# สมุดปกขาว
# อากาศสะอาด

Clean Air White Paper, Thailand

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Thailand Clean Air Network

# CLEAN AIR WHITE PAPER

## Foreword

The issue of fine particulate matter ($PM_{2.5}$) became a hot topic in Thailand since early-2019, as the rising air pollution in Bangkok deteriorated to *hazardous* levels and caused visible smog that covered the city. City dwellers descended into near-panic state as the negative impact of pollution on health – especially for children, elderly people, and those with chronic pulmonary and cardiovascular diseases and other chronic disease (e.g. diabetes mellitus, kidney, liver, dementia, etc.) – were felt. Several schools were shut down for many days and a number of organizations started getting involved in dealing with this issue. This public anxiety also drove the demand for N-95 respirators (called "masks") and air purifiers, resulting in a rapid shortage in market supplies. The issue of $PM_{2.5}$ and other pollutants (e.g. persistent organic pollutants (POPs), heavy metals, organic and elemental carbons) are relatively new for Thailand, with the term only becoming widely known over in the past few years. Unfortunately, information regarding $PM_{2.5}$ was contradictory at times, which caused further confusion amongst the general public. To this end, governmental agencies and academic institutions have all stepped forward to share knowledge, knowhow and precautionary measures to the public through various media. This then prompted the government to announce "the problem of particulate air pollution" as a *National Agenda* February 12$^{th}$, 2019.

Apart from government agencies, there were many people from academia, health profession and civil society also started sharing knowledge with several forums discussing the issue and possible short-, medium-, and long-term solutions. These forums resulted to the formation of **Thailand Clean Air Network**, an open and expanding network that aims to collaborate with various relevant sectors to address the issue sustainably. The Clean Air Network sees air pollution not only from the vantage of the impact in Bangkok, but as a countrywide issue.

As $PM_{2.5}$ air pollution issue is highly complex, thorough understanding of the issue is of paramount importance. An in-depth understanding needs to be based on several academic disciplines, and synthesized with experience and viewpoint from the general public. This **Clean Air White Paper** aims to do just that. By discussing the **9 Key Foundations of $PM_{2.5}$ Issue in Thailand**, this paper aims to be the starting point in establishing the pathway for effective collaboration among all relevant sectors in tackling this issue. Following the White Paper, Thailand Clean Air Network will publish the *Clean Air Blue Paper* and *Clean Air Green Paper* which will dive deeper into the issues, pulling into them an in-depth knowledge from academia as well as direct experience from the general public and community leaders.

The overarching goal for the Clean Air Network is to bring about **clean air for everyone to breathe equitably.**

Thailand Clean Air Network
May 2019

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# 9 Key Foundations of $PM_{2.5}$ Issue in Thailand

Solving the issue of $PM_{2.5}$ air pollution starts from ensuring that all stakeholders have a common understanding on the basics of the issue. This paper discusses 9 key questions that form the foundation, namely:

1. What is "$PM_{2.5}$" and why is it important?
2. Is $PM_{2.5}$ really a health hazard, and how so?
3. What is the "Air Quality Guideline"?
4. What is the "Air Quality Index"?
5. How does $PM_{2.5}$ issue affect Thailand's economy and society?
6. What are the differences and similarities between Bangkok smog and the Northern Thailand haze problems?
7. Have sufficient actions been taken?
8. Why are the previously explored solutions not working?
9. How to sustainably address the issue?

# 1. What is "$PM_{2.5}$" and why is it important?

## What is "$PM_{2.5}$"?

Particulates floating in the air come in many sizes. Larger sand-based particulates, on the one hand, will fall to the ground quickly due to their mass. On the other hand, smaller particulates – specifically ones that are equal to or smaller than 100 μm (100 x $10^{-6}$ m) in diameter – tend to stay afloat in the air for much longer. These are therefore classified as *Total Suspended Particulate (TSP)*, and they are further classified into different "PM" (*Particulate Matter*) groups. Particulates with diameters equal to or smaller than 10 μm are categorized as $PM_{10}$ and they can pass through the nasal filter into the respiratory system. Smaller particulates with diameters equal to or smaller than 2.5 μm are categorized as $PM_{2.5}$ and they can go even further into the alveoli inside human lungs. **Figure 1** shows the relative sizes of these particulates.

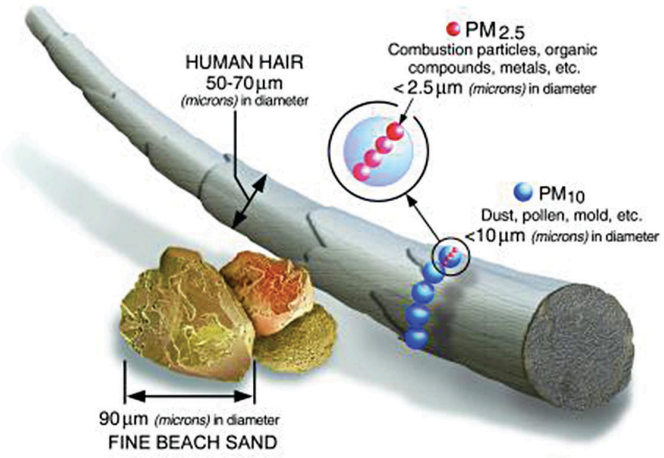



*Figure 1 - Relative Sizes of PM10 and PM2.5*

Emission sources for $PM_{2.5}$ particulates are abundant, both natural and man-made. Man-made sources include electricity generation (especially coal-based) power plants (Ehrlich et al., 2007), factories (Huang et al., 2007), automobile exhausts (Querol et al.,2001), open-air biomass burning (Tao et al., 2013), garbage burning (Mao et al., 2007), construction sites (Zhang et al., 2015), and open-air cooking (Li et al., 2015). Natural sources include forests' chemical (e.g. isoprene) emissions (Kourtchev et al., 2005, 2008). **Figure 2** shows the various key sources for $PM_{2.5}$.

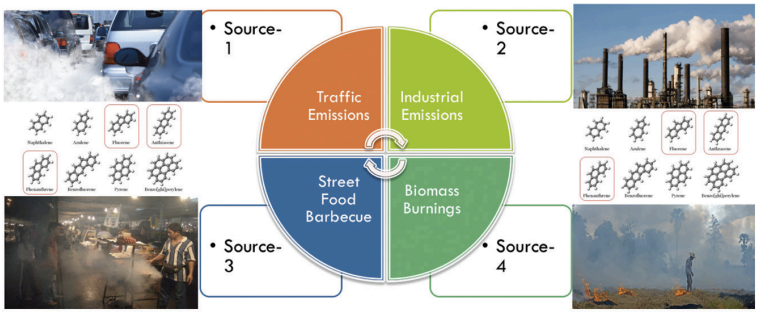



*Figure 2 – PM2.5 Emission Sources*

## What are included in $PM_{2.5}$ particulates?

$PM_{2.5}$ particulates stay afloat in the air among steam, smoke, and various gases. While small in size, they can combine together to create a large pollution mass floating around the atmosphere. These pollution mass contain heavy metals (Pongpiachan and Iijima, 2016; Pongpiachan et al., 2017a) including lead, mercury (D'itra, 1991), and cadmium (Inaba et al., 2005). They also contain cancer-inducing chemicals such as Polycyclic Aromatic Hydrocarbons or PAHs (Pongpiachan, 2013a,b,2016; Pongpiachan et al., 2015a,b) and mutation-inducing chemicals such as dioxin (Pongpiachan et al., 2016, 2019a,b) as well as hazardous microorganism (Aziz et al., 2018; Wolf et al., 2017). They can also react with allergens and induce allergic reactions in people prone to them.

$PM_{2.5}$ particulates, loaded with organic carbon and elementary carbon, that come through automobile emissions can also induce large-scale inclement weather as organic carbon substance tends to provide cooling effect while elementary carbon tends to provide heating effect to the earth (Koch and Del Genio, 2010; Menon et al., 2002; Ramanathan and Carmichael, 2008).

As the small $PM_{2.5}$ particulates can easily pass through nasal filters into the alveoli inside human lungs, they are considered to be amongst the most dangerous pollutants in the air.

*Note that there are both poisonous $PM_{2.5}$ particulates and non-poisonous ones. This paper deals solely with the poisonous particulates.*

## 2. Is $PM_{2.5}$ really a health hazard, and how so?

There has been ample evidence to suggest that air pollution – especially $PM_{2.5}$-based one – is a serious health hazard that warrant close monitoring. $PM_{2.5}$ was once known as the 5th most common cause of death among global population in 2015 (Cohen, 2017) while WHO announced that in 2016 air pollution was the cause of death for 7 million people globally, of this 4.6 million deaths was caused by pollution in the ambient air and 91% of which occurred in Southeast Asia and West Pacific (WHO, 2018a).

### $PM_{2.5}$ Impact on Respiratory, Cardiovascular, and Other Bodily Systems

$PM_{2.5}$ are small particulates that can permeate through lungs' alveoli; stimulating free radicals, reducing antioxidant, disrupting calcium balance, stimulating inflammatory substances and causing sudden and chronic allergic reactions. These effects can stimulate acute reactions among those with chronic cardiovascular diseases, and in the worst cases can increase the risk of lung cancer.

Black carbon components in the $PM_{2.5}$ particulates can damage vascular wall both directly and indirectly through the stimulated inflammatory substances. Damaged vascular wall can induce thrombosis and hardened blood vessels, increasing the risk of ischemia in the heart and the brain as well as cardiac arrhythmia including atrial fibrillation.

Latest research has further found increased risk of liver disease, kidney disease, rheumatic disease, Alzheimer's disease and diabetes among the population continuously exposed to high levels of $PM_{2.5}$ pollution (Bernatsky et al., 2016; Busso et al., 2018; Shou et al., 2019; Xu et al., 2019; Yang et al., 2018).

### $PM_{2.5}$ Impact on Children's Health

Children are considered highly at-risk to sustain negative impacts from $PM_{2.5}$ pollution, as they tend to breathe faster and have higher breathing volume proportion (per body weight) relative to adults. Furthermore, children are relatively shorter than adults so they spend more time closer to the ground where the air does not circulate well thus exposing them to higher risk. Children's immune systems are also not yet as effective as those of adults, furthering their chances of sustaining the negative impacts.

The adverse impacts from $PM_{2.5}$ in children can cause long-term problems and eventually lead to poor lung function and emphysema not unlike habitual smokers. Fetuses can also indirectly be exposed to pollution through their mothers, thereby sustaining the same long-term effects after birth (WHO, 2018b; Puranithee, 2019)

**Without sustainable and effective solutions to the air pollution problem, Thailand will most likely descend to become an aging society fill with sick people in the future.**

## 3. What is the "Air Quality Standard"?

One of the frequently confused matters surrounding the issue of $PM_{2.5}$ is the concept of **Air Quality Standard**. It is crucial, therefore, to understand the background and limitations of Thailand's Air Quality Standard for $PM_{2.5}$.

The increased interest in $PM_{2.5}$ was due, in part, to the publication of 1993 *Harvard Six-City Study* in which $PM_{2.5}$ was identified as a health hazard, prompting the U.S. to begin monitoring and controlling this pollutant in 1997 (Brugge and Olden, 2018).

Air Quality Guideline (AQG) was introduced by WHO in 2005 (WHO, 2006a; WHO, 2006b) following an increased interest in $PM_{2.5}$ issue in the U.S. and Europe. Recognizing that pollution affects people differently, AQG was developed to set a common *minimum target* of maximum acceptable level of $PM_{2.5}$ for countries to adopt. The guideline came with 3 levels of *interim targets* to enable countries to progressively enhance their pollution monitoring and control in accordance to their capabilities.

Thailand included $PM_{2.5}$ as one of the pollutants requiring monitoring and control in 2010 and adopted WHO's AQG interim target **level 2** as the national Air Quality Standard. This is the same level as that of Malaysia and South Korea. **Table 1** – WHO's Targets of PM2.5 Level and Nations' Air Quality Standard level (2019), (shows the breakdown of WHO's AQG target levels and how different countries use them.

| WHO's Target of $PM_{2.5}$ level<br><br>*adopted nations* | 24-Hour Average ($\mu g/m^3$) | Annual Average ($\mu g/m^3$) |
|---|---|---|
| Interim Target Level 1 | 75 | 35 |
| Interim Target Level 2<br>*Thailand, Malaysia, South Korea* | 50 | 25 |
| Interim Target Level 3 | 37.5 | 15 |
| *Japan, Taiwan* | 35 | 15 |
| *United States of America* | 35 | 12 |
| **WHO Target** | 25 | 10 |
| *Australia* | 25 | 8 |

*Table 1 – WHO's Targets of $PM_{2.5}$ Level and Nations' Air Quality Standard level (2019), (Adapted from Pongpiachan et al., 2019).*

To ensure progressive improvements, the U.S. had established the *Environmental Protection Agency (EPA)*; and there have been lawsuits against the EPA on the grounds that the established $PM_{2.5}$ standard had been non-compliant with the revision schedule stipulated in the US *Clean Air Act*.

**Thailand, on the other hand, does not have law nor legal enforcement mechanism to update local air quality standards regularly, in the same way as say the US EPA, which has been sued for failure to adjust air quality standard as required by the Clean Air Act.**

# 4. What is the "Air Quality Index (AQI)"?

## What is the "Air Quality Index (AQI)"?

**Air Quality Index (AQI)** is a common standard to assess and report air pollution concentration. It was developed as a friendly way to report air quality and to provide advance warning for the public when air quality deteriorates.

AQI was first developed and used in the U.S. and was further adopted by countries around the globe including Thailand. AQI is normally reported with a color-coding scheme. **It is important to note that the color-coding scheme used within a country is relative to the country's adopted standard air pollution level and will therefore differ from one country to the next.**

## What are the limitations of the existing scheme of AQI reporting?

- **AQIs reported concurrently by different organizations can differ** – As AQIs reported by different countries/organizations – Pollution Control Department (air4thai.pcd.go.th), World Air Quality Project (aqicn.org) and IQ Air (airvisual.com), to name a few – are based on different calculation techniques and factors.

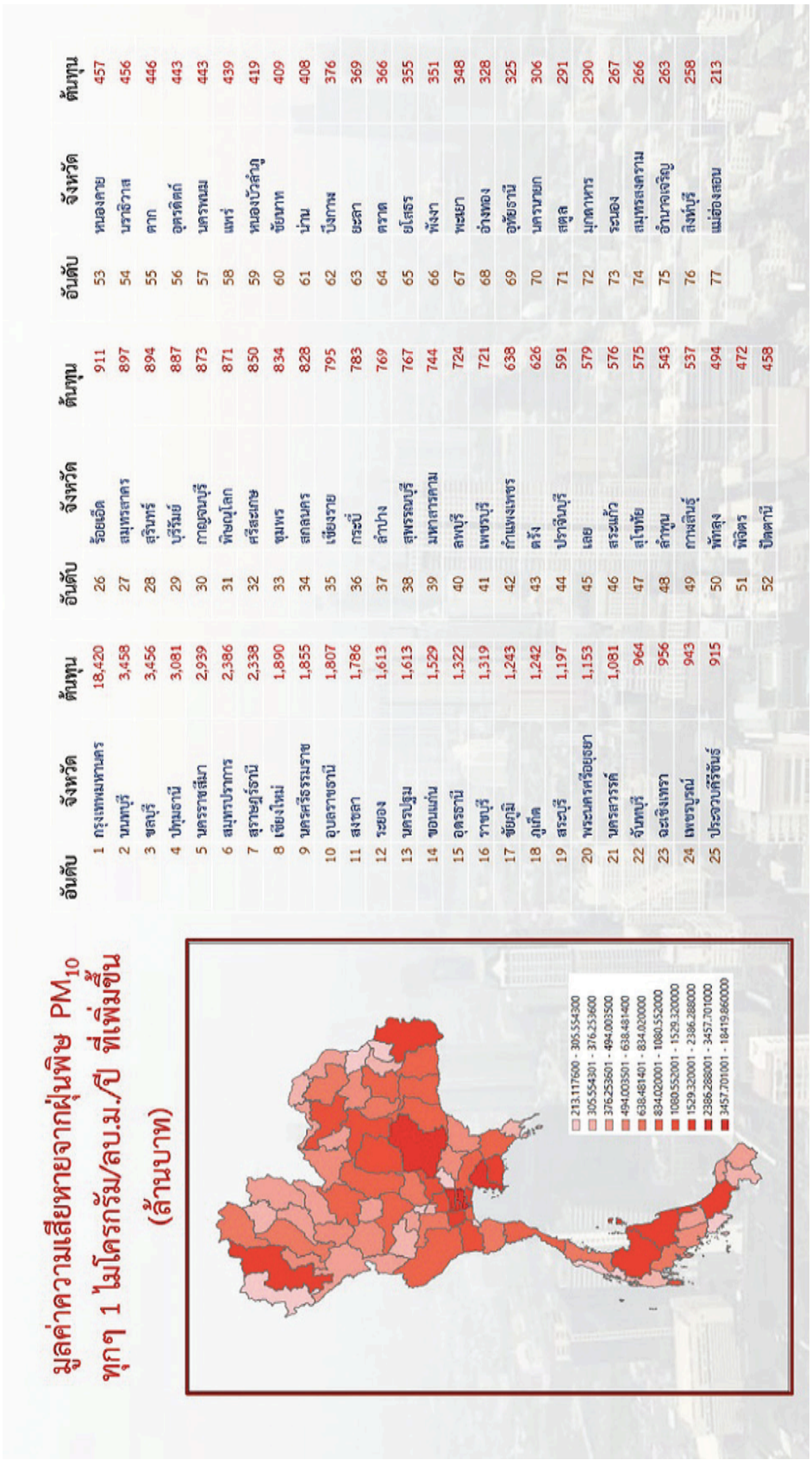
- **AQIs reported do not necessarily tell the current situation** – The reporting of AQI, whether by air4thai.pcd.go.th or many other sources, does not tell of the precise air quality level at a given time and location. This is because AQIs are commonly reported based on a rolling average of the past 24-hour. This was one of the reasons the *World Air Quality Project* (aqicn.org) proposed an *instant-cast* scheme, using a rolling average of the past 3 hours instead. The *instant-cast* scheme is relatively more accurate to the current situation that a similarly proposed *nowcast* scheme from the U.S. EPA (airnow.gov). In any case, a 24-hour rolling average monitoring of $PM_{2.5}$ is certainly not sufficient due to the rapidly changing nature of the weather (The World Air Quality Project, 2015).

- **AQIs do not take into account the effects from a combination of pollutants floating in the air** – Air pollution is normally a result of several categories of pollutants, each with their own health effects. While Ozone and Nitrogen Dioxide can cause acute problems, $PM_{2.5}$ cause less acute but longer-term effects. Therefore, the conventional wisdom of *individual AQI* may not be effective in providing the health hazard indicator. This limitation prompted the development of *Air Quality Health Index (AQHI)* (Stieb et al., 2008), which uses weighted average on a rolling 3-hour basis to determine health impact of the air quality level observed. AQHI is being used in Canada and Hong Kong (Pongpienchan et al., 2019). **Note that AQHI is based on epidemiology impacts of pollutants, and therefore is independent of the country's Air Quality Standards.**

# 5. How does $PM_{2.5}$ issue affect Thailand's economy and society?

## Effects on the Society

Several studies abroad have tried to quantify the cost of economic damage – both economically and socially – that results from air pollution. A study by Levinson (2012), for example, looked at the cost of air pollution in the U.S. between 1984 – 1996 and found that each American household was willing to contribute US$1,037 per annum to aid in 1 $\mu g/m^3$ reduction of $PM_{10}$. Such study has been limited in Thailand with a study by Attavanich (2019) being the first. Using a similar methodology as that of Levinson, Attavanich (2019) found that, in Bangkok, a household was willing to contribute THB 6,379.67 per annum for a 1 $\mu g/m^3$ reduction of $PM_{10}$. Multiplying this aforementioned number with Bangkok's 2017 household count of 2,887,274 (Department of Provincial Administration, 2018) resulted in an economic damage cost of THB 18,420 millions for each 1 $\mu g/m^3$ of $PM_{10}$ over the safe standard. Similar assessment was conducted for several other provinces in Thailand with a result shown in **Figure 3**.




| อันดับ | จังหวัด | ต้นทุน |
|---|---|---|
| 1 | กรุงเทพมหานคร | 18,420 |
| 2 | นนทบุรี | 3,458 |
| 3 | ชลบุรี | 3,456 |
| 4 | ปทุมธานี | 3,081 |
| 5 | นครราชสีมา | 2,939 |
| 6 | สมุทรปราการ | 2,386 |
| 7 | สุราษฎร์ธานี | 2,338 |
| 8 | เชียงใหม่ | 1,890 |
| 9 | นครศรีธรรมราช | 1,855 |
| 10 | อุบลราชธานี | 1,807 |
| 11 | สงขลา | 1,786 |
| 12 | ระยอง | 1,613 |
| 13 | นครปฐม | 1,613 |
| 14 | ขอนแก่น | 1,529 |
| 15 | อุดรธานี | 1,322 |
| 16 | ราชบุรี | 1,319 |
| 17 | ชัยภูมิ | 1,243 |
| 18 | ภูเก็ต | 1,242 |
| 19 | สระบุรี | 1,197 |
| 20 | พระนครศรีอยุธยา | 1,153 |
| 21 | นครสวรรค์ | 1,081 |
| 22 | จันทบุรี | 964 |
| 23 | ฉะเชิงเทรา | 956 |
| 24 | เพชรบูรณ์ | 943 |
| 25 | ประจวบคีรีขันธ์ | 915 |

| อันดับ | จังหวัด | ต้นทุน |
|---|---|---|
| 26 | ร้อยเอ็ด | 911 |
| 27 | สมุทรสาคร | 897 |
| 28 | สุรินทร์ | 894 |
| 29 | บุรีรัมย์ | 887 |
| 30 | กาญจนบุรี | 873 |
| 31 | พิษณุโลก | 871 |
| 32 | ศรีสะเกษ | 850 |
| 33 | ชุมพร | 834 |
| 34 | สกลนคร | 828 |
| 35 | เชียงราย | 795 |
| 36 | กระบี่ | 783 |
| 37 | ลำปาง | 769 |
| 38 | สุพรรณบุรี | 767 |
| 39 | มหาสารคาม | 744 |
| 40 | ลพบุรี | 724 |
| 41 | เพชรบุรี | 721 |
| 42 | กำแพงเพชร | 638 |
| 43 | ตรัง | 626 |
| 44 | ปราจีนบุรี | 591 |
| 45 | เลย | 579 |
| 46 | สระแก้ว | 576 |
| 47 | อุโมทัย | 575 |
| 48 | ลำพูน | 543 |
| 49 | ตาพลีบุรี | 537 |
| 50 | พัทลุง | 494 |
| 51 | พิจิตร | 472 |
| 52 | นิคตานี | 458 |

| อันดับ | จังหวัด | ต้นทุน |
|---|---|---|
| 53 | หนองคาย | 457 |
| 54 | นราธิวาส | 456 |
| 55 | ตาก | 446 |
| 56 | อุตรดิตถ์ | 443 |
| 57 | นครพนม | 443 |
| 58 | แพร่ | 439 |
| 59 | หนองบัวลำภู | 419 |
| 60 | ชัยนาท | 409 |
| 61 | น่าน | 408 |
| 62 | บึงกาฬ | 376 |
| 63 | ยะลา | 369 |
| 64 | ตราด | 366 |
| 65 | ยโสธร | 355 |
| 66 | พังงา | 351 |
| 67 | พะเยา | 348 |
| 68 | อ่างทอง | 328 |
| 69 | อุทัยธานี | 325 |
| 70 | นครนายก | 306 |
| 71 | สตูล | 291 |
| 72 | มุกดาหาร | 290 |
| 73 | ระนอง | 267 |
| 74 | สมุทรสงคราม | 266 |
| 75 | อำนาจเจริญ | 263 |
| 76 | สิงห์บุรี | 258 |
| 77 | แม่ฮ่องสอน | 213 |

*Figure 3 - Economic Damage Cost of $PM_{10}$*

Based on the above result, and with the annual average of $PM_{10}$ level in Bangkok in 2017 being 44.21 μg or 24.21 μg over the safe standard recommended by WHO, **the total**

**societal damage cost to Bangkok households for the year would be THB 446,023 millions** as shown in FIGURE. Other than Bangkok; Nakorn Ratchasima, Nonthaburi, Chonburi, Saraburi, Samut Prakarn, Pathum Thani, Ayutthaya, Chiang Mai, Khon Kaen, and Ratchaburi are among the most economically impacted provinces.

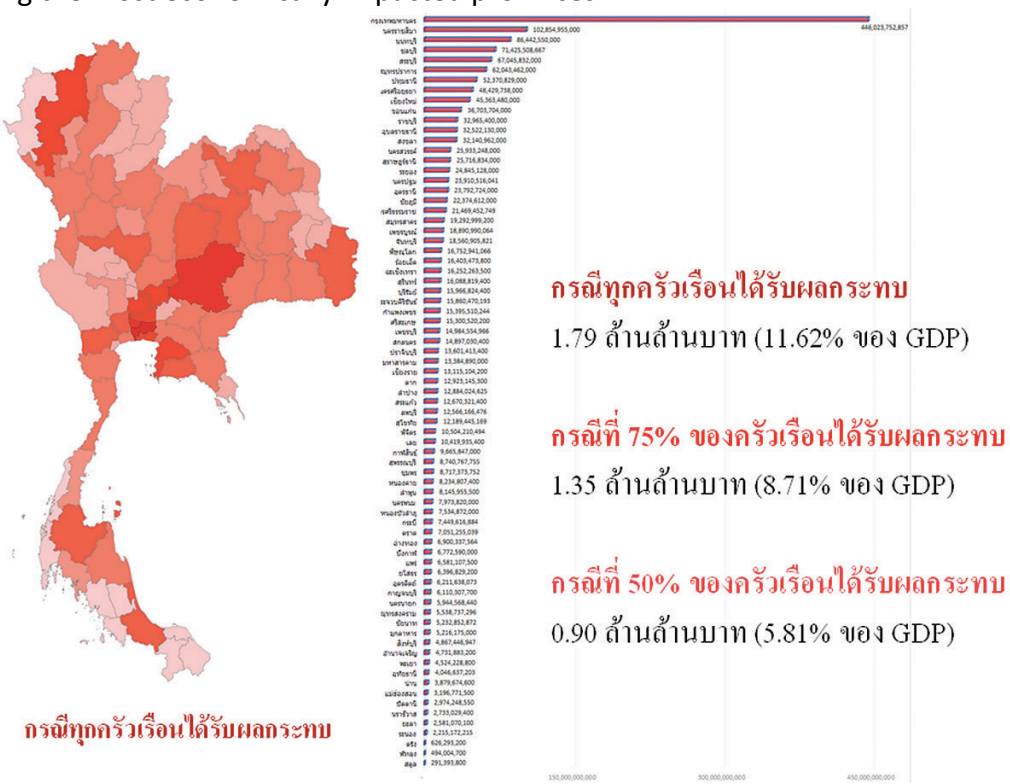



*Figure 4 - 2017 $PM_{10}$ Economic Impact Projection*

**Assuming uniform distribution of the impact on *every* Thai household, Thailand would have sustained THB 1.79 trillion in societal damage due to PM10 pollution in 2017. This was equivalent to 11.62 of the country's GDP that year.** Adjusting the assumption of $PM_{10}$ impact distribution; at 75% of Thai households being impacted, the damage number would have been THB 1.35 trillion (8.71% of GDP); at 50%, the damage number would have been THB 0.90 trillion (5.81% of GDP).

**Since there is yet a quantitative study on $PM_{2.5}$ economic damage in a similar manner, the use of $PM_{10}$ quantitative impact may be used as *minimum* estimated damage. The negative societal impact due to $PM_{2.5}$ will likely be more pronounced due to its relatively more hazardous nature compared to $PM_{10}$.**

## Effects on Tourism

While an assessment on economical and societal impacts mentioned above can provide an indication of the damage sustained due to air pollution in Thailand, it is not comprehensive enough as negative impacts on other income-generating industries have not been taken into account. Tourism, for one, is likely to take a direct hit as evidenced in past studies show decline in tourism in places with high air pollution. Cheung, Catherine & Law (2001), for example, studied the impact of Hong Kong air pollution on tourism and found that westerners residing in countries with good air quality tend to worry more about air pollution than easterners/Asians. Zhang et al. (2015) is another study that assessed tourism impact sustained by China during the haze crisis in Beijing and found evidence of trip cancellations and postponement driven by the issue.

**Thailand, whose economy relies heavily on tourism, will very likely be impacted should the air pollution remain high. This is particularly so between December to March when air pollution levels in many places around the country are relatively high, and is coincidentally also the same peak travel period for tourists traveling to Thailand.**

# 6. What are the differences and similarities between Bangkok smog and Northern Thailand haze problems?

## Differences: Sources and Actions

Smog in Bangkok is found to have been caused by diesel engine emissions, biomass burning, and secondary dust (Pollution Control Department, 2018). Haze in the Northern Thailand, on the other hand, is found to have been caused primarily by open-air biomass burnings that commonly occur between February to April each year.

Actions taken in response to the issue in Bangkok have been more concrete compared to counterpart in the north, including school shutdowns on some of the most polluted days to protect children from being exposed. In the north, on the contrary, no concrete actions were taken apart from the blanketed burning prohibition. The prohibition did not take into account the nuances of biomass burning, which stem from various reasons – agricultural land preparation, cyclic farming, wild animal hunting, etc. – and thus require different control measures.

## Similarities: Injustice and Inequality

$PM_{2.5}$ issue affects *everyone*, but people are impacted differently. Part of the impact variation is due to personal health, but a part of it is due to stark inequalities in society. Specifically:

- Inequality in the access to knowledge and facts, especially on the level of air pollution present due to the lack of monitoring equipment, which results in inadequate support for people living in these polluted areas;
- Inequality in the access to protective equipment, especially N-95 respirators and air purifiers which are relatively expensive compared to general income levels and;
- Inequality between urban and rural cities, which sees urban cities like Bangkok being the center of government's focus while far-flung rural towns are neglected.

# 7. Have the actions taken been sufficient?

Since the $PM_{2.5}$ issue began to grip the public's attention recently, the government has ordered several actions and measures to address it. A comprehensive review of the actions and measures taken is necessary. Here are examples of questions on certain key actions:

## Have the measures to increase awareness been sufficient?

**The answer is "*not sufficient*".** While the National Environment Board did set a $PM_{2.5}$ standard level in ambient air since 2010 (National Environment Board, 2010), currently the public's awareness of $PM_{2.5}$ health hazards are severely limited. This is evidenced by the lack of protective mask usage by city-dwellers on high-pollution days. Additionally, air quality monitoring and reporting are also not yet comprehensive, and many at-risk areas are still lacking proper equipment. Strengthened awareness drive and the increase in air quality monitoring/pre-warning equipment are therefore of paramount importance to ensure the public's safety.

## Are the Euro 3 / Euro 4 emission standards currently in enforced on commercial trucks sufficient?

**The answer is *"not sufficient".*** Thailand has been using *Euro 3* emissions standard for heavy trucks since 2007 (12 years ago) and *Euro 4* emissions standard for light trucks since 2012 (7 years ago). These standards have not been changed since then, despite reports of 3,259,945 increases in personal vehicles and light trucks along with 160,916 increase in heavy trucks over the period (Department of Land Transport, 2019). With stagnant standards and the increasing number of vehicles, air pollution due to engine exhaust has been rising along the way. While the government had planned to upgrade the national standards to be based on *Euro 5* emissions standard, the target enforcement has been shifted from 2020 to 2022 and subsequently to 2024. Though the government has attempted to fasten the pace of preparation and now targets 2023 for *Euro 5* enforcement, it is still a relatively long time to enact this standard compared to other countries including the European Union, Hong Kong, South Korea (3 years), and China (4 years) (European Environment Agency, 2016). The rapid enhancement of emission standards is therefore one key area to improve.

## Has biomass burning prohibition been effective?

**The answer is *"not effective".*** Despite the government's policy on biomass burning pollution control being included in all levels of legal provisions, from the 2017 Constitution to the National Economic and Social Development plans and Climate Change Management Master Plan, there is still a lack of framework to enable collaboration and integration of the work done by various sectors and governmental agencies. To further worsen the case, biomass burning prohibitions announced at the provincial levels are (a) not harmonized and (b) not enforced effectively. This is evidenced by satellite images showing a large number of

“hotspots” around the country and regular reports of high $PM_{10}$ and $PM_{2.5}$ concentrations every year between January and April.

As such, there needs to be a governmental framework to ensure harmonized actions and to enable collaboration between among all relevant sectors. Additional measures including scientific knowledge sharing, enhanced support for provincial administrations, systematic biomass burning control in areas where rotational farming is still active, and improved database documenting forest utilization are necessary.

**It should be evident from the examples above that the existing actions and measures to combat the air pollution issue do not suffice. Additional measures are required to sustainably and comprehensively tackle the issue in all aspects.**

# 8. Why are the previously explored solutions not working?

Two major contributors to the failure in sustainably combating the air pollution issue are (1) the lack of comprehensive information about the problem and (2) an unbalanced focus on economic growth without regard to the associated impacts.

## Lack of Comprehensive Information: A Case of Industrial Emission

The lack of reliable and comprehensive information on air pollution and major pollutants is most pronounced in the case of missing industrial emission information. A database documenting factories' emission profiles, known as the *Emission Inventory (EI)*, has not yet been created in Thailand. To enforce disclosure of factories' emission profiles and create EI, an enforceable regulation is required. Such regulation is known among the UN and OECD countries as *Pollutant Release and Transfer Registers (PRTR)* or otherwise known in the U.S. as *Toxics Release Inventory*. These do not exist currently in Thailand.

Despite the presence of more than 140,000 factories in the country, the Thai government has yet to establish industrial emission standard of $PM_{2.5}$ to control these pollutants. The public is therefore left to face the consequences of black smoke being emitted from factory smoke stacks on a regular basis, especially in Rayong, Saraburi and Samut Sakorn where high concentrations of these factories are present. **The lack of Emission Inventory causes inaccuracies in past and current analysis of $PM_{2.5}$ sources, especially in Bangkok, which is surrounded by many provincial factory hubs.**

Because $PM_{2.5}$ released from factories can travel huge distances, in order to manage smog and air pollution in Thailand, it is important to understand the industries located in each area and those in adjacent areas. This is particularly relevant in today's context given the Government's push to stimulate economic growth has prompted the relaxation of regulations on environmental protection, public health, and city planning. **These relaxed regulations have enabled – and driven – the rapid increase in new factories as manufacturers relocate their hubs from more stringent countries (such as Japan and China) to Thailand.**

## Unbalanced Focus on Economic Growth

Conventional wisdom in national development adopted by the Thai government has been rather unbalanced, with a strong focus on economic growth and a lack of focus on basic needs of the public. This unbalanced focus has rendered the nation crippled with unsustainable development, as evidenced by Attavanich et al. (2016) which estimated the value of environmental and resource costs to be as high as 14.58% of the nation's GDP. By taking a closer look at the THB 3 trillion national budget for the fiscal year 2019, environmental budget accounted for only THB 10,945 million. This was a stark contrast to the THB 642,031 million allocated for economic activities (Attavanich, 2019).

Further comparing Thailand's allocated environmental budget to those of other countries places Thailand on the low end of the spectrum, with the allocated budget accounting for only 0.05% of the nation's GDP while the European Union (EU) and China they account for 0.70% and 0.64% of their GDPs, respectively. Comparing the environmental budget to the nation's planned budget for the fiscal year 2016, Thailand's environmental allocation accounted for 0.25% of total planned spending while EU (EU-28) and China they are 1.62% and 2.52% of their total planned spending, respectively. (Attavanich, 2019; Bureau of Budget, 2017; EUROSTAT, 2019; OECD, 2019; World Bank, 2017).

A nation's stable, prosperous and sustainable development depends on equitable focus on the three pillars i.e. economic development, societal prosperity, and environmental sustainability. It is important that Thailand begins to seriously look at enhancing the focus on environmental sustainability and increasing allocated budget to concretely tackle environmental problems.

**The true *"under the iceberg"* foundation of the air pollution problem is the government's development paradigm that focuses more on economic growth to the detriment of people's well-being. This is considered a *structural violence* that renders the people – especially the impoverished and "out-of-sight" ones in the far-flung rural areas – powerless. Thai people end up having to succumb to the effects of governmental policies, ordered from the ivory tower, that do not take into account their livelihoods and well-beings.**

# 9. How to sustainably address this issue?

From the eight key questions above, it is evident that $PM_{2.5}$ air pollution is a complex and multifaceted problem. Furthermore, this issue also highlights the gross injustice and *structural violence* within Thai society. To effectively and sustainably tackle air pollution requires **major revisions to the legal mechanism and organizational structure of the related entities.** This section describes the legal issues and proposes two major solutions required.

## The Problem with Existing Legal Mechanism

Two major problems are evident with the existing legal mechanism within the Thai government in tackling the air pollution issues are:

1. **Existing regulations and organizational structure are not sufficient** – The existing environmental regulations are limited and scattered thus rendering them very weak in terms of enforceability. Part of the reason is the "silo" mode of operating among various relevant units within the Government. Furthermore, these Governmental entities are also severely limited as their focus and ability to drive changes by the laws that established them which limit their governing restrictions and bureaucracies. Additionally, the core Environmental Act has also not been updated since its initial effective date in 1992.

2. **Revisiting only some specific articles or regulations is Insufficient** – Air pollution issues, especially those related to $PM_{2.5}$, are highly complex and have strong adverse impacts on health and environmental sustainability. Tackling the problem will require an integrated and multi-disciplinary approach to establish the appropriate legal mechanism. Most critically, a *paradigm shift* in both the legal content and enforcement process is needed, with a focus on comprehensively and systematically addressing the problem as a whole rather than relying on existing systems in place. New values need to be injected into the entire legal system.

## Proposed Solutions

To effectively and sustainably address the air pollution issues, Thailand requires two new legal mechanisms:

1. **The development of a *Clean Air Act (CAA)*** – The Clean Air Act needs to be an integrated and comprehensive law that recognizes people's *right to breathe clean air*. The Act needs to establish *duties of the State* to continuously implement the processes of *Progressive Realization of Right: Respect – Protect – Fulfill*. The processes have to be done using the existing system of public administration and the participation of all sectors of Thai society. The processes include:

a. a provision that the people's right to breathe clean air is to be *respected;*
b. a provision that the people's right to breathe clean air is to be *protected* from violation and;
c. a provision that the people's right to breathe clean air is to be progressively *fulfilled* through the Government's measures

2. **The establishment of *Thai Environmental Protection Agency (TH EPA)*** – A Thai Environmental Agency needs to be established as a reform to the existing ineffective environmental protection infrastructure. This agency has to be the main organization authorized to take concrete measures on national environmental protection and be mandated to report directly to Parliament. In tackling the $PM_{2.5}$ issue, this agency needs to be able to integrate and enforce the various regulations required beyond the bounds of traditional ministerial structure within the Government.

## Conclusion and Pathway Forward

By thoroughly dissecting the **9 Key Foundations of $PM_{2.5}$ Issues in Thailand**, this paper has uncovered a large "iceberg" that forms the air pollution issue being faced in the country. The **events** – visible smog and poor air quality that choke the nation time and time again every winter – is but the tip of the iceberg. However, under the water surface invisible to the eyes, are **vicious pattern** and **failing structure** that have never been adjusted to suit the changing times. The pattern and structure are based on **conventional mental model** that focuses only on reactive fixes to the visible events rather than sustainable prevention and control of the problems (**Figure 5**). **Thailand requires a major paradigm shift in the mental model and a systemic change to the existing infrastructure to effectively and sustainably address the air pollution crisis.**

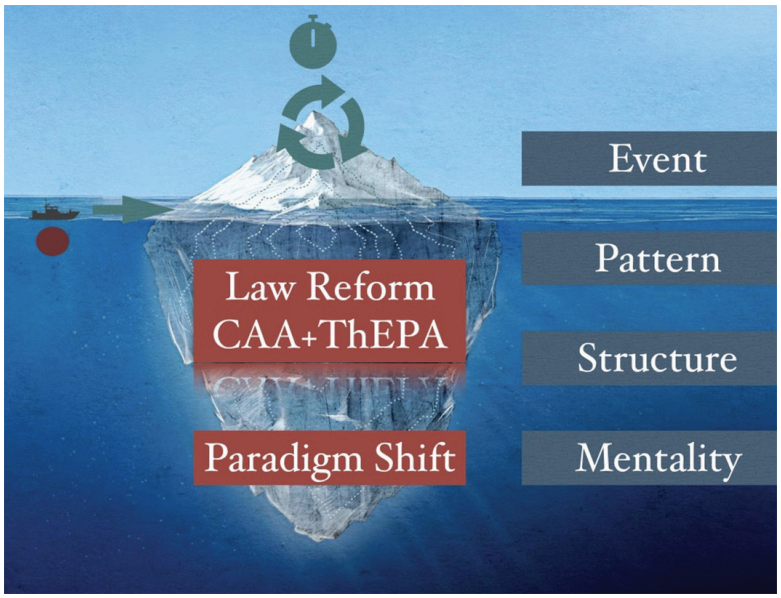



*Figure 5 - The Iceberg Metaphor*

To chart the path forward, the **Thailand Clean Air Network** will further analyze the issues and research relevant legislations before **drafting a proposal for the *Clean Air Act* and suggesting the pathway toward an establishment of Thailand Environmental Protection Agency**. The drafting of this proposed Clean Air Act would be predicated on The Three Bases of Legal Study (**Figure 6**) to ensure the ability to truly solve social problems rather than becoming the origin of the problems.

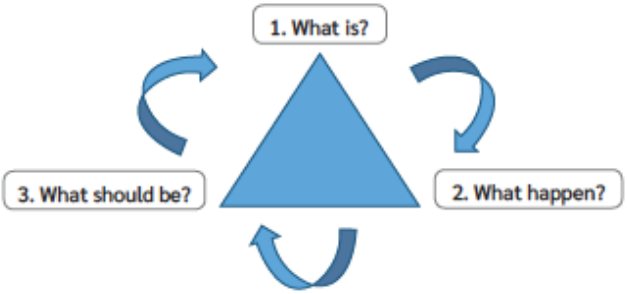



*Figure 6 – The Three Bases of Legal Study*

The draft Act will be a *bottom up legislation* both in its "content" and "process", achieving the "ultimate benefit" to most people in the country in the form of "public interest" based on two basic principles:

1. Sustainable development, with a balance between economic growth and environmental sustainability; and
2. Sufficient economy model philosophized by the late King Rama IX.

In summary, the draft Clean Air Act must be a "bottom up legislation" by its contents and process, where people from all sectors can significantly participate as oppose to the traditional "top down legislation."

***Thailand Clean Air Network is charting this path forward with the hope of protecting the right of the people to breathe clean air.***

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# References


Thai

กรมการขนส่งทางบก. (2562).
สถิติจำนวนรถที่จดทะเบียนใหม่ตามกฎหมายว่าด้วยรถยนตร์และล้อเลื่อน กฎหมายว่าด้วยการขนส่งทางบกปี พ.ศ. 2544 สำนักทะเบียนและภาษีรถ (กรุงเทพมหานคร) สืบค้นจาก https://web.dlt.go.th/statistics/

กรมควบคุมมลพิษ. (2561).
โครงการศึกษาแหล่งกำเนิดและแนวทางการจัดการฝุ่นละอองขนาดไม่เกิน 2.5 ไมครอนในพื้นที่กรุงเทพและปริมณฑล. สืบค้นจาก http://infofile.pcd.go.th/air/PM2.5.pdf?CFID=91361&CFTOKEN=38560989

คณะกรรมการสิ่งแวดล้อมแห่งชาติ. (2553). ประกาศคณะกรรมการสิ่งแวดล้อมแห่งชาติ ฉบับที่ 36 (พ.ศ. 2553) เรื่อง กำหนดมาตรฝุ่นละอองขนาดไม่เกิน 2.5 ไมครอน ในบรรยากาศทั่วไป. ราชกิจจานุเบกษา เล่ม 127 ตอนพิเศษ 37 ง หน้า 61. สืบค้นจาก http://infofile.pcd.go.th/law/2_99_air.pdf?CFID=1953647&CFTOKEN=59176941

ปองทอง ปูรานิธี. (2562, กุมภาพันธ์). PM 2.5 และสุขภาพเด็ก. บทความประกอบการนำเสนอในการเสวนาไทยพร้อมล้อมวงครั้งที่ 2 (1 กุมภาพันธ์ 2562), กรุงเทพฯ.

เพ็ญโฉม แซ่ตั้ง. (2562, กุมภาพันธ์). การนำเสนอ เวทีไทยพร้อมล้อมวง ครั้งที่ 4 (24 กุมภาพันธ์ 2562), กรุงเทพฯ.

ศิวัช พงษ์เพียจันทร์, รณบรรจบ อภิรติกุล, & รุจิกาญจน์ นาสนิท. (2562). PM 2.5 มัจจุราชเงียบ กรุงเทพฯ: บุ๊คด็อทคอม.

สำนักงบประมาณ. (2560). พระราชบัญญัติงบประมาณรายจ่ายประจำปีงบประมาณ พ.ศ.2560. สืบค้นจาก ttp://www.bb.go.th/topic.php?gid=543&mid=308

สำนักงบประมาณ. (2562). พระราชบัญญัติงบประมาณรายจ่ายประจำปีงบประมาณ พ.ศ.2562. สืบค้นจาก ttp://www.bb.go.th/topic.php?gid=543&mid=308

English

AirNow. (2016). Air Quality Index (AQI) Basics. Retrieved from US EPA's Air Now website: https://airnow.gov/index.cfm?action=aqibasics.aqi

Attavanich, W. (2019). Social cost of air pollution in Thailand and solutions. PIER Discussion Paper (forthcoming).

Attavanich, W., R. Mungkung, I. Mahathanaseth, S. Sanglestsawai, and A.Jirajariyavech. (2016). Developing Green GDP Accounting for Thai Agricultural Sector Using the Economic Input Output - Life Cycle Assessment to Assess Green Growth. Conference Proceeding of SEE 2016 in conjunction with ICGSI 2016 and CTI 2016. https://mpra.ub.uni-muenchen.de/83785/1/MPRA_paper_83785.pdf

Aziz, A.A., Lee, K., Park, B., Park, H., Park, K., Choi, I.G. and Chang, I.S., 2018. Comparative study of the airborne microbial communities and their functional composition in fine particulate matter (PM2. 5) under non-extreme and extreme PM2. 5 conditions. Atmospheric environment, 194, pp.82-92.

Bernatsky, S., Smargiassi, A., Barnabe, C., Svenson, L. W., Brand, A., Martin, R. V., ... & Edworthy, S. (2016). Fine particulate air pollution and systemic autoimmune rheumatic disease in two Canadian provinces. Environmental research, 146, 85-91.

Brugge, D., & Olden, K. (2018). Particles in the Air: The Deadliest Pollutant is One You Breathe Every Day. Springer.

Busso, I. T., Mateos, A. C., Juncos, L. I., Canals, N., & Carreras, H. A. (2018). Kidney damage induced by sub-chronic fine particulate matter exposure. Environment international, 121, 635-642.

Cheung, C., & Law, R. (2001). The impact of air quality on tourism: The case of Hong Kong. Pacific Tourism Review, 5(1-2), 69-74.

Cohen, A. J., Brauer, M., Burnett, R., Anderson, H. R., Frostad, J., Estep, K., . . . Dandona, R. (2017). Estimates and 25-year trends of the global burden of disease attributable to ambient air pollution: an analysis of data from the Global Burden of Diseases Study 2015. The Lancet, 389(10082), 1907-1918.

D'itra, F.M., 1991. Mercury contamination-what we have learned since Minamata. In Fourth Symposium on our Environment (pp. 165-182). Springer, Dordrecht.

Ehrlich, C., Noll, G., Kalkoff, W.D., Baumbach, G. and Dreiseidler, A., 2007. PM10, PM2. 5 and PM1. 0—emissions from industrial plants—results from measurement programmes in Germany. Atmospheric Environment, 41(29), pp.6236-6254.

European Environment Agency (2016) Adoption of the EU Euro emissions standards for road vehicles in Asian countries. Accessed online (April 20, 2019) https://www.eea.europa.eu/data-and-maps/figures/number-of-international-environmental-agreements-adopted-1

EUROSTAT. (2019). Government expenditure on environmental protection.

Huang, H., Lee, S.C., CAO, J.J., ZOU, C.W., CHEN, X.G. and FAN, S.J., 2007. Characteristics of indoor/outdoor PM2. 5 and elemental components in generic urban, roadside and industrial plant areas of Guangzhou City, China. Journal of environmental sciences, 19(1), pp.35-43.

Inaba, T., Kobayashi, E., Suwazono, Y., Uetani, M., Oishi, M., Nakagawa, H. and Nogawa, K., 2005. Estimation of cumulative cadmium intake causing Itai–itai disease. Toxicology letters, 159(2), pp.192-201.

Koch, D. and Del Genio, A.D., 2010. Black carbon semi-direct effects on cloud cover: review and synthesis. Atmospheric Chemistry and Physics, 10(16), pp.7685-7696.

Kourtchev, I., T. Ruuskanen, Willy Maenhaut, M. Kulmala, and Magda Claeys. "Observation of 2-methyltetrols and related photo-oxidation products of isoprene in boreal forest aerosols from Hyytiälä, Finland." Atmospheric Chemistry and Physics 5, no. 10 (2005): 2761-2770.

Kourtchev, I., Warnke, J., Maenhaut, W., Hoffmann, T. and Claeys, M., 2008. Polar organic marker compounds in PM2. 5 aerosol from a mixed forest site in western Germany. Chemosphere, 73(8), pp.1308-1314.

Levinson, A. (2012). Valuing public goods using happiness data: The case of air quality. Journal of Public Economics, 96(9-10), 869-880.

Li, Y.C., Shu, M., Ho, S.S.H., Wang, C., Cao, J.J., Wang, G.H., Wang, X.X., Wang, K. and Zhao, X.Q., 2015. Characteristics of PM2. 5 emitted from different cooking activities in China. Atmospheric Research, 166, pp.83-91.

Mao, I.F., Chen, C.N., Lin, Y.C. and Chen, M.L., 2007. Airborne particle PM2. 5/PM10 mass distribution and particle-bound PAH concentrations near a medical waste incinerator. Atmospheric Environment, 41(11), pp.2467-2475.

Menon, S., Hansen, J., Nazarenko, L. and Luo, Y., 2002. Climate effects of black carbon aerosols in China and India. Science, 297(5590), pp.2250-2253.

OECD. (2019). Environmental protection expenditure and revenues. Retrieved from: https://stats.oecd.org/Index.aspx?DataSetCode=EPER

Pongpiachan, S., Tipmanee, D., Khumsup, C., Kittikoon, I. and Hirunyatrakul, P., 2015a. Assessing risks to adults and preschool children posed by PM2.5-bound polycyclic aromatic hydrocarbons (PAHs) during a biomass burning episode in Northern Thailand. Science of the Total Environment, 508, pp.435-444.

Pongpiachan, S., Hattayanone, M., Choochuay, C., Mekmok, R., Wuttijak, N. and Ketratanakul, A., 2015b. Enhanced PM10 bounded PAHs from shipping emissions. Atmospheric environment, 108, pp.13-19.

Pongpiachan, S., 2013a. Diurnal variation, vertical distribution and source apportionment of carcinogenic polycyclic aromatic hydrocarbons (PAHs) in Chiang-Mai, Thailand. Asian Pacific Journal of Cancer Prevention, 14(3), pp.1851-1863.

Pongpiachan, S., 2013b. Vertical distribution and potential risk of particulate polycyclic aromatic hydrocarbons in high buildings of Bangkok, Thailand. Asian Pac. J. Cancer Prev, 14(3), pp.1865-1877.

Pongpiachan, S., Kudo, S. and Sekiguchi, K., 2014. Chemical characterization of carbonaceous PM10 in Bangkok, Thailand. Asian Journal of Applied Sciences, 7(5), pp.325-342.

Pongpiachan, S., Wiriwutikorn, T., Rungruang, C., Yodden, K., Duangdee, N., Sbrilli, A., Gobbi, M. and Centeno, C., 2016. Impacts of micro-emulsion system on polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) reduction from industrial boilers. Fuel, 172, pp.58-64.

Pongpiachan, S., Liu, S., Huang, R., Zhao, Z., Palakun, J., Kositanont, C. and Cao, J., 2017a. Variation in day-of-week and seasonal concentrations of atmospheric PM 2.5-bound metals and associated health risks in Bangkok, Thailand. Archives of environmental contamination and toxicology, 72(3), pp.364-379.

Pongpiachan, S., Wiriwutikorn, T., Sbrilli, A., Gobbi, M., Hashmi, M.Z. and Centeno, C., 2019a. Influence of Fuel Type on Emission Profiles of Polychlorinated Dibenzo-p-Dioxins and Polychlorinated Dibenzofurans from Industrial Boilers. Polycyclic Aromatic Compounds, pp.1-13.

Pongpiachan, S., Wiriwutikorn, T., Phetsomphou, P., Jieam, K., Vongxay, K., Choviran, K., Sbrilli, A., Gobbi, M. and Centeno, C., 2019b. Data relating to emissions of polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) from industrial boilers. Data in brief, 22, pp.286-295.

Querol, X., Alastuey, A., Rodriguez, S., Plana, F., Ruiz, C.R., Cots, N., Massagué, G. and Puig, O., 2001. PM10 and PM2.5 source apportionment in the Barcelona Metropolitan area, Catalonia, Spain. Atmospheric Environment, 35(36), pp.6407-6419.

Ramanathan, V. and Carmichael, G., 2008. Global and regional climate changes due to black carbon. Nature geoscience, 1(4), p.221.

Shou, Y., Huang, Y., Zhu, X., Liu, C., Hu, Y., & Wang, H. (2019). A review of the possible associations between ambient PM2.5 exposures and the development of Alzheimer's disease. Ecotoxicology and environmental safety, 174, 344-352.

Stieb, D. M., Burnett, R. T., Smith-Doiron, M., Brion, O., Shin, H. H., & Economou, V. (2008). A New Multipollutant, No-Threshold Air Quality Health Index Based on Short-Term Associations Observed in Daily Time-Series Analyses. Journal of the Air & Waste Management Association, 58(3), 435-450. doi:10.3155/1047-3289.58.3.435

Tao, J., Zhang, L., Engling, G., Zhang, R., Yang, Y., Cao, J., Zhu, C., Wang, Q. and Luo, L., 2013. Chemical composition of PM2.5 in an urban environment in Chengdu, China: Importance of springtime dust storms and biomass burning. Atmospheric Research, 122, pp.270-283.

The World Air Quality Project. (2015). A Beginner's Guide to Air Quality Instant-Cast and Now-Cast. Retrieved from: https://aqicn.org/faq/2015-03-15/air-quality-nowcast-a-beginners-guide/

US EPA. (2018), Particulate Matter (PM) Basics. Retrieved from: https://www.epa.gov/pm-pollution/particulate-matter-pm-basics#PM

Wolf, R., El-Haddad, I., Slowik, J.G., Dällenbach, K., Bruns, E., Vasilescu, J., Baltensperger, U. and Prévôt, A.S.H., 2017. Contribution of bacteria-like particles to PM2.5 aerosol in urban and rural environments. Atmospheric environment, 160, pp.97-106.

WHO. (2006a). WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide; Global update 2005; Summary of risk assessment. Geneva: WHO.

WHO. (2006b). Air quality guidelines global update 2005. Copenhagen: WHO Regional Office for Europe.

WHO. (2018a). Ambient (outdoor) air quality and health. Retrieved from: https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health

WHO. (2018b). Air pollution and child health: Prescribing clean air; Summary. Geneva: WHO.

Xu, M. X., Ge, C. X., Qin, Y. T., Gu, T. T., Lou, D. S., Li, Q., ... & Tan, J. (2019). Prolonged PM2.5 exposure elevates risk of oxidative stress-driven nonalcoholic fatty liver disease by triggering increase of dyslipidemia. Free Radical Biology and Medicine, 130, 542-556.

Yang, Y., Guo, Y., Qian, Z. M., Ruan, Z., Zheng, Y., Woodward, A., ... & Wu, F. (2018). Ambient fine particulate pollution associated with diabetes mellitus among the elderly aged 50 years and older in China. Environmental Pollution, 243, 815-823.

Zhang, A., Zhong, L., Xu, Y., Wang, H., & Dang, L. (2015). Tourists' perception of haze pollution and the potential impacts on travel: Reshaping the features of tourism seasonality in Beijing, China. Sustainability, 7(3), 2397-2414.

Zhan, H., Li, Q., Zhao, K., Zhang, L., Zhang, Z., Zhang, C. and Xiao, L., 2015. Evaluating PM2. 5 at a construction site using terahertz radiation. IEEE Transactions on Terahertz Science and Technology, 5(6), pp.1028-1034.

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## Thailand Clean Air Network (Incomplete Listing of Strategic Partners)

Circular Design Lab
GreenPeace Southeast Asia Pacific
Fire Fighting Group of Chiang Mai
Green Youth Forest Ranger of Chiang Dao
Love Lanna Group
Roong Aroon Public Service Group Lampang
Tin Nee Yom Gang (Baan Hua Thung)
The Joint Standing Committee on Commerce, Industry and Banking, Chiang Mai Chapter
Solving the Smog in Chiang Mai Network
National Health Security Group from 10 provinces in Ubon Ratchathani
Thailand Urban Tree Network
Protect the Forest in Doi Suthep Network
Bangkok Breathe Group
Womens' Health Network of Esarn
Friends in Need Network
Active Parents on Air Pollution Group
Thai Environmental Institute (TEI)
Thai PBS Foundation
Bangkok Forum
Big Tree Project
Thai Chamber of Commerce - Mae Hong Son Chapter
Chiang Mai Fire Fighting Comrade Network
Chum Chom Thai Foundation
EARTH Thailand Foundation
Love Lanna Network
Global Campuses Foundation
Northern Handicrafts Manufacturers and Exporters Association (NOHMEX)
Thai Chamber of Commerce – Mae Hong Son Chapter
Little Deer Project
Local Development Institute Foundation
Roong Aroon School
CivicNet Foundation
Chiangrai Fights Smog
Smoke Watch
Sconte Foundation
The Federation of Thai Industries, Chiang Mai Chapter
The Forest Creator
Thai Education Partnership (TEP)
ThaiPrompt Group
Tourism Council of Thailand, Chiang Mai Chapter
Thai Chamber of Commerce – Chiang Mai Chapter
Thai Health Promotion Foundation
National Health Commission Office (NHCO)
State Enterprise Workers' Relations Confederation (SERC)