

Air quality in Thailand

Understanding the regulatory context

SEI working paper
February 2021

Jae Nikam
Diane Archer
Chirat Nopsert





Stockholm Environment Institute
Linnégatan 87D 115 23 Stockholm, Sweden
Tel: +46 8 30 80 44 www.sei.org

Author contact: diane.archer@sei.org
Editor: Molly Killeen
Layout: Richard Clay
Cover photo: Traffic at night, Bangkok © d3sign / Getty

This publication may be reproduced in whole or in part and in any form for educational or non-profit purposes, without special permission from the copyright holder(s) provided acknowledgement of the source is made. No use of this publication may be made for resale or other commercial purpose, without the written permission of the copyright holder(s).

Copyright © February 2021 by Stockholm Environment Institute

Stockholm Environment Institute is an international non-profit research and policy organization that tackles environment and development challenges. We connect science and decision-making to develop solutions for a sustainable future for all. Our approach is highly collaborative: stakeholder involvement is at the heart of our efforts to build capacity, strengthen institutions, and equip partners for the long term. Our work spans climate, water, air, and land-use issues, and integrates evidence and perspectives on governance, the economy, gender and human health. Across our eight centres in Europe, Asia, Africa and the Americas, we engage with policy processes, development action and business practice throughout the world.

Contents

1. Introduction	4
2. Setting the context	5
2.1 Types of air pollution.....	5
2.2 Sources and determinants of pollution.....	8
3. Research methodology	12
3.1 Desk review	12
3.2 Key stakeholder interviews.....	13
4. Policy mapping	14
4.1 Barriers to and enablers of enforcement.....	18
5. Key actors driving change and success stories.....	23
5.1 Key actors driving change.....	23
5.2 Success stories.....	24
6. Conclusion	26
References	27
Appendix	29
Appendix references.....	42

1. Introduction

Poor air quality is a pressing concern in Thailand, not only in urban areas but across whole swathes of the country and particularly during what is becoming known as “burning season”, when crop fields are burned to harvest sugarcane or remove remnant biomass. At the same time, industrial and vehicular pollution are year-round problems. In 2019, an estimated 32 200 premature deaths in Thailand were attributed to PM_{2.5} (Health Effects Institute 2020). While the government makes pronouncements every year about the measures being taken to improve air quality, from burning bans to the removal of polluting vehicles from the road, there remain major gaps in enforcement. Why then, when Thailand has a number of Plans and Acts relating to the control of air quality and emissions from the national to the local level, does enforcement remain challenging, and what other factors hamper improvements in air quality?

In this working paper we present the initial findings of a comprehensive desk review of Thailand's existing institutional mechanisms related to air quality, mapping out their interlinkages and the remaining gaps. We also identify barriers to the implementation of existing policies and plans, as well as opportunities and examples of successes. We have supplemented the desk review with interviews with some key actors in this sector, as well as with academic and civil society actors, to come up with action points for cleaner air in Thailand.

These initial findings will serve as background to inform further planned practical research in 2021 relating to air quality, specifically in Bangkok, and will subsequently assist in identifying entry points for local and national policy recommendations arising out of this practical research. The paper will be the basis for at least one policy forum relating to air quality in Thailand and informs a forthcoming SEI discussion brief (Regulating air quality in Thailand-a review of policies) aimed at decision-makers. With the limited effectiveness of control measures in the past decade, government agencies in Thailand need to consider the effectiveness of current mitigation policies alongside the findings of relevant research projects, to find solutions appropriate to Thailand's current economic and social conditions.

This report opens by setting the context of both air quality trends and key sources of air pollution in Thailand. It then outlines the methodology applied in the study and presents a mapping of the key institutional mechanisms and relevant agencies and organizations involved in air quality in Thailand. This is followed by an analysis of barriers and opportunities, and examples of success stories, before recommendations are offered.

2. Setting the context

In this section, we outline the general context of air quality in Thailand, including the key types and sources of air pollution, historical trends and emissions and the implications. The intensity of air pollution varies across Thailand and is largely dependent on the following factors: a) the type of pollutants, including their size and lifetime in ambient air; and b) the concentration of sources in different regions, depending on the human activities in those regions.

2.1 Types of air pollution

This section outlines the main categories of air pollutants that affect ambient air quality and their observed levels in Thailand. The type of air pollutants largely depends on the sources of emissions. In urban areas, the major sources are vehicular traffic, construction and commerce. For rural and semi-urban areas, the main sources are the burning of agricultural residues, and industrial and power-generation activities.

Sulphur dioxide (SO₂): SO₂ is mostly produced by burning sulphur-containing fuels such as coal and oil. It is contained in vehicular emissions and is also emitted through power-generation and industrial processes, such as extracting metal, and the use of heavy equipment which burns fuel with a high sulphur content. Sulphur dioxide in ambient temperatures is a precursor for secondary air pollutants like PM_{2.5}. High concentrations of SO₂ in ambient air lead to photochemical reactions in the presence of sunlight, causing the formation of ground-level ozone (British Lung Foundation 2020; U.S. Environmental Protection Agency 2019). The Thailand State of Pollution Report stated that SO₂ levels in Thailand have been observed to be below the World Health Organization (WHO) standards since 1998 (Pollution Control Department 2015).

Nitrogen Dioxide (NO₂): NO₂ is a major component of urban air pollution in Thailand and is mainly emitted by vehicular exhaust and coal power plants (Greenpeace 2015, p. 201). According to the Pollution Control Department (PCD) (2015), annual monitoring around the country shows that, in 2015, NO₂ levels exceeded standards in areas of high traffic, such as roadsides in Bangkok and the city's district of Din Daeng.

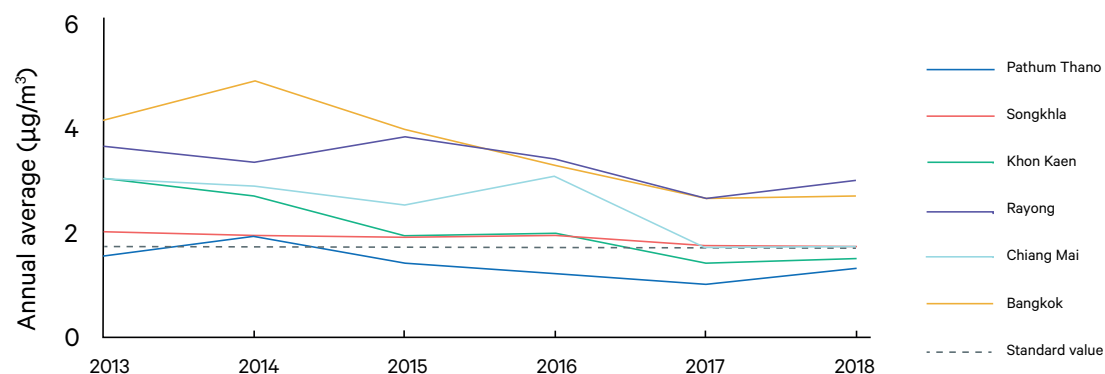
Carbon monoxide (CO): CO is formed by incomplete combustion of fuels containing carbon (National Academy of Sciences 2002). The Thailand State of Pollution Report stated that CO levels in Thailand have remained within the safe standard (Pollution Control Department 2015).

Volatile organic compounds (VOCs): VOCs, like SO₂, are precursors to ground-level ozone formation. According to JICA (Japan International Cooperation Agency) and the PCD, 40% of environmental complaints nationwide are about odor and smell, mostly related to VOCs (Pollution Control Department 2007). In 1997, the famous Map Ta Phut incident in Rayong province of Thailand led to school children being hospitalized due to serious air pollution-related health issues. The health impacts were considered likely to be from aromatic VOCs emitted from the nearby Map Ta Phut industrial estate. While there are a number of types of VOCs, benzene is the most observed VOC in urban areas with high traffic congestion (Figure 1).

Ground level ozone (O₃): O₃ is a secondary pollutant formed from a photochemical reaction of NO_x and VOCs. Thailand has seen ozone levels exceeding the Thai standard value of 100 parts per billion countrywide over the last 10 years (Pollution Control Department and Ministry of Natural Resources and Environment 2018). Monitoring stations around the country show the maximum 1-hour average value of ozone has been observed at 123 parts per billion, reaching a maximum value of 193 parts per billion, thus exceeding the Thai standard. Figure 2 outlines countrywide and regional levels of ozone.

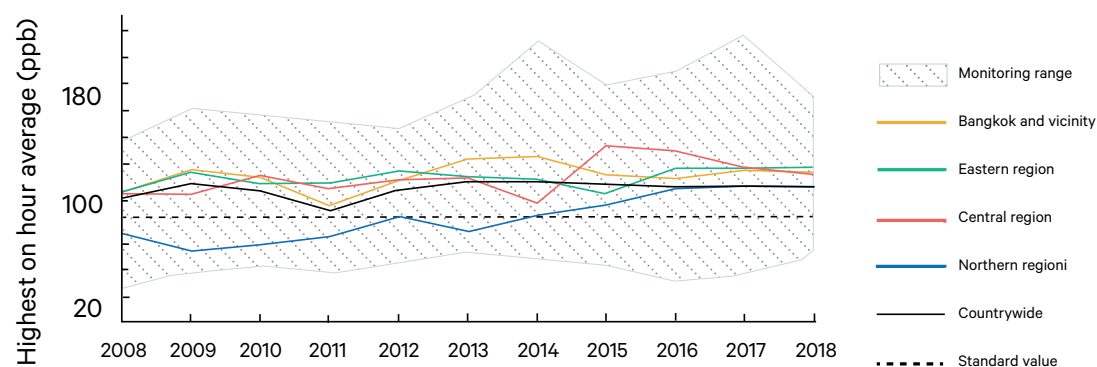
Airborne particulate matter (PM₁₀ and PM_{2.5}): Airborne particulate matter is a complex mixture of solid and liquid, organic and inorganic substances, divided into two sizes: fine particles of size smaller than 2.5 µm (known as PM_{2.5}), usually found in combustion exhaust and re-condensed organic and

Figure 1. The annual average levels of benzene within 6 provinces from 2013 to 2018



Source: PCD and Ministry of Natural Resources and Environment 2018

Figure 2. The average annual levels of ozone (maximum one-hour average) from 2008–2018

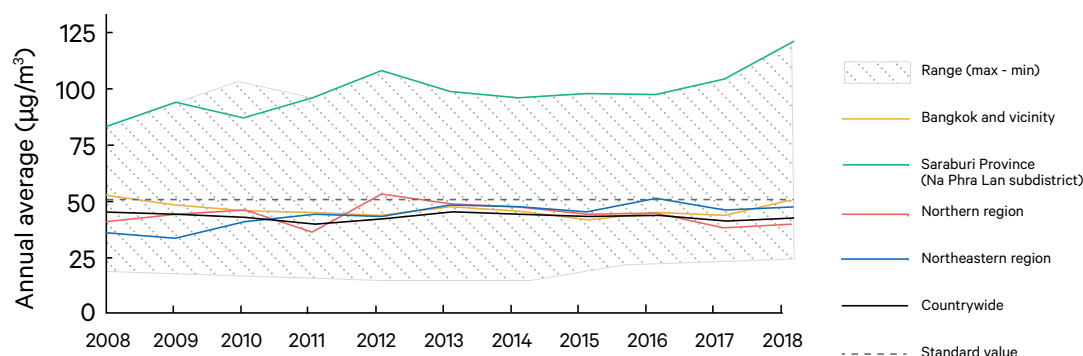


Source: PCD and Ministry of Natural Resources and Environment 2018

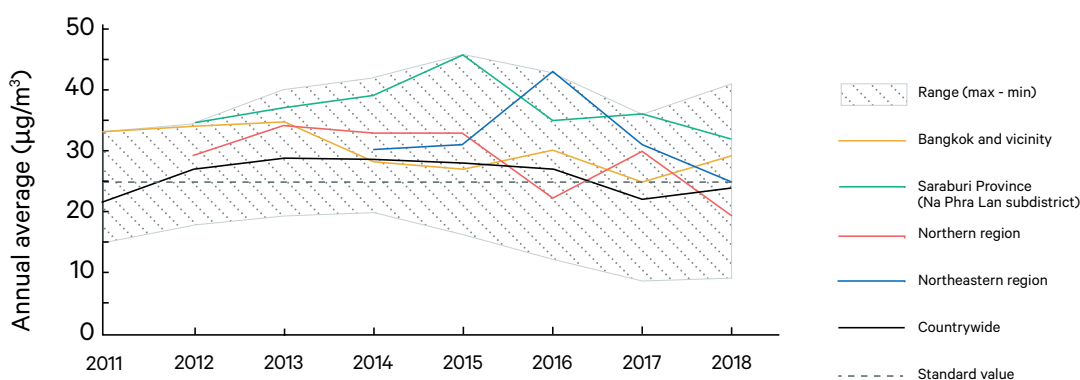
metal vapors, and coarse particles of sizes lesser than 10 micrometres in diameter (known as PM_{10}), usually found in road dust and industrial emissions. PM_{10} therefore also includes $PM_{2.5}$. The size of the particles determines the rate of dispersion in the air (Pollution Control Department and Ministry of Natural Resources and Environment 2018).

Saraburi Province, a center of cement production, has been observed to have the highest PM_{10} levels nationally, with the 24-hour average exceeding the WHO standard value of 50 micrograms per cubic metre for 165 out of 362 monitoring days in 2018. The national annual average value in 2018 was 119.5 micrograms per cubic metre (Pollution Control Department and Ministry of Natural Resources and Environment 2018). On average, national levels of PM_{10} in Thailand's cities continue to exceed WHO guideline values, especially in Bangkok where roadside particulate matter (PM_{10}) is the most serious air pollutant (Clean Air Network Thailand 2008).

The Thailand Pollution Control Department (PCD) monitors $PM_{2.5}$ levels in 10 provinces and in 2015, results showed that Saraburi Province had the highest number of days of $PM_{2.5}$ exceeding the standard value, followed by Samut Prakan, Lampang Bangkok and Ayutthaya (Pollution Control Department 2015). According to ASEAN and the PCD (Pollution Control Department and Ministry of Natural Resources and Environment 2018), from 2011 to 2018, annual average values across the country were between 9 and 41 micrograms per cubic metre, and the national average stood at 24 micrograms per cubic metre (as against the national annual average standard of 25 $\mu g/m^3$).

Figure 3. The annual average concentration of PM₁₀ from 2008 to 2018

Source: PCD and Ministry of Natural Resources and Environment 2018

Figure 4. The average annual concentrations of PM_{2.5} from 2011 to 2018

Source: PCD and Ministry of Natural Resources and Environment 2018

It is worth flagging that Thailand's national air quality standards are currently weaker than the highest WHO guidelines. For example, the country's daily standard for PM_{2.5} is 50 µg/m³ (equivalent to the WHO's Interim Target 2), which is twice as high as the WHO guideline of 25 µg/m³, and while there is talk of reducing the standard to 37.5 µg/m³ (WHO Interim Target 3), the timescale for this is unclear (Interviewee 1). For PM₁₀, the daily standard in Thailand is 120 µg/m³ (higher than WHO Interim Target 2), whereas the WHO guideline is 50 µg/m³. Similarly, Thailand's yearly standards for PM_{2.5} are equivalent to Interim Target 2 of 25 µg/m³, in contrast with the WHO guideline level of 10 µg/m³; for PM₁₀ these yearly standards are at 50 µg/m³ (level with Interim Target 2), compared with the WHO guideline of 20 µg/m³ (Greenpeace 2015). This means that monitoring applications developed by national agencies in Thailand use these interim standards that are less stringent than the guideline WHO levels.

It is estimated that the cost of PM₁₀ to Thailand can reach THB 2.06 trillion (12.64% of GDP) when it affects all households (Thailand Clean Air Network 2020), and while no similar national figures exist for PM_{2.5}, given that it is more harmful to human health, it is likely that the cost is even higher. Estimates for Bangkok, generated by the IQAir AirVisual application using the Greenpeace Cost of Air Pollution Counter, suggest that poor air quality caused 8900 deaths and cost US\$3.4bn between January and June 2020 (IQAir 2020).

2.2 Sources and determinants of pollution

This section outlines the major sources of pollutants and the determinants of their concentration. The concentration of sources and the type of pollutants largely depend on human activities in a specific region. For example, northern Thailand faces high levels of particulate matter and VOCs from January to April, which is the dry season, when wildfires are common and agricultural burning takes place. Meanwhile, Rayong's industrial zones experience high levels of VOCs due to the chemical and industrial activities which occur there, while Saraburi, a center of cement production, suffers high levels of particulate matter (Pollution Control Department 2019).

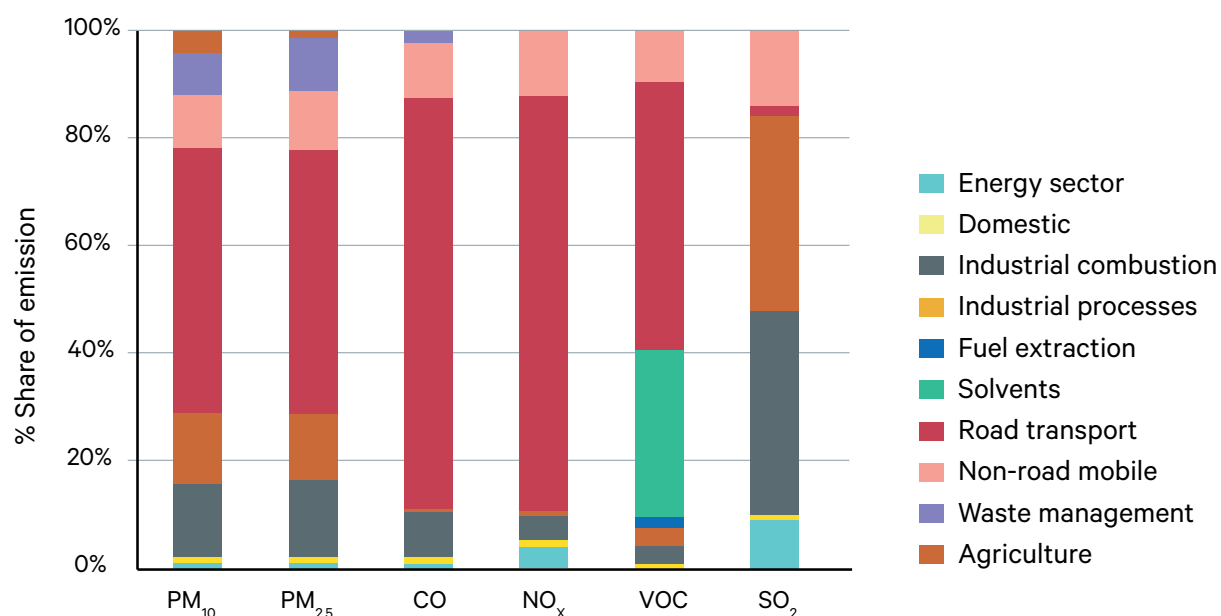
Topography and weather conditions

Topography and weather conditions like solar radiation, rain, temperature, windspeed and air pressure play a significant role in determining the concentration of pollutants. Thailand is 15° above the equator and has a tropical climate with an average temperature of about 30°C and temperature variations in different seasons (Srisurapanon and Wanichapun 2019). Thailand has three seasons: dry and hot from February to May, rainy from June to October, and cool from November to January. Nationally, the concentration of pollutants is observed to be lower during the rainy season due to dispersion caused by the monsoon winds and low air pressure. High air pollution episodes are observed in the rest of the year due to weaker wind currents and air pressure inversion near ground level, both of which restrict air pollutant dispersion (Pollution Control Department 2015).

Presence of precursors

In addition to the weather conditions described above, the presence of sunlight and slow wind speed, along with primary pollutants like NO_x and VOCs, give rise to secondary pollutants, such as ground-level ozone, through photochemical reactions. Ground-level ozone in high amounts can cause serious health issues, such as chronic lung disorders like bronchitis and cancer.

Figure 5. Air pollution sources in Bangkok and its vicinity in 2018



Source: Pollution Control Department (PCD) 2019

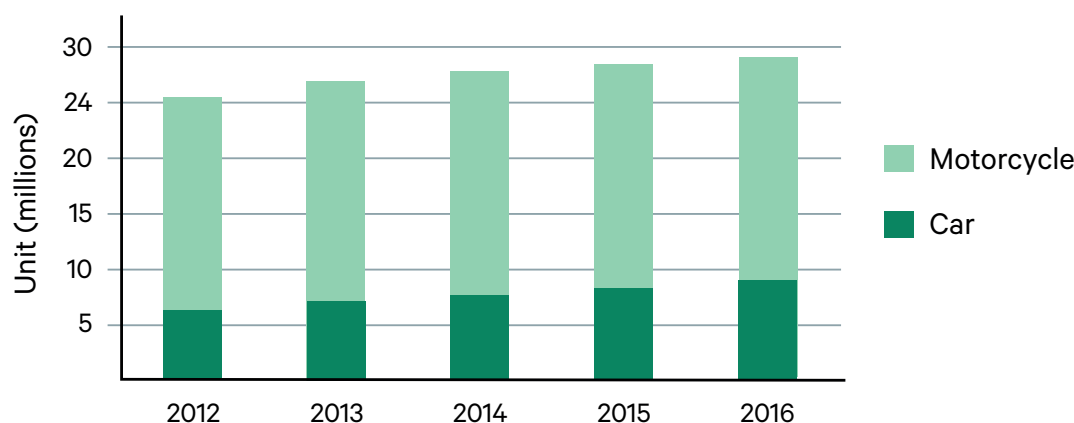
Sources of air pollution

The sources of air pollution in Bangkok and its vicinity are illustrated in Figure 5. This section outlines some of the major sources of air pollution in Thailand – there are a large variety, emitting different types of pollutants.

Land transportation

Increased income per capita has resulted in a rise in the ownership of private vehicles, especially in urban areas. According to Siri Wattanapong and Chantharasenawong (2018), new motorcycle registrations in Thailand reached 20 million in 2016. As shown in Figure 6, new vehicle registrations have been steadily rising every year, with motorcycle registrations being almost four times that of cars (Siri Wattanapong and Chantharasenawong 2018) and one million new cars being sold in 2019 (Reuters 2020).

Figure 6. Number of vehicle registrations from year 2012 to 2016 nationally in Thailand



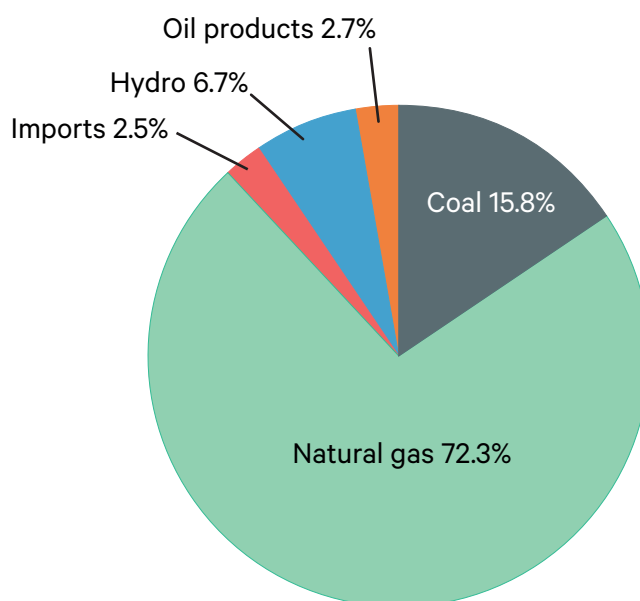
Source: Siri Wattanapong and Chantharasenawong 2018

The transport sector is one of the largest consumers of energy in Thailand. The majority of road vehicles use fossil fuels like gasoline, diesel and biodiesel (the number of electric vehicles remains insignificant, though is growing annually). Almost 50% of Thailand's population lives in urban areas, which have a high concentration of motorized vehicles, thus leading to associated air quality problems. It is estimated that road transport accounts for over half of $PM_{2.5}$ emissions and high concentrations of SO_2 , NO_x , and VOCs like benzene and 1,3-butadiene in urban settings (Outapa and Thepanondh 2014).

Electricity generation

As seen in Figure 7, a large amount of Thailand's electricity is generated through fossil fuels. Natural gas, which Thailand produces domestically, accounts for the major share, followed by coal. While natural gas is cleaner than coal, it produces nitrogen oxides (NO_x) (a precursor for smog) upon burning. Leakage of methane (a greenhouse gas) occurs during drilling and extraction of natural gas. Coal-fired power plants emit harmful pollutants such as nitrogen and sulphur oxides, hydrogen chloride and hydrogen fluoride gases, and arsenic and lead (Kielmas n.d.). Thailand currently has five coal-fired power plants over 300 megawatts and nine smaller plants of around 100 megawatts or less. While the Power Development Plan of 2015 pushed for coal in future power capacity, the 2018-2037 revision of the Plan aims to reduce the proportion of coal-generated power by 12% (Hong 2019). Coal power plants accounted for an estimated 70% of Thailand's energy-related SO_2 and PM_{10} emissions, and 25% of NO_x emissions in 2008 (Greenpeace 2015). This might be something to do with low emission standards, as "Thai emissions standards allow new coal fired power plants to emit up to and above ten times the amount of pollution allowed in other countries like China and US" (Greenpeace 2015).

Figure 7. Types of fuel used for electricity generation in Thailand



Source: US Energy Information Administration 2019

As Thailand has grown economically to become an upper-middle income country, it has seen an increase in the consumption of goods, including those requiring electricity. Thailand's electrification program led to 97% coverage nationally by 2000, up from 7% in the early 1970s (US Energy Information Administration 2019). These factors have increased demand for electricity and therefore have increased its generation.

Industrial emissions

Industrial sources are key sources of air pollutants due to their scale and the types of chemicals and processes used. The chemical processes used in industrial production have been known to release concentrated pollutants in the form of chemical fumes, vapors, VOCs, carbon- and carbon-based chemicals, SO_x and NO_x (Kielmas n.d.). Most of these pollutant emissions can be avoided by installing industrial control measures like scrubbers and filters. The main industries in Thailand are electronics (electrical components and appliances), steel, automotive, computers, cement production, furniture and plastic production (Nordea 2020). These industries are in vast industrial, or special economic, zones which, due to the concentration of industrial activity, are hotspots for high levels of pollution. One example is the Map Tha Phut Industrial Estate in Rayong, which processes petrochemicals and other heavy industries, causing the surrounding area to suffer from heavy metal poisoning, such as mercury, cadmium and organophosphates poisoning (Hays 2014), with significant health impacts on the local population.

Crop burning

While the contribution of agriculture to Thailand's GDP has been falling, it still accounts for around 35% of the country's labour force (FAO 2018). Rice is the major crop, accounting for 21% of agricultural land, or 9.73 million hectares, with other crops such as corn, sugarcane, cassava, soybean and mungbean accounting for 20% of land (Vichit-Vadakan and Vajanapoom 2011). The majority of rice and other crop plantations are concentrated in northern and northeastern Thailand, with a growing season from May to October. The short period between the two crop cycles means that crop residue is commonly removed through burning, as the fastest approach and one which also helps to control weeds. The burning of sugarcane to speed up harvesting is also common. However, this has severe consequences for air quality: incomplete combustion leads to the production of black carbon, $\text{PM}_{2.5}$ and PM_{10} , ash, and VOCs. Since the crop burning

occurs from November to April, which are primarily cooler months, the higher air pressure and wind speed does not disperse the smoke, leading to the concentration of air pollution in the Northern regions of Thailand which also sweeps across central Thailand. It is estimated that the open burning of crop residue and biomass contributes over 30% of $PM_{2.5}$ in Thailand.

Transboundary haze

Haze is an atmospheric phenomenon in which dust, smoke and other particulate matter obstruct visual clarity. Haze consists of smog and ozone and is formed due to photochemical reactions of hydrocarbons and NO_x . In Thailand, haze is observed between November and February, due to crop burning and climatic conditions. Additionally, neighboring countries like Myanmar, Indonesia and Cambodia follow similar agriculture burning practices, leading to the formation of haze which travels across boundaries into Thailand when the temperature rises and therefore favours pollutant dispersion. Thailand experiences transboundary haze in the northern region from Myanmar and in the southern region from Indonesia. Another source, particularly in the northern region, is forest fires, which, when added to agricultural burning, have contributed to increasing $PM_{2.5}$ to critical levels since 2006 (Vichit-Vadakan and Vajanapoom 2011). While Thailand has ratified the legally binding ASEAN Transboundary Haze Agreement, which focuses on tackling the issue of transboundary haze pollution arising from forest and land fires through both national enforcement and international cooperation, in practice it is very difficult to control and mitigate this problem.

3. Research methodology

This study was largely desk-based, with a few interviews with key stakeholders to validate and supplement the initial desk review findings.

3.1 Desk review

The search of relevant literature was done using Google Scholar and Scopus as the primary search engines, with a succession of key search words as outlined in Table 1. In these searches we were open to both grey and academic literature, in Thai and in English and including newspaper articles from media like the Bangkok Post or The Nation, relating to air pollution measures and public perceptions and awareness.

We also included material that was found through other sources, such as previous projects, or was shared by interviewees. Selection for all the documents identified in Scopus and the first 15 pages of documents identified in Google and Google Scholar was conducted based on the relevance of their abstracts, according to three criteria: air policies in Thailand; challenges/ barriers and enablers for policy implementation; and policy success stories. The documents with relevant abstracts were then read in detail and relevant data was extracted for insertion into the codebook. Additionally, a Google search was done for the same criteria and relevant articles, like newspaper articles and reports from international organizations, were identified.

Table 1. Search words for literature review

Search Engine	Search terms	Number of documents identified	Number of relevant documents
Google/Google scholar	Thailand air quality regulation, Clean Air Network Thailand, Clean Air in Thailand: Summary of Progress on Improving Air Quality, Thailand air quality standards, pollution control department Thailand, air quality and noise management bureau Thailand, air quality success stories Thailand, Greenpeace, Greenpeace - air quality, earth Thailand - publications, TCAN publications, UNEP Thailand air policy report, air quality – Thailand, PM _{2.5} - Thailand, air quality – Thailand, citizen awareness to air pollution, air pollution mitigation, environment issues outreach	Thousands identified, first 15 pages of results reviewed	56
Scopus	air, quality, Thailand, policies	48	15
	air, quality, Thailand, poli*	57	7
	Thailand, air, quality, standards	101	6
	Thailand, air, quality, regulations	14	1
Total		220	85

The documents identified in the literature search were analyzed in a codebook - a spreadsheet allowing extracted data to be entered across a systematic list of variables (Levett 2020). The purpose of the codebook was to provide an overview of the type, name, relevant penalties and enablers, and barriers for enforcement of each policy from the identified literature. Data from the documents that included suggestions on policy and its application was added to a separate sheet. The information obtained in the codebook, along with information provided by interviewees, was used to develop Table 2, as well as Annex 1 which summarizes this information.

Policy mapping was done on the basis of the policies identified in the literature or mentioned by key interviewees, followed by a review of the specific policies for detailed information, including whether it is directly or indirectly relevant to controlling air pollution. This information was added to a policy mapping table (see Annex 1). The interconnections between policies identified in the literature are depicted in Figures 8 and 9.

3.2 Key stakeholder interviews

In order to supplement and validate our desk review and policy mapping, we carried out a small number of key stakeholder interviews. The first stage was an online search of key search terms for organizations in Thailand involved in air quality, from various sectors including government, NGOs, research and industry groups. We also made use of our existing contacts.

Stakeholder interview were carried out in person or online. A project information sheet and a consent form with an option for full, partial or no anonymity was provided prior to the interview. The interview took the form of semi-structured questions (Annex 2) and lasted around one hour. While we attempted to carry out interviews with the relevant departments at the Bangkok Metropolitan Administration (BMA) and the PCD, we were unable to secure these.

We also attended relevant events and webinars, including the Thailand Clean Air Network Roadshow events which were held in 2020 and featured many key stakeholders discussing issues covered by this review.

4. Policy mapping

This section reflects on the key policies relevant to air quality control and mitigation in Thailand as identified through our desk review and also considers some of the challenges to their implementation and the remaining gaps in coverage. These policies are individually covered in more detail in Annex 1.

As illustrated by Annex 1, the majority of the Acts and Plans directly relevant to air quality fall under the Ministry of Energy or the Ministry of Natural Resources and the Environment (MONRE). Those under the Ministry of Energy regulate emissions arising from power generation, while those under MONRE have a broader scope, including climate change mitigation, waste management and environmental quality standards. Thailand's international climate change commitments are managed through MONRE. Other relevant ministries include the Ministry of Industry, in terms of industrial emissions, and the Ministry of Interior, which is relevant to disaster prevention and mitigation (including fire), town and country planning, and enforcement of regulations, through its responsibility for provincial and local governments.

Figure 8 and Figure 9 attempt to map out and demonstrate the interconnectedness between the policies and Acts. The policies either directly address the air pollution issues or have some component that is indirectly related to air pollution mitigation. As the Figures show, most of the policies are under the jurisdiction of different Ministries that may not always carry out their regulatory efforts in collaboration with each other—there is very little integration across Ministries. This siloed approach means the policies have a limited impact and reach, and each Ministry's regulations may be motivated by different factors. For instance, public health will drive the Ministry of Health's actions, but will not be a core concern of the Ministries of Energy, Industry, or Natural Resources and the Environment. While more integrated plans like the Climate Change Master Plan and the National Adaptation Plan encompass a broad range of sectors, they have limited direct impact on sources of air pollution. On top of the Ministerial regulations are also special orders, such as those of the National Council for Peace and Order (NCPO) which may supersede some Ministerial regulations – particularly, in this context, around what types of development projects require environmental impact assessments (EIA) or environmental health impact assessments (EHIA).

Enforcement is determined by a range of actors and agencies. In a Blue Paper review of policy by Thailand Clean Air Network (TCAN) (2020), regulations controlling emissions fall largely under the Factory Act of 1992 and the Promotion and Conservation of Natural Environmental Quality Act of 1992. The main national regulatory bodies that can control emissions from the industrial sector are the Department of Industrial Works, the Provincial Industry Office, the Industrial Estate Authority of Thailand, the Department of Primary Industries and Mines, the Electricity Generating Authority of Thailand (EGAT) and the Energy Regulatory Commission. Responsibility for enforcement, however, depends on the size of the factories at hand: large factories (of which there are 78 798 nationally) are regulated by the latter three agencies, while small and medium factories (of which there are 60 000) are controlled by local authorities (Thailand Clean Air Network 2020).

The siloed approach means that regulations are very specific – for example, emissions standards for NO_x and SO_x are only with regard to industrial emissions rather than ambient air, and these standards are more lenient than those of other countries (Interviewee 3). There is also a fundamental conflict of interest in the Ministry of Industry's role, as its remit is both to promote new industry but also control pollution, which are competing goals.

The Pollution Control Department (PCD), which falls under MONRE, operates as an advisory body to other agencies on issues relating to pollution control, carries out monitoring of pollutants and develops environmental quality management plans and systems. Therefore, the PCD alerts the relevant Ministries, such as the Ministry of Industry, of the need to take action

where pollutant limits have been breached, rather than having any enforcement capacity itself, being a small agency. It can also advise the government on the appropriate standards – for example, it is currently considering tightening the $PM_{2.5}$ standard from the Interim Target 2 level of $50 \mu g/m^3$ to the Interim Target 3 level of $37.5 \mu g/m^3$ (though this still falls short of the WHO guideline level of $25 \mu g/m^3$) (Interviewee 1).

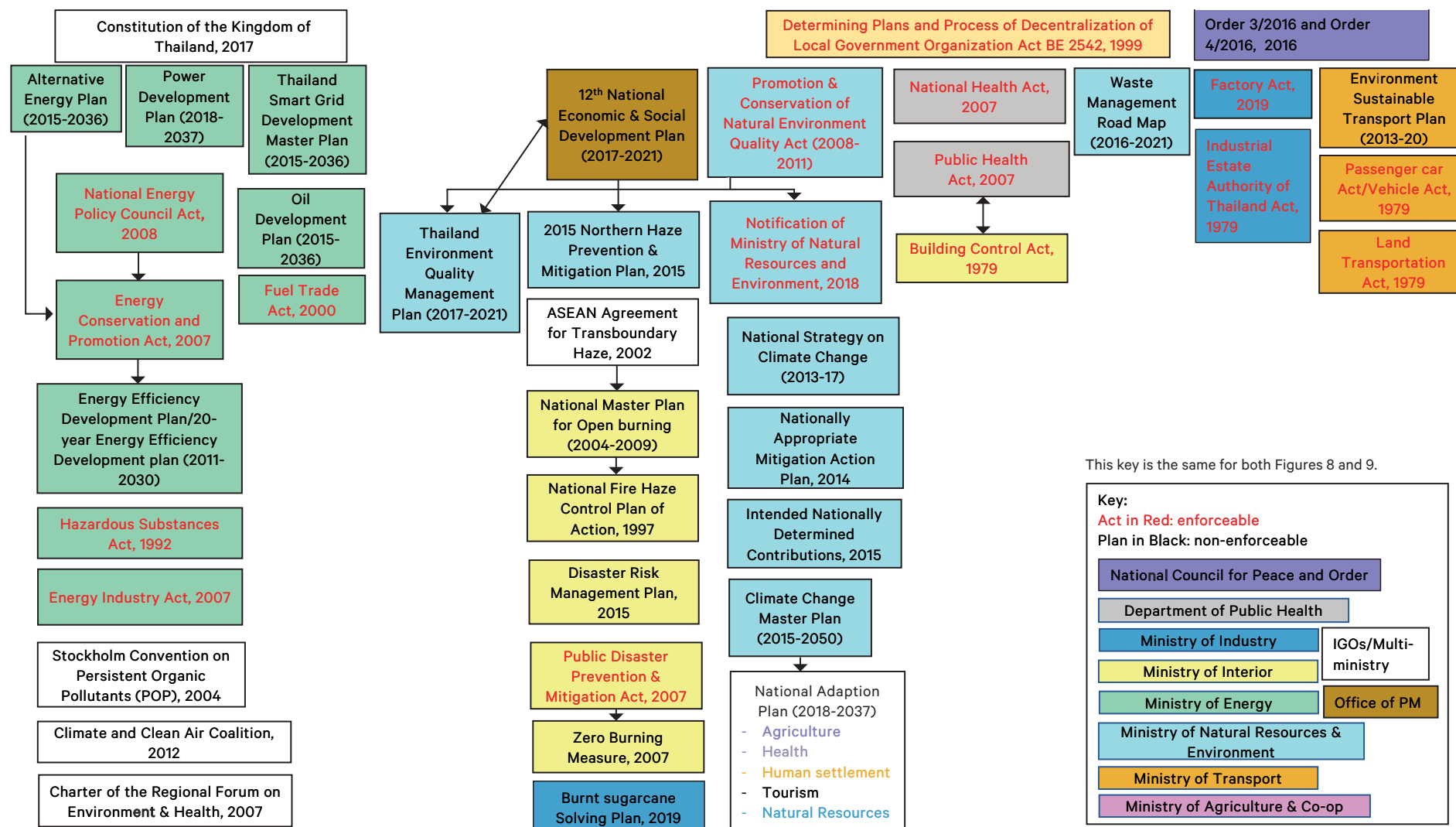
Following severe haze in February 2019, the government of Thailand declared a national crisis and requested that the PCD come up with an operations plan to address the air pollution problem. This was approved in October 2019 (Saetang 2020) and includes tackling the problem more effectively when pollution levels reach “unsafe” levels and, in the longer term, looking at better management and tackling pollution at source (The Nation 2019). Transport remains a key area of action during the seasonal haze crises, with emphasis on checking vehicle emissions (see 4.6 for more).

The PCD also works with provincial governments to help them during times of peak pollution. For example, it is working to help find solutions to open burning by developing an air quality forecasting tool that could help to identify the appropriate weather conditions for burning to occur. However, a current limitation is the low number of PCD monitoring stations countrywide; there are, for example, only three stations in northeastern Thailand, a largely agricultural area.

The Acts and policies under the Ministry of Interior place power in the hands of provincial authorities who are able to take some of their own measures against pollution, for instance imposing 60 day “burning bans” during certain times of year, as part of the National Disaster Prevention and Mitigation Act of 2007. However, in practice, burning takes place even during the ban, for example at night, when detection is less likely, so enforcement remains a challenge (Interviewee 3). The Ministry of Industry’s Office of Cane and Sugar Board is implementing stricter rules on the proportion of burnt sugar that can be purchased by mills, with a goal of reaching zero burnt sugar by 2022, but many farmers remain without alternative affordable methods. Local governments also have many responsibilities for managing their local area, but lack the necessary tools, such as local monitoring stations, and data to take effective action.

While there are a number of regulations focused on emissions, the TCAN Blue Paper (Thailand Clean Air Network 2020) and Greenpeace (2015) identify gaps in urban planning and zoning laws, which have been relaxed in favour of economic investment under the 2016 Order of the National Council for Peace and Order (NCPO), a council under the then-military regime which followed the 2014 coup. The 1992 National Environmental Quality Act requires that 23 specific project types such as dams, airports, mass transit infrastructure, power plants and industrial estates require an Environmental Impact Assessment (EIA) or an Environmental Health Impact Assessment (EHIA), managed by the Ministry of Natural Resources and Environment. However, following the 2014 coup, the interim military government NCPO instituted orders 3/2016 and 4/2106 which allow certain large-scale projects to bypass regulations under the Town and County Planning Act, and enable projects to be endorsed before their EIAs and EHIAs have been completed, or, in certain instances, even remove the EIA requirement. This is enabling concentrations of industrial factories in special economic zones that can exceed the pollution “loading” limit of the area and comprehensive EHIAs are not being carried out for new waste to energy plants (Interviewee 3). In the places where such projects are being developed, it has also led to conflict between local communities and the organizations or agencies running the projects, as the locals feel sidelined in the planning process and suffer the environmental and health consequences. A Greenpeace (2015) study on coal power plants in Thailand called for stricter standards of allowable emissions, but also for more thorough assessments of the health and environmental impacts of coal power plants – this was before the NCPO order came into being. The study also calls for the Ministry of Social Development and Human Security to play a more active role in ensuring the health of Thai people (Greenpeace 2015) – this ministry doesn’t appear in our policy mapping.

Figure 8. Policy interconnections



This key is the same for both Figures 8 and 9.

Figure 9. Policy mapping for different air pollution sources

Source of air pollutants	Plans	Legislation	Over-arching / multi-sectoral
Energy	<div>Power Development Plan (2018-2037)</div> <div>Alternative Energy Plan (2015-2036)</div> <div>Thailand Smart Grid Development Master Plan (2015-2036)</div> <div>Oil Development Plan (2015-2036)</div> <div>Energy Efficiency Development Plan/20-year Energy Efficiency Plan (2011-2030)</div>	<div>Fuel Trade Act, 2000</div> <div>Energy Conservation and Promotion Act, 2007</div> <div>National Energy Policy Council Act, 2008</div>	<div>Public Disaster Prevention & Mitigation Act, 2007</div> <div>Disaster Risk Management Plan, 2015</div> <div>Building Control Act, 1979</div> <div>Public Health Act, 2007</div> <div>National Health Act, 2007</div>
Industry	<div>Burnt Sugarcane Solving Plan, 2019</div>	<div>Energy Industry Act, 2007</div> <div>Factory Act, 2019</div> <div>Industrial Estate Authority of Thailand Act, 1979</div> <div>Order 3/2016 and Order 4/2016, 2016</div> <div>Zero Burning Measure, 2007</div>	<div>12th National Economic & Social Development Plan (2017-2021)</div> <div>ASEAN Agreement for Transboundary Haze, 2002</div> <div>Hazardous Substances Act, 1992</div>
Forestry and agriculture	<div>National Master Plan for Open Burning (2004-2009)</div> <div>National Fire Haze Control Plan of Action, 1997</div> <div>2015 Northern Haze Prevention & Mitigation Plan, 2015</div>	<div>Passenger car Act/Vehicle Act, 1979</div> <div>Land Transportation Act, 1979</div>	<div>Determining Plans and Process of Decentralization of Local Government Organization Act BE 2542, 1999</div> <div>Climate Change Master Plan (2015-2050)</div> <div>Climate and Clean Air Coalition, 2012</div>
Transport	<div>Environment Sustainable Transport Plan (2013)</div>		<div>National Adaption Plan (2018-2037)</div> <div>- Agriculture - Health - Human settlement</div> <div>- Tourism - Natural Resources</div>
Waste management	<div>Waste Management Road Map (2016-2021)</div>		<div>Intended Nationally Determined Contributions, 2015</div> <div>Nationally Appropriate Mitigation Action Plan, 2014</div>
Environment protection	<div>Thailand Environment Quality Management Plan (2017-2021)</div> <div>National Strategy on Climate Change (2013-17)</div> <div>Constitution of the Kingdom of Thailand, 2017</div>	<div>Promotion & Conservation of Natural Environment Quality Act (2008-2011)</div> <div>Notification of Ministry of Natural Resource and Environment, 2018</div>	<div>Charter of the regional Forum on Environment & Health, 2007</div> <div>Stockholm Convention on Persistent Organic Pollutants (POP), 2004</div>

The TCAN Blue Paper also identifies a need for a database of factories and pollutants, in order to enable a Pollutant Release and Transfer Register (PRTR) (Thailand Clean Air Network 2020) which can be accessed by the general public and would allow for the identification of the hazardous substances which might be emitted by these factories. At the moment, there is a lack of transparency and affected populations have no means to monitor what is being emitted by nearby industrial zones and in what quantities. For example, the Committee on the Management of Prevention and Resolution of Industrial Emission-based PM_{2.5}, established in 2019 in response to the national air pollution crisis, investigated 120 factories out of an estimated 160 000 nationally – a PRTR register would have enabled immediate findings (Saetang 2020). There is also no existing pollution “loading” standard in terms of what emissions a local area can bear (Saetang 2020).

Figure 8 attempts to map some of the interconnections between plans and policies with a relevance to air pollution and to highlight which are directly enforceable (red text) and which are Plans (black text). The Constitution of the Kingdom of Thailand overarches all and sets out the right of people to use environmental resources in a sustainable manner but also to conserve and protect the environment. The Local Government Organization Act determines the powers and structure of local government (falling under the Ministry of Interior), which are relevant to their ability to enforce laws, while the 2016 Orders were special orders under the temporary military government. The remainder of the Acts and Plans fall under the remit of specific Ministries. The diagram illustrates how many of the policies stand independently and are specific to certain sources of pollutants. The flow of the arrows depicts the flow of implementing authority or influence.

4.1 Barriers to and enablers of enforcement

Thailand requires a more integrated approach to managing air pollution, as currently many disparate Ministries and agencies are involved with different mandates and specific areas of focus. The civil society group Thailand Clean Air Network (TCAN), a network of academics and specialists, has drafted a Thailand Clean Air Act which they have submitted to Parliament for debate (subject to receiving the necessary 10 000 supporting signatures from the general public). Similarly, the Thai Chamber of Commerce have also submitted a draft Act on air pollution to Parliament for consideration.

One objective of the proposed TCAN Clean Air Act is to bring together the relevant stakeholders and agencies to manage the issues together, rather than trying to increase the burden of responsibility of a single agency. As the proposed Act is driven by a belief in the “right to clean air”, it also pushes for the right of the general population to play a role in setting policies and managing air quality. This entails giving the general public access to information and data about emissions, including their source and type, and enabling a greater role for civil society in monitoring air quality (Interviewee 2). There is also a role for civil society in exerting more pressure to require the monitoring of air quality and emissions.

According to Interviewee 2, other barriers to enforcement include a lack of data. For example, forest fires have been an issue for more than a decade but there is no process of post-fire analysis that could provide information to help prevent future fires. Similarly, monitoring of air pollution is often based on data sampling and a daily average index, rather than real-time air quality levels (Saetang 2020).

A key barrier to change is the conflict between the drive for economic growth, and protecting the environment (Interviewee 1). This conflict means that there is a severe lack of political will to properly tackle the issue of air pollution (Interviewee 2). For example, the Ministry of Industry is more focused on financial returns for industrial investors and is heavily lobbied by investors who don't see a substantial return on investment on clean technologies (Interviewee 3).

When it comes to peak pollution season, the response of government agencies is often reactive and the focus tends to be on addressing transport emissions through plans such as the “12 measures”, which restrict movement of large trucks in the city, conduct exhaust checks on vehicles or restrict construction activity. They could be regarded as largely separate from what is already set down in law (though control of vehicle exhaust is already mandated by the Ministry of Transport and suggests failure of implementation) and indicative of the failure of current laws and policies to mitigate air pollution. A sustained effort at reducing emissions is needed year-round, not simply during peaks, and greater recognition of the role of industrial emissions is also needed.

Table 2 highlights some of the key barriers to effective enforcement of air pollution controls, as identified in the desk review and through the interviews. Fundamentally, general barriers remain both in the fact that clean air appears to be secondary to economic growth in the eyes of many government agencies, and because awareness among the general population of the levels and dangers of air pollution is still quite low, meaning there is little drive to address the issue. Because monitoring remains patchy and standards have not been updated in the last decade, there is insufficient data to drive action, though the PCD is taking the initiative to address both of these challenges.

Many of the barriers also require not just enforcement of air quality-specific policies but also the addressing of underlying drivers of air pollution, in a more holistic approach. For example, urban planning and transport planning for large cities need to shift away from a car-centric approach. While there is heavy investment in mass transit (especially in Bangkok) there remains a gap in changing behaviours to ensure people switch from private cars to public or active transportation. Similarly, the push to end open burning of crops needs to address the affordability and accessibility of alternative methods of clearing fields.

Table 2. Barriers to and opportunities for policy enforcement

Air pollution source	Barriers to enforcement	Opportunities for enforcement
Agriculture and open burning and energy	Insufficient air quality monitoring ¹ .	Pollution Control Department's (PCD) initiative to increase the number of air quality monitoring stations ¹ .
	Limited number of official stations ¹ (up to 70 nationally, which means large areas are not covered, especially in rural settings).	Development and continuous update of emission database ² .
	Lack of up-to-date database and documentation of the air pollution problem ¹ .	
	Lack of public awareness regarding health impacts of haze and open burning ¹ .	Support to increase awareness and technical capacities of the locals ² .
	Lack of government support in provision of information ¹ .	Enhance public participation with air pollution mitigation measures like monitoring the level and type of emission sources ² .
	Lack of adequate technical knowledge-sharing and support from government to provide knowledge to farming communities ¹ .	Increase in awareness of all stakeholders regarding environment and health significance of burning ² .
	Insufficient measures for controlling open burning ² .	Implement and enforce open burning control measures and develop monitoring and early warning systems ² .
		Construct guidelines and rules for controlling open burning ³ .
	Slow progress to increase energy efficiency ² .	Use of greener sources of electricity-generation like renewables ¹ being prioritized in 2018 Power Development Plan .
	In Thailand, majority of the farmlands are leased , leading to lack of incentives for investment in alternative farming practices and lack of protection of farmers rights on financial returns, in turn leading to lack of will to invest in alternative waste management practices ³ .	Currently, farming is dominated by the older generation of farmers. An increase in farmers' incomes would encourage the younger generation, who have more innovative residue management practices, to be involved ¹ .
	Inadequate and inefficiently implemented policies ³ .	Air pollution policies need to be integrated with other national policies for higher impact ³ .
	Laws to reduce biomass burning are not harmonized and/or enforced effectively ³ .	
	The ASEAN Agreement on Transboundary Haze Pollution is not sufficiently effective due to lack of active efforts taken by the member states ² .	
References: ¹ (Kittikongnaphang 2017); ² (Unapumnuk n.d.); ³ (Narita et al. 2019)		
Vehicular Emissions	Tax on older vehicles is lower than new ones, which promotes the buying of inefficient older cars ¹ .	Enforce policy on vehicular age limit ¹ .
		Use of economic incentive measures to promote buying newer, more efficient cars ² .
	Urban areas are inadequately planned to promote mass transit and active transport.	Promote mixed use of land to reduce traveling time ² .
		Promote use of cars that cause less pollution, such as electric cars ² .
		Promote use of alternative forms of transportation, like public transport, biking and walking ² .
	The process of upgrading to EURO 5/6 standards (measures to reduce vehicular exhaust emissions) is moving slowly ³ . EURO 5 was originally scheduled for 2020 but has now been pushed back to 2024.	Support the production of diesel exhaust smoke meter to reduce private car production cost ³ .
		Use concrete control measures like linking results from monitoring to determine the active lifespan of vehicles ² .
References: ¹ (Thailand Clean Air Network (2020)); ² (Pollution Control Department 2015); ³ (Pollution Control Department 2018)		

Industrial emissions	Lack of communication and public participation in the decision-making processes of mega construction development projects resulting in limited and uneven awareness amongst local communities ¹ .	Decentralize the state's authority and powers and provide the local communities with greater power in decision-making processes ⁶ .
	Lack of trust of the impacted stakeholders in participatory forums due to lack of participation in the early stages of decision-making and public participation only done to ratify the decisions already made ¹ .	Strong governmental initiative to ensure awareness and shared responsibility of the stakeholders ⁷ .
	Policy focus on higher economic growth leading to expansion of petrochemical plants, mostly in Rayong province ⁸ and other special economic zones.	Engage private sector groups in policy-making processes to ensure their concerns are sufficiently accounted for ² .
	Lack of governmental will towards implementation of environmental laws due to fear of reduction of economic activity and investors moving to other provinces/countries with lax environmental laws ⁷ .	Enforce standards for controlling emissions ⁸ .
	Shortage of industrial emissions data collection or measurement due to lack of adequate air quality planning ⁴ .	Information on air quality condition should be regularly updated and published in an open-sourced website through a Pollutant Release and Transfer Register (PRTR) process ² .
		More community-centric data should be collected from stakeholders as opposed to local leaders in order to represent accurate information ⁶ .
	Inadequate standardized monitoring measures⁵.	Add new air quality parameters including mercury and black carbon ⁴ .
	The measure for mercury is in nanograms/cubic metres which is different from the WHO guidelines (which are in micrograms/cubic metres). This makes it difficult to assess the negative impacts ⁸ .	
	Lack of public participation in inspection and monitoring of industrial air emissions due to lack of awareness and available data ⁵ .	A PRTR process would enable public access to information about emissions.
References: ¹ (Chompunth 2013); ² (Thailand Clean Air Network (2020)); ³ (Vichit-Vadakan and Vajanapoom 2011); ⁴ (Climate and Clean Air Coalition 2018); ⁵ (Pollution Control Department 2015); ⁶ (Hirota 2006); ⁷ (Soytong and Perera 2014); ⁸ (Pollution Control Department 2018)		

General	No clear enforcement of environmental policies and insufficient number of governmental organizations involved in air pollution mitigation. This is due to the minimal allocation of budget for air quality policies as opposed to economic growth-aiding policies ⁴ .	Establishment of a single organization (e.g. Thai Environmental Protection Agency) authorized to take concrete measures on the national level and mandated directly by the Parliament would help strengthen the current ineffective environmental protection infrastructure ⁴ .
	Lack of integrated policies that link Public Health Act and municipal laws ⁶ .	
	No updated air quality standards (last updated in 2010)¹.	Air pollution and climate change policies should use a co-benefit approach. The inclusion of air quality co-benefits in the design and evaluation of climate policy would enhance the social outcomes ³ . PCD is investigating changing the daily average PM _{2.5} standard from 50 to 37.5 µg/m ³ .
	Lack of public engagement in identifying solutions due to the lack of activities raising awareness on the adverse impact of air pollution. Only a very small group of people are aware of the severe harm caused by air pollution ² .	Creation of policy framework for knowledge-sharing and implementation of environmental programs ⁶ .
	Shortage of knowledge of the connection between environmental quality and human health impacts⁶.	
	Air quality monitoring and reporting is not yet comprehensive with limited monitoring sites and lack of framework that enables multi-sectoral collaboration⁴.	Provision of more real-time air quality monitoring systems ⁵ . A new SERVIR Mekong Air Quality Tool co-developed with PCD will enable forecasting of air quality using satellite data.
	Lack of publicly available real-time quality information in many populated areas ⁵ .	Generate more public data through low-cost sensors ⁵ .
	Inadequate information linking environmental situations with health problems⁶.	
	Databases for supporting environmental health program implementation are inadequate ⁶ .	
	Lack of systems for collection of data which can be used in the diagnosis of environment-related diseases, lack of efficient environmental health monitoring system ⁶ .	
References: ¹ (Thailand Clean Air Network (2020); ² (Climate and Clean Air Coalition 2018); ³ (Nemet et al. 2010); ⁴ (Thailand Clean Air Network (2019); ⁵ (IQAir AirVisual 2018); ⁶ (Bureau of Environmental Health, Department of Health, Ministry of Public Health 2012)		

5. Key actors driving change and success stories

In this section, we consider the role of different societal actors in driving forward a process of change towards cleaner air. We also draw on the literature review and interview data to highlight selected stories which demonstrate success in regulating air quality in the Thailand context, in order to identify possible opportunities to improve air quality in Thailand. The success stories highlighted below demonstrate different approaches to tackling specific sources of air pollution.

5.1 Key actors driving change

While the policy review in Section 4 demonstrated that many different government agencies are involved in air quality, the success stories above highlight that initiatives involving non-government actors can also bring positive results. The two-stroke motorbike phase out involved the cooperation of private sector motorbike makers and dealers (see 5.3). Individuals and civil society organizations adept at using social media are helping to raise awareness and share data about air quality, while certain NGOs work closely with affected communities. This includes public health officials who have spoken out to provide practical information about what measures individuals can take to protect their health.

In Thailand, the high availability of smart phones and internet connections has meant that the reach of social media has drastically increased. Around 30% of Thailand's population uses the internet as their main source of new information (Chachavalpongpon 2014). Facebook is the most popular social media network in Thailand with 52 million users, amounting to around 75% of the total population (Statista Research Department 2019). While mass media coverage of news related to air pollution is mainly only during the winter season, or on days when the air quality is significantly poor, social media has permitted the transfer of information relating to poor air quality to a much larger population, particularly in Bangkok and Chiang Mai. In Bangkok, the Bangkok Metropolitan Administration (BMA) displays Air Quality Index (AQI) updates alongside real-time traffic updates on key roads, as well as messages exhorting car owners to check their vehicles' emissions to help reduce $PM_{2.5}$. The issue of $PM_{2.5}$ has therefore entered the public consciousness, at least in metropolitan areas, while in areas adjoining industrial estates or power plants which have suffered localized pollution, a broader range of pollutants will be of concern. Certain public health figures have also spoken out to the public about the impacts of $PM_{2.5}$ through press conferences and by giving practical advice about how to protect children, for example.

The recent air quality crises have also spurred on civil society action to address clean air, with TCAN launching comprehensive reports on the causes and impacts of poor air quality and challenges to resolving the problem. In 2020, TCAN held a series of online and in-person workshops focusing on issues relating to air pollution in Thailand and how to address them. It also organized practical workshops catering to all ages, with support from the volunteer-led Circular Design Lab. These events have helped to raise awareness, especially among concerned population groups, keeping the issue in the spotlight even outside of the poor air quality season.

Certain environmental NGOs have also made air quality a priority. Greenpeace South East Asia (based in Thailand) has focused on the issue of power plants and coal power plants and the $PM_{2.5}$ emissions arising from them since 2015. From this, Greenpeace launched a report ranking the cities in Thailand most affected by $PM_{2.5}$, and an educational animation about $PM_{2.5}$. Another NGO, Ecological Alert and Recovery Thailand (EARTH) has focused on industrial and hazardous waste pollution, pushing for PRTR and public access to information. EARTH is working with local communities such as those affected by the Map Tha Phut industrial estate in Rayong, carrying out citizen science projects to collect pollution data. EnLaw Thai Foundation is a legal NGO which has supported local communities in the process of challenging polluters in the courts, including those affected by air pollution. Forest fires in the northern region of Chiang Mai have also led to the establishment of a number of civil society, such as Blue Sky for Chiang Mai. These groups

help coordinate fire responses and identify sustainable solutions to the causes of forest fires, including promoting non-burnt forest produce like mushrooms.

With regard to biomass burning, it is essential to involve local stakeholders – from local communities to local governments and local academics who have been researching the topic for many years and have “dashboards” and other tools to hand (Interviewee 3). This could also help to avoid conflict between rural communities who are frequently blamed for fires without being given a say in how to manage them.

5.2 Success stories

This section outlines a number of different past approaches to reducing specific sources of emissions, which have involved different stakeholders and have been successfully implemented in Thailand. These examples highlight that collaboration between different actors, including government agencies working with the private sector, can lead to effective action to address air pollution.

IMO 2020 Low Sulphur Regulation: In an effort to reduce air pollution caused by shipping fleets, Thailand implemented a new International Maritime Organization (IMO) Low Sulphur regulation that requires all shipping companies to reduce the sulphur content in their fuels from 3.5% to 0.5% (and to 0.5% in Environmental Control Areas) (Chantaraserekul 2018). Compliance with this is achieved by using fuel oils with a Sulphur content of 0.5 % concentration, or an equivalent exhausted gas cleaning system like scrubbers, or by switching to non-fuel oil alternatives like liquified natural gas (Holness n.d.). This regulation is applicable for all international shipping fleets, globally and throughout the industry, for fuels used in the open sea (Kuehne+Nagel 2020). Due to the interruptions of COVID-19, the impact of this regulation is yet to be assessed as it only came into being on 1 January 2020.

Collective cross-boundary monitoring: In 2018, the Ministry of Interior, under the Public Disaster Prevention and Mitigation Act, B.E. 2550, led several awareness training sessions focusing on reducing air quality data gaps, especially for transboundary haze. This was done by strengthening cross-boundary air quality monitoring through bilateral cooperation with neighboring countries: Laos, Myanmar and Cambodia. Thailand provided mobile air quality measurement units to Laos, Myanmar and Cambodia, helped to build a permanent air quality measurement station in Laos, and conducted personnel training on air and noise pollution management in Laos. This was a successful attempt to foster cross-country collaborative efforts to combat transboundary haze (Pollution Control Department and Ministry of Natural Resources and Environment 2018).

Two-stroke motorcycle engine phase-out: Motorcycles have a majority share of road presence in urban areas like Bangkok. These motorcycles are known to cause much more PM and carbon emissions than other forms of land transportation, such as cars. Until 1999, two-stroke engines accounted for 80% of the motorcycle fleet in Bangkok (United Nations Development Programme (UNDP)/World Bank Energy Sector Management Assistance Programme (ESMAP) 2003). Two-stroke engines emit almost double the amount of hydrocarbons and particulate matter, are louder and consume more fuel than four-stroke engines. In 1993, in order to curb the increasing air pollution in Bangkok, the Bangkok Metropolitan Administration (BMA) adopted regulatory methods to encourage the use of four-stroke motorcycles. One example was a trade-in incentive of THB 4000 for owners trading in their two-stroke motorbikes for a new motorbike, financed by the government and covering 30 000 bikes. Dealers and manufacturers also provided financial incentives. Other methods included outreach to community organizations for awareness-raising, and capacity building for emissions-testing by agencies like the Land Transport Department (UNDP/ESMAP 2003). This resulted in a sharp rise in four-stroke motorcycle sales in Bangkok and around Thailand, which was a major factor in the control of air pollutant levels (Energy Smart Communities Initiatives 2014). As of 2007, almost 100% of new motorcycles sold in Thailand had four-stroke engines (Fuller 2007).

Leaded Gasoline Phase out: Thailand experienced high levels of economic growth during the 1980s (about 8% per year from 1986 to 1996) (Hirota 2006). The increase in income levels and improved lifestyles boosted car ownership and, in turn, raised the car stock growth exponentially, to about 10.4% per year since 1990 (Hirota 2006). This in turn has led to increased congestion in urban areas and heightened air pollution due to car exhaust. In the late 1980s, there was increasing awareness about the health risks posed by lead in fuel, the fact that lead detected in ambient air mainly came from the transport sector and that it could trigger health problems. In 1985, in order to curb the rising health issues, the Government of Thailand and automobile manufacturers reached a consensus that removing lead from the automobile fuel would limit further health issues related to lead exposure. The Seventh Plan for Urban and Regional Transport Project, established in 1992, set a target for 85% of lead reduction from 1991 levels (Asian Development Bank 2005), which was the year that premium unleaded petrol was introduced into the Thai market, with regular unleaded following in 1993. Since Bangkok had the highest density of vehicles, a drastic reduction of lead in outdoor air was observed. In 1994, regular leaded petrol was completely phased out and the total phase-out of all kinds of leaded petrol started on 1 January 1996 with the introduction of the EURO 1 vehicle emission standard, which required a switch to unleaded petrol and the fitting of catalytic convertors on all petrol vehicles. The Government of Thailand also considered the feasibility of refinery modification through the Bangchak Oil Refinery Reconstruction Project. This was an interdepartmental effort that included the national government, the Ministry of Energy, the Pollution Control Department, the Public Works Department and the Excise Department. Since 2000, the levels of lead found in the blood of traffic policemen have been constantly below the WHO lead concentration standard (Hirota 2006), demonstrating the success of the phase-out.

Increased public information and awareness of the need for clean air: The last few years have seen increasingly poor air quality, particularly during the peak haze season, and, with this, public awareness increased as people have made use of social media to highlight the problem. Additionally, the rise of freely available apps such as IQAir AirVisual and the Pollution Control Department's (PCD) equivalent, Air4Thai, has enabled people to access localized data about air quality in their area. This has been spurred on by the increasing use of social media, allowing people to share updates on air quality and express their displeasure at the poor air. As a result, an increasing number of institutions such as schools, hospitals and universities have installed low-cost air quality sensors which feed directly into the applications. This has allowed the general population to take protective measures such as wearing appropriate filtering masks and buying air purifiers for use at home and in the office. The peak haze periods have also led to the Bangkok Metropolitan Administration (BMA) to close schools on certain days (though this is not guaranteed to reduce children's exposure, as the air at their homes may not be any cleaner) and the Public Health Ministry to issue guidance about limiting exposure.

"Safe schools" in Khon Kaen: The northeastern city of Khon Kaen frequently suffers from poor air quality, particularly during the crop-burning season. As a result, the municipality has instituted a "safe schools" policy. Based on the readings of the PCD-owned air quality sensor, if the readings exceed the safe levels, the schools will implement their "safe classrooms" approach whereby the students are confined to classrooms which have the necessary safety equipment in place (Interviewee 3). This allows schooling to continue and students to breathe safe air, rather than shutting down schools when air is poor, thus affecting educational provision.

6. Conclusion

This paper has provided an overview of the various sources of air pollutants in Thailand, and the policies and Acts which seek to address the growing problem of air pollution. It has outlined that air pollution from various sources (industrial, agricultural and transport) continues to breach standards despite the number of policies and laws which seek to address these pollutants at their source. At the same time, orders which remain from the post-coup military government's efforts to boost industrial investment undo some of the previous measures aimed at mitigating industrial emissions.

Because the policies are owned and enforced by the agency or ministry under which the point source falls, there remains little integration across sectors in the battle for clean air. At the same time and at the local level, both local and provincial governments frequently lack the necessary data and mandate to take enforcement action. There is no overarching agency with a responsibility for clean air, the power to ensure the implementation and enforcement of the existing laws and the ability to bring together the various actors involved.

Thailand is a signatory to international conventions and agreements that bind it to reducing greenhouse gas emissions and achieving the Sustainable Development Goals (SDGs). SDG3.9 includes the target of substantially reducing the number of deaths and illnesses from hazardous chemicals, and air, water and soil pollution and contamination by 2030; however, the Thai Government has no masterplan to achieve this (Interviewee 3). Climate change targets do not seem to be integrated with objectives to reduce air pollution, a missed opportunity in terms of achieving co-benefits. Having an overarching agency with a mandate to address air pollution could help to emphasize the cross-sectoral co-benefits that could be achieved, in areas including climate change, health, environmental protection and agricultural productivity.

As much of the public and governmental discourse on air pollution seems to be focused on PM_{2.5}, due to its seasonal and visible nature, government responses also take a reactive, seasonal approach. This means that other pollutants which are also harmful to health, and are present all year round, may be left by the wayside – particularly emissions stemming from transport, industry and power-generation. There is therefore a need for further awareness-raising within the general public about the harmful effects and continued presence of other pollutants in order to push for wide-ranging air pollution measures that take a sustained approach to reducing emissions year-round. A public debate about the trade-offs between economic growth and its environmental and health costs, including costs on labour productivity, could help to foster a pathway towards greener growth. Private sector actors need to be part of the process, as they were in the successful two-stroke motorbike and leaded fuel phase-outs.

Thailand has previously demonstrated its capacity to take concrete action to address air pollution, with the successful and prompt phase-out of leaded fuel as a case in point. However, current emissions and “safe” pollutant standards remain weak, and lower than their international counterparts, seemingly favouring industrial productivity over health and environmental protection. There is an opportunity here for civil society to build on global momentum around air quality and the need to address climate change in order to push for wholesale change in the importance given to air quality, and to drive change in government policies and actions on this topic.

References

- Asian Development Bank. (2005). *Bangkok Urban Transport Project* (Loan 1195-THA) (Performance Evaluation Report PPE: THA 25345). <https://www.oecd.org/countries/thailand/36053654.pdf>
- British Lung Foundation. (2020). *Types of Air pollution. Air Pollution*. <https://www.blf.org.uk/support-for-you/air-pollution/types>
- Bureau of Environmental Health, Department of Health. Ministry of Public Health. (2012). *The Second National Environmental Health Strategic Plan, 2012-2016* (No. 978-616-11-1218-9). Bureau of Environmental Health, Department of Health. Ministry of Public Health. <http://infofile.pcd.go.th/mgt/EngPlan.pdf>
- Chachavalpongpun, P. (2014). Redefining Power: The Politics of Social Media and Information in Thailand. *GlobalAsia*, 9(4), 54–60.
- Chantaraserkul, N. (2018). *Oil & Gas – IMO 2020*. Krungsri Securities. https://www.krungsrisecurities.com/images.aspx?filename=http://www.krungsrisecurities.com/uploads/2018/09/research_en_US_6338_1_Energy%20sector_180903_U.pdf
- Chompunth, C. (2013). Enhancing public participation in air pollution management from coal-fired power plant projects in Thailand. *WIT Transactions on Ecology and the Environment*, 174, 11. <https://doi.org/10.2495/AIR130241>
- Clean Air Network Thailand. (2008). *Clean Air in Thailand: Summary of progress on improving air quality*. https://www.cleanairnet.org/caiasia/1412/articles-70822_Thailand.pdf
- Climate and Clean Air Coalition. (2018). *2018 Asia Pacific Clean Air Partnership Joint Forum*. 2018 Asia Pacific Clean Air Partnership Joint Forum. <https://ccacoalition.org/en/event/2018-asia-pacific-clean-air-partnership-joint-forum>
- Energy Smart Communities Initiatives. (2014). *Shift from two- to four-stroke motorcycles in Bangkok*. Smart Transportation ST-1.3 Bus Rapid Transit (BRT). <https://www.esci-ksp.org/archives/project/shift-from-two-to-four-stroke-motorcycles-in-bangkok>
- Fuller, T. (2007). *Bangkok's template for an air-quality turnaround*. New York Times. <https://www.nytimes.com/2007/02/23/world/asia/23iht-bangkok.html>
- Greenpeace. (2015). *Human Cost of Coal Power: How coal-fired power plants threaten the health of Thais*. Greenpeace Southeast Asia. <https://www.greenpeace.or.th/Thailand-human-cost-of-coal-power/en.pdf>
- Hays, J. (2014). *Industries and Manufacturing in Thailand*. Industries and manufacturing in thailand: textiles, food and japanese carindustries and manufacturing in thailand: textiles, food and japanese cars. http://factsanddetails.com/southeast-asia/Thailand/sub5_8g/entry-3314.html
- Health Effects Institute. (2020). *State of Global Air 2020*.
- Hirota, K. (2006). Review of Lead Phase Out for Air Quality Improvement in the Third World Cities Lessons from Thailand and Indonesia. *Journal of Regional Studies*, 36(2), 14. <https://doi.org/10.2457/srs.36.527>
- Holness, C. (n.d.). *IMO 2020: Are we ready?* Norton Rose Fulbright. <https://www.nortonrosefulbright.com/en-th/knowledge/publications/5c72cf58/enforcing-imo-2020-are-we-ready>
- Hong, C.-S. (2019). *Thailand's Renewable Energy Transitions: A Pathway to Realize Thailand 4.0*. The Diplomat. [https://thediplomat.com/2019/03/thailands-renewable-energy-transitions-a-pathway-to-realize-thailand-4-0/#:~:text=Under%20the%20new%20PDP%2C%20Thailand's,to%2077%2C211%20MW%20in%202037.&text=By%202037%2C%20the%20country's%20power,and%20coal%20\(12%20percent\)](https://thediplomat.com/2019/03/thailands-renewable-energy-transitions-a-pathway-to-realize-thailand-4-0/#:~:text=Under%20the%20new%20PDP%2C%20Thailand's,to%2077%2C211%20MW%20in%202037.&text=By%202037%2C%20the%20country's%20power,and%20coal%20(12%20percent))
- IQAir. (2020). *The cost of air pollution*. IQAir. <https://www.iqair.com/blog/air-quality/cost-of-air-pollution>
- IQAir AirVisual. (2018). *World Air Quality Report 2018*. <https://www.iqair.com/>
- Kielmas, M. (n.d.). *How Do Factories Cause Air Pollution?* Sciencing. <https://sciencing.com/factories-cause-air-pollution-5169.html>
- Kittikongnaphang, R. (2017, December 12). Greenpeace. “Because We Are Not More Iron Lung People than Anyone,” CCDC Chiang Mai Center with PM2.5 Air Quality Reporting. <https://www.greenpeace.org/thailand/story/2064/ccdc-and-air-pollution-monitor/>
- Kuehne+Nagel. (2020). *IMO 2020 FAQ*. Kuehne+Nagel. https://th.kuehne-nagel.com/en_gb/seafreight/faq-imo-2020/
- Levett, P. (2020). *Systematic reviews: Data Extraction/Coding/Study characteristics/Results*. The George Washington University: Himmelfarb Health Sciences Library. https://guides.himmelfarb.gwu.edu/systematic_review/data-extraction
- Narita, D., Nguyen, T. K. O., Keiichi, S., Mingqun, H., Didin, P. A., Nguyen, N. H. C., Tanatat, R., & Ittipol, P. (2019). Pollution Characteristics and Policy Actions on Fine Particulate Matter in a Growing Asian Economy: The Case of Bangkok Metropolitan Region. *Atmosphere*, 10(5). <https://doi.org/10.3390/atmos10050227>
- National Academy of Sciences. (2002). *Sources and Effects of Carbon monoxide pollution. In The Ongoing Challenge of Managing Carbon Monoxide Pollution in Fairbanks, Alaska: Interim Report* (pp. 19–48). National Academic Press. <https://www.nap.edu/read/10378/chapter/3#20>

- Nemet, G. F., Holloway, T., & Meier, P. (2010). Implications of incorporating air-quality co-benefits into climate change policymaking. *Environmental Research Letters*, 5. <https://doi.org/10.1088/1748-9326/5/1/014007>
- Nordea. (2020). *The economic context of Thailand: Economic indicators*. Thailand: Economic and Political Overview. nordeatrade.com/fi/explore-new-market/thailand/economical-context
- Outapa, P., & Thepanondh, S. (2014). Development of Air toxic emission Factor and inventory of on-road Mobile Sources. *Air, Soil and Water Research*, 7(1), 1–10. <https://doi.org/10.4137/ASWr.S13320>
- PCD and Ministry of Natural Resources and Environment. (2018). *Booklet on Thailand State of Pollution 2018*.
- Pollution Control Department. (2007). *Development of Environmental and Emissions standards of Volatile Organic Compounds (VOCs) in Thailand*. https://www.pcd.go.th/wp-content/uploads/2020/06/pcdnew-2020-06-05_03-01-48_753915.pdf
- Pollution Control Department. (2015). *Thailand State of pollution report 2015*. http://infofile.pcd.go.th/mgt/PollutionReport2015_en.pdf
- Pollution Control Department. (2018). *Air and Noise Pollution Management Report 2018*. <http://air4thai.pcd.go.th/webV2/download.php>
- Pollution Control Department (PCD). (2019). *Booklet on Thailand State of Pollution 2018* (No. 978-616-316-511-4). Pollution Control Department, Ministry of Natural Resources and Environment. <http://www.oic.go.th/FILEWEB/CABINFOCENTER3/DRAWER056/GENERAL/DATA0001/00001462.PDF>
- Reuters. (2020). *Car sales to plunge 30-50% in 2020: FTI*. Bangkok Post. <https://www.bangkokpost.com/business/1937008/car-sales-to-plunge-30-50-in-2020-fti>
- Rujivanarom, P. (2018). *Coal-fired power plants 'partly to blame for Bangkok pollution.'* The Nation.
- Saetang, P. (2020). *The gaps that remain* [Webinar presentation]. Getting from (PM) 2.5 to Zero, Thailand.
- Siriwattanapong, A., & Chantharasenawong, C. (2018). *Electric motorcycle charging station powered by solar energy*. IOP Conference Series Materials Science and Engineering, 297(1). <https://doi.org/10.1088/1757-899X/297/1/012060>
- Soytong, P., & Perera, R. (2014). Use of GIS Tools for Environmental Conflict Resolution at Map Ta Phut Industrial Zone in Thailand. *Sustainability*, 6, 2435–2458. <https://doi.org/10.3390/su6052435>
- Srisurapanon, V., & Wanichapun, C. (2019). *Environmental Policies in Thailand and their Effects*. <https://www.un.org/esa/gite/iandm/viroatpaper.pdf>
- Statista Research Department. (2019). *Number of Facebook users Thailand 2017-2025*. Statista.Com. <https://www.statista.com/statistics/490467/number-of-thailand-facebook-users/>
- Thailand Clean Air Network (TCAN). (2019). *Clean Air White Paper, Thailand*. http://www.tei.or.th/file/library/2019-clean-air-white-paper_26.pdf
- Thailand Clean Air Network (TCAN). (2020). *Clean Blue Air Paper*. <https://www.greenpeace.org/static/planet4-thailand-stateless/2020/08/9f177db4-clean-air-blue-paper.pdf>
- The Nation. (2019). *Cabinet okays anti-pollution measures proposed by PCD*. The Nation. <https://www.nationthailand.com/news/30376951>
- Unapumnuk, K. (n.d.). *Air Quality and Noise Management*. http://infofile.pcd.go.th/air/cr170353_sec2.pdf
- United Nations Development Programme (UNDP)/World Bank Energy Sector Management Assistance Programme (ESMAP). (2003). *Thailand: Reducing Emissions from Motorcycles in Bangkok* (No. 275/03). https://www.esmap.org/sites/default/files/esmap-files/FR275-03_Thailand_Reducing_Emissions_from_Motorcycles_in_Bangkok.pdf
- US Energy Information Administration. (2019). *Electricity and the environment*. Electricity Explained. <https://www.eia.gov/energyexplained/electricity/electricity-and-the-environment.php>
- Vichit-Vadkan, N., & Vajanapoom, N. (2011). Health Impact from Air Pollution in Thailand: Current and Future Challenges. *Environmental Health Perspective*, 119(5), A197–A198. <https://doi.org/10.1289/ehp.1103728>

Appendix

Responsible agency	Name of the Act/Plan	Date (English) (original and all amendment dates)	Level	Air quality-related section	Directly or indirectly related
Constitutional Court	Constitution of the Kingdom of Thailand 2017	2017		<p>Section 43. A person and community shall have the right to:</p> <p>(2) manage, maintain and utilise natural resources, environment and biodiversity in a balanced and sustainable manner, in accordance with the procedures as provided by law;</p> <p>(3) sign a joint petition to propose recommendations to a State agency to carry out any act which will benefit the people and community, or refrain from any act which will affect the peaceful living of the people or community (Constitutional Court 2017);</p> <p>Section 50. A person shall have the following duties:</p> <p>(8) to cooperate and support the conservation and protection of the environment, natural resources, biodiversity, and cultural heritage (Constitutional Court 2017);</p> <p>Section 57. The State shall:</p> <p>(2) conserve, protect, maintain, restore, manage and use or arrange for utilisation of natural resources, environment and biodiversity in a balanced and sustainable manner, provided that the relevant local people and local community shall be allowed to participate in and obtain the benefit from such undertaking as provided by law (Constitutional Court 2017);</p> <p>Section 58. In regard to any undertaking by the State or that the State will permit any person to carry out, if such undertaking may severely affect the natural resources, environmental quality, health, sanitation, quality of life or any other essential interests of the people or community or environment, the State shall undertake to study and assess the impact on environmental quality and health of the people or community and shall arrange a public hearing of relevant stakeholders, people and communities in advance in order to take them into consideration for the implementation or granting of permission as provided by the law (Constitutional Court, 2017).</p> <p>In the implementation or granting of permission under paragraph one, the State shall take precautions to minimise the impact on people, community, environment, and biodiversity and shall undertake to remedy the grievance or damage for the affected people or community in a fair manner without delay (Constitutional Court 2017).</p>	Indirect
Ministry of Natural Resources and Environment	Intended National Determined Contributions- Thailand	2015	National	<p>Thailand intends to reduce its greenhouse gas emissions (CO₂, CH₄, N₂O, HFCs, PFCs, SF₆) by 20 percent from the projected business-as-usual (BAU) level by 2030 (Office of Natural Resources and Environmental Policy and Planning (ONEP) 2015).</p> <p>Thailand pledges a 20 to 25 percent reduction in its emission of greenhouse gases by 2030. The country has launched several environmental campaigns, especially those concerning garbage disposal and reforestation in ASEAN. It also promotes the use of eco-cars and electric trains and has a roadmap to reduce haze pollution (Office of Natural Resources and Environmental Policy and Planning (ONEP) 2015).</p>	Direct

Ministry of Natural Resources and Environment	Waste Management Roadmap	2016-2021	National	Application of the "Polluters Pay Principle" (Thai Ministry of Natural Resources and Environment 2016).	Direct
Ministry of Natural Resources and Environment	Promotion and conservation of natural environmental quality Act	1992, 2008-11	National	<p>The Act has provisions on the promotion of public participation in enhancing and conserving environmental quality and establishing of environmental management systems with pollution control measures as well as environmental funding and assistance measures, and on the duties of state agencies, state enterprises, and LGOs in the conservation of environmental quality (Ministry of Natural Resources and Environment 1992).</p> <p>A person has the right to receive relevant information from the government relating to environmental quality unless the information is considered an official secret or confidential information relating to a individual or property rights (Greenpeace 2015).</p> <p>Compensation can be received from the state for loss arising from harm caused by pollution emitted by a company or government agencies or state enterprises (Greenpeace 2015).</p>	Direct
Ministry of Natural Resources and Environment	Thailand Environmental Quality Management Plan	2017-21	National	7-20% GHGs Reduction by 2020, 99% Air Quality under AQI standard (Karatna 2017).	Direct
Ministry of Natural Resources and Environment	Notification of Ministry of Natural Resource and Environment	2018	National	<p>1) Enforcement of Diesel opacity meter from 1 Jan 2025 onwards. (indexed in the notification on 11 Nov 2018)</p> <p>2) Setting air pollutants emission standard from petroleum factory (Office of Natural Resources and Environmental Policy and Planning 2015b).</p>	Direct

Ministry of Natural Resources and Environment	Notification of Ministry of Natural Resource and Environment	2010	National	<p>Standards of Air Pollution from Ventilation Stack of New Power Plants (Industrial Estate Authority of Thailand 2009). This notification follows the suggestion of Pollution Control Committee and specifies the following regulations:</p> <p>Standard level of air pollution from ventilation stack of new power plant as listed in below table:</p> <p>Fuel type</p> <p>PM (mg/m³)</p> <p>SO₂ (ppm)</p> <p>NO₂ (ppm)</p> <p>Coal power plant (>50MW power generation)</p> <p>>80</p> <p>>360</p> <p>>200</p> <p>Coal power plant (<50 MW power generation)</p> <p>>80</p> <p>>180</p> <p>>200</p> <p>Oil power plant</p> <p>>120</p> <p>>260</p> <p>>180</p> <p>Natural gas power plant</p> <p>>60</p> <p>>20</p> <p>>120</p> <p>Biomass power plant</p> <p>>120</p> <p>>60</p> <p>>200</p> <p>Please note that this notification does not specify the type of PM (PM₁₀/PM_{2.5}) to be measured or controlled (Industrial Estate Authority of Thailand 2009)</p>	Direct
Ministry of Natural Resources and Environment	Notification of Ministry of Natural Resource and Environment	2018	National	<p>This notification follows the advice of Pollution Control Committee and specifies the following regulations:</p> <ul style="list-style-type: none"> – New power plants or existing plants with permission to expand as originators of pollution must control air pollution before releasing it into the environment. – The owner or possessor of the power plant is not permitted to release air pollution into the environment, except where there is processing of emissions following the standard of air quality control as specified in 'The Notification of the Ministry of Resources and Environment Enforcement: The Standard Level of Air Pollution from Ventilation Stack of New Power Plant' without dilution for new power plants (Industrial Estate Authority of Thailand 2009). 	Direct

Ministry of Natural Resources and Environment	National Strategy on Climate Change	2008-12, 2013-17	National	Promote greenhouse gas mitigation activities based on sustainable development by the following measures: - Promote use of renewable energy: power generation, transportation, and industrial processes - Improve energy efficiency: transportation, industrial processes, commercial and residential buildings - Promote forest conservation, afforestation, and reforestation to increase carbon sinks - Increase urban green space (Action for Climate Improvement Thailand 2009)	Direct
Ministry of Natural Resources and Environment	2015 Northern Haze prevention and mitigation plan	2015	Provincial	Assigns the provincial administrations of nine northern provinces including Chiang Mai, Chiang Rai, Nan Phayao, Lampang, Lumphun, Maehongson and Tak as the main authority under the single command center (which includes the provincial governor in each of the nine provinces), focused on resolving the issue at the sources of air pollution and participation from all stakeholders (Pollution Control Department 2015).	Direct
Ministry of Natural Resources and Environment	National Adaption plan- natural resources	2018-21, 2022-26, 2027-37	National	- Preserve and protect conservation forest areas - Promote and develop eco-villages (Songkhao n.d.)	Indirect
Ministry of Natural Resources and Environment	Nationally Appropriate Mitigation Action (NAMA) plan	2014	National	Thailand's NAMA plan proposes intended action points for the energy and transportation sectors to reduce emissions between 7 to 20 percent below projections for 2020. The named measures include renewable and alternative energy sources, energy efficiency improvements, biofuels in transportation, and a sustainable transit system (United Nations Climate Change (UNCC) 2015).	Indirect
Ministry of Natural Resources and Environment	Climate Change Master Plan	2015-2050	National	The main purposes for the Climate Change Master Plan: (1) To provide a long-term national framework for climate change adaptation and low carbon growth promotion according to sustainability development principle; (2) To provide a policy framework for the development of mechanisms and tools, at sectoral and national level, to achieve effective resolutions for climate change. (3) To provide government agencies and relevant organizations with a framework for detailed action plans; facilitating awareness and mutual understanding by means of a common framework of reference points, thereby increasing integration and reducing redundant processes. (4) To provide budgeting agencies with a clear framework for budget allocation, thus enabling the mobilization of concrete climate change resolutions (Office of Natural Resources and Environmental Policy and Planning 2015a)	Indirect

Ministry of Energy	Alternative Energy Plan	2015-2036	National	<p>The power generation costs from some renewable energy resources have still been higher than those of conventional energy resources such as coal, natural gas, and hydro while renewable energy has been promoted to address global warming and climate change issues causing by greenhouse gases (GHGs). The most well-known GHG is Carbon Dioxide (CO₂) mostly emitted from combustion of fossil fuels in industrial sectors and electricity power generation. Therefore, the government has been trying to push forward the Alternative Energy Development Plan (AEDP) to become a Low Carbon Society. In the past, to attract investors, the Adder System was used to encourage renewable power generation, while nowadays Feed-in Tariff (FIT) has been planned to be implemented to reflect the actual cost of renewable power generation and to specify the timeframe of purchasing (International Renewable Energy Agency 2017).</p> <p>Increase the proportion of renewable energy in the form of electricity, heat, and biofuels for 30 percent of final energy consumption by 2036. which will reduce the greenhouse gas emission for about 140 million tons of carbon dioxide equivalent (International Renewable Energy Agency 2017).</p>	Indirect
Ministry of Energy	National Energy Policy Council Act	1992, 2007, 2008	National	<p>Section 6: The National Energy Policy Council has the power to:</p> <p>(i) recommend national energy policies and national energy management and development plans to the cabinet.</p> <p>(ii) monitor, supervise, coordinate, support and expedite the operations of all committees with authority and duties related to energy, including government agencies, state enterprises and the private sector, to ensure that their operations are in accordance with national energy policies and national energy management and development plans.</p> <p>(ii) evaluate the implementation of national energy policies and national energy management and development plans (The Office of the Council of State 1992).</p>	Indirect
Ministry of Energy	Energy Conservation and Promotion act	1992, 2007	National	<p>Section 9: The owner of the designated factory must conserve energy, audit and analyze energy utilization in his factory, in accordance with the standard, criteria, and procedures as provided by the Ministerial Regulations issued by the Minister under the recommendation of the National Energy Policy Council (Ministry of Energy 1992).</p> <p>Section 25: The fund for promoting energy conservation shall be used as follows:</p> <ul style="list-style-type: none"> - Study or research projects on energy development, promotion and conservation, environment protection, and correction of environmental problems resulting from energy conservation, and energy policy and planning. - Advertisements, information dissemination, and public relations work, regarding energy development, promotion, and conservation, and environment protection and correction of environmental problems arising from energy conservation (Ministry of Energy 1992). 	Indirect
Ministry of Energy	Energy Efficiency development plan/20-year energy efficiency plan	2011-2030	National	<p>Government anticipated that energy prices would be one of key concerns due to limited energy resources, environmental issues, global warming, and climate change challenges which affect people's quality of life and the country's competitiveness. Therefore, the 20-year Energy Efficiency Development Plan 2015-2036 (EEDP) was developed by the Energy Policy and Planning Office, Ministry of Energy (Thailand) to address these issues (Ministry of Energy 2011).</p>	Indirect

Ministry of Energy	Power development plan (PDP)	2010-2030; 2015-2037; revised 2018-2037	National	<p>The themes of PDP2010 focus on security and adequacy of power system along with the policies of the Ministry of Energy (MoEN) on the aspects of environment concern, energy efficiency and renewable energy promotion to be in line with the 15-Year Renewable Energy Development Plan (REDP 2008 - 2021) (Ministry of Energy 2015).</p> <p>The MoEN suggests considering coal-fired power plant development alongside other fuel types. The plan enables the expansion of coal power with large coalfired power plants of 7,390 MW combined within the next 21 years⁴⁹. For greenhouse gas emission reduction, CO₂ in particular, clean coal technologies should be recommended (Ministry of Energy 2015).</p> <p>In the PDP2015, the expected CO₂ emission from power sector would be less than that of the previous plan because of fuel diversification and renewable energy promotion. In year 2030, the estimated CO₂ intensity would be 0.342 kgCO₂/kWh or 0.043 kgCO₂/kWh less than that of the previous plan. Moreover, the estimated CO₂ intensity at the end of the plan (year 2036) would reach 0.319 kgCO₂/kWh (Ministry of Energy 2015).</p> <p>Principles on the formulation of PDP2015 was to reduce environmental impacts, reduce CO₂ emissions per kilowatt hour and promote power generation from renewables (Ministry of Energy 2015).</p> <p>The 2018 Revision scales back the emphasis on coal power and envisages 67% increase in production of power by 2037. It sets a goal of new power capacity of 56,431 MW, of which renewable energy projects are planned to account for about 37 percent (up from around 10% in 2018). This means that by 2037, the sources of power generation will come from natural gas (53 percent), non-fossil fuels (35 percent), and coal (12 percent) (Hong 2019).</p>	Indirect
Ministry of Energy	Thailand smart grid development master plan	2015-2036	National	Upgrading the power infrastructure to be environmentally friendly (Green Society): Increasing capabilities for the grid to handle power generation from renewable sources and support the development of Micro Grids to develop sustainable energy in communities (Energy Policy and Planning Office 2014).	Indirect
Ministry of Energy	Energy Industry act	2007	National	<p>Restructuring the energy industry management by distinctly separating the functions of policymaking, regulation and operation from one another in order to achieve efficient, secure, adequate and extensive energy service provision with reasonable prices and up-to-standard quality to meet the demand and contribute to sustainable development of the country in terms of social, economic and environmental aspects (Ministry of Energy 2007).</p> <p>Under the Act, the Energy Regulatory Commission (ERC) of Thailand is established to issue regulations, rules, announcements or criteria, procedures and conditions in order to regulate various issues in the energy industry as prescribed by law. Prior to issuing any ERC regulations, rules and announcements which will affect persons, groups of persons or licensees, a hearing process shall be arranged. In addition, the ERC is tasked with promotion of renewable energy and efficient use of energy (Ministry of Energy 2007).</p>	Indirect

Ministry of Energy	Oil Development Plan	2015-2036	National	Oil Plan 2015 -2036 will be a long-term plan to support fuel management in line with the goal of energy conservation plan and alternative energy development plan and serve as a framework for the management of the future fuel mix which considers the environment and risks that may impact both directly and indirectly to the development of the country's energy (Energy Policy and Planning Office 2015).	Indirect
Ministry of Energy	Fuel trade act (Lead phase out, Euro 2,3, Eco car, 1st buyer incentive program, Fuel, and engine quality standards, E20 gasohol policy)	2000	National	<p>Section 8: In the case of necessity for the benefits of national security, prevention, and remedy of fuel shortage, as well as determination and control of fuel quality, the Minister may issue a Notification to determine conditions concerning any trading operations as deemed appropriate to be observed by a fuel trader under section 7 (Energy Policy and Planning Office 2000).</p> <p>Section 25. The Director-General shall have the power to determine features and quality of fuel to be enforced throughout the Kingdom. In the case of necessity, the Director-General may determine the same to be enforced within a certain region or several regions, as deemed appropriate, or may require a fuel trader of a certain type of fuel to notify features and quality of fuel for approval in accordance with the criteria and procedures prescribed by the Director-General. In this regard, the Director-General may prescribe conditions to be complied with by the person receiving such approval (Energy Policy and Planning Office 2000).</p>	Indirect
National Council for Peace and Order (NCPO)	Order 3/2016 and Order 4/2016	2016	National	<p>The Head of the NCPO issued Order 3/2016 which concerns the exemption from the 1975 Town and City Planning Act and other regulations on buildings for constructing Special Economic Zones (SEZ). As the rules on how to utilize land under city planning laws and laws on building control are inconsistent and could obstruct the establishment of SEZ, this order allows such establishment SEZs to be expedited. The order also takes away from local government the authority to impose regulations on construction in SEZs.</p> <p>This order facilitates investment by decreasing legal limitations, such as location of industrial factories. Previously, certain prohibitions under those laws applied on the land declared as SEZ; certain factories could not be built. However, this order will lead to ministerial regulations on city planning and to new regulations on building control which will facilitate the SEZ policy and investment conditions.</p> <p>NCPO Order No. 4/2016 exempts power plants, water treatment plants, garbage disposal and collection plants, recycling plants, and gas processing plants from regulations under the Town and City Planning Act. The rationale of this order is to restrain and to fix some legal objections obstructing the State's attempt to urgently fix problems on energy security in Thailand and on the environment, especially excessive garbage.</p> <p>This order reduces legal limitations on factory location or other enterprises related to energy production and waste management. Previously, there were certain prohibitions under ministerial regulations on city planning in certain districts or provinces such as rural and agriculture reservation areas where power plants could not be built.</p> <p>Thus, with this order, certain developments can be approved without considering city planning laws; however the process must still consider the suitability of the project area and conditions set under other legislation. The authority may approve the enterprises (1)-(8) without having to consider laws on city planning which is a crucial measure to protect the environment (iLaw 2015)</p>	Indirect

Office of the Prime Minister	12th National Economic and Social Development Plan	2017-2021	National	<p>Strategy for Environmentally Friendly Growth for Sustainable Development</p> <p>- development in the coming period should aim at conserving and restoring the stock of natural resources, building water security and managing both surface and underground water resources efficiently, creating good environmental quality, reducing pollution and minimizing the impacts of environmental pressures on public health and ecosystems, reducing greenhouse gas emissions and enhancing the capacity for climate change adaptation, increasing the efficiency in disaster risk management and reducing the loss of life and damage of properties due to public hazards (Office of the National Economic and Social Development Board- Office of the Prime Minister 2017).</p> <p>Key development approaches are: (1) conserving and restoring natural resources as well as creating a balance between conservation and sustainable usage in an equitable manner; (2) increasing efficiency in water resource management to achieve security, balance, and sustainability; (3) solving the critical problem of environmental pollution; (4) promoting sustainable consumption and production; (5) promoting greenhouse gas (GHG) reduction and raising adaptive capacity to climate change; (6) managing disaster risk reduction; (7) developing management systems and conflict resolution mechanisms for natural resource and environmental issues; and (8) fostering international environmental collaboration (Office of the National Economic and Social Development Board- Office of the Prime Minister 2017).</p>	Direct
Ministry of Industry	Industrial Estate Authority of Thailand Act	1979	National	<p>Section 10. IEAT shall have the power to carry out any business within the scope of its objectives under section 6, including the powers as follows:</p> <p>(4) to supervise operation of an industrial entrepreneur, trader, entrepreneurs of other businesses which are beneficial to, or connected with, industrial undertaking or commerce and that of any person utilizing of land in industrial estate to be in compliance with the rules, regulations and laws, including all requirements relating to public health or environmental quality (Ministry of Industry 1979).</p>	Indirect
Ministry of Industry	Factory Act	1992, 2019	National	<p>The Act has provisions on the powers to lay down criteria and standards for controlling the discharge or emission of wastes, pollutants or anything that affects the environment because of the engagement in a factory business, for example waste, human waste/excreta and solid waste disposal, wastewater discharges and air-pollutant emissions from industries, and waste treatment systems (Office of the Council of State 1992).</p>	Direct

Office of the Cane and Sugar Board (OCSB), Ministry of Industry	Burnt Sugarcane solving plan	June 2019	National	<p>The cabinet has set a goal of zero burnt sugarcane by 2022, and in 2020 burnt sugarcane should account for no more than 50% of the market (Office of the Cane and Sugar Board (OCSB) 2020).</p> <p>The law prescribes that the sugar mills cannot refuse to buy sugarcane from farmers, otherwise the mills will be charged 500,000 THB. However the law also prescribes that the mills cannot buy burnt sugarcane over the limit set by the government, otherwise the mill will have to pay the fine (12 THB/ton).</p> <p>The policy to reduce burnt sugarcane includes the following provisions:</p> <ol style="list-style-type: none"> 1. Law enforcement: the mills can buy and store burnt sugarcane as follows: <ul style="list-style-type: none"> • no more than 30% each day during production season 2019-2020 • no more than 20% each day during production season 2020-2021 • only 0-5% each day during production season 2021-2022 <p>If a small amount of burnt sugarcane is found in a truck, all of the sugarcane on that specific truck will be considered burnt sugarcane.</p> <ol style="list-style-type: none"> 2. Support the use of agricultural machinery by giving loan to sugarcane farmers during 2020-2022. 3. Appoint role-model provinces to promote zero sugarcane burning in each region (Kanchanaburi, Ratchaburi, Chaiyaphum, Loei, Uttaradit). Specify sugarcane-burning-free area within 5 km radius around community zones and within 10 km. radius around sugarcane factory (Office of the Cane and Sugar Board (OCSB) 2020). 	Direct
Ministry of Transport	Environment Sustainable Transport Plan	2013-20	National	<ul style="list-style-type: none"> - Upgrade capability of bus services quality - Development and Training in "Global warming and transport" - Plan for development of public transport in regional cities - Study of sustainable and environmental- friendly water and air transport - Procurement of new efficient buses with low pollution emissions (BMTA's 3183 NGV buses) - Promotion of the use of eco-friendly vehicle (Ministry of Transport 2014). 	Direct
Ministry of Transport	Passenger car act/Vehicle Act	1979	National	<p>Annual tax for a vehicle driven by renewable energy, ecological conservation energy, or economical energy prescribed in the Ministerial Regulation shall be collected at half the rate prescribed (Ministry of Transport 1979).</p> <p>The vehicle driven by engine fueled by natural gas, which is a hydrocarbon compound mainly composing of methane, shall pay annual tax at the following rate:</p> <ol style="list-style-type: none"> (a) the vehicle having fuel system using solely natural gas, shall pay annual tax at half the rate prescribed. (b) the vehicle having combination fuel system of such natural gas and petroleum shall pay annual tax at three quarters of the rate prescribed (Ministry of Transport 1979). 	Indirect

Ministry of Transport	Land transportation Act	1979	National	<p>Section 71. Vehicles used in transport must be strong, firm and well equipped with accessories and components prescribed in the Ministerial Regulation under section 73 and have already paid tax under 85. Vehicles used in transport which have already paid tax under this Act shall be exempt from motor vehicle tax levied under the law on motor vehicle (Ministry of Transport 1979a).</p> <p>Section 72. A vehicle applying for registration and tax payment must have undergone vehicle condition examination by the Vehicle Condition Examining officer or the vehicle condition examination center licensed under section 74 except the vehicle of any category and type appropriate to be exempted from time to time as prescribed in the Ministerial Regulation.</p> <p>The Registrar shall have power to order the transport operation licensee who is the owner of the vehicle under paragraph one to send such vehicle to the Vehicle Condition Examining Officer or the licensed vehicle condition examination center for examining the defect reported by the Inspector within the prescribed period (Ministry of Transport 1979a).</p>	Indirect
Ministry of Agriculture and Cooperatives	National Adaption plan- agriculture	2018-21, 2022-26, 2027-37	National	Support new theory agriculture in parallel with environmentally friendly agriculture (Songkhao n.d.).	Indirect
Ministry of Public Health	National Adaption plan – Health	2018-21, 2022-26, 2027-37	National	<ul style="list-style-type: none"> - Develop the network of early warning and surveillance in risk areas and population. - Improve health insurance systems to cover climate-risk/ vulnerable population - Develop prototype communities in risk areas (Songkhao n.d.). 	Indirect
Ministry of Public Health	Public Health act	1992, 2007	National	The Act has provisions relating to environmental health for the protection of people's health covering the operations of activities affecting the public health, from the family and community levels to small and large businesses, such as street food vending stalls, food storage places, fresh markets, and health-threatening operations. The law also deals with decentralization to local administration agencies (LGOs) to have powers to issue their own regulations for enforcement within their designated localities and to authorize local competent officials to take control over such operations (Ministry of Public Health 1992).	Indirect
Ministry of Public Health	National Health Act	2007	National	According to Chapter 1 on “rights and duties in respect of health” of the Act, Section 5 prescribes in paragraph one that a person shall enjoy the right to live in healthy environmental conditions and in paragraph two that a person shall have the duties in cooperation with state agencies in creating environmental conditions stated in paragraph one. Moreover, Section 10 of the Act prescribes that in the case where there exists an incident affecting health of the public, a state agency having information related to such incident shall expeditiously provide and disclose such information and the protection thereof to the public; and Section 11 prescribes that an individual or a group of people has the right to make a request for an assessment and participation in the assessment of health impact resulting from a public policy; and an individual or a group of people shall have the right to acquire information, explanation and underlying reasons from a state agency prior to giving a permission or performance of a programme or activity which may affect his or her health or the health of a community, and shall have the right to express his or her opinion on such a matter (Ministry of Public Health 2007).	Indirect
Ministry of Tourism and Sports	National Adaption plan – Tourism	2018-21, 2022-26, 2027-37	National	<ul style="list-style-type: none"> - Promote ecological, cultural, and sustainable tourism (Songkhao n.d.). - Promote environmentally friendly management and activities (Songkhao n.d.). 	Indirect

Ministry of Interior	National Adaption plan- Human settlement	2018-21, 2022-26, 2027-37	National	<ul style="list-style-type: none"> - Study and review the feasibility of the enforcement and the development of specific city plans in climate risk areas for long-term solutions (Songkhao n.d.). - Develop the infrastructures necessary for coping with emergencies as the result of natural disasters (Songkhao n.d.). 	Indirect
Ministry of Interior	National Fire Haze Control plan of action	1997	National	Emphasizes open burning and forest fire controls and public awareness (Tiyapairat 2012).	Direct
Ministry of Interior	National Master Plan for Open Burning	2004-09	National	<ol style="list-style-type: none"> 1. Act upon ASEAN Agreement on Transboundary Haze Pollution 2. Effective agriculture waste management 3. Effective community waste management 4. Effective forest fire management 5. Promotion of renewable energy usage 6. Effective public relations to highlight the importance of open burning control and increase public participations. 7. Relevant law enforcement <ul style="list-style-type: none"> - Revise relevant laws by adding concrete legal regulations/penalties for open burning control - Revise relevant laws by adding more authority to LGOs for open-burning law enforcement. - Improve PM standards (Pollution Control Department 2003). 	Direct
Ministry of Interior	Disaster Prevention and Mitigation Act	2007	National	<p>Sections 11 and 12 of the Act prescribe that a National Public Disaster Prevention and Mitigation Plan shall be formulated covering essential elements, including at least guidelines and procedures for providing assistance and reliefs, on a short- and long-term basis, for affected people when a public disaster occurs, as well as people's evacuation, state agencies and LGOs' roles, welfare and health care for affected people, and solutions to communication and public utilities problems (Department of Interior, 2007).</p> <p>Section 15 (related to Zero burning measure) Provincial Governor as Provincial Director shall be responsible for disaster prevention and mitigation of their own province. He or she shall have power as follows. (1) Formulate the Provincial Disaster Prevention and Mitigation Plan in accordance with the national plan. (2) Oversee and train all volunteers of local administration in the province. (3) Oversee and investigate all local administrations on preparing of disaster prevention and mitigation equipment, materials, vehicles and other related hardware for their own use in accordance with Provincial plan. (4) Operate as a government service unit at local administration level to provide basic support to disasters affected people, and other activities related to disaster prevention and mitigation (5) Support local administrations on any related activities of disaster prevention and mitigation. (6) Perform other duties as may be required by the Commander in Chief or the Central Director. For benefit of operations under Section 15 (3), (4), and (5), Provincial Director shall have power to demand other government agencies and other local administrations in their own province to cooperate to Provincial Disaster Prevention and Mitigation Plan and shall have power to control and oversee activities of Officers and Volunteers in according to this law (Department of Interior 2007)</p>	Indirect
Ministry of Interior	Zero burning measure	2007	Provincial	Provides the authority to the provincial governments to prohibit all burning in the designated area, of their province, for 60 days by using the authority of Public Disaster Prevention and Mitigation Act (National 2020).	Direct.

Ministry of Interior	Disaster Risk Management Plan	2015	National	<p>The Ministry of Natural Resources and Environment is assigned to coordinate and cooperate with other relevant agencies for the purpose of developing the plan, preventing, and mitigating the impacts of natural disasters on natural resources and environment, such as forest fires and haze, geohazard (landslide, earthquake, tsunamis and sink hole) as well as diverse types of pollutions, etc. (Department of Interior 2015).</p> <p>In the Guidelines for Activating Emergency Support Functions 4, the Ministry of Interior as a primary agency along with Ministry of Industry and Ministry of Mineral Resources and Environment as support agencies have a responsibility to provide support for fire prevention and suppression efforts in specific areas and places, including national parks, industrial estates, airports, or within the areas that may result in possible environmental pollution, etc. (Department of Interior 2015).</p> <p>In the Guidelines for Activating Emergency Support Functions 10, as a primary agency, Ministry of Industry together with Ministry of Natural Resources and Environment, Ministry of Defense, Ministry of Science and Technology, Pollution Control Department, and Office of Atoms for Peace as support agencies have a responsibility to</p> <ol style="list-style-type: none"> 1. Put in place an action plan for the prevention of chemical and radioactive hazards and other hazardous material incident, as well as controlling their harmful effects on human health, natural resources and environment (Department of Interior, 2015). 2. develop appropriate systems, models, or methods for management of chemical, radioactive, and other hazardous material disasters. 3. work to eliminate or minimize hazardous effects of the residual chemicals, radioactive, and other hazardous material contamination remaining in the polluted areas, and to conduct environmental damage assessments. 4. provide technical assistance and consultation services for management of chemical, radioactive, and other hazardous material disasters. 5. provide information and technical knowledge on chemical, radioactive, and other hazardous materials to support emergency management operations (Department of Interior 2015). 	Direct
Ministry of Interior	Building Control Act	1979	National	The Act has provisions on the requirements for any building to have proper systems for ventilation, air-conditioning, air purification, wastewater treatment, and solid and human waste management as per the established standards to enhance the efficiency of public health and environmental conservation measures (Department of Interior 1979).	Indirect
Multi-ministerial (Ministry of Public Health, the Ministry of Natural Resources and Environment, the World Health Organization (WHO), the United Nations Environment Programme (UNEP) and the Chulabhorn Research Institute (CRI))	Charter of the regional forum on environment and health	2007	International	A tool for collaboration and formulation of a Regional Environment and Health Action Plan in seven priority areas, namely: (1) air quality; (2) water supply, hygiene, and sanitation; (3) solid and hazardous wastes; (4) toxic chemicals and hazardous substances; (5) climate change, ozone depletion and ecosystem changes; (6) contingency planning, preparedness, and response in environmental health emergencies; and (7) health impact assessment (Narasystem 2007).	Direct

Pollution Control Department, Ministry of Natural Resources and Environment.	Stockholm Convention on Persistent Organic Pollutants (POP)	2004	International	Thailand signed and ratified the Stockholm Convention on 22 May 2002 and 31 January 2005 respectively and has taken actions according to the guidelines of the Convention as follows: (1) using legal and administrative measures in prohibiting the production and use of nine POPs; (2) allowing import/export of POPs only for the purpose specifically permitted; (3) formulating a national action plan pursuant to the Convention on the reduction or ending of POP emissions from the manufacturing process; (4) promoting the use of substitute or modified materials, based on the principles of best available techniques (BAT) and best environmental practices (BEP); (5) ensuring that any warehouse having POPs will be supervised so that there will be no adverse effects on human health and the environment; and any waste resulting from such POPs has to be properly managed; (6) making all administrators and policy-makers have a good understanding about POPs; (7) disseminating the information about POPs to the public and designing a plan and guidelines for informing women, children and the educationally disadvantaged about POPs and their hazards to health and the environment; (8) supporting research on impacts of POPs at the national and international levels; and (9) setting up a national coordinating center for exchanging information and performing other duties (United Nations Environmental Program n.d.).	Direct
UNEP	Climate and Clean Air Coalition (CCAC)	2012	International	By joining the Climate and Clean Air Coalition, Thailand will build upon the findings of the Coalition's recent assessment of air pollution in Asia Pacific to develop its understanding of national black carbon and tropospheric ozone emissions and determine mitigation opportunities. Key emissions sources in Thailand include biomass burning, vehicles and industrial production (World Health Organization 2020).	Direct
ASEAN	ASEAN Agreement for Transboundary Haze	2002	International	1. cooperate in developing and implementing measures to prevent, monitor, and mitigate transboundary haze pollution by controlling sources of land and/or forest fires, development of monitoring, assessment and early warning systems, exchange of information and technology, and the provision of mutual assistance (The ASEAN Secretariat 2020). 2. respond promptly to a request for relevant information sought by a State or States that are or may be affected by such transboundary haze pollution, with a view to minimizing the consequence of the transboundary haze pollution; and 3. take legal, administrative and/ or other measures to implement their obligations under the Agreement (The ASEAN Secretariat 2020).	Direct
Ministry of Energy	Hazardous Substance Act	1992	National	Set controlling measures against the use, production, import, disposal, and transport of Hazardous Substance that may affect the environment (Ministry of Interior 1992).	Direct
Ministry of Interior and Ministry of Finance	Determining Plans and Process of decentralization of local government organization Act BE 2542	1999	National	Under section 16, Provincial Administrative organization shall give powers and duties to systemize the public services for the benefit of local communities for management of the environment and other pollution (Department of Interior 1999).	Direct

Appendix references

- Action for Climate Improvement Thailand. (2009). *Thailand's National Strategy on Climate Change 2008-2012*. Action for Climate Improvement Thailand. <https://actionforclimate.deqp.go.th/?p=6432&lang=en>.
- Constitutional Court. (2017). *Constitution of the Kingdom of Thailand*. https://www.constitutionalcourt.or.th/occ_en/download/article_20170410173022.pdf
- Department of Interior. (1979). *Building Control Act, B.E. 2522 (1979)*. (Vol. 96, Part 80, Special issue). Department of Interior; Government Gazette. <http://asean-law.senate.go.th/file/law/pdf/file-192-13.pdf>.
- Department of Interior. (1999). *Determining Plans and Process of decentralization of local government organization Act BE 2542*. http://thailaws.com/law/t_laws/tlaw0070_6.pdf
- Department of Interior. (2007). *Disaster Prevention and Mitigation Act, B.E. 2550 (Vol. 124, Part 52A (i))*. Department of Interior; Royal Gazette. <http://extwprlegs1.fao.org/docs/pdf/tha89587.pdf>
- Department of Interior. (2015). *National Disaster Risk Management Plan*. Department of Interior. https://www.disaster.go.th/upload/download/file_attach/584115d64fcee.pdf
- Energy Policy and Planning Office. (2000). *Fuel Trade Act, B.E. 2543 (Vol. 117 part 111a)*. Government Gazette. 2000
- Energy Policy and Planning Office. (2014). *Annual Report 2014*. http://www.eppo.go.th/images/Infomation_service/EppoAnnualReport/EPPOAnnualReport2014.pdf
- Energy Policy and Planning Office. (2015). *Oil Plan 2015-2036*. http://www.eppo.go.th/images/POLICY/ENG/oil_plan2558.pdf
- Greenpeace. (2015). *Human Cost of Coal Power: How coal-fired power plants threaten the health of Thais*. Greenpeace Southeast Asia. <https://www.greenpeace.or.th/Thailand-human-cost-of-coal-power/en.pdf>
- Hong, C.-S. (2019). *Thailand's Renewable Energy Transitions: A Pathway to Realize Thailand 4.0*. The Diplomat. [https://thediplomat.com/2019/03/thailands-renewable-energy-transitions-a-pathway-to-realize-thailand-4-0/#:~:text=Under%20the%20new%20PDP%2C%20Thailand's,to%2077%2C21%20MW%20in%202037.&text=By%202037%2C%20the%20country's%20power,and%20coal%20\(12%20percent\)](https://thediplomat.com/2019/03/thailands-renewable-energy-transitions-a-pathway-to-realize-thailand-4-0/#:~:text=Under%20the%20new%20PDP%2C%20Thailand's,to%2077%2C21%20MW%20in%202037.&text=By%202037%2C%20the%20country's%20power,and%20coal%20(12%20percent)).
- iLaw. (2015). *Report on the Exercise of Power under Section 44 of the Interim Constitution of Thailand*. <https://ilaw.or.th/node/3938>
- Industrial Estate Authority of Thailand. (2009). *Notification of Ministry of Natural Resources and Environment: The Standard Level of Air Pollution from Ventilation Stack of New Power Plan*. https://ieat.go.th/handbook/Program_IEAT/pdf/laws/en/ENV054.pdf
- International Renewable Energy Agency,. (2017). *Renewable Energy Outlook: Thailand (No. 978-92-9260-035-8)*. International Renewable Energy Agency. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2017/Nov/IRENA_Outlook_Thailand_2017.pdf
- Karatna, P. (2017). *Thailand Environmental Quality Management Plan 2017 – 2021*. https://www.unescap.org/sites/default/files/ONEP%20_%20NEQMP.pdf
- Ministry of Energy. (1992). *Energy conservation and promotion Act, B.E.2535 (1992)*. http://thailaws.com/law/t_laws/tlaw0072.pdf
- Ministry of Energy. (2007). *Energy Industry Act B.E. 2550 (2007) (Vol. 124, Part 89 a)*. The Government Gazette. http://www.eppo.go.th/images/law/ENG/energy_industry_act-2007.pdf
- Ministry of Energy. (2011). *Thailand 20-Year Energy Efficiency Development Plan (2011–2030)*. http://www.eppo.go.th/images/POLICY/ENG/EEDP_Eng.pdf.
- Ministry of Energy. (2015). *Thailand Power Development Plan 2015-2036 (PDP2015)*. http://www.eppo.go.th/images/POLICY/ENG/PDP2015_Eng.pdf.
- Ministry of Industry. (1979). *INDUSTRIAL ESTATE AUTHORITY OF THAILAND ACT, B.E. 2522 (1979)*. http://web.krisdika.go.th/data/outside/outside21/file/INDUSTRIAL_ESTATE_AUTHORITY_OF_THAILAND_ACT,B.E._2522.pdf
- Ministry of Interior. (1992). *Hazardous Substance Act, B.E. 2535 (1992) (Vol. 109, Part 39)*. Government Gazette. http://web.krisdika.go.th/data/document/ext809/809927_0001.pdf
- Ministry of Natural Resources and Environment. (1992). *Promotion and conservation of natural environmental quality Act*. http://thailaws.com/law/t_laws/tlaw0280.pdf
- Ministry of Public Health. (1992). *Public Health Act, B.E. 2535 (1992) (Vol. 109, Part 38)*. Government Gazette. http://web.krisdika.go.th/data/document/ext838/838066_0001.pdf
- Ministry of Public Health. (2007). *National Health Act, B.E. 2550 (2007) (Vol 124, Part 16a)*. Government Gazette. http://thailawforum.com/laws/National%20Health%20Act_2007.pdf.
- Ministry of Transport. (1979a). *Land Transportation Act, B.E. 2522 (1979) (Vol. 96, Part 38, Special issue)*. Government Gazette. [http://web.krisdika.go.th/data/outside/outside21/file/Land_Transport_Act_BE_2522_\(1979\).pdf](http://web.krisdika.go.th/data/outside/outside21/file/Land_Transport_Act_BE_2522_(1979).pdf)

- Ministry of Transport. (1979). *Vehicle Act. B.E. 2522 (1979)* (Vol. 96, Part 77, Special Issue). Government Gazette. [http://web.krisdika.go.th/data/outside/outside21/file/Vehicle_Act_BE_2522_\(1979\).pdf](http://web.krisdika.go.th/data/outside/outside21/file/Vehicle_Act_BE_2522_(1979).pdf)
- Ministry of Transport. (2014). *Thailand's Environmental Sustainable Transport Master Plan*. <http://www.gms-eoc.org/uploads/resources/420/attachment/2.6.Thailand-Low-Carbon-Transport-Policy-Chutinthorn-Pradipthet.pdf>
- Narasystem. (2007). *Ministerial Regional Forum on Environment and Health*. RYT9. <https://www.ryt9.com/en/prg/55026>.
- National. (2020). *Strict no-burn zone measures to be implemented in North*. The Nation. <https://www.nationthailand.com/news/30381686>.
- Office of Natural Resources and Environmental Policy and Planning. (2015a). *Climate Change Master Plan 2015-2050*. https://climate.onep.go.th/wp-content/uploads/2019/07/CCMP_english.pdf
- Office of Natural Resources and Environmental Policy and Planning. (2015b). *Notification of ministry of natural resource and environment*. (Vol. 126, Special Issued 188 Ngo). Government Gazette. http://www.onep.go.th/eia/wp-content/uploads/2018/07/ehia-eng-law_01.pdf
- Office of Natural Resources and Environmental Policy and Planning (ONEP). (2015). *Intended Nationally Determined Contribution and Relevant Information*. https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Thailand%20First/Thailand_INDC.pdf
- Office of the Cane and Sugar Board (OCSB). (2020). *Depressing 29 rn. Sugar, buy sugarcane, burn more than limit, increase dust, pollution PM 2.5*. <http://www.ocsb.go.th/th/cms/detail.php?ID=11388&SystemModuleKey=economic>
- Office of the Council of State. (1992). *Factory Act, B.E.2535 (1992)* (Vol. 119, Part 44, Page 62). Government Gazette. http://web.krisdika.go.th/data//document/ext809/809898_0001.pdf
- Office of the National Economic and Social Development Board- Office of the Prime Minister. (2017). *Summary the Twelfth National Economic and Social Development plan (2017-2021)*. https://www.nesdc.go.th/ewt_dl_link.php?nid=9640.
- Pollution Control Department. (2003). *Thailand State of Pollution Report 2003*. http://infofile.pcd.go.th/mgt/pollution2546_6admin_en.pdf
- Pollution Control Department. (2015). *Thailand State of pollution report 2015*. http://infofile.pcd.go.th/mgt/PollutionReport2015_en.pdf
- Songkhao, C. (n.d.). *The First Draft of Thailand National Adaptation Plan*. <https://www.adaptation-undp.org/resources/presentation/first-draft-thailand-national-adaptation-plan>
- Thai Ministry of Natural Resources and Environment. (2016). *Solid Waste Management for 2016-2021, Master Plan*.
- The ASEAN Secretariat. (2020). *ASEAN Agreement on Transboundary Haze Pollution*. Haze Action Online. <https://haze.asean.org/asean-agreement-on-transboundary-haze-pollution/>
- The Office of the Council of State. (1992). *National Energy Policy Council Act. B.E. 2535 (1992)*.
- Tiyapairat, Y. (2012). *Public Sector Responses to Sustainable Haze Management in Upper Northern Thailand*. Environment Asia, 5(2), 1–10.
- United Nations Climate Change (UNCC). (2015). *Thailand Submits NAMA*. <https://unfccc.int/news/thailand-submits-nama#:~:text=Thailand's%20National%20NAMA%20proposes%20action,and%20a%20sustainable%20transit%20system>
- United Nations Environmental Program. (n.d.). *Thailand Case Study*. <https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjTrbvo9PTsAhVfzgzGHdZCCC0QFjABegQIBRAC&url=http%3A%2F%2Fchm.pops.int%2FTheConvention%2FLegalMatters%2FLegalMattersAdditionalResources%2Ftabid%2F2245%2Fctl%2FDownload%2Fmid%2F7339%2FDefault.aspx%3Fid%3D8%26ObjID%3D11934&usg=AOvVaw1zUwt7U6ptNlsvAM3LIi3>
- World Health Organization. (2020). *The Climate and Clean Air Coalition (CCAC)*. <https://www.who.int/news/item/01-01-2020-the-climate-and-clean-air-coalition-ccac>

Visit us

SEI Headquarters

Linnégatan 87D Box 24218
104 51 Stockholm Sweden
Tel: +46 8 30 80 44
info@sei.org

Måns Nilsson

Executive Director

SEI Africa

World Agroforestry Centre
United Nations Avenue
Gigiri P.O. Box 30677
Nairobi 00100 Kenya
Tel: +254 20 722 4886
info-Africa@sei.org

Philip Osano

Centre Director

SEI Asia

10th Floor, Kasem Uttayanin Building,
254 Chulalongkorn University,
Henri Dunant Road, Pathumwan, Bangkok,
10330 Thailand
Tel: +66 2 251 4415
info-Asia@sei.org

Niall O'Connor

Centre Director

SEI Tallinn

Arsenal Centre
Erika 14, 10416
Tallinn, Estonia
Tel: +372 6276 100
info-Tallinn@sei.org

Lauri Tammiste

Centre Director

SEI Oxford

Oxford Eco Centre, Roger House,
Osney Mead, Oxford,
OX2 0ES, UK
Tel: +44 1865 42 6316
info-Oxford@sei.org

Ruth Butterfield

Centre Director

SEI US

Main Office

11 Curtis Avenue
Somerville MA 02144-1224 USA
Tel: +1 617 627 3786
info-US@sei.org

Michael Lazarus

Centre Director

SEI US

Davis Office

400 F Street
Davis CA 95616 USA
Tel: +1 530 753 3035

SEI US

Seattle Office

1402 Third Avenue Suite 900
Seattle WA 98101 USA
Tel: +1 206 547 4000

SEI York

University of York
Heslington York
YO10 5DD UK
Tel: +44 1904 32 2897
info-York@sei.org

Sarah West

Centre Director

SEI Latin America

Calle 71 # 11-10
Oficina 801
Bogota Colombia
Tel: +57 1 6355319
info-LatinAmerica@sei.org

David Purkey

Centre Director