

Silent Killers:  
Why Turkey Must Replace Coal Power Projects  
With Green Energy

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## Executive Summary

Coal-fired power plants are among the worst sources of toxic air pollutants in Turkey 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<sup>1</sup>. Thousands of kilograms of toxic metals such as mercury, lead, arsenic and cadmium are spewed out of the stacks<sup>2</sup>, contributing to cancer risk and harming children's development.

Despite these health risks, the Turkish government has failed to steer clear of the dirty old - fashioned energy source. On the contrary, Turkey has become the country with the most planned coal power plants in Europe with approximately 80 new dirty power plants in the pipeline that have been promoted and permitted by the government policies. **Consequently, Turkey is now the 4<sup>th</sup> biggest coal threat in the world after China, India and Russia.**

To shed light on the health impacts of coal-burning power plants in Europe, Greenpeace commissioned a report from Stuttgart University<sup>3</sup>. The report investigates the health impacts of each of the 300 operating large power plants in the European Union and the 19 power plants in Turkey, as well as the predicted impact of the 100 new projects, if they come online.

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<sup>1</sup> Ruckerl 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.

<sup>2</sup> Calculating from average coal and lignite trace elements concentrations in Turkey, based on the USGS World Coal Quality Inventory, and the total particulate emissions estimated for this report, arsenic emissions from Turkish coal power plants exceed 10,000 kilograms, and mercury, chromium, nickel, manganese and lead emissions each exceed 1,000 kilograms per year.

<sup>3</sup> Preis P, Ross J & Friedrich R (2013) Assessment of Health Impacts of Coal Fired Power Stations in Germany.

Report Commissioned by Greenpeace Germany. Institute for Energy, Economics and Rational Use of Energy (IER), University of Stuttgart, Germany.

[http://www.greenpeace.de/sites/www.greenpeace.de/files/publications/130401\\_deliverable\\_ier\\_to\\_greenpeace\\_de\\_0.pdf](http://www.greenpeace.de/sites/www.greenpeace.de/files/publications/130401_deliverable_ier_to_greenpeace_de_0.pdf)

Using a sophisticated health impact assessment model, the report estimates that pollution from coal-fired power plants in Turkey resulted in thousands of premature deaths. According to the results, in Turkey, the lives of exposed people to the coal power plants only in 2010 has been shortened by 79.000 hours. **In other words, there have been 7900 premature deaths due to the coal power plants in 2010 in Turkey. The results indicate that almost 2 times as many people are killed by coal in Turkey as in traffic accidents<sup>4</sup>.**

The research also estimates that a total of approximately 1.7 million working days were lost in Turkey in 2010 due to illnesses and disability associated with pollution from coal-fired power plants. Other estimated health impacts include 200,000 asthma attacks and 8 million days of respiratory illness.<sup>5</sup> The estimated negative health impacts, measured in decreased life expectancy, from coal power plant pollution in Turkey in 2010, was equivalent to the damage to health from the smoking of 7 million cigarettes by every day of that year<sup>6</sup>. Turkey's coal-fired power generation increased 40% from 2009 to 2012<sup>7</sup>, which will have caused a dramatic increase in the negative impacts on the population's health.

**According to the modeling results, another 34,000 life years would be robbed every year if the 42 power plants that were under construction or in planning go into operation in 2010. It means that, a total of 1.4 million lost life years will be lost if the power plants operate for a full lifetime of 40 years. In August 2014, the number of plants that coal industry is building or**

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<sup>4</sup> 4,045 people were killed in road accidents in Turkey in 2010 according to Turkish Statistical Institute road transport statistics, <http://www.turkstat.gov.tr/>. The number of attributable deaths was calculated from the Stuttgart University air pollution exposure results unit using the concentration-response coefficients from European Environment Agency 2011: Revealing the costs of air pollution from industrial facilities in Europe. <http://www.eea.europa.eu/publications/cost-of-air-pollution>.

<sup>5</sup> Please see footnote 3.

<sup>6</sup> 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>

<sup>7</sup> 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.

**planning in Turkey has increased to roughly 80 new power plants in 2014, which means that the hazard from the addition of planned projects has increased to 39,000 life years lost.**

The Turkish power plants operating in 2010 with the worst estimated health impacts are Afşin-Elbistan Termik Santrali Unite A (EÜAŞ), Soma Termik Santrali (EÜAŞ) and Tunçbilek Termik Santrali (EÜAŞ) (Please see Table 2 at page 17). **The first two also rank as the power plants with the highest estimated death toll in all of Europe<sup>8</sup>.** Only the extension project of Afşin-Elbistan alone is projected to cause over 8000 lost life years for every year of operation, if the project is fully realized. It is agreed that it will be the new power plant project with the worst estimated health impacts in all of Europe.

#### **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 person, 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 9 months of life. The Stuttgart University results indicate that in 2010, approximately 7,900 deaths were attributable to pollution from coal-fired power plants, and the researchers estimate that their lives were shortened by a total of 79,000 years. The increased risk of death due to air pollution has been estimated in a study that followed 500,000 adults in 50 U.S. 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 U.S. National Health Interview Survey.

(Please see the Annex.)

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<sup>8</sup> Greenpeace 2013: Silent Killers: Why Europe must replace coal power plants with green energy  
<http://www.greenpeace.org/international/Global/international/publications/climate/2013/Silent-Killers.pdf>

However, this loss of life is entirely unnecessary, as renewable energy and the latest cutting edge energy efficiency solutions enable us to keep the lights on without a single new coal-fired power plant, and to start phasing out all existing coal in Turkey's power generation. Coal burning also needs to be reduced rapidly to stem the catastrophic impacts of climate change.

**Greenpeace Demands: Turkish government needs to rein in coal pollution**

- Turkish government urgently needs to put a stop to the construction of new coal-fired power plants, and start phasing out the existing ones.
- The dirtiest power plants, estimated to cause hundreds of deaths per year, must be closed down.
- Government must take immediate action to end public subsidies to the coal sector.

**... and to speed up the energy revolution:**

- The Turkish government should set legally binding targets to reduce carbon emissions and set binding greenhouse gas reductions and energy savings targets for 2030. These targets should be in line with phasing out coal in power generation by 2020 at the latest.
- Government should maintain the successful policies to promote renewable energy growth, and change the unsuccessful ones.
- Investments in electric grids are central to enabling a near 100% renewable power system. All new investments should be planned with a view to rapidly increasing renewable energy generation, rather than building around dirty and old-fashioned power plants.

# 1. No Future for Coal

Air pollution is a serious public health risk in Turkey, with toxic fine particulate matter (PM2.5) levels at least three times the World Health Organization (WHO) recommendations in each of the 12 cities for which the WHO has data, including Istanbul and Izmir. Pollution levels are at least twice as high as the typical values in large European and U.S. cities.<sup>9</sup> Despite the air pollution levels in the EU being much lower than in Turkey, EU citizens are estimated to live on average almost 9 months shorter due to air pollution-related deaths<sup>10</sup>.

Coal-fired power plants are Turkey's 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 one of the largest sources of arsenic and mercury emissions.<sup>11</sup>

Air pollution is an environmental risk that has serious impacts on human health. Countries can help to decrease the global burden of disease resulting from respiratory illnesses, public health and lung cancer by decreasing the air pollution. The lower the air pollution level in a city, the better the respiratory system (both in middle and long term) and the hearth and circulatory system of the people living in that city.

World Health Organization (WHO) estimates that outdoor air pollution caused 3.7 million deaths in 2012 from urban and rural sources worldwide<sup>12</sup>. People living in countries with middle

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<sup>9</sup> WHO 2011: Database: outdoor air pollution in cities.

[http://www.who.int/phe/health\\_topics/outdoorair/databases/en/index.html](http://www.who.int/phe/health_topics/outdoorair/databases/en/index.html).

PM10 values converted to PM2.5 using average ratio for low and middle income European cities of 68%.

<sup>10</sup> European Environment Agency 2012: Air quality in Europe — 2012 report. Copenhagen. p.24

[http://www.eea.europa.eu/publications/air-quality-in-europe-2012/at\\_download/file](http://www.eea.europa.eu/publications/air-quality-in-europe-2012/at_download/file)

<sup>11</sup> SO<sub>2</sub>, NO<sub>x</sub> and particulate matter emissions data reported by Turkey to EMEP under the Convention on Long Range Transboundary Air pollution (CLRTAP). Retrieved from the WebDab database: <http://www.ceip.at/webdab-emission-database/officially-reported-emission-data/>. Heavy metal emissions estimated using average concentrations in Turkish coal from USGS 2010: World Coal Quality Inventory, Version 1.

<http://pubs.usgs.gov/of/2010/1196/>, and emission factor equations in U.S. EPA 2009: AP-42.

<http://www.epa.gov/ttn/chief/ap42/ch01/final/c01s01.pdf>.

<sup>12</sup> WHO 2013: 7 million premature deaths annually linked to air pollution.

<http://www.who.int/mediacentre/news/releases/2014/air-pollution/en/>

level income are paying the bill of this burden disproportionately. It is not the own choice of the individuals to be exposed to the polluters in the air or not. The responsible institutions at national, regional and even international level should urgently come into action on that topic.

**World Health Organization (WHO) Air Quality Guidelines** provides the most updated and widely accepted assessment of the health- related impacts of the air pollution. These guidelines also recommend exposure limits to key air pollutants so that the health impacts could be considerably reduced. It is underlined that the air pollution related deaths could be decreased by %15, if the particulate matter (PM 10) could be decreased from 70 to 20  $\mu\text{g}/\text{m}^3$ <sup>13</sup>.

### ***Air Pollution***

Air pollution is a big environmental health problem, regardless of the fact that whether it is indoor or outdoor air pollution. Many people in developing countries as well as developed countries are being affected due to that problem.

There are serious health risks in many cities of both developed and developing countries as a result of the exposure to particulate matter (PM) and ozone (O<sub>3</sub>). It is possible to make a quantitative connection among air pollution levels and some health problems. In other words, when concentrations of small and fine particulates are reduced, related mortality will also go down – presuming other factors remain the same.

Even the smallest amounts of polluting particles in the air are hazardous. Poor indoor air quality is causing a health risk for more than half of the world. The PM levels can be up to 10-50 times more than the guideline values in the houses, where biomass and coal is used for cooking and heating.

If the concentration of some of the air pollutants that occur when fossil fuels are burnt, air pollution levels can be reduced by considerable amounts. This measurement could help to decrease the green house gases and contribute to the fight with climate change.

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<sup>13</sup> WHO 2005. Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide. Global Update 2005. Summary of Risk Assessment.



As WHO also states, particulate matters (PM) affects more people than any other pollutant. The major components of PM are sulfate, nitrates, ammonia, sodium chloride, black carbon, mineral dust and water. It consists of a complex mixture of solid and liquid particles of organic and inorganic substances suspended in the air. The particles are defined according to their aerodynamic diameters as PM 10 (aerodynamic diameters are equal or smaller than 10 µg) and PM 2.5 (aerodynamic diameters are equal or smaller than 2.5 µg). Particles are those with a diameter of 2.5 microns or less (PM<sub>2.5</sub>) have more damage to health, which can penetrate and lodge deep inside the lungs and can inhibit the air exchange<sup>14</sup>.

***PM10: guideline value - 20 µg/m<sup>3</sup> annual arithmetical mean***

The effects of PM on health occur at levels of exposure currently being experienced by many people both in urban and rural areas and in developed and developing countries – although exposures in many fast-developing cities today are often far higher than in developed cities of comparable size. Chronic exposure to particles contributes to the risk of developing cardiovascular and respiratory diseases, as well as of lung cancer. In developing countries, indoor exposure to pollutants from the household combustion of solid fuels on open fires or traditional stoves increases the risk of acute lower respiratory infections and associated mortality among young children; indoor air pollution from solid fuel use is also a major risk factor for cardiovascular disease, chronic obstructive pulmonary disease and lung cancer among adults.

However, even in the European Union, where PM concentrations in many cities do comply with WHO guideline levels, it is estimated that average life expectancy is 8.6 months lower than it would otherwise be, due to PM exposures from human sources<sup>15</sup>.

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<sup>14</sup> WHO 2014. Ambient (outdoor) air quality and health. Fact sheet No: 313.

<http://www.who.int/mediacentre/factsheets/fs313/en/>

<sup>15</sup> *ibid.*

***Ozone (O<sub>3</sub>): guideline value - 100 µg/m<sup>3</sup> 8 hours arithmetical mean***

The recommended limit in the 2005 Air Quality Guidelines was reduced from the previous level of 120 µg/m<sup>3</sup> in previous editions of the "WHO Air Quality Guidelines" based on recent conclusive associations between daily mortality and lower ozone concentrations.

It is formed by the reaction with sunlight (photochemical reaction) of pollutants such as nitrogen oxides (NO<sub>x</sub>) from vehicle and industry emissions and volatile organic compounds (VOCs) emitted by vehicles, solvents and industry. As a result, the highest levels of ozone pollution occur during periods of sunny weather.

Excessive ozone in the air can have a marked effect on human health. It can cause breathing problems, trigger asthma, reduce lung function and cause lung diseases. In Europe it is currently one of the air pollutants of most concern. Several European studies have reported that the daily mortality rises by 0.3% and that for heart diseases by 0.4%, per 10 µg/m<sup>3</sup> increase in ozone exposure<sup>16</sup>.

***Nitrogen dioxide (NO<sub>2</sub>): guideline value - 40 µg/m<sup>3</sup> annual mean***

Nitrogen dioxide (NO<sub>2</sub>) is a toxic gas, which causes significant inflammation of the airways, at short-term concentrations exceeding 200 µg/m<sup>3</sup>. NO<sub>2</sub> is the main source of nitrate aerosols, which form an important fraction of PM<sub>2.5</sub> and of ozone, in the presence of ultraviolet light.

Epidemiological studies have shown that symptoms of bronchitis in asthmatic children increase in association with long-term exposure to NO<sub>2</sub>. Reduced lung function growth is also linked to NO<sub>2</sub> at concentrations currently measured (or observed) in cities of Europe and North America<sup>17</sup>.

***Sulfur dioxide (SO<sub>2</sub>): guideline value - 20 µg/m<sup>3</sup> 24 hours mean***

Studies indicate that a proportion of people with asthma experience change in pulmonary function and respiratory symptoms after periods of exposure to SO<sub>2</sub> as short as 10 minutes.

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<sup>16</sup> *ibid.*

<sup>17</sup> *ibid.*

SO<sub>2</sub> can affect the respiratory system and the functions of the lungs, and causes irritation of the eyes. Inflammation of the respiratory tract causes coughing, mucus secretion, aggravation of asthma and chronic bronchitis and makes people more prone to infections of the respiratory tract. Hospital admissions for cardiac disease and mortality increase on days with higher SO<sub>2</sub> levels. When SO<sub>2</sub> combines with water, it forms sulfuric acid; this is the main component of acid rain that is a cause of deforestation<sup>18</sup>.

## 2. Saving Ourselves from Coal

Turkish coal power plants are extremely dirty compared with the rest of Europe. The Turkish government has failed to require and enforce even rudimentary emission controls<sup>19</sup>, putting corporate profit before its own citizens' health. However, requiring improved end-of-pipe controls is not enough. Even 'clean coal' – the favorite buzz word of the dirty energy lobby – is unacceptably dirty, as shown by the results in this report. (Please see Figure 1) The OECD Environmental Outlook recently warned that air-pollution related deaths were bound to increase in both developing and developed countries, even as pollution controls improve<sup>20</sup>.

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 urbanization. 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 Turkey is to phase out these dirty power plants in favor of clean and modern renewable energy sources. This report not only exposes the impacts of dirty energy on Turkish people's health, but also illustrates how smart decisions by governments and energy companies can eliminate coal pollution in Europe and Turkey.

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<sup>18</sup> *ibid.*

<sup>19</sup> For example, average SO<sub>2</sub> emission rates from Turkish lignite power plants are well above 2000 mg/m<sup>3</sup>, while the EU standard for old power plants is 400 mg/m<sup>3</sup>, and for new power plants 150 mg/m<sup>3</sup>. For how Turkish emission rates were calculated, see the Annex.

<sup>20</sup> OECD 2012: OECD Environmental Outlook to 2050: The Consequences of Inaction, p. 287.

<http://www.oecd.org/environment/indicators-modelling-outlooks/oecdenvironmentaloutlookto2050theconsequencesofinaction.htm>

### ***Examples of Studies on Health Problems around Coal-Fired Power Plants<sup>21</sup>***

- In a district of Northern Italy, women's risk of dying of 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<sup>22</sup>.
- A Spanish study found an elevated risk of lung, throat and bladder cancer within 50 kilometers of coal-fired power plants, with higher risks associated with living closer to the plant<sup>23</sup>.
- 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<sup>24</sup>.
- 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<sup>25</sup>.
- It is found that Çatalağzı Termik Santrali has big impacts on human and environmental health. 20% of the birth in the region face problems such as underdeveloped lungs, asthma and chronic obstructive pulmonary disease (KOA). The number of cancer incidents in the region is also increasing day to day.

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<sup>21</sup> 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.

<sup>22</sup> 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>

<sup>23</sup> 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.

<sup>24</sup> 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. <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1241521/>

Pesch B et al 2002: Environmental Arsenic Exposure from a Coal-burning Power Plant as a Potential Risk Factor for Nonmelanoma Skin Carcinoma: Results from a Case-Control Study in the District of Prievidza, Slovakia. *Am. J. Epidemiol*. 155(9): 798-809. <http://aje.oxfordjournals.org/content/155/9/798.short>

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/>

<sup>25</sup> Tang et al 2008: Effects of Prenatal Exposure to Coal-Burning Pollutants on Children's Development in China. <http://dx.doi.org/10.1289/ehp.10471>

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>

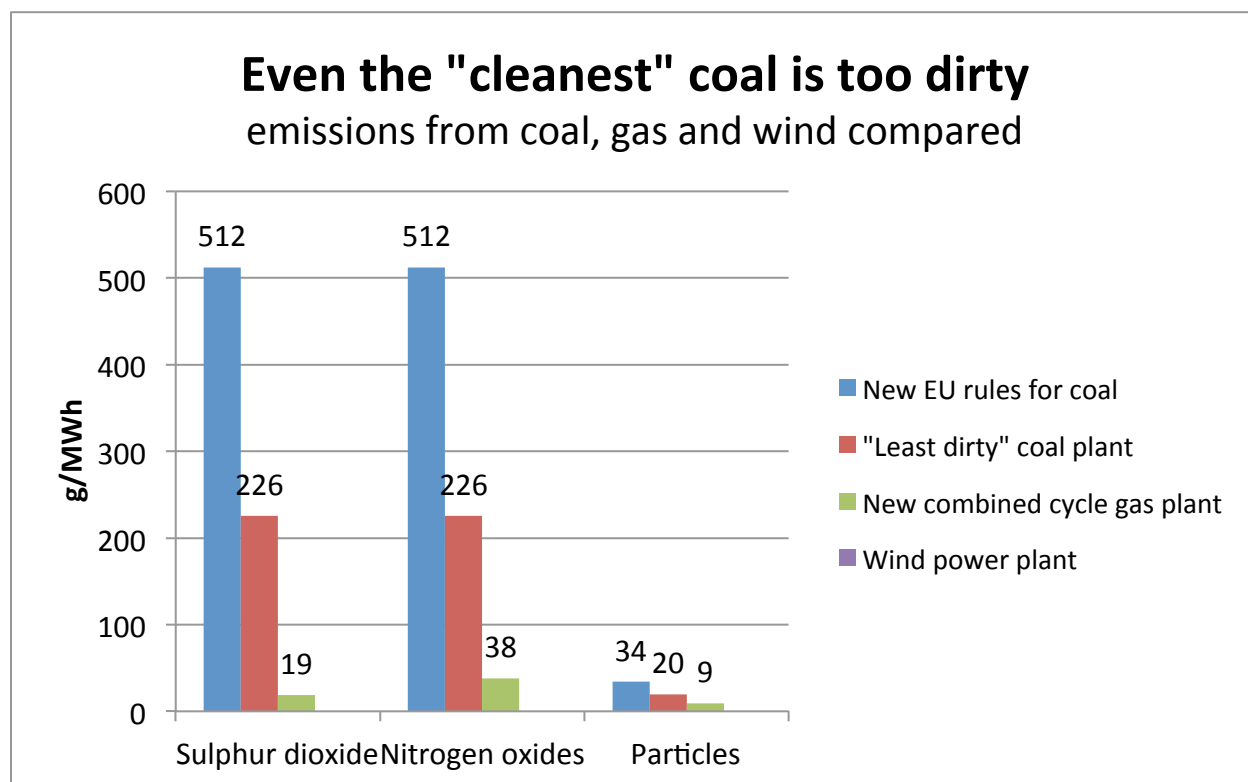


Figure 1: EU's new air pollution rules for coal-fired power plants allow much higher emissions than can be achieved with best available technology, and more than 10 times higher emissions than a new gas-fired power plant.<sup>26</sup>

### 3. The Current Health Impacts of Coal in Europe

Coal-fired power plants are silent killers. Spread all over Turkey, they spew out millions of tonnes of toxic gases and particles<sup>27</sup>. These emissions enter the lungs and the bloodstream, causing respiratory diseases, heart attacks, lung cancer, asthma attacks and other health damage. Even though you won't find a single death certificate listing "air pollution" as cause of death, the impact on health is real and significant.

<sup>26</sup> Calculated based on 38% average coal power plant efficiency, Industrial Emission Directive norms for coal and gas, 70/70/7 mg/Nm<sup>3</sup> stack concentrations for SO<sub>2</sub>/NO<sub>x</sub>/TSP and 46% efficiency for "least dirty" power plant and 56% efficiency for gas.

<sup>27</sup> The large coal-fired power plants included in this report emitted 1.8 million tonnes of SO<sub>2</sub>, 1.0 million tonnes of NO<sub>x</sub> and 65 kilotonnes of primary particles in 2010. EEA 2012: The European Pollutant Release and Transfer Register. <http://prtr.ec.europa.eu/FacilityLevels.aspx>

In 2010, there were 19 large coal and lignite fired power plants in operation in Turkey, that produced 26% of all electricity<sup>28</sup>. Coal-fired power plants are responsible for over 80% of the EU's sulphur dioxide emissions and over 50% of nitrogen oxide emissions from the power sector. They are among the largest sources of mercury and arsenic emissions into the air. These 19 coal-fired power plants are also responsible for more than fifth of Turkey's CO<sub>2</sub> emissions.<sup>29</sup>

Greenpeace commissioned the Stuttgart University Institute for Energy Economics (IER) to quantify the health impacts of the coal-fired power plant emissions. 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 modeling 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. ( Please see Annex: How the study was carried out for more details). The results of the study are staggering. In Germany, it is estimated that coal power stations are associated with almost twice as many deaths as road accidents.<sup>30</sup>

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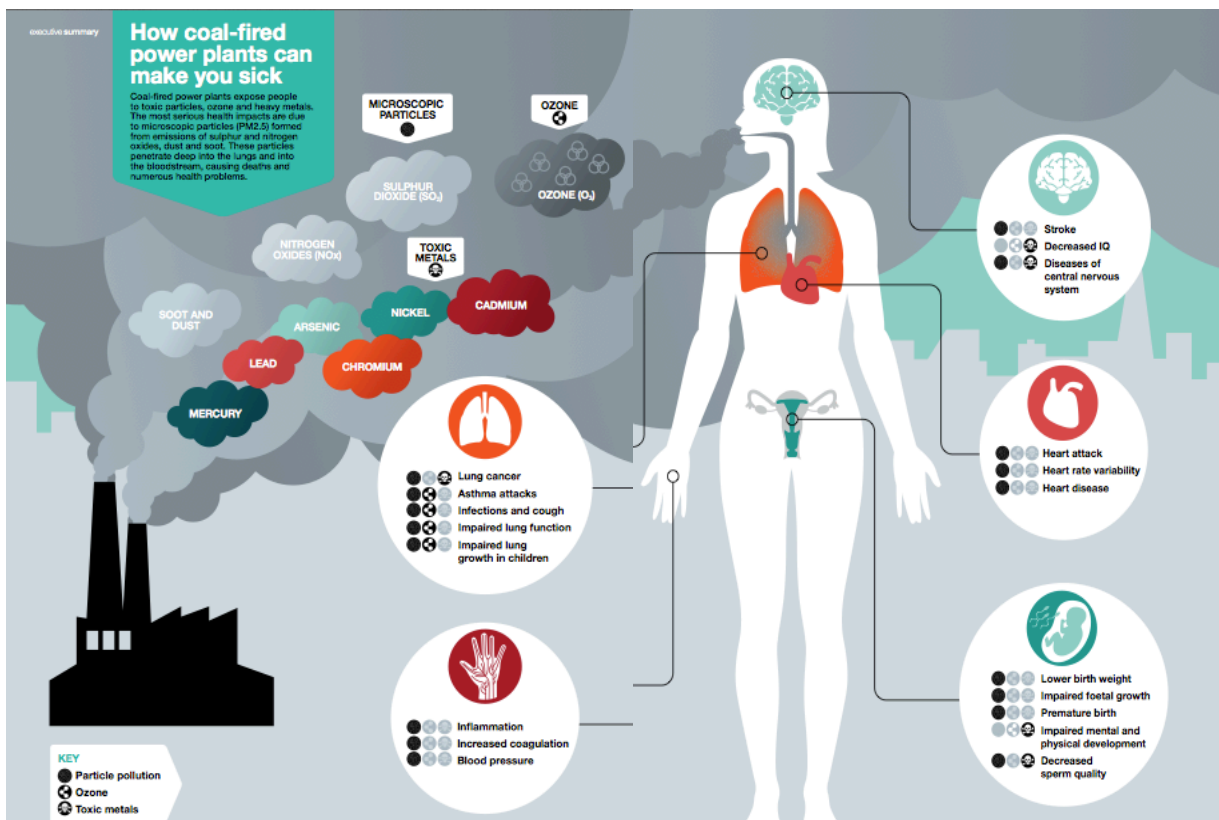
<sup>28</sup> Eurostat annual energy statistics for 2010.

<http://epp.eurostat.ec.europa.eu/portal/page/portal/energy/data/database>

<sup>29</sup> See the Annex for details of how the emission inventory was developed.

<sup>30</sup> 4,045 people were killed in road accidents in Turkey in 2010 according to Turkish Statistical Institute road transport statistics, <http://www.turkstat.gov.tr/>. The number of attributable deaths was calculated from the Stuttgart University air pollution exposure results unit using the concentration-response coefficients from European Environment Agency 2011: Revealing the costs of air pollution from industrial facilities in Europe. <http://www.eea.europa.eu/publications/cost-of-air-pollution>.

Overall, the deaths of approximately 7,900 people in 2010 are estimated to be attributable to pollution from coal-fired power plants, resulting in a total of 79,000 lost life-years. The same year, illnesses and health problems from coal plant pollution were associated with an estimated total of 1.7 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<sup>31</sup>. 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.

## 4. The Future: Choosing Between Polluting and Clean Energy

Despite the technological advances and the amazing growth of renewable energy, many power utilities are still stuck in the past. Mapping carried out by Greenpeace for this report shows that in 2012, there are a total of over 80 new coal-fired power plant projects, which are in planning or permitting stage in Turkey. The construction of new dirty power plants would add to the

<sup>31</sup> See Figure 1: Even the cleanest coal is too dirty.

already too large death toll from currently operating coal-fired power plants, and lock in dirty energy production for decades to come<sup>32</sup>. These new power plants would almost double Turkey's CO<sub>2</sub> emissions.<sup>33</sup> This would make it much harder to cut CO<sub>2</sub> emissions fast enough to prevent catastrophic climate change.

The large death toll associated with coal-fired power plants is in large part due to a lack of resolve by the Turkish government to step up and make the power industry clean up its act. Power generation from coal increased by 70% from 2002 to 2010, with no decline in the share of the dirtiest form of power generation. This will have caused a major increase in negative health impacts from coal-related air pollution.

Climate targets and implementation measures such as CO<sub>2</sub> pricing, renewable energy and energy efficiency targets and support policies 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 Turkey as shown in the graphic below. The country needs to embrace smart 21<sup>st</sup> energy solutions and relegate 19<sup>th</sup> century energy such as coal to the past where it belongs.

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

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<sup>32</sup> Preis P, Ross J & Friedrich R (2013) Assessment of Health Impacts of Coal Fired Power Stations in Germany. Report Commissioned by Greenpeace Germany. Institute for Energy, Economics and Rational Use of Energy (IER), University of Stuttgart, Germany.  
[http://www.greenpeace.de/sites/www.greenpeace.de/files/publications/130401\\_deliverable\\_ier\\_to\\_greenpeace\\_de\\_0.pdf](http://www.greenpeace.de/sites/www.greenpeace.de/files/publications/130401_deliverable_ier_to_greenpeace_de_0.pdf)

<sup>33</sup> The new power plant projects included in this report would emit approximately 240 million tonnes of CO<sub>2</sub> per year, while Turkey's CO<sub>2</sub> emissions were 266 million tonnes in 2011, according to IEA 2012: CO<sub>2</sub> Emissions from Fuel Combustion 2012.



**Table 1 - The Dirtiest Coal Power Plant Operators in 2010**

Owner Company	Coal Power Plant	Years of Life Lost	Lost Working Days
EÜAŞ	Afşin Elbistan Ünite A-B, Çan, Çatalağzı, Kangal, Kemerköy, Orhaneli, Seyitömer, Soma, Tunçbilek, Yatağan, Yeniköy S.	52.570	1.114.330
İsken Enerji	Sugözü Termik S.	1.950	41.780
Eren Enerji	Zonguldak Eren S. (ZETES) 1-2	1.850	39.670
İÇDAŞ	İÇDAŞ Termik, İÇDAŞ Bekirli S.	1.330	28.370
Park Termik	Çayırhan Termik S.	1.300	27.250

**Table 2 - Life Years Lost Due to The Coal Power Plants in 2010 in Turkey**

Coal Power Plant	Owner Company	Years of Life Lost	Lost Working Days
Afşin-Elbistan Termik Santrali A Ünitesi	EÜAŞ	20.190	431.270
Soma Termik Santrali	Soma Elektrik	13.400	282.640
Tunçbilek Termik Santrali	EÜAŞ	7.060	149.160
Seyitömer Termik Santrali	EÜAŞ	2.580	54.350
Kangal Termik Santrali	EÜAŞ	2.490	52.620
Afşin-Elbistan Termik Santrali B Ünitesi	EÜAŞ	2.190	46.840
İsken Sugözü Termik Santrali	İsken Enerji	1.950	41.780
Zonguldak Eren Termik Enerji Santrali (ZETES 1-2)	Eren Enerji	1.850	39.670
Çayırhan Termik Santrali	Park Termik	1.300	27.250

<b>Kemerköy Termik Santrali</b>	Kemerköy Elektrik	1.180	24.590
<b>Yatağan Termik Santrali</b>	Yeniköy Elektrik	1.120	23.350
<b>Çatalağzı Termik Enerji Santrali (ÇATES)</b>	EÜAŞ	900	18.750
<b>Silopi Termik Santrali</b>	Silopi Elektrik	820	17.170
<b>Çolakoğlu Termik Santrali</b>	Çolakoğlu Enerji	710	14.800
<b>İÇDAŞ Termik Santrali</b>	İÇDAŞ Çelik Enerji	700	15.070
<b>Çan Termik Santrali</b>	EÜAŞ	690	14.540
<b>İÇDAŞ Bekirli Termik Santrali</b>	İÇDAŞ Elektrik	630	13.300
<b>Yeniköy Termik Santrali</b>	Yeniköy Elektrik	420	8.850
<b>Orhaneli Termik Santrali</b>	EÜAŞ	350	7.370

**Table 3 - 10 Dirtiest Coal Power Plant Investor of the Planned Projects in 2010<sup>34</sup>**

<b>Investor Company</b>	<b>Project Number</b>	<b>Project Name</b>	<b>Years of Life Lost</b>	<b>Lost Working Days</b>
<b>EÜAŞ</b>	4	Afşin Elbistan C-D-E-G Üniteleri	8.250	176.320
<b>HATTAT Holding</b>	4	Amasra ve Kandilli Termik Santralleri (HEMA Holding), Bartın ve Kireçlik Termik Santralleri (Batı Karadeniz Elektrik)	4.600	97.080
<b>Eren Holding</b>	1	Mersin Eren Termik Santrali, Modern Enerji Termik Santrali	2.170	46.300
<b>Emba Enerji</b>	2	Trakya Entegre Termik Santrali	1.180	24.740
<b>Atagür Enerji</b>	1	Bezci Termik Santrali	1.410	29.720
<b>Cenal Elektrik (Cengiz</b>	1	Cenal Termik Enerji Santrali	1.320	27.710

<sup>34</sup> Projected health impacts if new coal-fired power plants go into operation. The impacts of planned power plants are compared with the existing impacts.

İnşaat & Alarko)				
Suez Güney Enerji	1	Ada Termik Santrali	1.280	26.910
Tabiat Enerji	1	Yeşilovacık Termik Santrali	1.240	26.550
Diler Holding	1	Atlas Enerji Santrali	1.230	25.780
Tosyalı Grup	1	Tosyalı Enerji Santrali	1.180	24.820

## 5. Choosing Clean and Safe Energy

Renewable energy is an applicable alternative to the dirty and expensive energy sources like coal. The Energy [R]evolution report, published by Greenpeace and the European Renewable Energy Council (EREC), shows that renewable energy can provide 38% of the global energy demand in 2020 and can meet %95 until 2050<sup>35</sup>. Renewable energies have had an incredible rise in the last 25 years. Wind power is now highly accepted as the most economic new energy plant technology due to the low installation costs, non-existence of fuel expenses and construction periods of less than a year. Renewable energies could contribute a lot to the fight with climate change by decreasing the fossil fuel consumption too. Switching to renewable energies could help to cut %90 of the fossil fuel used in the world for heating and electricity until 2050. Moreover, the percentage of fossil fuel used for transportation can be reduced from %98 to %30, again with the usage of renewable energies.

However, the 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 (and also by phasing the existing ones out).

<sup>35</sup> Teske S. 2012: Energy Revolution: A Sustainable World Energy Outlook. Greenpeace International, Amsterdam, The Netherlands. <http://www.greenpeace.org/international/en/publications/Campaign-reports/Climate-Reports/Energy-Revolution-2012/>

For instance, 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 Czech Republic or Austria<sup>36</sup>.

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<sup>37</sup>, 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<sup>38</sup> and can halve power sector coal use while completely phasing out nuclear<sup>39</sup>. 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.<sup>40</sup>

Despite the fact that Turkey has one of the biggest wind, solar and geothermal power capacity in Europe, the installed wind power capacity in Turkey constitutes only 4% of the installed power. The percentage of solar and geothermal power is 0%. The energy model explained at

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<sup>36</sup> 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](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/>.

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

<sup>38</sup> 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](http://www.netzausbau.de/cln_1931/DE/Bedarfsermittlung/Szenariorahmen%20zum%20NEP%202013/szenarios_nep2013_node.html;jsessionid=D4730BEF253B8049B18C005F79289112).

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

<sup>40</sup> 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](http://www.erneuerbare-energien.de/files/english/pdf/application/pdf/ee_bruttobeschaeftigung_en_bf.pdf)

Energy [R]evolution report, requires sustaining current growth rates of renewable energy sources, investing in 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. Turkish government should foster positive health, economic and environmental impacts by implementing this energy blueprint.

## **6. Demands For Energy Sector**

- Stopping the subsidies given to fossil fuels and nuclear energies,
- Including the external costs (social and environmental costs) to the energy prices through emission limit and trade (cap & trade),
- Making energy efficiency standards obligatory for all energy consuming equipment, buildings and vehicles,
- Transition to the smart grids, improving the transmission and distribution of electricity,
- Providing guarantee for grid connection to unlicensed electricity production,
- Determining legally binding targets for renewable energy and combined heat and electricity production,
- Reformation of the electricity market with a prioritization connection of the renewable energy producers to the grid,
- Providing defined and stabilized returns to the renewable energy investors with programs such as purchase guarantee,
- Labeling in order to provide environmental friendly product information and improving the awareness raising mechanisms,
- Increasing the budgets allocated to R&D studies for renewable energy and energy efficiency.

## **7. Conclusions: What Needs to be Done?**

The coal investments that are currently surviving with the help of the coal lobby will soon start to fall in line with the technological advancements in renewable energies and decrease in fixed purchase guarantees. Besides, the fact that coal can not be used in the near future any more because of the climate change is giving the way to technically and economically fast development of renewable energies. It is accepted by energy actors worldwide that solar is the energy source whose efficiency and usage will increase the most in the coming decade. The important factor of that increase is the possibility of producing more electricity in the areas with the least hours of sunshine than the one currently produced with PV panels as a result of the increase in efficiency of the panels. Solar power is playing a big role in hybrid systems and grid installed capacity planning.

There has been a decline in the last decade at the infrastructure of electricity power and wind turbine costs. It is expected that this falling trend would continue in the coming years and the kw/h unite cost of the electricity produced from wind to be much more lower. Under these circumstances, the wind energy shows up as a serious alternative to the coal power plants.

It is told that renewable energy investments are disadvantageous. However, the global trends show that renewable energy would be more advantageous against coal. Wind power has high credibility over many people in pioneering countries in renewable energies such as Germany and Denmark. Due to the decentralization property of the renewable energy sources, many investors who see the economical advantages of the renewable energies are heading towards them. This tendency is shaping the government policies as well. According to the public opinion pool that Greenpeace has conducted, 84,2 % of the Turkish people think that we should switch to renewable energies to meet our renewable energy demand.

It will be a more successful choice in the middle and long run if the companies that are getting involved with energy business today to choose renewable energies instead of the already outdated coal and fossil fuels. Even the ministries and other institutions accept the fact that coal would not be an alternative during the transition to the low carbon economy. The energy production types from fossil fuels in Turkey, especially from coal has a very limited time left.

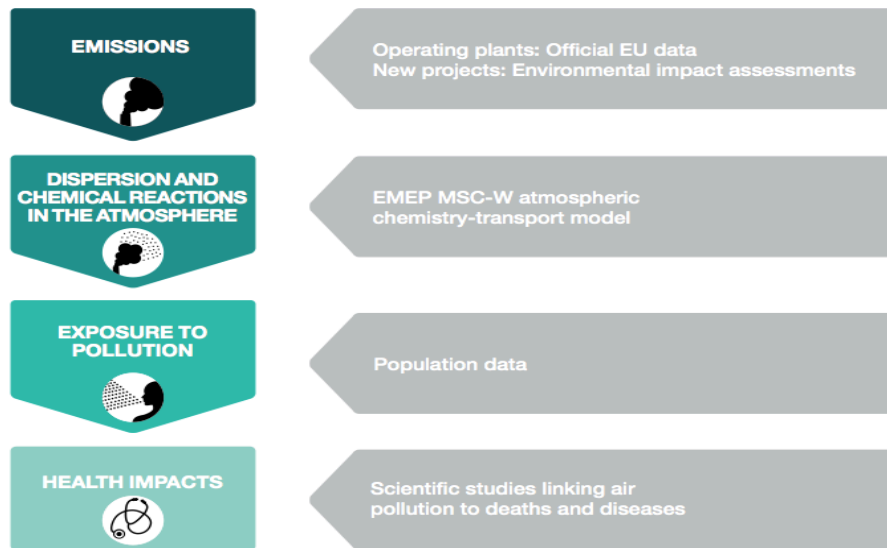
The additional costs that will be added to fossil fuels in the coming decade and the carbon taxes that European Union is applying are some of the important indicators of that transition.

The transition to clean energies not only reinforces us in the fight with climate changes, but also guarantees the strong and healthy society. Turkey deserves a future like that. It is possible to phase out the coal-fired power plants starting from the oldest and the dirtiest ones, when the scale of the renewable energies grows. The decisions given by the governments and energy companies will determine the energy demand in the coming decades. However, the coal-fired power plants are not in line with an energy mix that is designed to prevent the climate change before it is out of control. Therefore, an energy revolution that will decrease the emissions can only become real as a result of the choices of political decision makers would make today.

## Annex: How the Study Was Carried Out

Greenpeace commissioned the modeling for the coal power plant health impact study 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<sup>41</sup> 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.

Figure 2- A simplified flow-chart of the health impact assessment methodology



### *From the Power Plant to the Air: Quantifying Emissions*

The first step in modeling 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<sub>2</sub>), nitrogen oxides (NO<sub>x</sub>) and very fine particulates (PM2.5), as well as toxic metals and CO<sub>2</sub> were included in the study. Since Turkey does not report plant-level emission data, unlike EU member states, other approaches have to be used. For existing Turkish plants, two different

<sup>41</sup> The model is documented in Preiss P & Klotz V 2007: Description of updated and extended draft tools for the detailed site-dependent assessment of external costs. Technical Paper no. 7.4 RS 1b. [http://www.needs-project.org/RS1b/NEEDS\\_Rs1b\\_TP7.4.pdf](http://www.needs-project.org/RS1b/NEEDS_Rs1b_TP7.4.pdf)



approaches are used. Emission concentration values, thermal efficiencies, fuel type and operating hours for individual plants are based on data reported by the Ministry of Environment and Forestry under the Air Quality Twinning Project between German and Turkish authorities<sup>42</sup>. The data was reported for the years 2008 and 2016 (projected). This data was adjusted by power sector coal and lignite consumption reported by Turkey to Eurostat for the year 2010.

However, the emissions calculated using the data above were not consistent with the total emissions from public power generation in 2010 officially submitted by Turkey under the Convention on Long Range Transboundary Air Pollution<sup>43</sup>: estimated SO<sub>2</sub> emissions were 65% lower and NO<sub>x</sub> emissions 50% lower than the reported emissions. Therefore, the plant-level data was used to estimate the share of coal-fired power plants out of the total power sector emissions, and these estimated national total emissions were used as an alternative input to the health impact analysis. The second approach gives a more reliable picture of the total emissions, while the first approach enables the emissions to be broken down by power plant. Data on power plants under construction or in planning was compiled by the Greenpeace Mediterranean office, based on a project listing provided by European Climate Foundation in October 2012. The coordinates of these power plant sites were obtained from the CARMA<sup>44</sup> database 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.

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<sup>42</sup> Ministry of Environment and Forestry (Turkey): EU-Twinning-Project Air-Quality. <http://www.havakalitesi.cevreorman.gov.tr/english/frameset.htm>

<sup>43</sup> EMEP: WebDab. [http://webdab1.umweltbundesamt.at/official\\_country\\_year.html](http://webdab1.umweltbundesamt.at/official_country_year.html). The database website warns that the data submitted by countries can be inconsistent and EMEP emission inventory data should be used instead. The consistency of the Turkish submission with the EMEP gridded data was confirmed.

<sup>44</sup> Carbon Monitoring for Action. <http://carma.org/>

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 based on short-term measurements of emission stack concentrations, or assumed performance of emission control equipment, reported by the Turkish government. The uncertainty in such data is much higher than when emission data based on continuous stack measurements is available. The Turkish government should follow the EU countries in making such data publicly available.

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, 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 modeling 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 modeled 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 modeled 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 1000 tonnes of a pollutant emitted by a power plant, between 200 grams and 5 kilograms of toxic particles are inhaled by Europeans<sup>45</sup>. 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.<sup>46</sup> 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<sup>47</sup>, 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.

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<sup>45</sup> Range calculated as the 5<sup>th</sup> and 95<sup>th</sup> percentiles from EMEP Source-Receptor matrices assuming a 20 m<sup>3</sup>/d breathing rate. EMEP 2012: EMEP/MSW modelled Source-Receptor Relationships.

[http://www.emep.int/mscw/sr\\_main.html](http://www.emep.int/mscw/sr_main.html)

<sup>46</sup> EMEP 2012: EMEP/MSW model performance for acidifying and eutrophying components and photo-oxidants in 2010. Supplementary material to EMEP Status Report 1/2012.

[http://www.emep.int/mscw/mscw\\_publications.html](http://www.emep.int/mscw/mscw_publications.html)

<sup>47</sup> EMEP 2012 [op](#) cit.

## ***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<sup>48</sup> and adapted e.g. 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 U.S. 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.<sup>49</sup> 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 U.S. National Health Interview Survey<sup>50</sup>, 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<sup>51</sup>.

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

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<sup>48</sup> 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](http://www.needs-project.org/RS1b/NEEDS_Rs1b_D3.7.pdf)

<sup>49</sup> Pope et al 2002: Lung cancer, cardiopulmonary mortality, and long-term exposure to fine particulate air pollution. The Journal of the American Medical Association. <http://www.ncbi.nlm.nih.gov/pubmed/11879110>

<sup>50</sup> Centers for Disease Control and Prevention, US. National Health Interview Survey.

<http://www.cdc.gov/nchs/nhis.htm>

<sup>51</sup> Torfs et al op. cit.

asthma symptoms is taken from a World Health Organization analysis<sup>52</sup> using data from several studies, mainly from Europe.

The number of people hospitalized due to an increase in air pollution levels was estimated in a 2005 study<sup>53</sup> covering seven European cities plus the country of the Netherlands. The data showed that increases in air pollution levels caused more people to be hospitalized 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.<sup>54</sup> Greenpeace 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 9 months of life. The risk factors estimated from large statistical studies include uncertainty ranges. The 95% confidence interval for deaths is 127 to 1194 years of life lost per 100,000 people for each 10 µg/m<sup>3</sup> 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; 79,000, has a 95% confidence interval of 1,450 to 13,600. Similarly, the estimate of lost working days, 1.695 million, has a 95% confidence interval of 1.442 to 1.704 million.<sup>55</sup>

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<sup>52</sup> Anderson et al 2004: Meta-analysis of time-series studies of Particulate Matter (PM) and Ozone (O<sub>3</sub>). World Health Organization Regional Office for Europe. [http://www.euro.who.int/\\_data/assets/pdf\\_file/0004/74731/e82792.pdf](http://www.euro.who.int/_data/assets/pdf_file/0004/74731/e82792.pdf)

<sup>53</sup> APHEIS 2005: Air Pollution and Health: A European Information System. Health Impact Assessment of Air Pollution and Communication Strategy. Third-year Report. <http://www.apheis.org/vfbisnvsApheis.pdf>

<sup>54</sup> Hurley et al 2005: Methodology for the Cost-Benefit analysis for CAFE: Volume 2: Health Impact Assessment. AEA Technology Environment. [http://www.cafe-cba.org/assets/volume\\_2\\_methodology\\_overview\\_02-05.pdf](http://www.cafe-cba.org/assets/volume_2_methodology_overview_02-05.pdf)

<sup>55</sup> Torfs et al 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 µg/m<sup>3</sup> increase in PM2.5 concentrations.