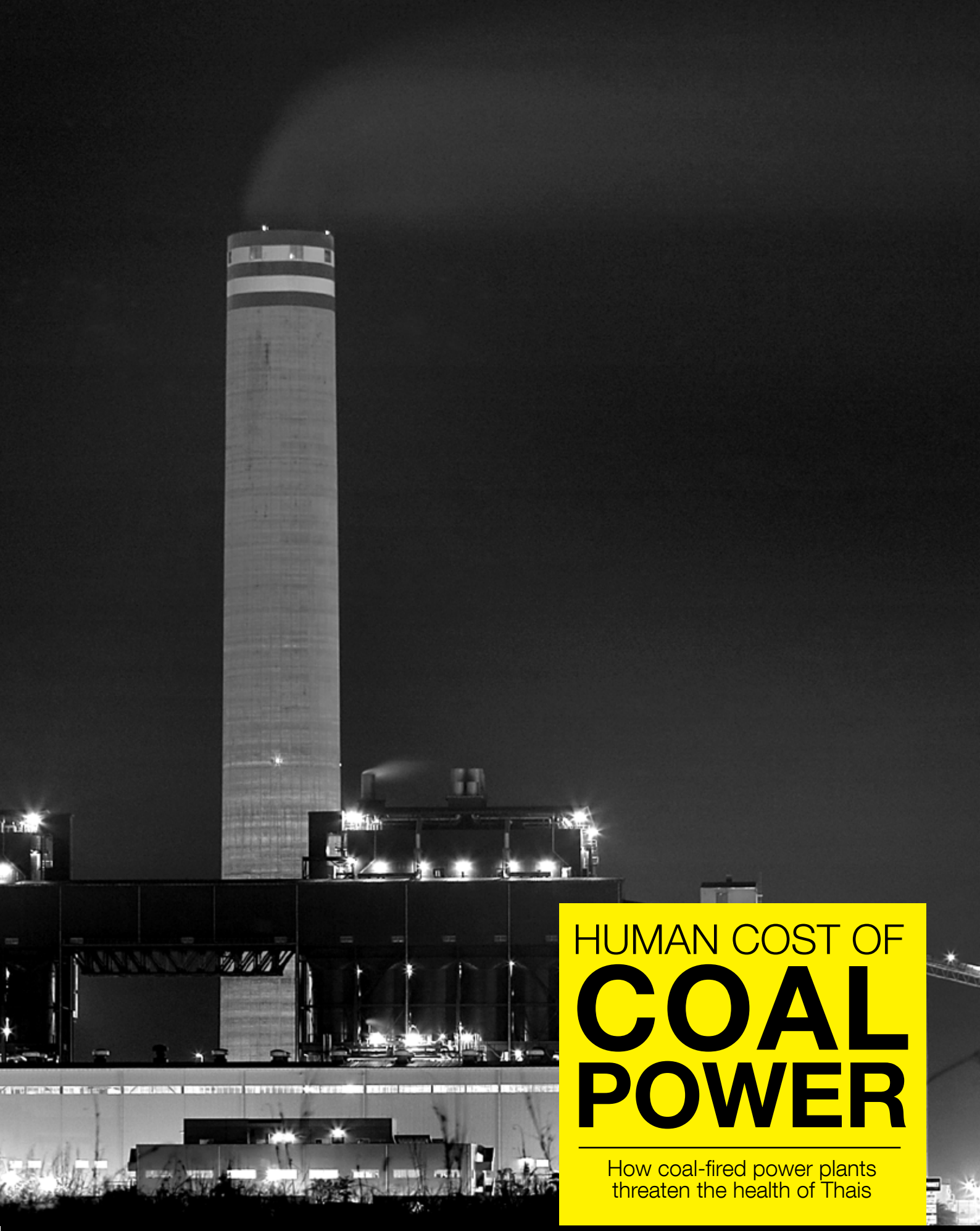


HUMAN COST OF COAL POWER

How coal-fired power plants threaten the health of Thais

November 2015

GREENPEACE

TABLE OF CONTENTS

EXECUTIVE SUMMARY

As the world prepares to negotiate a global deal at the Conference of the Parties in Paris this December, Thailand finds itself at a crossroad. Will the nation begin the transition away from damaging fossil fuelled energy – fossil fuel that is leading to the premature deaths of thousands of Thai every year – or will it maintain a business-as-usual approach to energy and consolidate the deadly impact of the coal industry in Thailand?

It has been known for many years that air pollution is responsible for the deaths of millions globally, however in recent months countries across South-East Asia have been able to quantify the real impact of coal on populations from Indonesia to Vietnam.

This report continues that work and reveals the true cost of coal-fired power being paid by the Thai people. A cost that is paid in thousands of lives lost prematurely, in a devastated environment, a climate destabilised, tourism and small businesses compromised and national energy security undermined. The price paid for coal-fired power in Thailand is already too high.

Tragically the Thai government has more coal-fired power stations planned in communities across the country. This report makes it clear there is a choice to be made. It concludes with a series of recommendations designed to facilitate Thailand's coming of age in clean, accessible renewable energy and real energy security.

Based on the results of research carried out at Harvard University, the report expands the work that initially focused on the health impact of coal-fired power in Indonesia and now reveals the health impacts of coal-fired power plants in Thailand. Emissions from coal-fired power plants expose millions of people to toxic particulate and ozone pollution, increasing the risk of diseases such as stroke, heart attack and lung cancer, which are among the leading causes of death in Thailand. It is estimated that in 2011, air pollution emissions from Thailand's coal-fired power plants were responsible for 1,550 premature deaths (95% confidence interval 800-2,300 deaths). If the coal-fired power plants under construction and proposed are taken into, the health impacts could increase to 5,300 deaths per year.

This report also includes two case studies carried out specifically for this report: They are the proposed coal-fire power station in Krabi, as well as BLCP and Gheco in Maptaphut Industrial Zone.

These additional case studies provide a detailed analysis of the air quality and health impacts of these individual power plants, which was outside the scope of the initial Harvard project.

Air pollution is responsible for over three million premature deaths globally every year. This pollution leads to an increased risk of lung cancer, stroke, heart diseases, and respiratory diseases. Coal burning is one of the biggest contributors to this pollution.

The case studies in this report have found emissions from the two coal-fired power stations, BLCP and Gheco, bring premature death to approximately 360 people per year - over 14,000 people in total, assuming a forty-year operating life. While the emissions from the proposed coal-fire power station in Krabi are projected to cause approximately 1,800 premature deaths over an operating life of forty years.
With the political changes and turmoil affecting the country, the report challenges Thailand's government by asking what energy future will the government promote? The evidence is in, coal-fired power is bad for the nation's health, environment, energy security and international standing, it is time to make the switch to safe, clean, reliable and Thai-based renewable energy options. But will the country go green, or stay on the dirty old path of fossil fuels?

1 INTRODUCTION
CURRENT STATE OF PLAY

Thailand has struggled to successfully implement a national plan for power generation that satisfies the nation's objectives for the power sector:

- Energy security: procuring sufficient energy supply to meet demand
- Energy reliance: reduced dependency on imports
- Promotion of renewable energy: increasing renewable energy share
- Efficient use of energy: reducing energy intensity
- Diversifying fuel risks
- Reducing CO2 emissions
- Minimizing impacts from energy procurement
- Fair and reasonable costs of energy service to consumers

As this report underscores, continuing to prioritise coal-fired power and planning an expansion of coal-fired power stations, is at odds with both Thai energy policy and the interests of the vast majority of Thai people. The well-documented casualties are predominantly the rural poor. Afflictions include acute respiratory disease in thousands of villagers from operations of coal mining and power plants detailed below, a number of violent conflicts associated with power plants (Polkla, 2010) and higher prices because of excessive investment (Sirasoontorn, 2008).

As the government prepares to build even more coal-fired power stations the global market is now considered to be in structural decline with the US[1] and China[2] both recording real declines in coal consumption as the world market continues to be massively over-supplied. At the same time world leaders are preparing to meet for the Conference of the Parties (COP) in Paris in December to negotiate a new deal on curbing carbon emissions.

That deal will focus on the need to share an already small global carbon budget because policy makers have agreed the world needs to limit global temperature increase to less than 2 °C.[3] The bad news for the coal industry is that means a third of oil reserves, half of gas reserves and over 80 per cent of current coal reserves should remain unused from 2010 to 2050 in order to meet the target of 2 °C. As Nature points out:

Implementation of this policy commitment would also render unnecessary continued substantial expenditure on fossil fuel exploration, because any new discoveries could not lead to increased aggregate production.

As the international coal industry continues to decline, its impact on global warming, community health, the environment and other industries have led to a loss of social license across the developed world. International Financial Institutions (IFIs), like the World Bank, US Export Import Bank, and the European Bank for Reconstruction and Development, have stopped investing in coal-fired plants, as has Norway's sovereign wealth fund. Divestment movements against coal are proliferating around the globe as Coalswarm reported; "that two-thirds of coal-fired power plants proposed worldwide since 2010 have been stalled or

1 The US Coal Crash – Evidence for Structural Change http://www.carbontracker.org/report/the-us-coal-crash/
2 Institute for Energy Economics and Financial Analysis. http://ieefa.org/in-chinas-turmoil-further-declines-for-coal/
3 http://www.nature.com/nature/journal/v517/n7533/full/nature14016.html

cancelled. The growth rate in coal-fired generating capacity is slowing, down from 6.9% in 2010 to 2.7% in 2013." [4] This trend will make raising capital for new coal power capacity increasingly difficult and unlikely. Furthermore the burden of disease now associated with burning coal will see its social license further undermined in Thailand particularly as renewable energy options become cheaper

4 Coal mining: In the depths. The Economist. 2015.

2 METHODOLOGY

The steps followed to estimate the health impacts of coal-fired power plants are:

1) Compile a list of all coal-fired power plants in operation, under construction, in permitting and in planning, including their location, capacity and other technical details.
2) Estimate emissions of air pollutants from coal-fired power plants based on emission standards, installed emission control equipment and amount of coal burned.
3) Use a state-of-the-art air pollution chemistry-transport model (GEOS-Chem) to estimate current pollution levels. The model has data on emissions from all the different sectors and locations, and it first uses this data to generate "baseline" pollution levels, which can be compared to measurements to validate the model.
4) Use the atmospheric model and estimate the share of total pollution on the ground level in different location caused by the power plants:
   a) For existing plants, the model is run with the emissions from the operating power plants removed, to see how much air quality improves in different locations if the power plant emissions are eliminated. This gives the estimate of the share of current pollution levels that is connected to the power plant emissions.
   b) For new power plants that are not yet in operation, another model run is performed with the projected emissions from the new power plants added to the model. This gives an estimate of how much the new power plants would increase the pollution levels.
5) Use high-resolution population data, together with the modeling results, to assess the population exposure to pollution caused by the power plant emissions.
6) Use Global Burden of Disease data for Thailand and other Southeast Asian countries on the current risk of diseases that are connected to air pollution, and results of scientific studies showing how much the risk of those diseases increases with higher pollution levels, to establish the total health impacts of the modeled power plants.

In addition to estimating the total health impacts of all coal-fired power plants in Thailand, two case studies were carried out for this report:

- The operating coal-fired power plants BLCP and Gheco One coal-fired power plants in Rayong
- The proposed Krabi coal-fired power plant project

These additional case studies provide a detailed analysis of the air quality and health impacts of these individual power plants, which is outside the scope of the Harvard project. The impacts were modeled over a 1500 km x 1500 km domain covering Thailand as well as Cambodia and the southern parts of Vietnam, Laos and Myanmar. There are approximately 150 million people living within this domain.

The case studies follow the methodology of the Harvard study for emission estimates and health impact assessment, while using the CALPUFF modeling system for pollutant dispersion modeling in order to obtain a more detailed picture of the local and regional impacts of these power plants.

3 A SUSTAINABLE ENERGY FUTURE CANNOT BE BUILT ON COAL

Today, about 40% of the electricity generated[5] worldwide is from coal-fired power plants, damaging our planet and jeopardizing our children's future. Coal generates pollutants during its entire life cycle, from mining, to transport, to processing, and finally to combustion for electricity generation.

Airborne pollutants from coal-fired power plants can be transported by wind, spreading over hundreds of kilometers and affecting human health and the environment. In recent years, there has been a growing recognition in scientific and medical communities of the severe health risks of fine particles (PM2.5) in these air emissions. Coal-fired power plants emit a large quantity of pollutants like NOx and SO_2, the main ingredients in the formation of acid rain and a major ingredient of PM2.5 pollution. Coal plants also emit soot and dust contributing to PM2.5, as well as harmful chemicals like mercury and arsenic.

Coal related air pollution causes deaths and hospitalizations.[6] In 2011, the World Health Organization (WHO) compiled air quality data from 1,100 cities in 91 countries and found that residents living in many urban areas were exposed to persistently elevated levels of fine particle pollution and that coal-fired power plants were one of the main causes.[7]

According to the International Energy Agency (IEA), although coal represented 29% of the world's total primary energy supply in 2012, it accounted for 44% of global CO2 emissions.[8] Coal burning is the largest source of the planet's GHG emissions, which are triggering climate change. In 2009, James Hanson, then the head of the NASA Goddard Institute for Space Studies, contributed an article about CO2 emissions and environmental problems caused by coal to The Guardian, a British daily newspaper. In his article, "Coal-fired power stations are death factories. Close them," Mr. Hanson stressed that coal is the single greatest threat to civilization and all life on our planet.[9]

Coal-fired power stations are losing ground worldwide as the reality of growing energy efficiency, evidence of the true costs of pollution, more affordable and reliable renewable resources, and a rising tide of community resistance across the world voice their concerns against expansion of the coal industry. For example, the United States now has over 200 coal plants retired or scheduled to be retired. In the same period that 23% (78 gigawatts) of coal-fired energy has been coming offline, the U.S. added 46 gigawatts of renewable energy from wind, solar, and geothermal technology.[10] Financial markets confirm the decline of coal. The Dow Jones Total Coal Market index has fallen by 76% in the past five years. High-cost deep mines in the rich world have been hit the hardest. Nor is the US alone in the movement away from coal.

Recent media reports[11] have found levels of PM2.5, reached 1,157 micrograms per cubic meter in Liaoning province's Shenyang on the 8th of November 2015. Exposure to PM2.5 increases the risk of cardiovascular, cerebrovascular, and respiratory diseases, as well as cancers, all of which raises the mortality rate. All data from China indicates a drastic energy policy change to reduce reliance on coal power generation, incentivized

5 International Energy Agency (IEA). 2014. Key World Energy Statistics 2014. http://www.iea.org/publications/freepublications/publication/key-world-energy-statistics-2014.html
6 University of Illinois at Chicago School of Public Health. 2013. Scientific Evidence of Health Effects from Coal Use in Energy Generation. April 2013.. http://noharm.org/lib/downloads/climate/Coal_Literature_Review_2.pdf
7 World Health Organization (WHO). 2011. Tackling the Global Clean Air Challenge. 26 September 2011. http://www.who.int/phe/eNews_37.pdf.
8 IEA. 2014. CO2 Emissions From Fuel Combustion Highlights 2014. http://www.iea.org/publications/freepublications/publication/co2-emissions-from-fuel-combustion-highlights-2014.html.
9 Hansen, J. 2009. Coal-fired power stations are death factories. Close them. The Guardian, 15thFebruary ,2009. http://www.theguardian.com/commentisfree/2009/feb/15/james-hansen-power-plants-coal
10 Brune, M. Winning Numbers. Coming Clean: The Blog of the Executive Director-Sierra Club. 8th, April 2015. http://sierraclub.org/michael-brune/2015/04/beyond-coal-climate-clean-energy. U.S. Energy Information Administration (EIA) data shows that 145 plants (15GW) out of 1,308 coal plants (310GW, as of 2012) in the U.S. were closed between 2010 and 2012. In addition, over 100 units or a total of 60 GW will be retired by 2020. U.S. Energy Information Administration (EIA). 2014. AEO2014 projects more coal-fired power plant retirements by 2016 than have been scheduled. http://www.eia.gov/todayinenergy/detail.cfm?id=15031. For more information on the growth of RE, see Boren, Z. 2014. Renewables cutting US emissions more than gas as coal consumption drops. Energy Desk: Greenpeace, 20th October, 2014. http://energydesk.greenpeace.org/2014/10/20/renewables-cutting-us-emissions-gas-coal-consumption-drops/.
11 http://www.abc.net.au/news/2015-11-09/china-smog-almost-50-times-who-recommendations/6925682

by air pollution concerns and structural economic change. According to the International Energy Agency, Chinese thermal power generation in the first quarter of 2015 was down 3.7%, hydropower generation was up 17%, and wind and solar power generation were up over 20%. Meanwhile, coal imports saw a dramatic 40% drop during the same period. A key element behind the reduction in China's use of coal for power generation is fundamental recognition of the massive air pollution emissions from burning coal, which is the main cause of the country's crisis-level air pollution. China has required many of the biggest coal-consuming provinces to reduce total coal usage and to close down polluting factories and power plants.

In Europe, more than a hundred coal-fired power plant units are expected to close over the next decade, pushed out of the market by rapid expansion in renewable energy and new standards for controlling air pollution.[12] Since the year 2000, the capacity of European coal-fired power plants has fallen by 25 gigawatts, while wind and solar power have increased by 120 and 90 gigawatts respectively Essentially, all new power generation capacity in Europe comes from renewable energy and gas.[13]

Given the existing momentum to tackle coal as a contributor to the global crisis of climate change, International Financial Institutions (IFIs) like the World Bank, US Export Import Bank, and the European Bank for Reconstruction and Development, have stopped investing in coal-fired plants. This year, in an unprecedented vote the Norwegian Government unanimously agreed to divest its $890 billion USD government pension fund, considered to be the largest sovereign wealth fund in the world, from coal companies. The divestment movement continues to gather steam, which may be contributing to Coalswarm report showing "that two-thirds of coal-fired power plants proposed worldwide since 2010 have been stalled or cancelled. The growth rate in coal-fired generating capacity is slowing, down from 6.9% in 2010 to 2.7% in 2013."[11] As such, raising capital for new coal projects will be increasingly difficult and unlikely.

12 Economist Intelligence Unit 2014: Coal's last gasp in Europe. http://www.eiu.com/industry/article/741997658/coals-last-gasp-in-europe/2014-07-09
13 The European Wind and Energy Association (EWEA). 2013. Wind in Power. http://www.ewea.org/fileadmin/files/library/publications/statistics/EWEA_Annual_Statistics_2013.pdf.

4 HEALTH IMPACTS OF COAL-FIRED POWER PLANTS

Emissions from coal-fired power plants expose millions of people to toxic particulate and ozone pollution, increasing the risk of diseases such as stroke, heart attack and lung cancer, which are among the leading causes of death in Thailand. It is estimated that in 2011, air pollution emissions from Thailand's coal-fired power plants were responsible for 1,550 premature deaths (95% confidence interval 800-2,300 deaths). If the under construction and planned power plants are taken into operation, the health impacts could increase to 5,300 deaths per year.

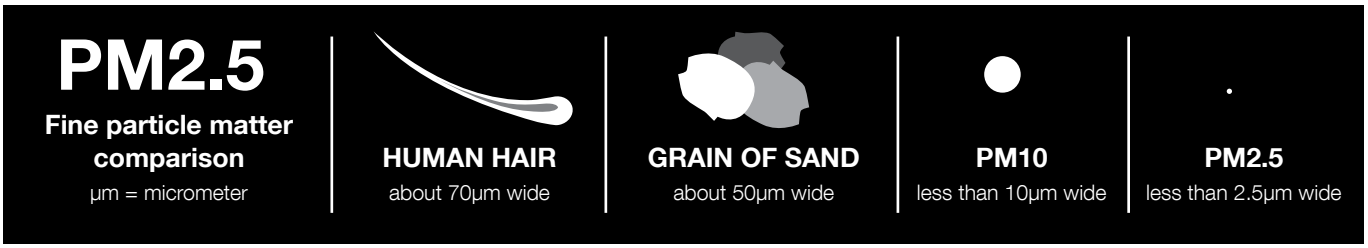
The case studies in this report have found emissions from the two coal-fired power stations, BLCP and Gheco, bring premature death to approximately 360 people per year - over 14,000 people in total, assuming a forty-year operating life. While the emissions from the proposed coal-fire power station in Krabi are projected to cause approximately 1,800 premature deaths over an operating life of forty years.

Estimated premature deaths caused by Thailand's coal-fired power plants in 2011

		Within Thailand	Total
PM2.5 exposure to adults	Stroke	190	260
	Ischemic Heart Disease	540	620
	Lung Cancer	70	80
	Other cardiovascular diseases	90	120
	Respiratory diseases	160	200
PM2.5 exposure to children	Lower Respiratory Infections	0	10
Ozone exposure to adults	Respiratory diseases	90	260
Total	Central	1150	1550
	Low	650	830
	High	1670	2300

Projected additional premature deaths caused every year by new projects, if realized

		Within Thailand	Total
PM2.5 exposure to adults	Stroke	320	610
	Ischemic Heart Disease	1010	1540
	Lung Cancer	160	240
	Other cardiovascular diseases	130	290
	Respiratory diseases	290	550
PM2.5 exposure to children	Lower Respiratory Infections	0	30
Ozone exposure to adults	Respiratory diseases	20	540
Total	Central	2040	3790
	Low	1160	2060
	High	2960	5600



What is PM2.5?

The term "PM" stands for "particulate matter," which is characterized according to size and expressed in terms of micrometers (µm) or one-millionth of a meter. Particulate matter that is 10µm or less in diameter - PM10 - is defined as 'respirable' particles, as it can enter into the lungs, and particulate matter that is 2.5µm or less in diameter is defined as a fine particle - PM2.5. The latter, which is smaller than one twenty-fifth of the diameter of a human hair, penetrates the respiratory system, directly reaching the alveoli and entering the bloodstream, causing a wide range of physiological and biological harm and increasing the risk of chronic diseases.

Fine particles or PM can be classified as either "primary particles," which are directly released into the air, or "secondary particles," which are formed through the atmospheric chemical reactions of other pollutants initially released as gases. The former consists of organic carbon, elemental carbon, minerals, and ash (containing heavy metals.) The latter can be divided into organic and inorganic particles. The secondary organic particles are formed from the oxidation reaction of organic compounds with OH, O_3 or NO_3 and the secondary inorganic particles are formed through the reaction of atmospheric ammonia, NOx, or sulfur dioxide to form sulfate, nitrate, or ammonium.

Among others, PM2.5 is a long-range transboundary pollutant, which stays a long time in the atmosphere and causes high concentration levels of air pollution. It is likely that the chemical composition of PM influences health impacts, but the current understanding is that all PM2.5 is dangerous regardless of chemical composition, and there is little consistent evidence of how the health impacts of different types of PM2.5 differ. Exposure to PM2.5 causes serious short-term and long-term health effects.

Fine particles or PM2.5 generated by human activities, such as burning of fossil fuels in power plants and vehicles are the dominant source of the PM2.5 in the atmosphere.[14] The secondary formation of PM2.5 cannot be ignored. PM2.5 is formed through the chemical reactions of airborne pollutants, including NOx, SOx, VOC and NH_3.

PM2.5 is extremely damaging because it is so small and can penetrate deep into the lungs and the bloodstream. That's why it is more harmful to the human body than larger particles.[15] Exposure to PM2.5 increases the risk of cardiovascular, cerebrovascular, and respiratory diseases as well as cancers, all of which raises the mortality rate.[16]

The most comprehensive evidence of the health risks from PM2.5 pollution comes from a American Cancer Society study that followed half a million U.S. adults for 20 years, and found that people living in more polluted cities had a significantly higher risk of dying from cardiovascular and respiratory diseases as well as from lung cancer. For example, a 10µg/m3 increase in the average PM2.5 pollution level increased the risk of lung cancer by 14% and overall risk of death by 4-8%.[17] Another study found that the same increase in the PM2.5 level also increases children's risk of death from acute respiratory infections by 12%.[18] The Global Burden of Disease Study found that PM2.5 caused 3.2 million premature deaths around the world

14 Anenberg, S., Horowitz L., Tong, D., West, J. 2010. An estimate of the global burden of anthropogenic ozone and fine particulate matter on premature human mortality using atmospheric modeling. Environ. Health Percept. 118: 1189-95..http://www.ncbi.nlm.nih.gov/pubmed/20382579.
15 Greenpeace. 2012. Dangerous Breathing-PM2.5: Measuring the human health and economic impacts on China's largest cities. 18th December 2012. http://www.greenpeace.org/eastasia/Global/eastasia/publications/reports/climate-energy/2012/Briefing%20Dangerous%20Breathing%20-%20Greenpeace.pdf.
16 Greenpeace. 2012. Dangerous Breathing.
17 Krewski, D. et al. 2009. Extended Follow-Up and Spatial Analysis of the American Cancer Society Study Linking Particulate Air Pollution and Mortality. Research Report Health Effects Institute140: 5-114. http://www.ncbi.nlm.nih.gov/pubmed/19627030.
18 Mehta, S., Hwashin, S., Burnett, R., North, T., Cohen, A. 2011. Ambient particulate air pollution and acute lower respiratory infections: a systematic review and implications for estimating the global burden of disease. Air Quality, Atmosphere & Health6(1): 69–83. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3578732/.
19 Murray, C. et al. 2010. Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. The Lancet380 (9859): 2197-2223. http://www.thelancet.com/pdfs/journals/lancet/PIIS0140-6736(12)61689-4.pdf.

in 2010. Then, the WHO officially designated PM2.5 as a Group 1 carcinogen in 2013 and declared that it is a leading environmental cause of cancer deaths.[20]

Unfortunately coal power plants emit more than just fine particles (PM2.5). The ozone is affected because NOx emissions contribute to O3 formation. PM2.5 emitted from coal-fired power plants contains toxic heavy metals and penetrates deep into our lungs and into the bloodstream, increasing the risk of death and various diseases. Coal-fired power plants produce Sulphur Dioxide (SO2), Nitrous Oxides (NO2), particulate matters (PM2.5 & PM10), mercury, lead (Pb), Arsenic (As), Chromium (Cr) and Cadmium (Cd). These pollutants cause diseases presented in the following table.[21]

Coal burning also releases harmful chemicals like mercury and arsenic. Air pollutants emitted from coal plants can be transported by the wind, spreading over hundreds of kilometers. This pollution increases the risk of serious illnesses like lung cancer, stroke, heart disease, chronic respiratory ailments and acute respiratory infection. Infants, pregnant women, and the elderly are most vulnerable to the acute effects of air pollution.[22] Air pollution is the largest environmental health risk humans face and the leading environmental cause of cancer deaths.

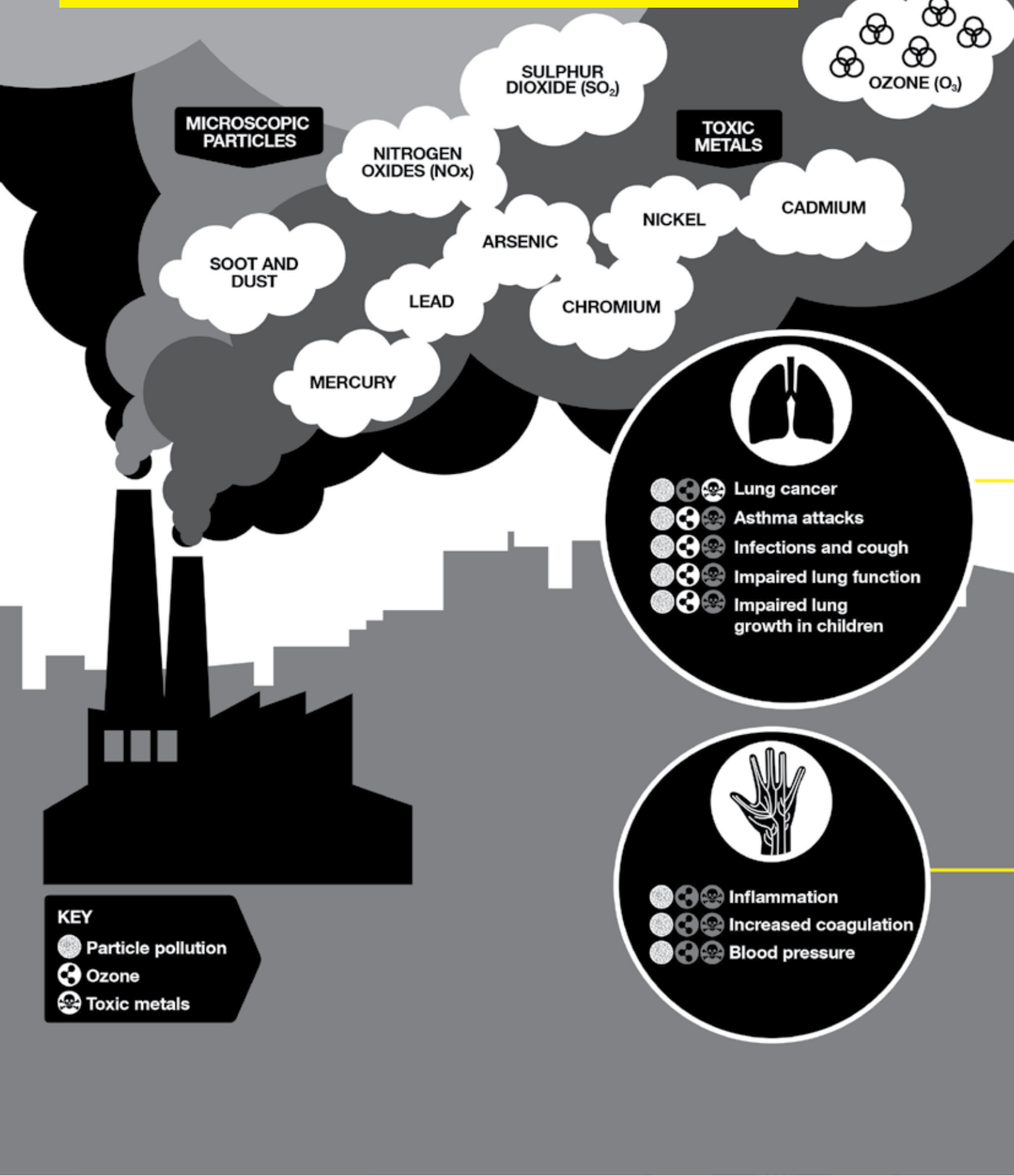
Coal burning accounted for an estimated 70% of Thailand's energy-related SO2 and PM10 emissions, and 25% of NOx emissions in 2008.[23] Emissions from coal are likely to have grown as coal use has increased by 20% from 2008 to 2014.[24]

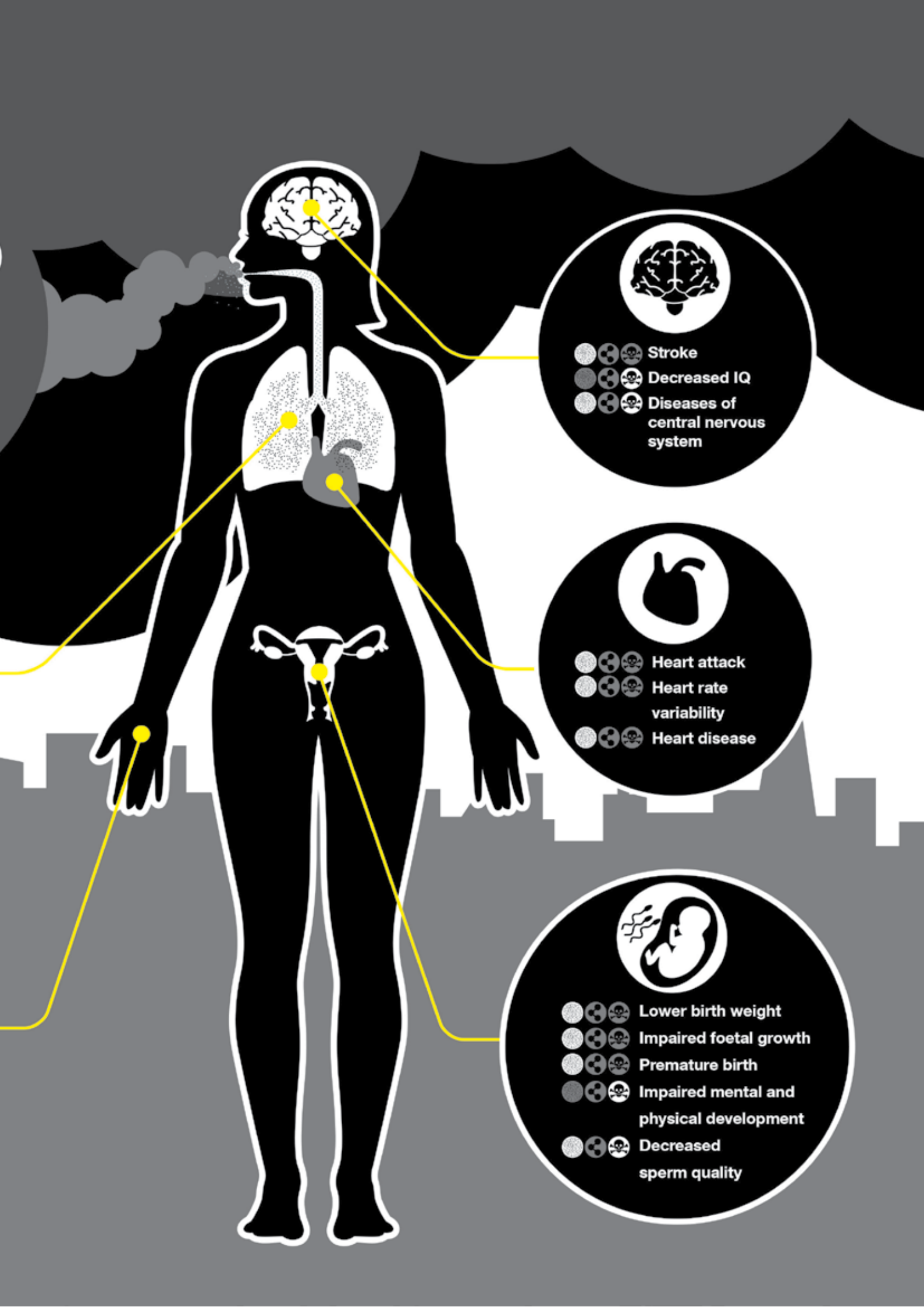
POLLUTANT	RELATED HEALTH RISKS
Carbon dioxide (CO_2)	Indirect health impacts from climate change
High Volume Hazardous Air Pollutants	
Sulphur dioxide (SO_2)	Affects respiratory system and lung functions; aggravates asthma and chronic bronchitis; irritation of eyes; cardiac disease; ischemic stroke.
Nitrous oxides (NO_2)	Asthma development and exacerbation; chronic obstructive pulmonary disease; stunted lung development; cardiac arrhythmias; ischemic stroke. Reacts with VOCs in sunlight to form ground-level ozone (O_2).
Particular matter; PM10, PM2.5	Respiratory: asthma development and exacerbationl chronic obstructive pulmonary disease; lung cancer. Cardiovascular: Cardiac arrhythmias; acute myocardial infarction; congestive heart failure. Nervous system: ischemic stroke.
Ammonia (NH_2)	Respiratory irritation; skin and eye burns; precursor of secondary particulates.
Hydrogen Chloride and Fluoride (HCl, HF)	Acute irritation to skin, eyes, nose, throat, and breathing passages.
Organic Pollutan	
Dioxins and furans	Probable carcinogen: affects reproductive, endocrine and immune systems. Dioxins accumulate in the food chain.
Polycyclic Aromatic Hydrocarbons (PAHs)	Probable carcinogen: may have adverse effects on the liver, kidney, and testes; may damage sperm cells and impair reproduction.
Non-Methane Volatile Organic Compounds (VOCs)	
Aromatic hydrocarbons	Irritation of the skin, eyes, nose, and throat; difficulty breathing; impaired function of the lungs; delayed response to visual stimulus; impaired memory; stomach discomfort; effects to the liver and kidneys; may cause adverse effects on the nervous systems. Benzene is a strong carcinogen.
Aldehydes including formaldehyde	Probable carcinogen: irritation of eyes, nose, and throat; respiratory symptoms.
Heavy Metal	
Mercury, in food as Methylmercury	Damage to brain, nervous systems, kidneys, and liver.
Lead (Pb)	Damages the nervous systems of children; may have adverse effects on learning, memory, and behavior; may damage kidneys; causes cardiovascular disease and anemia.
Antimony (Sb), Arsenic (As), Beryllium (Be), Cadmium (Cd), Chromium (Cr), Nickel (Ni), Selemium (Se), Manganese (Mn)	Carcinogens (lung, bladder, kidney, and skin cancers); may have adverse effects on nervous, cardiovascular dermal, respiratory, and immune systems. Agency for Research on Cancer classifies arsenic and its compounds as Group1 carcinogens.
Radioisotopes	
Radium (Ra)	Carcinogen (lung and bone cancers); bronchopneumonia; anemia; brain abscess
Uranium (Ur)	Carcinogen (lung and lymphatic systems); kidney disease

20 Murray, C. et al. 2010. Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. The Lancet380 (9859): 2197-2223. http://www.thelancet.com/pdfs/journals/lancet/PIIS0140-6736(12)61689-4.pdf.
21 HEAL 2013.
22 University of Illinois at Chicago School of Public Health. 2013. Scientific Evidence of Health Effects from Coal Use in Energy Generation.
23 Kurokawa, J., Ohara, T., Morikawa, T., Hanayama, S., Janssens-Maenhout, G., Fukui, T., Kawashima, K., and Akimoto, H.: Emissions of air pollutants and greenhouse gases over Asian regions during 2000–2008: Regional Emission inventory in ASia (REAS) version 2, Atmos. Chem. Phys., 13, 11019-11058, doi:10.5194/acp-13-11019-2013, 2013.
24 BP Statistical Review of World's Energy 2015.

AIR POLLUTANTS FROM COAL POWER PLANTS AND THEIR HEALTH RISK

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**




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

5 CLIMATE CHANGE IMPACTS OF COAL-FIRED POWER PLANTS


©greenpeace / Luke Duggleby

To avoid the worst impacts of climate change, including widespread drought, flooding and massive population displacement caused by rising sea levels, global temperatures must not rise above 2ºC (compared to pre-industrial levels). To do this, global greenhouse gas emissions must peak by 2015 and from there go down to zero. A third of all carbon dioxide emissions come from burning coal.

In its Fifth Assessment Report in 2013, the Intergovernmental Panel on Climate Change (IPCC) stressed that in order to avoid severe and disastrous climate change, the global temperature should not go 2ºC above pre-industrial levels, and 40-70% of GHG emissions should be cut by 2050. Coal is the single largest source of GHG emissions, responsible for 44% of global CO_2 emissions in 2011. Coal burning is the world's biggest contributor to CO_2 emissions.[25]

The CO2 produced from a coal plant with the most efficient technology available today is still more than twice that of a natural gas plant and 15 times higher than that of a renewable power plant.[26]

Commercial operation of the 1,600 planned coal-fired power plant units around the world would lead to significant growth in carbon emissions, exacerbating climate change.[27] The growth in CO2 emissions would follow a trajectory consistent with average global temperature rise of 5 to 6ºC by 2100.[28] Professor Kevin Anderson, a renowned climate scientist, once said, "a 4ºC future is incompatible with an organized global community, is likely to be beyond 'adaptation', is devastating to the majority of ecosystems and has a high probability of not being stable." [29]

Coal burning was responsible for 21% of Thailand's energy-related CO_2 emissions in 2014.[30]

25 IEA. CO2 Emissions From Fuel Combustion Highlights. 2014. ,
26 European Climate. New unabated coal is not compatible with keeping global warming below 2 °C- Statement by leading climate and energy scientists. http://www.europeanclimate.org/documents/nocoal2c.pdf.
27 CoalSwarm and Sierra Club 2015: Boom and Bust. Tracking the Global Coal Plant Pipeline. http://action.sierraclub.org/site/DocServer/Coal_Tracker_report_final_3-9-15.pdf?docID=17381
28 This refers to the emission trajectory of the Current Policies Scenario in IEA: World Energy Outlook 2012. The CO2 emissions from new coal-fired power plant projects would significantly overshoot the increase in power sector CO2 emissions in the Current Policies Scenario, which the IEA estimates to be consistent with 5-6 degree global warming.
29 Roberts, D. The Brutal logic of climate change. The Grist, 6th December 2011. http://grist.org/climate-change/2011-12-05-the-brutal-logic-of-climate-change/. (Quoting Professor Kevin Anderson of the Tyndal Institute).
30 Calculated from British Petroleum (BP). 2015. Statistical Review of World's Energy 2015. http://www.bp.com/en/global/corporate/about-bp/energy-economics/statistical-review-of-world-energy.html.

6 ENVIRONMENTAL IMPACTS OF COAL-FIRED POWER PLANTS

Coal-fired power not only endangers lives through its toxic emissions and impacts on our global climate, it produces pollutants during its entire life cycle that affect water resources and fouls waterways. It is one of the most water-intensive methods of generating electricity as it consumes and pollutes a huge amount of water during extraction, processing, and combustion at power plants. Coalmines deplete groundwater and pollute rivers and lakes. Coal washing turns large amounts of freshwater into toxic wastewater. Coal power plants consume vast amounts of water for cooling and pollution controls and their coal ash ponds can contaminate surrounding water bodies.

In general, the water consumption of a 1,000MW coal plant is equivalent to the amount of water consumed by a half million people for one year.[31] The IEA found that global water consumption for power generation is expected to more than double, from 66 billion cubic meters (bcm) in 2010 to 135 bcm, by 2035, and that coal would account for 50% of this growth.[32]

Coal-fired power plants that use seawater for cooling (as opposed to freshwater) still create major problems. The plants create thermal pollution that can kill or damage fragile marine ecosystems, especially in warm tropical waters. The plants suck in vast quantities of water for cooling and become giant fish blenders, killing aquatic life that is sucked up against the intake pipes filters.

The toxic chemicals in coal power plant exhausts, also affect rivers and lakes. Research found that fish caught in a rural area downwind from a coal-fired power plant had 19 times more mercury than store-bought fish.[33] Mercury is a neurotoxin, a heavy metal that bio-accumulates as it works its way up the food chain and into the human body. Eating fish contaminated with mercury can have serious effects on human health and is particularly damaging for the physical and mental development of children. Acid rain can harm aquatic life and mobilize toxic heavy metals into water ecosystems.

Burning pulverized coal in boilers to create steam for power generation produces a number of combustion residuals. One is bottom ash, which is removed from the bottom of coal furnaces. Another is fly ash, most of which is captured by filtration equipment before flue gases reach the chimneys of power plants. Other combustion residuals are emitted through the stack.

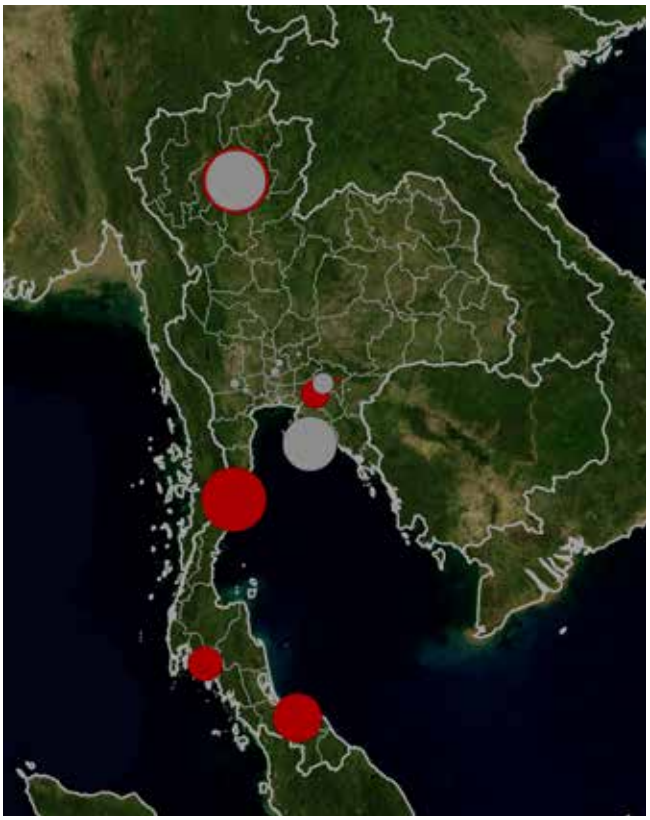
Such coal ash is generally trucked in dry or sent through pipelines with water to a disposal facility. The former generates fugitive dust and the latter often leads to groundwater contamination as heavy materials and other toxic chemicals flow into bodies of natural water. Coal ash `is highly likely to contaminate soils, as well as harm ecosystems and human health as it contains various heavy metals like arsenic, cadmium, chrome, cobalt, copper, lead, and mercury, as well as radioactive substances such as radium, thorium, and uranium.

31 Naidoo, K. The Unquenchable Thirst of an Expanding Coal Industry. The Guardian, 1st April 2014. http://www.theguardian.com/sustainable-business/unquenchable-thirst-expanding-coal-industry.
32 Greenpeace. 2014.Coal Impacts on Water. 21st March 2014. http://www.greenpeace.org/international/en/campaigns/climate-change/coal/Water-impacts/.
33 University of Pittsburg Schools of the Health Sciences. 2007. Higher Levels Of Pollutants Found In Fish Caught Near A Coal-fired Power Plant. Science Daily, 8th November 2007. http://www.sciencedaily.com/releases/2007/11/071107083907.htm.

7 STATUS OF COAL-FIRED POWER PLANTS IN THAILAND

Compared to Indonesia – a nation with approximately 70 coal-fired power plants – Thailand currently has five coal-fired power plants over 300 megawatts and nine smaller plants of around 100 megawatts or less. But like Indonesia, the Thai government has approved the new power development plan (PDP2015) to expand the use of coal power with large coal-fired power plants of 7,390 MW combined within the next 21 years.

As has already been noted, these coal plants don't just lead to the premature deaths of thousands of Thai people, they also foul the air, water and immediate surroundings, they displace entire communities, destroy some of Thailand's most renown tourist destinations and contribute to global warming.



Map of existing coal-fired power plants

Map of new projects in Thailand

with the size of the circles indicating generating capacity.

Operating coal-fired power plants in Thailand

Power plant name	Capacity, MW
MAE MOH	2400
BLCP	1434
GHECO ONE	700
GLOW SPP PHASE 3-5	431
THA TOOM	300
MUANG IRPC	108
WANG SALA MILL	60
AYUTHAYA MILL	57
BANGKOK HSFC PLANT	50
KAENG KHOI FACTORY	17
BAN PONG SPI	15
AMPHAR SAMPRAN	15
BAN PONG SKI	15
ELITE KRAFT FACTORY	10
PRACHINBURI IPC	10
PRACHIN BURI UTP	8

New coal-fired power plant projects in Thailand

Project name	Status	Sum of Capacity, MW
Thap Sakae power station	Announced	**2,800**
Thepa power station*	Announced	**2,000**
KRABI NEW	Planning	**800**
Mae Moh power station	Pre-permit development	**600**
PRACHIN BURI TCP	Pre-permit development	**600**
โรงไฟฟ้าปราจีนบุรี ทีซีพี	Planning	**20**
Grand Total		**5020**

* Not included in the impacts estimated in this report as the project had not been announced at the time of data collection for atmospheric modeling

8 INADEQUATE LEGAL PROTECTION FOR THE RIGHT TO CLEAN AIR

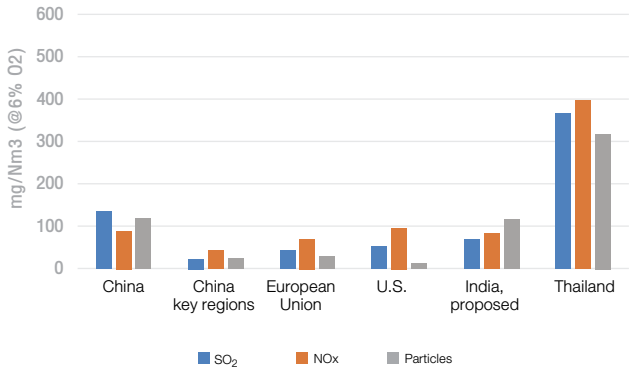
Emission standards

Emission standards in Thailand allow new coal-fired power plants to emit up to and above ten times the amount of pollution allowed in the EU, China and the U.S. Unfortunately Thailand's national air quality standards are also quite weak compared to the recommendations of the World Health Organisation (WHO): the yearly standard for the most dangerous pollutant, PM2.5, is 25µg/m3 – 2.5 times as high as the WHO guideline. The daily standard, at 50µg/m3, is twice as high. Similarly, for PM10, the yearly standard in Thailand is 50µg/m3, against a WHO guideline of 20, and the daily standard is 120, compared to WHO guideline of 50 – yet official measurements compiled by WHO indicate that even the national standard is being violated in a number of cities. Thai legislation clearly protects polluters rather than the right to clean air.

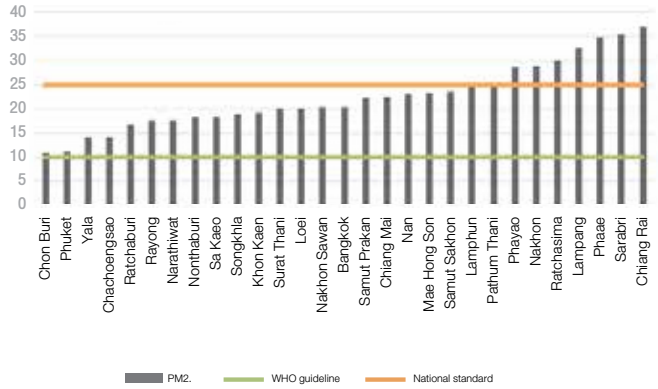
Air Pollution Laws of Thailand must be remedied as a matter of urgency. Thais need Clean Air Legislation and we need it now.

The Thailand Constitution (The Constitution of the Kingdom of Thailand BE 2550, Article 67) protects the right of the Thai people to enjoy a healthy environment. It regulates projects and activities that may cause severe impacts on the environment and on health. Further, it requires the owner of these projects to complete the Environmental Health Impact Assessment-EHIA. Coal power plants and coal mining projects are under this regulation. The process of conducting a Health Impact Assessment is obligated under the Regulation and Evaluation of Health Impact Assessment from Public Policy of 2009.

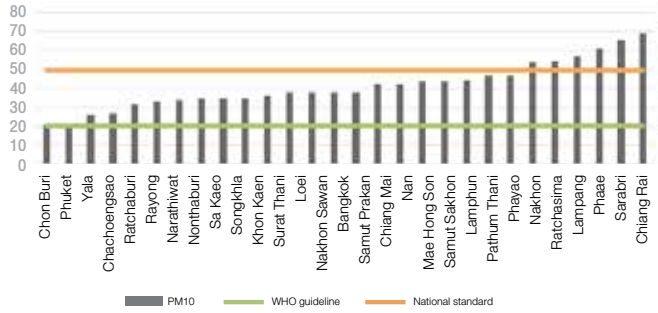
Emission standards in Thailand allow new coal-fired power plants to emit up to and above 10 times the amount of pollution allowed in the EU, China and the U.S.



Average PM2.5 levels in cities in Thailand



Average PM10 levels in cities in Thailand



Both PM2.5 and PM10 levels exceed the WHO guideline in all cities with monitoring stations (Source: WHO Ambient Air Quality database, May 2014. Data for Thailand for the year 2012).

The Enhancement and Conservation of National Environmental Quality Act 1992, is intended to jointly promote and maintain the quality of the environment. A person has the right and duty to receive news and information from the government on matters relating to environmental quality unless the data or information is considered official secrets related to national security, or confidential information about individual rights and property rights, or the right of trade of any person or entity who are protected by law. It is possible to get compensation from the state in the matter of a loss arising from harm caused by the spread of pollution caused by the company or any project initiated supported or conducted by government agencies or state enterprises.

The Government Regulation - Ministry of Resources and Environment Enforcement, 2010 - on Air Pollution Control of New Coal Power Plants Emission imposes ambient air quality standard as below. These standards allow up to ten times as much pollution from coal-fired power plants than corresponding regulation e.g. in China, EU and the U.S. (see comparison above).

Air Polliution Control of New Coal Power Plant Emission

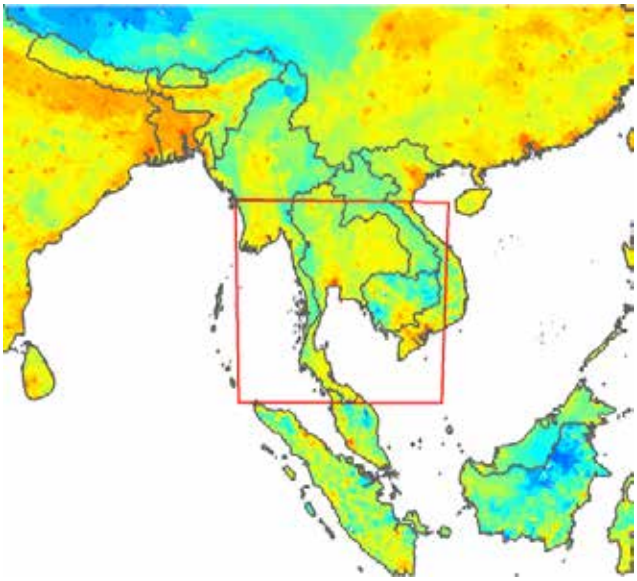
Fuel Source	Particulate (mg/m3)	Sulphur Dioxiden SO_2 (ppm)	Nitrous Oxides NOx (ppm)
Coal power plant with installation capacity not more than 50 megawatt	Not more than 80	Not more than 360	Not more than 200
Coal power plant with installation capacity more than 50 megawatt	Not more than 80	Not more than 360	Not more than 200

9 CASE STUDIES KRABI AND RAYONG CASE STUDIES

In addition to estimating the total health impacts of all coal-fired power plants in Thailand, two case studies were carried out for this report:

1. The operating coal-fired power plants BLCP and Gheco One coal-fired power plants in Rayong
2. The proposed Krabi coal-fired power plant project

These additional case studies provide a detailed analysis of the air quality and health impacts of these individual power plants, which is outside of the scope of the Harvard project. The impacts were modeled over a 1500km x 1500km domain covering Thailand as well as Cambodia and the southern parts of Vietnam, Laos and Myanmar. There are approximately 150 million people living within this domain. The case studies follow the methodology of the Harvard study for emission estimates and health impact assessment, while using the CALPUFF modeling system for pollutant dispersion modeling in order to obtain a more detailed picture of the local and regional impacts of these power plants.



Calpuff modeling domain (in red) and map of population density in the region

The emissions from the power plants

1. Elevate the levels of toxic particles in the air over a large part of the and beyond, increasing the risk of diseases such as stroke, lung cancer, heart and respiratory diseases in adults, as well as respiratory infections in children. This leads to premature deaths from these causes. SO_2, NOx and dust emissions contribute to toxic particle exposure.
2. Cause acid rain, which can affect crops and soils.
3. Cause fallout of toxic heavy metals such as mercury, arsenic, nickel, chrome and lead.

BLCP and Gheco One coal-fired power plants

The BLCP coal-fired power plant comprises two 717 MW units brought into operation in 2006 and 2007 in the Rayong industrial complex. Gheco One is a 700MW unit commissioned in the same industrial port area in 2012.

	PM10	NOx	SO_2
Gheco One	553	1,570	2,067
BLCP	1,221	20,977	31,726

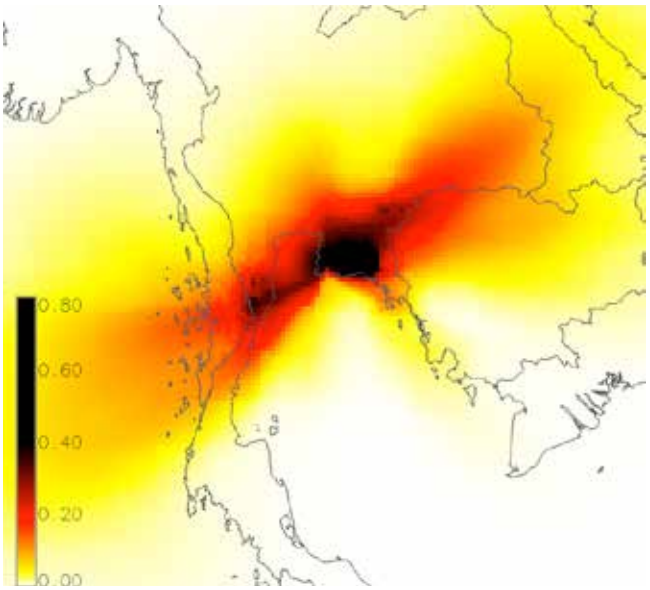
Estimated annual emissions from the power plants (t/a)

The power plants can significantly affect air quality in the nearby tourism destinations of Koh Samet, Koh Samae San and Pattaya as well as the entire Bangkok metropolis, particularly from February to September when predominant wind direction is from south to southwest. During worst-case conditions, the two power plants can increase daily average PM2.5 levels in the tourist areas by 40% and in the city of Bangkok by 20% compared to yearly average levels.

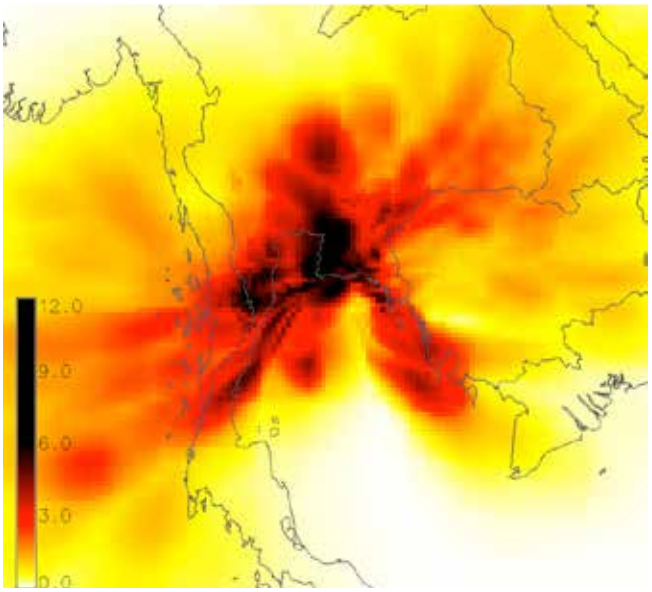
The emissions from the two power plants are estimated to be responsible for 360 premature deaths per year (95% confidence interval 220-500).

	Best Estimated	95% Confidence Interval
Cerebrovascular disease	100	60-140
Ischemic Heart Disease	160	100-210
Chronic Obstructive Pulmonary Disease	30	21-47
Trachea, bronchus, and lung cancers	40	15-39
Other Chronic Cardiovascular And Respiratory Diseases	30	16-37
Total	**360**	**220-500**

Estimated premature deaths attributable to emissions from the BLCP and Gheco One coal-fired power plants, cases per year



Estimated annual average PM2.5 concentration attributable to emissions from the BLCP and Gheco One coal-fired power plants (µg/m3)



Estimated 24-hour maximum PM2.5 concentration attributable to emissions from the BLCP and Gheco One coal-fired power plants (µg/m3)

Proposed Krabi coal-fired power plant project

The Krabi coal-fired power plant project is a proposed 800MW unit in Krabi, in the vicinity of the Krabi tourist resorts and the Krabi estuary wetlands conservation area.

PM10	PM2.5	NOx	SO_2
651	289	4,790	5,554

Projected annual emissions from the project (t/a)

The most significant health impacts occur to the east and to the west of the proposed power plant site. The areas to the west are mainly affected during low wind days during the November to April period when predominant wind directions are from the east to northeast. During worst-case conditions, the emissions from the power plant could increase daily average PM2.5 levels by 20-30% compared to yearly average levels.

The emissions from the power plant would be projected to cause approximately 1,800 premature deaths over an operating life of 40 years (95% confidence interval 1,100 to 2,500). These estimates take into account projected changes in death rates due to epidemiological transition.

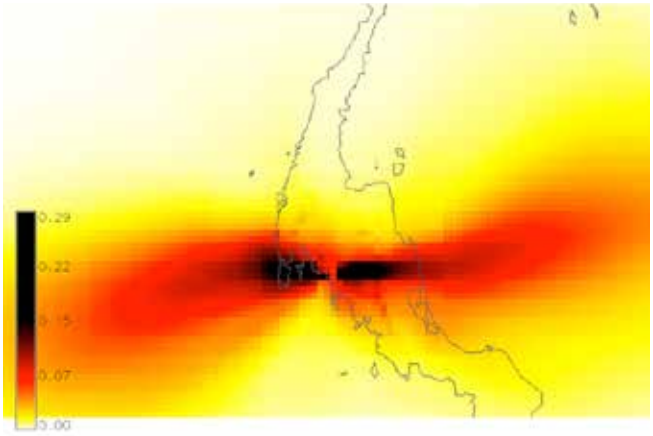
The pollution emissions from coal-fired power plants also lead to heavy metals deposition and fly ash deposition. The deposition mainly occurs during the rains of the southwestern monsoon, and hence most of the deposition takes place to the east of the proposed power plant, with the deposition hotspot falling within the Ramsar site.

Total direct fly ash deposition into the 21,300ha area covered by the Ramsar site is projected to be approximately 9 tonnes of fly ash per year, or approximately 40kg per square kilometer. Acid deposition is projected at a total of 95 tonnes SO2 equivalent per year, or approximately 450 kg per square kilometer. Water quality and ecosystems are potentially affected both by deposition taking place directly into the surface water bodies and into the water catchments of rivers and streams flowing into the bay area. Fly ash deposition into the bay and the watershed as a whole is projected at approximately 150 tonnes per year.

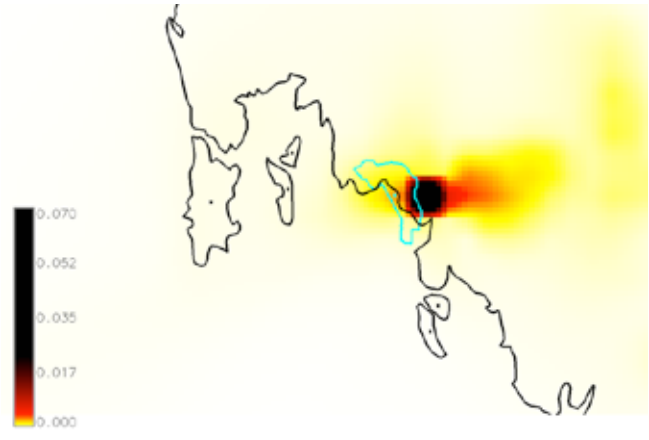
	Best Estimated	95% Confidence Interval
Cerebrovascular disease	500	310-700
Ischemic Heart Disease	770	500-1,050
Chronic Obstructive Pulmonary Disease	170	102-230
Trachea, bronchus, and lung cancers	180	76-289
Other Chronic Cardiovascular And Respiratory Diseases	130	80-182
Total	**1,750**	**1,060-2,400**

As an indicative estimate, based on USGS analysis of,[34]. Projected premature deaths caused by the Krabi coal-fired power plant project over an assumed operating life of 40 years

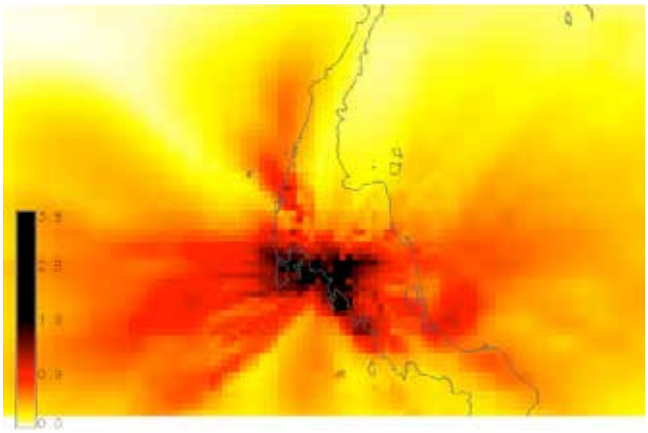
34 ประมาณการจากการคำนวณการสะสมตัวของโลหะหนักในตะกอนดิน 1-2 จากเถ้าถ่านหินที่ยังไม่ถูกเผาไหม้ และเถ้าลอยในปล่อง ประกอบกับผลการทดลองเชิงประจักษ์โดย Linak et al 2000 http://www.tandfonline.com/doi/adf/10.1080/10473289.2000.1046417



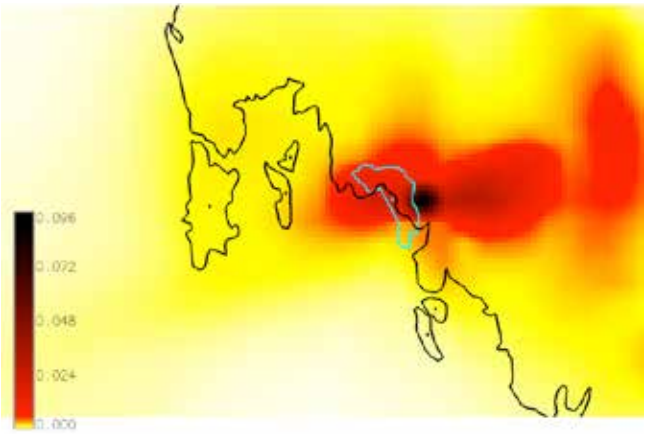
Projected increase in annual average PM2.5 concentrations caused by the Krabi coal-fired power plant project (µg/m3)



Projected fly ash deposition due to the Krabi coal-fired power plant project, with the boundaries of the Ramsar site (µg/m2/s, average)



Projected 24-hour maximum PM2.5 concentration caused by the Krabi coal-fired power plant project (µg/m3)



Projected acid deposition (SO2 equivalent) due to the Krabi coal-fired power plant project, with the boundaries of the Ramsar site (µg/m2/s, average)

10 RECOMMENDATION

Thailand - like much of the rest of the world - is at a crossroads as it considers how to manage its energy needs into the 21st century. Does it try to proceed with a business-as-usual approach of adding more and more coal-fired power plants or does it seize the moment and fast-track clean, safe renewable energy options. Energy options that would protect the health, jobs, environment, climate, tourism and national security needs of the Thai people.

This report makes clear what the cost of business-as-usual is when it comes to burning coal. In light of these findings the following is recommended in the interests of health, equity, clarity and national security

First, Thailand does not build any more coal-fired power plants:

According to the analysis by Harvard University, if all of the planned coal power plants start operation, Thailand will see an estimated 1,550 premature deaths each year. This will treble if all the new coal projects currently being considered are approved for construction. This loss of life is entirely unnecessary. Fast tracking the uptake of renewable energy and deploying energy efficient technologies would generate enough energy to keep Thailand powered and maintain an energy reserve standard of more than fifteen percent without coal. With this in mind, Thailand must cancel its plan to build more power plants.

Secondly as this report has revealed, Thailand needs to strengthen the monitoring and regulations on air pollutants from coal-fired power plants. The nation needs a Clean Air Act.

There is a fundamental duty of care from the Thai government toward the people of Thailand. Thailand's laws must squarely and specifically address the harms of coal-fired power plants. NOx and SO2 cause formation of secondary PM2.5 through chemical reactions in the atmosphere. The impact of air pollution from coal-fired power plants on PM2.5 can no longer be ignored. Air pollution – particularly PM 2.5 and mercury - need to be measured at the source of the pollution, not just atmospherically as is the case at present. Further, Thailand's standard of SO_2, NOx and dust emission is significantly higher than most other countries therefore; this standard needs to be reviewed under global policy implementation. The people of Thailand have the same right to clean air as the rest of the world and air pollution standard's need to change to ensure that happens

Third, the Strategic Environmental Impact – a policy framework to identify the impact assessments on coal investment in Thailand –

needs to have more effective and efficient decision-making for sustainable energy development. In order for that to happen, the Ministry of Environment must manage the Environmental Impact Assessments; the Ministry of Health must manage the Health Impact Assessment for coal power plant projects and the Ministry of Social Development and Human Security needs to take a more active role in building the health of the Thai people and need to take into account all the data presented in this report. Any assessments of impacts on health and environment or of carbon emissions in EIA/EHIA need to be strengthened. These Ministries need to have a more active and enhanced role in the ongoing EIA/ EHIA of coal-fired power plant projects and conduct thorough examinations of damages caused by these plants.

The coal industry should not be treated any differently to the rest of Thai society. If coal-fired power plants breach pollution emission limits they need to be fined accordingly. It is vital to levy penalty surcharges for NOx (one of precursors to the secondary formation of PM2.5). Without meaningful penalties coupled with rigorous enforcement the coal industry will not have any incentive to change its currently woeful practices.

The first step in managing PM2.5 effectively is to create a functional air quality monitoring network throughout the country; identify major emission sources, and support research in to the health, environment, social, and economic impacts of PM2.5. In addition it is necessary to introduce a systematic and publicly accessible emission source management system based on research and monitoring data. The government should mandate regular inspection of pollution-control devices at power stations and strengthen the monitoring and punishment for over-emission of pollutants.

Finally the Thai government must put renewable energy targets into law.

Coal-fired power becomes redundant when renewable energy and the Thai government takes energy efficiency seriously. Therefore it is possible to replace the current and planned coal-fired power plants by introducing a robust and strategic plan for energy efficiency and passing the first draft of Renewable Energy Act. This Act would prioritize renewable energy supply on grid with net metering, smart grid rollout and a nationwide development of renewable energy resources and grid transition.

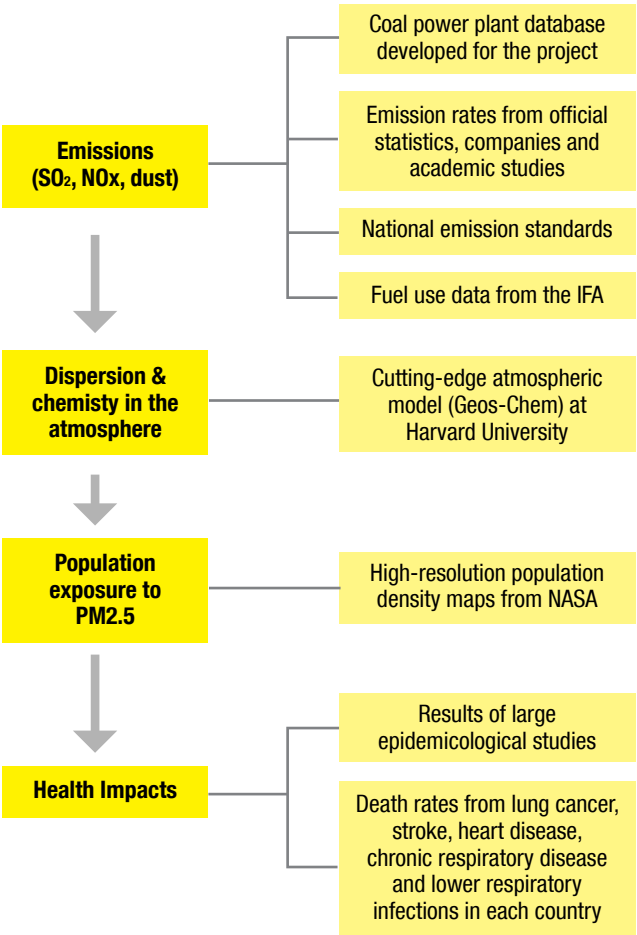
Greenpeace has predicted that by 2030, when all planned coal power plants (and those under construction) begins operation; renewable energy will be cheaper than coal-based power generation. Thailand has been a leader in the past with the Small Power Producer (SPP) and Very Small Power Producer (VSPP) programme. It can remain a leader as we move into the future. Greenpeace endorses a better alternative to the government's dirty coal proposal. Thailand needs an integrated solution to be implemented across the region to address rising energy demand and this demand needs to be realized through a decentralized system and supplemented by a rural and community-based development approach.
Fast-tracking the rollout of renewable energy and energy efficiencies will give Thailand a win-win solution for the climate, local job creation, empowerment of communities, clear air, water and reinvigorated Thai businesses. The nation stands at the crossroads.


©greenpeace / Luke Duggleby

APPENDIX 1: Methodology of the Study

The most common approach for studying the health impacts of coal-fired power plants is the "impact pathway" approach, which follows air pollution from emissions from the studied sources, to the dispersion and chemical transformation of emissions, to resulting pollution levels in different locations, to population exposure, resulting increase in health impacts, and finally to the total health impacts on the population-level.

The impact pathway approach with information sources used in the study



Emissions

First, the study of the health impacts of coal-fired power plants requires detailed information on the location, operation and emissions of the power plants. The inventory is based on a detailed listing of coal-fired power plants and their technical data in the covered countries. The basis for the listing is the Platts World Electric Power Plants database, complemented by a comprehensive mapping of new power plant projects by CoalSwarm and by the national groups participating in this project.

The operating data (thermal efficiency and capacity factor) for most plants was obtained from the CARMA database, and for the rest, average national values were calculated by power plant size category and steam conditions. Total coal consumption estimated in this way for each country for 2011 matched the IEA data quite well, but fuel use was scaled to the IEA numbers. The plant-specific operating data was, in other words, used to differentiate coal use among power plants. Flue gas volumes were estimated using EEA default factors for hard coal and lignite.

The national emission standards applied to each power plant were identified and were used to calculate air pollutant emissions as a first approximation. Indonesia's state power company, PLN, has said they design their power plants for 4300 kcal coal with 0.35% sulfur, so emission rates for plants for which Platts reports "compliance fuel" as the SO2 control method were calculated on this basis. Non-PLN plants without SO2 controls were assumed to burn average Indonesian coal with 0.6% sulfur.

However, it is common for the power sector to significantly under- or over-achieve the legally required performance. For example, all Japanese utilities report average emission rates far below the legal standards, and in Indonesia it is common for small power plants not to have any pollution

© Greenpeace

controls, resulting in emission levels exceeding the national standards. The following sources were used to adjust emission rates for power plants:

- **Power-plant specific information, if this could be found, from company presentations etc.**
- **Company average emissions performance, typically in g/kWh from CSR reports**
- **National emissions statistics**
- **REAS 2.1 estimates for air pollutant emissions from coal-fired power plants for each country, scaled by change in coal consumption from 2008 to 2011**

When the available statistics covered all thermal power plants, the REAS values for average emission per TJ fuel were used to estimate shares of coal, using fuel use data from IEA (national statistics) or from company reports. When plant-specific data was available, this was preferred. Emission rates for power plants for which individual data was not available were scaled to the available national emission data.

The overall inventory is significantly lower than national statistics or the REAS 2.1 estimates. In many cases (Thailand SO2, Indonesia SO2 and PM, Philippines PM), it was not possible to reconcile national statistics with emissions performance reported by operators of individual large power plants without assuming very high emission rates for the rest of the power plant fleet, bordering on the physically implausible. In these cases, the information reported by power plant operators, even if potentially selective, was relied on, making the estimates conservative. (Side note: it might be interesting to do a set of model runs with the REAS inventory for CFPPs, our estimates, and an inventory calculated assuming full compliance with national standards.)

Power plant emission standards for PPM are set in terms of total PM. The PM10 and PM2.5 fractions were estimated using US EPA AP-42 PM size distributions for different control technologies on the plant level, when information on technique was available from Platts. In other cases, an ESP was assumed for stack emission concentrations below 500 mg/Nm3 and uncontrolled combustion otherwise.

New power plants are assumed to meet national emission standards for new plants (when more specific information is not available), with the exemption of SO2 emissions from “compliance fuel” plants, which are treated the same way as in the case of operating power

©Greenpeace / Jonas Gratzer

plants. New units are assumed to operate at a capacity factor of 80%, in line with available data for newly commissioned units in the region. For countries and power plant operators whose actual reported emission rates are below national standards, new power plants are assumed to over-achieve the standards by the same ratio. In addition, technology-specific minimum emission control performance is defined for circulating fluidized bed boilers, flue gas desulphurization and selective catalytic reduction devices, low-NOx boilers, subcritical boilers burning subbituminous coal without NOx control measures and for baghouses. All new power plants for which information on particulate control technology is not available are nevertheless assumed to install an electrostatic precipitator with a minimum 99% removal rate. In countries with lenient emission standards for new power plants, such as Philippines, Indonesia and Myanmar, all of these minimum performance assumptions lead to significantly lower estimated emission rates from new plants than simply assuming the highest permissible emission rates.

Atmospheric modeling

Atmospheric modeling was carried out by the research group of professor Daniel Jacobs at Harvard University. The group used the GEOS-Chem global model of atmospheric composition (www.geos-chem.org) to quantify the surface air concentrations of particulate matter (PM) and ozone resulting from present and future scenarios of coal-fired power plant emissions. GEOS-Chem is a widely used, open-source tool for modeling atmospheric composition on global and regional scales. It describes the transport and chemical evolution of species in the atmosphere and thus serves to relate emissions from specific sources to receptor concentrations.

Professor Jacob's group at Harvard has considerable experience and credentials in global/regional modeling of atmospheric composition for air quality and climate applications. Jacob leads the GEOS-Chem modeling community of over 100 research groups worldwide. The GEOS-Chem model is centrally managed at Harvard by Jacob's group.

The model is first run with all air pollution emissions from different sources included. Then the emissions from the operating coal-fired power plants are eliminated, and the model is run again. The difference in pollution levels in the results of these two model runs is the share of pollution attributable to coal-fired power plants. To estimate air quality impacts of proposed new power plants, the emissions from these plants are added to the total current emissions from all sources, and the model is run with this new emission inventory.

Health impacts

The assessment of health impacts from the coal-fired power plants is based on the estimates of total health impacts of air pollution in the Global Burden of Disease study, published in the prestigious medical journal Lancet in 2012. These estimates take into account population age structure, mortality from different air-pollution related causes, and air pollution levels in different locations in Taiwan.

The atmospheric model produces estimates of the total air pollution level at each grid location, and the share of the pollution that can be attributed to pollution emissions from coal-fired power plants each country. This share of the health impacts is then attributed to the coal plants. The same approach was used for the health impact assessments in a 2014 World Bank study on health impacts of transport-related air pollution. [35]

35 Bhalla, K., Shotten, M., Cohen, A., Brauer, M., Shahraz, S.,Burnett, R., Leach-Kemon, K., Freedman, G., Murray, C. 3rd March 2014. Transport for health : the global burden of disease from motorized road transport. World Bank Group. http://wwwwds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2014/03/28/000333037_20140328141207/Rendered/PDF/863040IHME0T4H0ORLD0BANK0compressed.pdf.

Thank you to:
Research Team Harvard University
Atmospheric Chemistry Modeling Group
(ACMG)
Greenpeace International
Publication: Greenpeace Southeast Asia,
November 2015

Research Consultant:
Lauri Myllyvirta
Julie Macken
Chariya Senpong

Editorial Board:
Arif Fiyanto
Inthira Thanakeeree
Tanit Klaewyotha
Tara Buakamsri
Somrudee Panasudtha

Design:
Tanadet Wong-Uparaj

Cover:
BLCP Coal Power Plant

GREENPEACE

Greenpeace is an independent global campaigning organization that acts to change attitudes and behaviour, to protect and conserve the environment, and to promote peace.

Greenpeace Southeast Asia
1371 Capital Building, G Floor, Paholyothin Road, Samsen Nai,
Payathai, Bangkok, 10400
greenpeace.or.th

Printed on recycled paper with soya ink