US. National Health Interview Survey.
http://www.cdc.gov/nchs/nhis.htm

54 Torfs et al (2007) op cit.

55 Anderson et al (2004). Meta-analysis of time-series studies of Particulate Matter (PM) and Ozone (O_3). World Health Organisation Regional Office for Europe.
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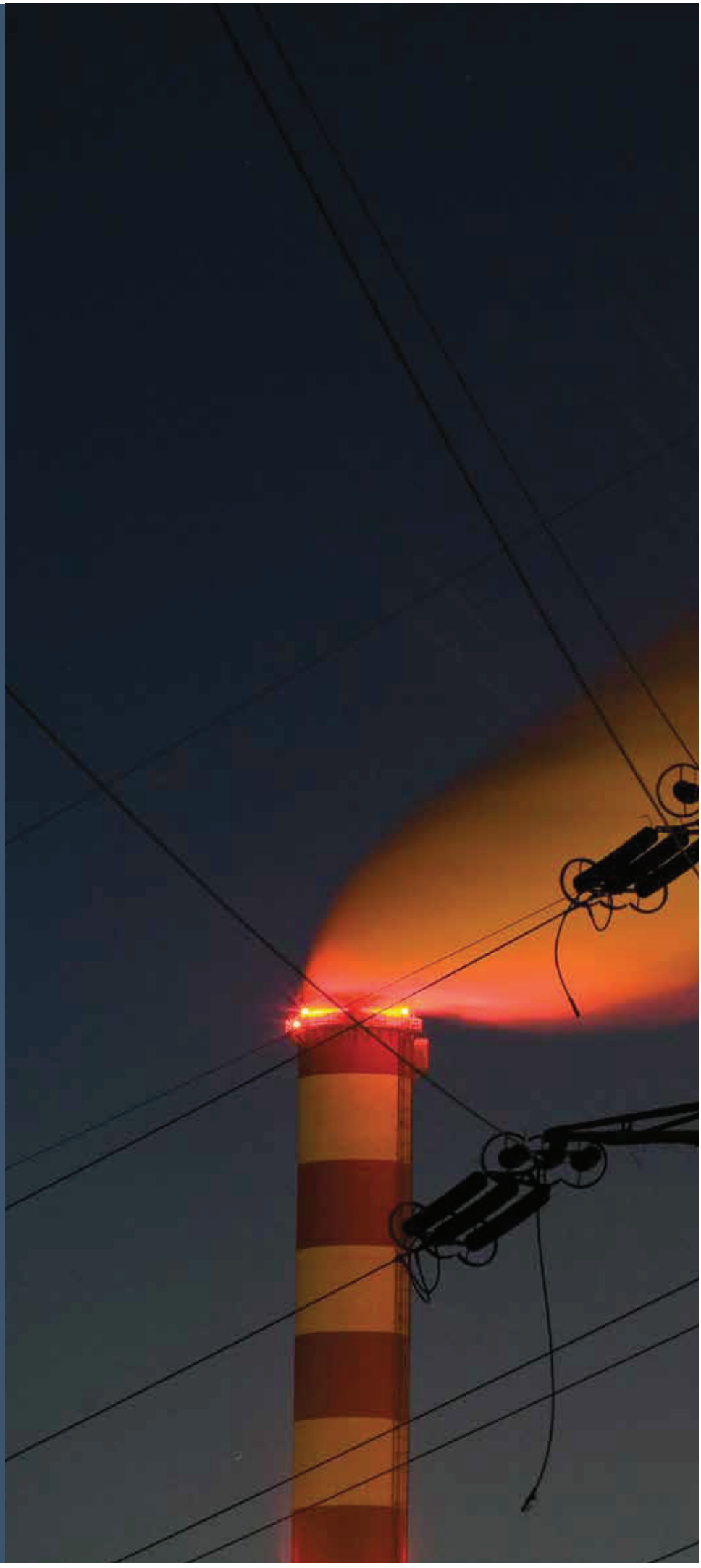
58 Torfs et al (2007) op cit. The concentration-response factor for lost working days is 207 (95% CI 176–208) days per year per 1000 adults aged 15–64 for each 10 ug/m3 increase in PM2.5 concentrations.



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