The Health Cost of Coal in Indonesia

GSI REPORT

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Global Subsidies Initiative

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1. Introduction – Coal in Indonesia

Coal plays a very important role in the life of Indonesians, affecting many economic and social aspects in the country. Indonesia is among the world's five largest coal producers and the second largest coal exporter (International Energy Agency, 2017). More than 60 per cent of the electricity produced in Indonesia is sourced from coal power plants, and the amount of coal power is expected to almost double by 2027 (MEMR, 2018). The majority of coal power plants in the country are located on the highly populated island of Java, followed by Sumatra. In 2017, there were 22 coal power plant units operating within 100 kilometres of Jakarta, with 22 more units planned (Greenpeace, 2017).

Coal is proven to have very noxious effects on human health. Burning coal to produce electricity or heat releases small particles ($PM_{2.5}$[1] and smaller) and different toxic elements that are related to cardiovascular and respiratory diseases and cancer. Air pollution from coal is considered a direct cause of several non-communicable diseases (NCDs) which in 2015 caused 1.3 million deaths in Indonesia (World Health Organization [WHO], 2015). Failing to recognize and address these externalities can have a very negative impact on the health of Indonesians.

Other large coal consumers such as China and India are taking measures to reduce their reliance on coal, limiting air pollution and its noxious effects on their populations. Coal-driven air pollution was estimated to cause over 241,000 premature deaths in China in 2013 (Tsinghua University, 2016) and 169,000 in India in 2015 (Indian Institute of Technology [IIT], the Health Effects Institute [HEI] and the Institute for Health Metrics and Evaluation [IHME], 2018). One study in Indonesia estimated 7,500 premature deaths due to coal in 2011 and expected this number to increase to 25,000 by 2030 if no measures are taken (Koplitz, Jacob, Sulprizio, Myllyvirta, & Reid, 2017). NCDs caused by air pollution in Indonesia are among the main causes of premature death in the country (Institute for Health Metrics and Evaluation [IHME], n.d.).

The Indonesian government has taken steps to reduce air pollution from haze and to improve public transit. But it also continues to support coal and considers it a main source of electricity for Indonesia. Research by the International Institute for Sustainable Development (IISD) (Attwood, et al., 2017) estimates that subsidies to coal production in Indonesia reached USD 946 million (IDR 12.4 trillion) in 2014, almost 10 per cent of Indonesia's public health expenditure in 2013. This makes coal an expensive source of electricity generation, especially considering that the price of renewable energy is going down significantly.

The following sections outline the main NCDs associated with coal combustion, the primary affected population groups and an estimate of how much air pollution is costing Indonesians.

[1] $PM_{2.5}$ refers to particulate matter with an aerodynamic diameter of less than 2.5 µm, which are the most harmful to health, since they can enter the circulatory and respiratory systems.

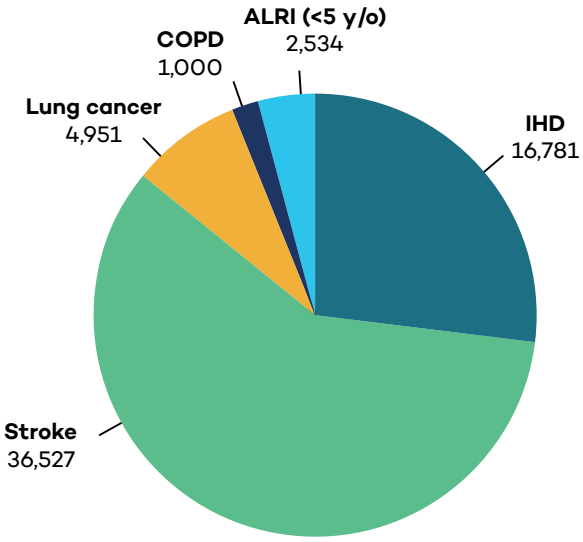
2. What Are the Health Effects of Coal?

2.1 Health Effects of Coal and Air Pollution

Coal combustion contributes to air pollution, along with burning fuels for transportation (diesel and gasoline), seasonal forest burning, etc. This burning releases gases and small particles that can be inhaled by humans. Some of these components are toxic for human health, and when inhaled they can have negative effects on health. There is little research about the direct impacts of coal-driven air pollution in Indonesia. However, the components released by coal combustion are well known, as are their potential effects on human health. Therefore, this section will start evaluating the overall impacts of air pollution on health and then specify the diseases attributable to coal, based on the elements released by its combustion.

Air pollution is a major cause of non-communicable diseases (NCDs) (Health and Environment Alliance [HEAL], 2017). Air pollution affects the respiratory, cardiovascular and the nervous system, being associated to serious NCDs such as ischemic heart disease (IHD), chronic obstructive pulmonary disease (COPD), lower respiratory infection (LRI), cardiovascular diseases (CVD), acute low respiratory infections (ALRI), asthma and lung cancer. WHO estimated that air pollution-related NCDs caused around 62,000 deaths in Indonesia in 2012. Stroke, IHD, and lung cancer were the most observed diseases (see Figure 1) (WHO, 2016b).

Figure 1. Deaths attributable to outdoor air pollution in Indonesia in 2012, per disease.



Source: WHO, 2016b.

Among the main pollutants released in the combustion of coal are nitrogen oxides (NO_x), Sulphur dioxide (SO_2) and particulate matter (PM). Mercury is a very important and toxic component of coal, and it gets into the food chain through the ingestion of fish, becoming particularly harmful for populations that rely on fish as their main source of protein (WHO, n.d.b). Nitrogen dioxide (NO_2) is also released and reacts with the atmosphere becoming a major component of smog, also a health hazard (Anderson, et al., 2013). In addition, coal contains arsenic, cadmium and lead (Basel Convention Regional Centre for South East Asia/Stockholm Convention Regional Centre Indonesia, 2017), which can have lethal effects in humans consuming contaminated fish, water or agricultural products. In China, high soil concentrations of lead, cadmium and arsenic caused by coal combustion have led to the so-called "cancer villages" (Jing, 2013), and Chinese officials have recognized that large areas of farmland are so polluted that no agriculture should be allowed on it at all (*The Economist*, 2017).

Table 1 summarizes the main toxic substances emitted by coal combustion and the associated health impacts.

Table 1. Summary of main pollutants from coal combustion and their associated health impacts, based on WHO information and international research.

Substance	Health Impacts	Related NCD	Population Most Affected	Guideline Value (WHO)
Nitrogen oxides (NO_x), Nitrogen Dioxide (NO_2)	Are a major contributor to the formation of fine particulate matter (PM). NO_2 is a lung irritant, causing inflammation of the airways and can increase the chance of respiratory illness by lowering resistance to infection (Anderson, et al., 2013; WHO, 2018a). NO_2 has been associated to low birth weight in Indonesia (Septiawati, Fitria, Wulandari, Zahra, & Listianti, 2017).	Asthma, bronchitis, PM-related (Anderson, et al., 2013)	People with pre-existing respiratory problems (Anderson, et al., 2013), pregnant women and fetuses (Septiawati, et al., 2017)	NO_2: 40 µg/m³ annual mean 200 µg/m³ 1-hour mean (WHO, 2018b)
Sulphur dioxide (SO_2)	SO_2 causes irritation, reflex cough and narrowing of the airways, affecting breathing and resulting in respiratory illness and alteration of pulmonary defence. SO_2 negatively affects human embryo development, being associated with shorter gestation and lower body mass of newborns. SO_x can react with other substances in the air to create particulate matter (Anderson et al., 2013; EPA, 2018).	PM-related respiratory diseases such as asthma, COPD (bronchitis, emphysema), aggravate existing CVD, eyes irritation, preterm birth and low birth weight (Anderson, et al., 2013; EPA, 2018; Guarnieri & Balmes, 2014; Yunus, et al., 2011)	Fetal, children, the elderly, and those who suffer from asthma and pre-existing CVD (EPA, 2018; Yunus, et al., 2011)	20 µg/m³ 24-hour mean 500 µg/m³ 10-minute mean (WHO, 2018a)
Mercury	Transformed by bacteria into methylmercury, it becomes highly toxic and can have effects on the nervous, digestive and immune systems as well as on lungs, kidneys, skin and eyes and can be fatal. Exposure to mercury is a threat to the development of the child in utero and early in life (WHO, n.d.b, 2013; CAN Europe; HEAL; WWF European Policy Office; Sandbag, 2016).	Immune, neurological and behavioural disorders, cognitive and memory impairment, CVD (heart attack, hypertension) (WHO, n.d.b, 2013; CAN Europe; HEAL; WWF European Policy Office; Sandbag, 2016)	Newborns and infants, pregnant women, and populations who depend on fish as a traditional food source (Anderson, et al., 2013; WHO, n.d.b, 2013)	Water: 1 µg/litre for total mercury 8 Air: 1 µg/m³ (annual average) (WHO, 2007)

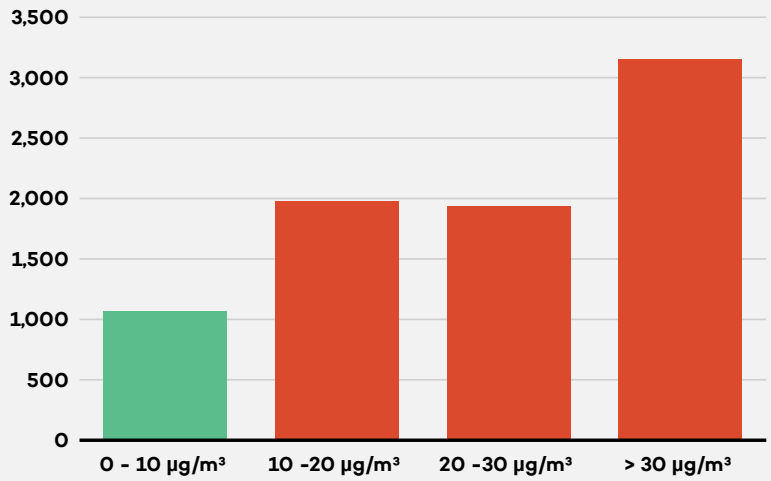
Substance	Health Impacts	Related NCD	Population Most Affected	Guideline Value (WHO)
Particulate Matter ($PM_{2.5}$)	$PM_{2.5}$ and lower penetrate deep into the lungs, can enter into the bloodstream and eventually reach vital organs such as brain, lung, heart, pancreas, and reproductive system, creating a range of physiological responses. PM affects fetus development. Ultrafine PM have higher possibility to enter organ and the cells (Schlesinger, Kunzli, Hidy, Gotschi, & Jerrett, 2006).	Cardiovascular and respiratory diseases (IHD, COPD, LRI), lung cancer, asthma, impaired lung function (WHO, 2018a; Huaab, et al., 2014; Haryanto, Resosoedarmo, Utami, Hartono, & Hermawati, 2011; Qomariyatus, Khairiyati, & Setyaningrum, 2008; Sugiharti, 2015)	Children, the elderly and people with pre-existing medical conditions (Huaab, et al., 2014; Health Canada, 2008)	10 µg/m³ annual mean 25 µg/m³ 24-hour mean (WHO, 2018a)
Arsenic	Inorganic arsenic is a confirmed carcinogen and is one of WHO's 10 chemicals of major public health concern, affecting humans through contaminated drinking-water (WHO, 2017).	Cancer and skin lesions, cardiovascular disease and diabetes (WHO, 2017)	All populations	10 µg/L (WHO, 2017)
Cadmium	Cadmium exerts toxic effects on the kidney, the skeletal and the respiratory systems, and is classified as a human carcinogen (WHO, 2018b).	Lung cancer, renal tubular dysfunction (WHO, 2018b)	All populations	5 ng/m³ per year (WHO, 2013)
Lead	Lead is a cumulative toxicant that affects multiple body systems, including the neurologic, hematologic, gastrointestinal, cardiovascular, and renal systems (WHO, n.d.a) and can cause reproductive dysfunction (Anderson, et al., 2013).	Cancer, nervous system dysfunctions (Anderson, et al., 2013; WHO, n.d.a)	All populations, particularly children and women of childbearing age (WHO, n.d.a)	0.5 µg/m³ per year (WHO, 2013)

Acronyms: IHD = ischemic heart disease, COPD = chronic obstructive pulmonary disease, LRI = lower respiratory infection, CVD= cardiovascular disease

Text Box 1: Measurements of air pollutants in Indonesia

Measurements of air pollutants from coal combustion are scarce. $PM_{2.5}$ measurements are available for Central Jakarta (Real-time Air Quality Index [AQI], n.d.), but they are missing in other points of the country. According to measurements in Central Jakarta, the average annual $PM_{2.5}$ level was 28.4 µg/m³ in 2017 (AirNow, n.d.), well above the World Health Organization (WHO) Air Quality Guideline for $PM_{2.5}$ of 10 µg/m³. In 2017 87 per cent of the $PM_{2.5}$ measurements were above this WHO guideline (see Figure B.1.1).

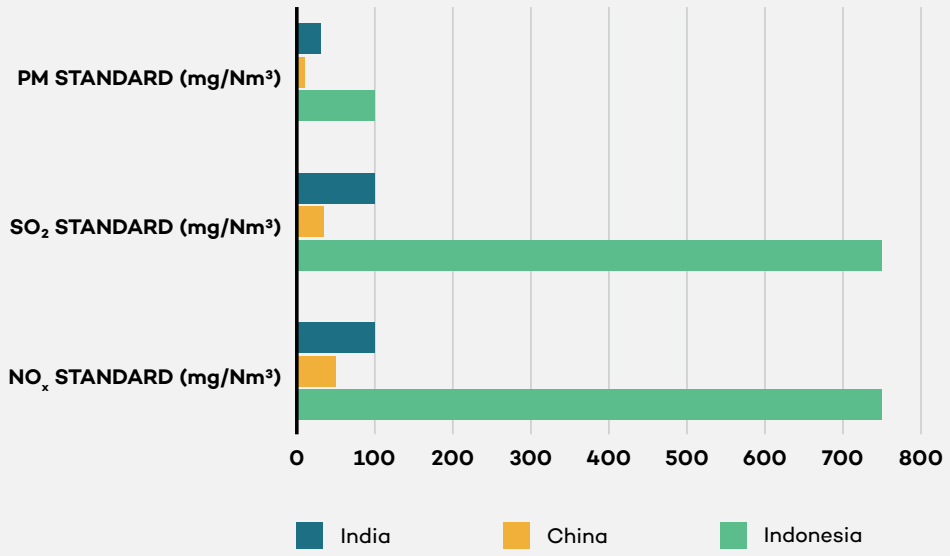
Figure B.1.1: Number of measures per range of $PM_{2.5}$ concentration in Central Jakarta in 2017. In green, the number of measures below WHO's guideline of 10 µg/m³ (13% of the measurements); in red (87% of the measurements) those above the WHO guideline.



Source: AirNow, n.d.

In addition to the scarce measurements, emission standards for coal power plants in Indonesia are much weaker than in other countries, even for new coal power plants (see figure B.1.2), and there is no standard for mercury emissions (Greenpeace, 2017). This means that coal power plants in Indonesia can be much more polluting than those of neighbouring countries.

Figure B.1.2: Emission standards for several pollutants for new coal power plants in India, China and Indonesia.



Source: Greenpeace, 2017.

2.2. Most Affected Population Groups

One of the major problems of air pollution is that all population groups are exposed, although they are differently affected.

The most vulnerable groups, such as newborns, infants, children and the elder are more sensitive to some of the diseases related to substances released by coal combustion (see Table 1). Children and newborns are more susceptive to air pollution risks since they inhale a higher volume of air relative to their body weight compared to adults and consequently take in higher proportional levels of pollutants. Pregnant and breast-feeding women are special groups, since they can transmit the toxins to babies and fetuses.

Mercury and lead exposure are of special concern among **pregnant women and babies**. Mercury can affect fetal development, causing lifelong symptoms in the newborns, including mental retardation, memory disability, attention deficits, hearing and vision loss, and deformities (Kondo, 2000). Lead can cause serious and, in some cases, irreversible neurological damage, even at relatively low levels of exposure (WHO, n.d.a).

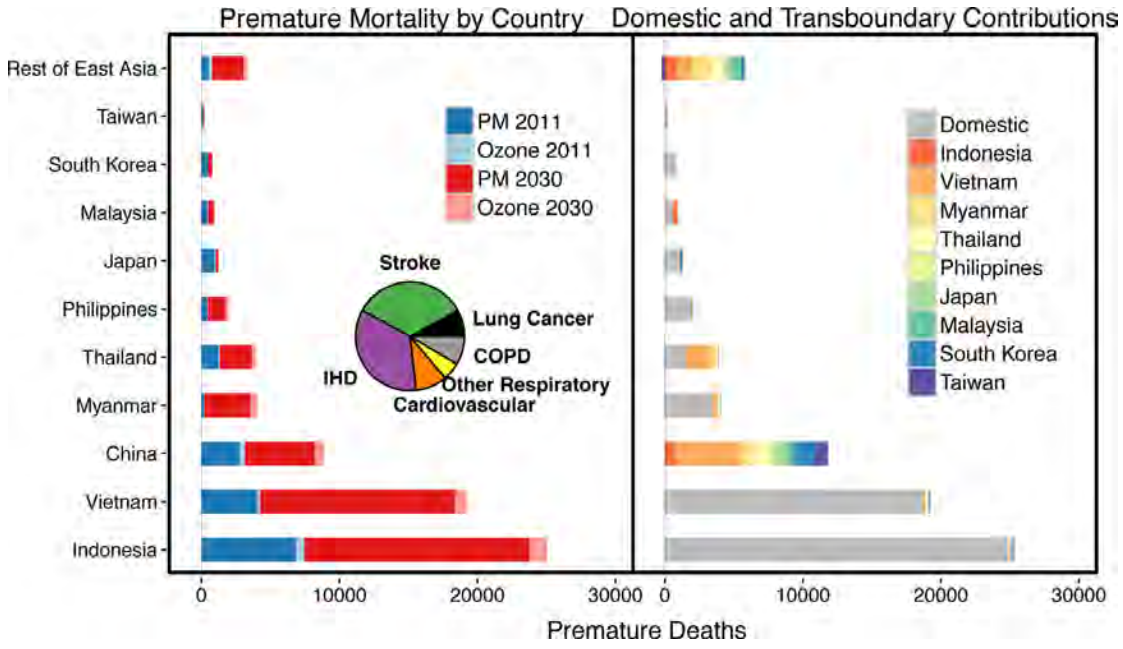
The elderly and those with pre-existing respiratory and cardiovascular problems such as asthma, congestive heart failure or COPD are also particularly vulnerable and susceptible to premature mortality. $PM_{2.5}$-attributable IHD among those above 70 accounted for 16.2 per cent of DALYs in China and 17.8 per cent in India (Health Effects Institute [HEI], 2018).

2.3. The Health Burden of Coal-Driven Air Pollution in Indonesia

The health burden of coal-driven air pollution in Indonesia is higher than in other countries in the region, and it is expected to increase significantly as new coal power plants are built in the country. In 2011, Indonesia registered the highest mortality from coal emissions compared to its neighbours, mostly due to the coal burned in the country (see Figure 2). Koplitz et al. (2017) estimate a total of 7,480 excess deaths per year in Indonesia due to coal combustion. This is almost twice the estimates in Vietnam (4,250 excess deaths per year) and almost six times more than in Thailand (1,330 excess deaths per year). Considering the government's plans to

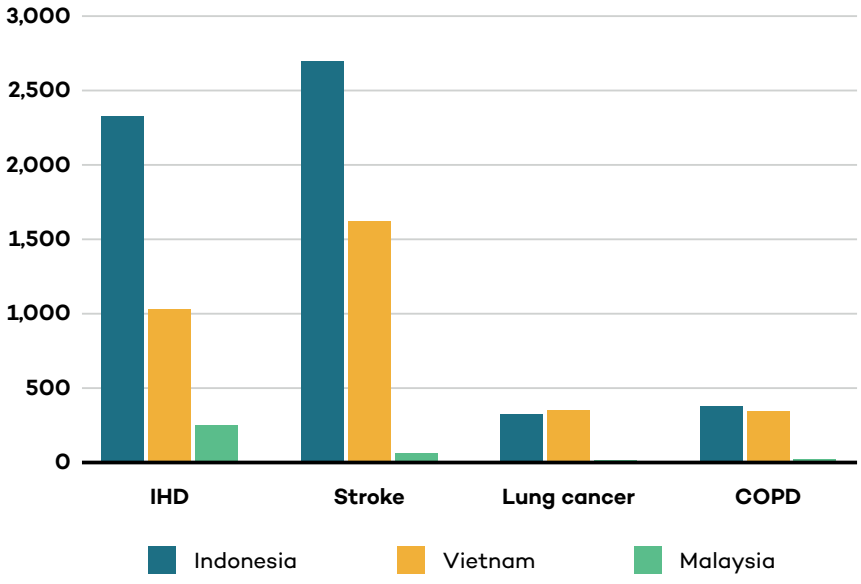
significantly increase the number of coal power plants in the coming years, the number of additional premature deaths could raise up to 25,000 per year, more than triple the number in 2011, as shown in Figure 2. The main diseases observed were stroke and IHD (See Figure 3).

Figure 2. Coal-related mortality due to emissions in Southeast Asia.



Source: Koplitz et al. 2017.

Figure 3. Number of coal-related deaths[1] in Indonesia per disease compared to neighbouring countries in 2011.



Source: Own elaboration with data from Koplitz et al. 2017.

[1] $PM_{2.5}$ was used to calculate premature death attributable to coal in 2011.

3. What Is the Health Cost of Coal in Indonesia?

3.1. The Health Cost of Air and Coal Pollution

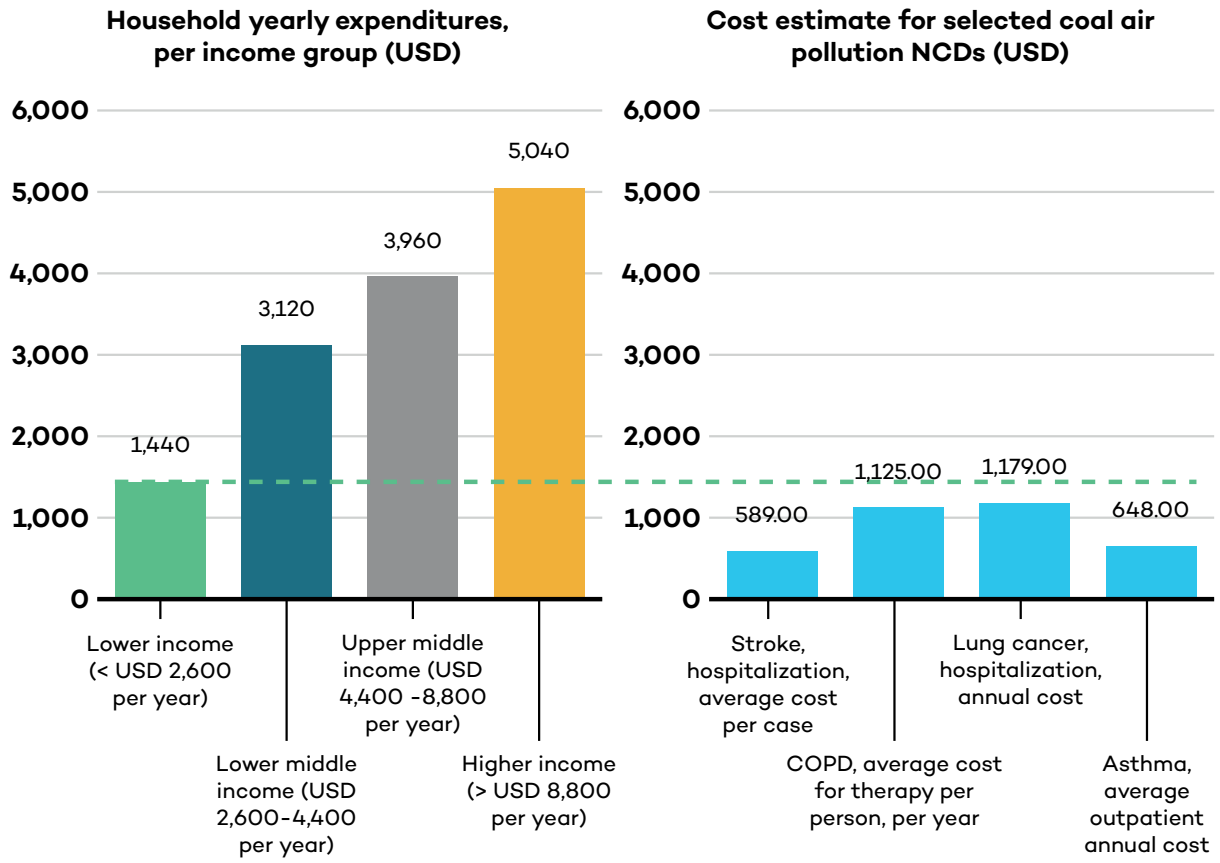
NCDs related to air pollution from coal impose a significant burden in the budget of Indonesians, both at the family and national levels. A study by the Harvard T. Chan School of Public Health and the World Economic Forum (WEF) estimates that respiratory diseases in Indonesia can cost the country up to USD 805 billion (IDR 11,250 trillion) between 2012 and 2030 (Bloom, et al., 2015). Some NCDs such as COPD, asthma or hypertension are chronic conditions that affect people over an extended period of time and require lifelong health service (El-Jawahri, Greer, & Temel, 2011), and can cost families a significant part of their incomes.

Table 2 summarizes the main costs of NCDs caused by coal-driven air pollution. Most frequent respiratory diseases such as asthma or chronic obstructive pulmonary disease (COPD) can be significant cost burdens for households. The outpatient cost (the cost of treating a disease at a hospital, clinic, or associated facility for diagnosis or treatment without hospitalization) for asthma, can cost on average USD 54 (IDR 755,100) per month, which is more than half of the average monthly per capita income of the lower-middle-income class in Indonesia (World Bank (WB), 2017). More than half of that cost goes for treatment drugs (Muslim, 2012; Listuhayu, 2010).

In the case of COPD, the average cost for therapy is USD 1,125 (IDR 16 million) per person and per year, based in estimates for Jakarta between 2010 and 2014 (Anwar, Yusi, & Afdal, 2016). COPD prevents an individual from working for at least two months per year due to sick leave and bed confinement combined (Patel, Nagar, & Dalal, 2014), resulting in a significant loss of income.

In Indonesia, 6.8 per cent of the population lives below the poverty line (less than USD 2/day) (World Bank, 2017) and a third of the population is not covered by national health insurance (Kemenkes K. K., 2017; Sánchez-Triana, Enriquez, Afzal, Nakagawa, & Khan, 2014). This implies that the costs of air pollution-related diseases are borne heavily by households that are least able to afford extra health costs. Figure 4 compares the average household income and expenditure per income group with the cost of selected diseases. It shows health costs associated with NCDs can represent up to the total expense budget of lower-income Indonesian households, and around a third of the total expenditures of middle-income households.

Figure 4: Comparison of household average yearly expenditure per income group with the estimated treatment cost of selected NCDs



Sources: Author figure, based on data from Deloitte, 2015; Misbach & Wendra, 2000; Anwar, Yusi, & Afdal, 2016; Saputro, 2013; Listuhayu, 2010.

Table 2. Treatment cost and impacts of coal-related NCDs, in USD and number of days

	Stroke	IHD	COPD	Lung Cancer	Asthma	Hyper-tension
Number of hospitalization days, per occurrence	11–17[7]		5–10[2]	7-22[9]		
Number of days of restricted activity, per occurrence			27-63[1]			
Average days of sick leave or disability, per year			2-20[1]			
Number of days in bed, per year			13-32[1]			
Average cost of hospitalization, per case (USD)	589-932[8]		347[2]			
Direct cost per case, per year (USD)		677-1,523[6]	152-1,617[3]	1,179[5]		
Non-medical cost, per year (USD)	357-1,552[6]					

	Stroke	IHD	COPD	Lung Cancer	Asthma	Hyper-tension
Indirect cost (transport, home adaptation and hospitalization), per case and per year (USD)	872-1,719[6]					
Outpatient, cost average per month (USD)		47[6]			54[4]	32[6]

Table references:

[1] *United States, estimated mean annual direct cost/person (Patel, Nagar, & Dalal, 2014)*

[2] *Surakarta in 2010–2011, with average of medical cost is USD 272 or 80 per cent of total hospitalization cost (Aprilia, Andayani, & Wahyuningtyas, 2013)*

[3] *Jakarta in 2010–2014. Average cost for therapy USD 1,125/person/year (Anwar, Yusi, & Afdal, 2016)*

[4] *Medan in 2010, per monthly cost for outpatient (Listuhayu, 2010)*

[5] *Purwokerto in 2009–2012, per year (Saputro, 2013)*

[6] *India & Pakistan (Walker et al., 2018) (Walker, et al., 2018)*

[7] *Indonesia in 1996–1997 (Misbach & Wendra, 2000)*

[8] *Yogya in 2014 (Feladita & Marchaban, 2014)*

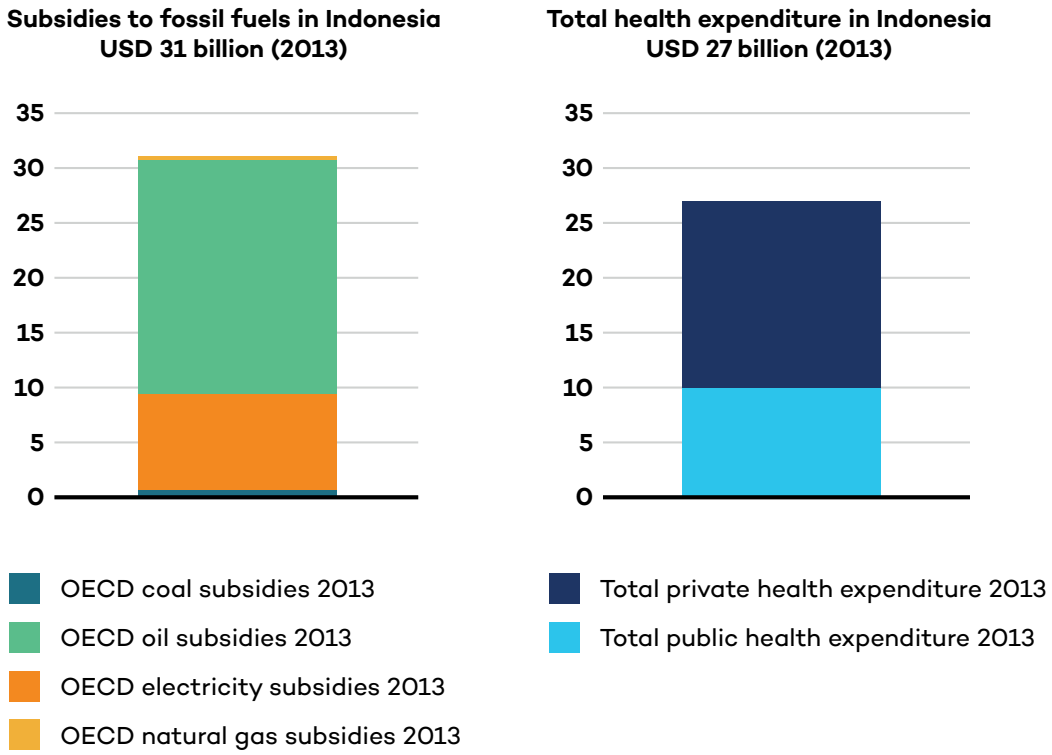
[9] *(Putranto, Trisnantoro, & Hendra, 2017)*

3.2. Coal Subsidies and Health

As seen in the previous section, air pollution caused by coal is expensive. In addition, there is a significant portion of the Indonesian public budget dedicated to support coal.

In 2013, the Government of Indonesia spent USD 10 billion (IDR 140 trillion) on public health. The total health expenditure in the country in 2013, including private and public, was USD 27 billion (IDR 377 trillion) in the same year. At the same time, the Government of Indonesia spent a total of USD 31 billion (IDR 433 trillion) in 2013 in subsidizing fossil fuels (OECD). This is more than three times the public spending in health (see Figure 5). Subsidies to the production of coal alone cost the government USD 946 million (IDR 12.4 trillion) in 2014 (Attwood, et al., 2017), that is, around 10 per cent of public health expenditure in 2013.

Figure 5. Comparison of total spending on health versus fossil fuel subsidies in Indonesia in 2013.



The main objective of subsidies to coal is reducing the price of electricity for consumers. The average cost of generating electricity in Indonesia in 2016 was 75 USD per MWh (Ministry of Energy and Mineral Resources, 2017). However, neighbouring countries, such as India, are showing that the cost of generating renewable energy can be much lower than that. In India, recent solar projects are selling electricity at USD 40 per MWh (Safi, 2017); in Mexico, prices went even further down to USD 21 per MWh (Frankfurt School UNEP Centre; BNEF, 2018). This means that renewable electricity can be much cheaper to produce than coal electricity. The Government of Indonesia aims to reach 23 per cent of renewable electricity by 2025. However, since 2007 most of the increase in electricity production has come from coal while the share of renewable electricity production has remained at around 12 per cent of total. Bridle, et al. (2018) show that unless there are major policy changes, it will be difficult to reach the 23 per cent target. New renewable energy sources as solar represented less than 0.1 per cent of the total electricity capacity in 2015. A transition from coal power to renewable power would have very positive effects on reducing air pollution and thus also on the health of Indonesians.

4. What Can the Government Do?

First, stop subsidizing coal: By subsidizing coal and other fossil fuels, the Indonesian government is de factor subsidizing harmful air pollution and respiratory illness and other diseases of Indonesians. Reform of these subsidies can reduce these health impacts and open up much-needed budgetary revenues for health care infrastructure and services.

Second, invest in health: Data and research are needed to help understand the health impacts of coal in Indonesia. The government should continue to strengthen the efforts to measure and monitor stations to indicate the level of air pollution in main Indonesian cities and areas surrounding coal power plants, tracking against air quality standards. Air pollution-related diseases should be reported as such, and the Ministry of Health should start analyzing the actual impacts. The risks of coal-caused pollution on health should be evaluated. The right parameters should be measured ($PM_{2.5}$, mercury emissions, etc.), and the concrete impacts of coal should be carefully analyzed.

Third, turn to cleaner forms of energy: The expansion of coal generation will entail significant health risks from air pollution that can be avoided through a shift to renewable energy. The Government of Indonesia has already defined a target to source 23 per cent of its energy from new and renewable energy, but coal capacity is still predicted to double within the next 10 years. Meeting the renewable energy target and reducing the share of electricity from coal would have significant positive consequences in the health of Indonesians, as avoiding problems such as those encountered in China (Global Subsidies Initiative, n.d.).

5. Main Messages and Conclusion

Coal is a very important source of energy in Indonesia, but it costs the government hundreds of millions of USD in the form of subsidies and negative health effects. This paper shows that burning coal emits several toxic substances for humans and that have been associated with non-communicable cardiovascular and respiratory diseases, such as stroke, asthma or lung cancer. Vulnerable groups are particularly affected by coal-related diseases. In Indonesia, it is estimated that coal pollution causes around 75,000 premature deaths per year, and this number could increase dramatically if the projected power plants are built (Koplitz, et al., 2017).

Treating coal-related NCDs is expensive and can take a significant part of the yearly incomes of low-income families. For example, therapy for chronic obstructive pulmonary disease (COPD) is estimated to cost around USD 1,125 per person per year (Anwar, Yusi, & Afdal, 2016). This is almost half of the yearly income of low-income families (USD 2,400, according to 2014 estimates) (Deloitte, 2015).

Subsidies to coal can lock the country into a future of high electricity and health costs, but this could be reversed if the government invested in renewable electricity sources. Renewable energy sources are proving to be cheaper than coal in many countries, including India. However, there are no price incentives for renewables in Indonesia. The country's government spends much more on subsidies to coal than on health. Total subsidies to fossil fuels in Indonesia are more than three times public spending in health (2013 figures) (see Figure 5).

The Government of Indonesia should phase out subsidies to coal and invest instead in health and clean energy. This can result in significant progress toward reducing NCD prevalence, resulting in lower health expenditures over time and higher productivity: healthier children can study better, and a decrease in workers' sick days per year can save money to businesses. Measures taken to reduce the burden of coal will support all the positive effects of a healthier Indonesia.

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