Strengths and Challenges of City-level Action Plan for Adopting Technologies for Air Pollution Control in Bangkok

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APCTT Asian and Pacific Centre for Transfer of Technology

AIT Asian Institute of Technology

Project “City-level assessment studies on air pollution control in Bangkok”

The project aims to undertake three related activities for Bangkok:

- Study the technological interventions and gaps/needs for air pollution control in Bangkok, Thailand;
- Study to examine the city level action plan of Bangkok and assess the strengths and challenges related to the strategies for adopting air pollution control technologies;
- Provide recommendations for strengthening the city action plan for adoption of enabling mechanism for innovative technologies.

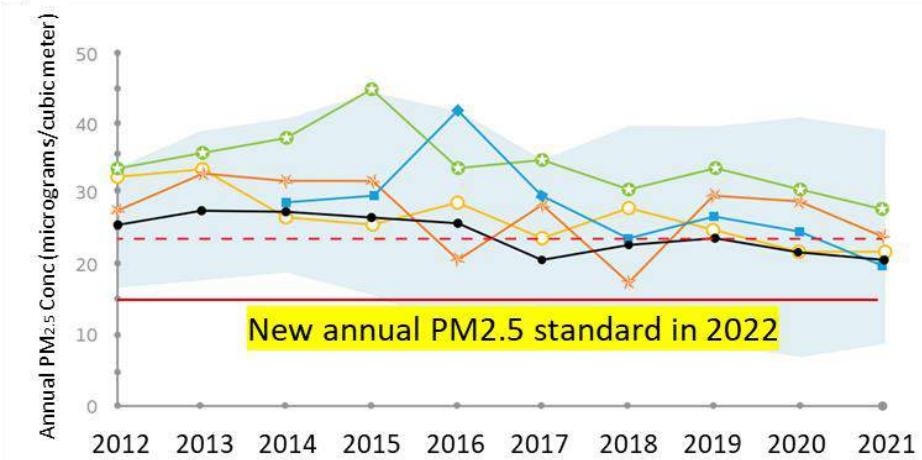
Approach/Methodology

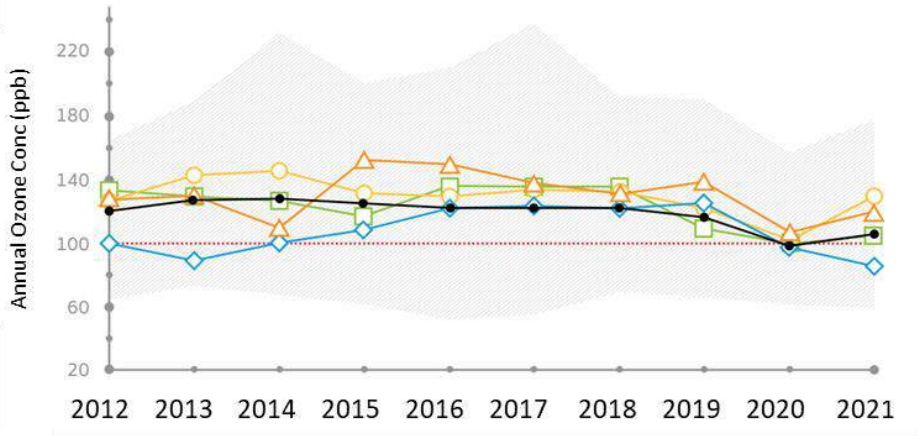
This project collected data from two major sources: literature review and interviews with key stakeholders involved in technology implementation in Bangkok.

- The literature review focused on various aspects of air quality and air quality management which includes, but not limited to:
  - Current air quality in Bangkok and ambient air quality standard in Thailand
  - National Roadmap for PM2.5 and the Bangkok Air Quality Plan
  - Technologies used in other countries that can be used in Bangkok to reduce air pollution.
- The interviews involved individuals who work on air pollution in Thailand.

Current Situation of Air Quality in Bangkok/Thailand

Current Situation of Ambient Air Quality in Thailand





Criteria air pollutants

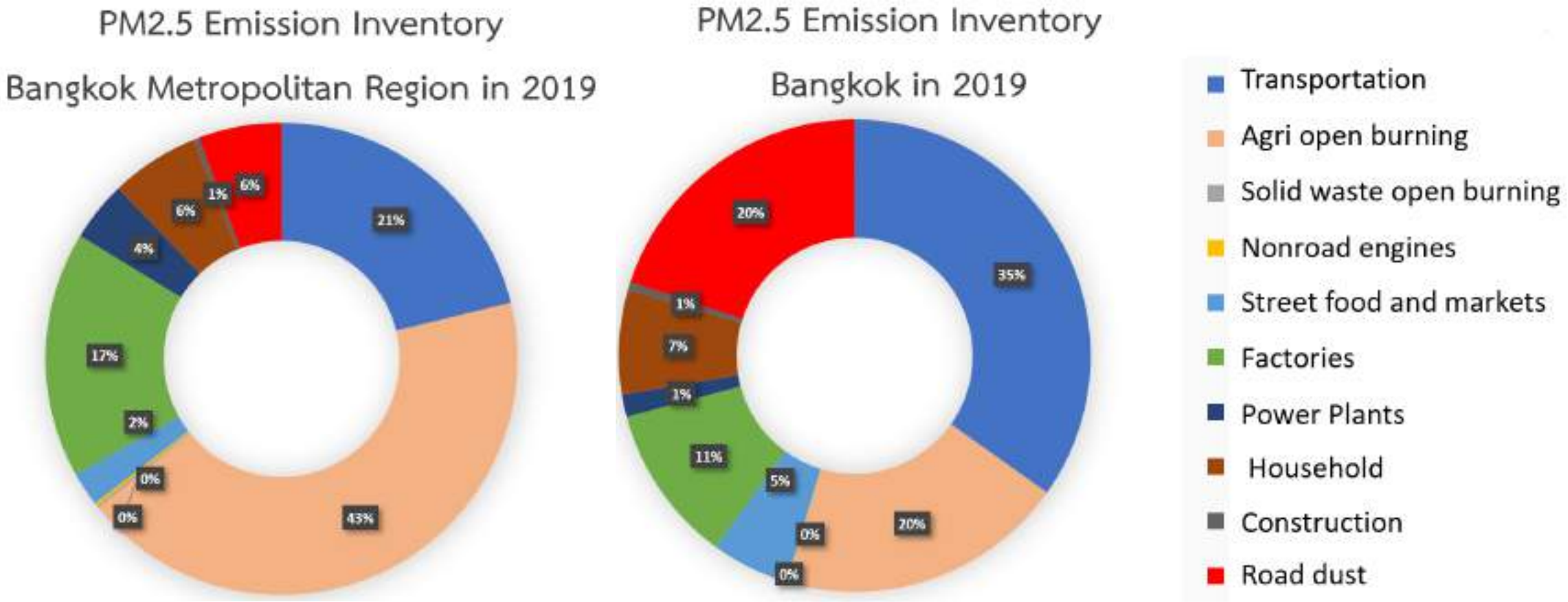
- $PM_{2.5}$ (PM_{10} in some area) and Ozone are still problems in Thailand
- Others (NOx, SOx, CO) are well controlled

Transboundary contribution in $PM_{2.5}$ Concentration in Bangkok

Emission Inventory & Modeling Study of Sources of $PM_{2.5}$ Concentration (Primary and Secondary)in Bangkok

Funding: National Research Council of Thailand

Emission Inventory for Bangkok Metropolitan Region & Bangkok

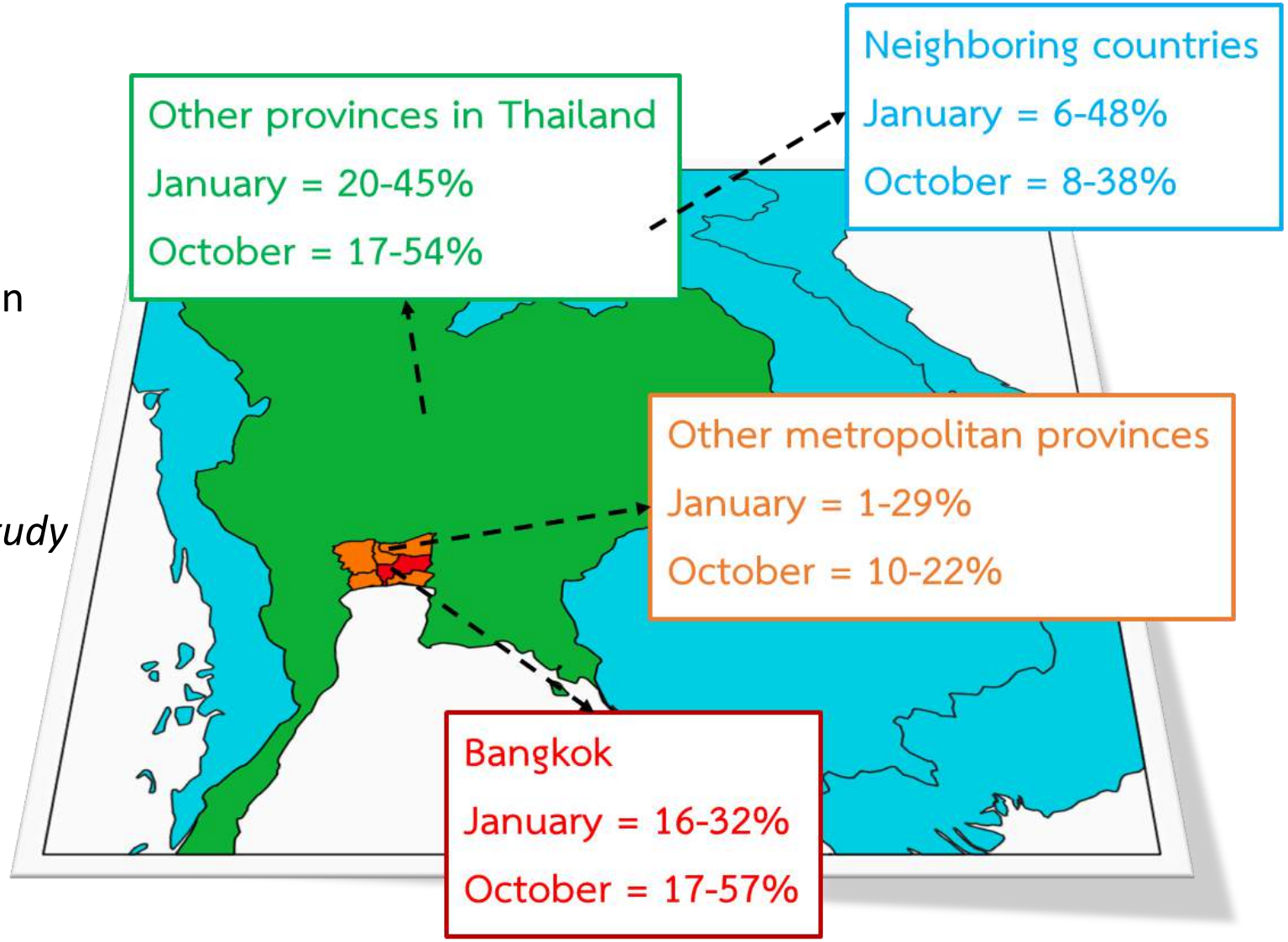


*** Different area --> different sources to be controlled, but air pollution has no boundary ***

Sources of PM2.5 Concentration in Bangkok

*** $PM_{2.5}$ concentration in Bangkok has been contributed from sources in different area ***

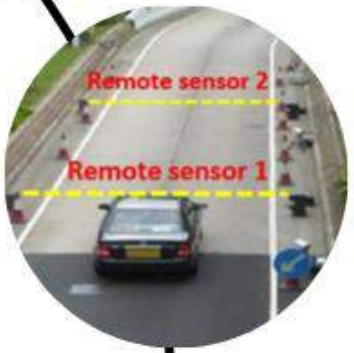
*Note that this study **did not** study on the low $PM_{2.5}$ month in Bangkok*



Possible Technologies to Control Emission in Bangkok: A Review Part

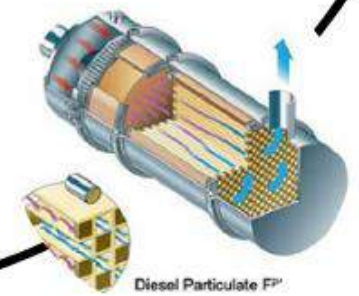
Transportation sector

Electric Vehicles (EVs) can completely reduce $PM_{2.5}$ and greenhouse gas (GHGs) emissions because of their non-reliance on fossil fuel combustion.



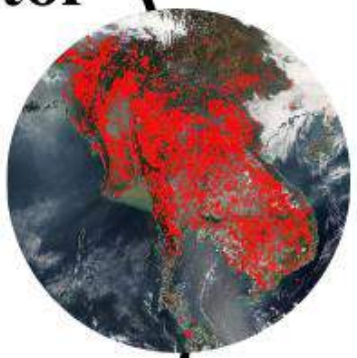
Remote Sensing for On-road inspection is a monitoring device that helps to screen high emission vehicles on the road.

Low Emission Zone (LEZ) is a management practice from European countries and should be used in combination with other supplementary measures, such as 'Work from Home' to reduce private vehicles during high levels of $PM_{2.5}$.



Diesel Particulate Filter (DPF) is a device that reduces emission from diesel engines because it can capture soot particles and other pollutants before releasing exhaust gases through the tailpipe.

Agricultural sector



Industrial sector

Burn check application can be used to manage agricultural wastes. The application does not directly reduce pollution, but it can help managing agricultural wastes to avoid burning during high $PM_{2.5}$ concentration period.

Satellite detection of fire hotspots can be used to monitor open burning of agricultural wastes and forest fire to better management of the fire situation.

Continuous Emission Monitoring System (CEMs) is a real-time online monitoring technology that helps to control emission emitted from the industrial sector. This technology can help to prevent the factory not to emit pollution higher than the standard.

Residential sector

Cleaner cooking (cleaner fuel and stove) is the technology that helps to control $PM_{2.5}$ emitted from the residential sector. It is evidence that changing to modern stoves in households can reduce fuel use by 30%-60%. Moreover, clean stoves and clean fuels can reduce emissions by 50%-90% with significantly improved indoor air quality.

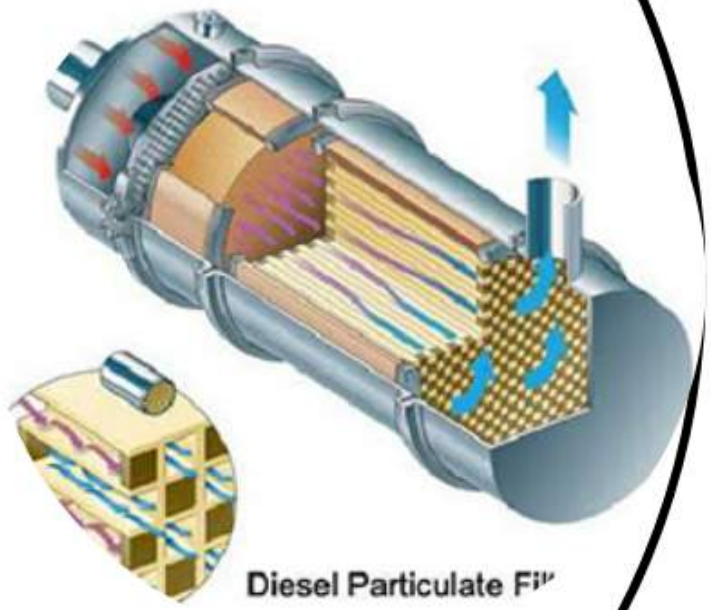
Monitoring device

Low-cost Sensors is an air quality monitoring device that helps to expand provincial-level monitoring network. Moreover, it helps to rise citizens' awareness of the air pollution problem situation in the area when properly calibrate and use.

Possible Technologies to Control Emission in Bangkok: An Assessment Part

Technologies with High Potential to Reduce $PM_{2.5}$ in Bangkok

Diesel Particulate Filter (DPF)

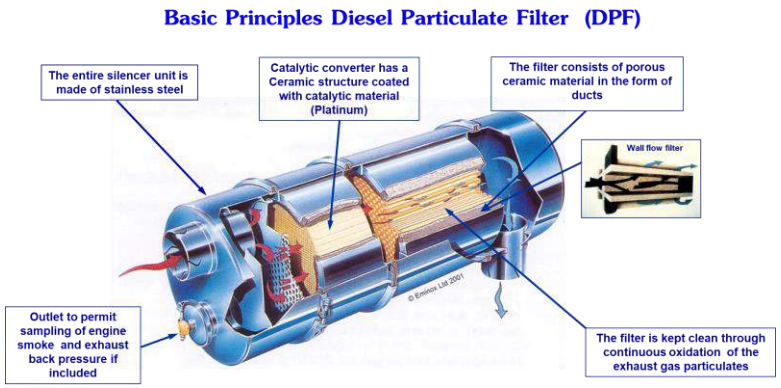


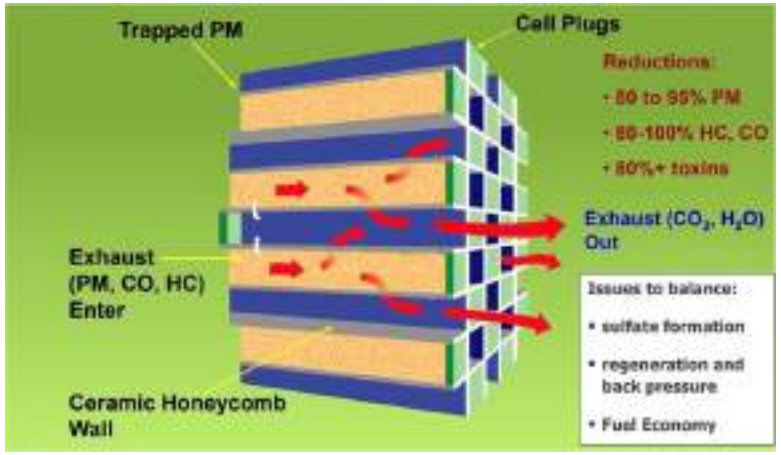
Innovativeness	Low	The technologies have been used before 2000
Affordability	Medium	The technologies can be purchased with the supports from the government.
Availability	Medium	There are demonstration project in Thailand, but its quantity is still insufficient to solve the $PM_{2.5}$ pollution problem. People in the country are beginning to have knowledge of using technology, but it is not enough to enable the development and production of devices for use widely in Thailand without supports.

$PM_{2.5}$ reduction potential	Importance of problem	High	Technology helps to reduce $PM_{2.5}$ from diesel vehicles (major emitters) in transportation sector
	Efficiency of technology	High	Technology has the efficiency to reduce $PM_{2.5}$ at source more than 50%.
Assessment	**The technology has high potential to reduce $PM_{2.5}$ in Bangkok**		

Practical	Need financial supports from government to implement. This should be options for fleet owner, not individual.

Policy Gaps/Challenges and Supports for Adopting Control Technologies





- Policy gaps
  - Not effective to vehicles older than Euro II (or need partial flow).
  - High cost of DPF
  - The process of implementing Euro V/VI standard is moving slowly. For example, Euro V was originally scheduled for 2020, but has now been pushed back to 2024 (Nikam J. et al., 2021).

- **Challenges and supports needed for adopting air pollution control technologies**
  - Supporting the production of low sulfur fuel and NOx reduction technologies for Euro VI standard in Thailand.
  - Providing financial and other incentives for DPF installation.
  - Providing study on possibility of using partial flow filter on in-used pre-Euro – Euro I vehicles.

Low Emission Zone

Innovativeness	Low	This practice has been used before 2000
Affordability	High	The zone can be set up anywhere, but the problem is how to achieve its target.
Availability	Medium	There are demonstration zones in Thailand, but they are not managed efficiently. People in the country are beginning to have knowledge of this, but it is difficult to expand to other area or effectively implement it.

$PM_{2.5}$ reduction potential	Importance of problem	High	Technology helps to reduce and manage $PM_{2.5}$ that emits from transportation sector
	Efficiency of technology	Medium	The technology has the efficiency to reduce $PM_{2.5}$ at source by less than 50%
Assessment	**The technology has high potential to reduce $PM_{2.5}$ in Bangkok**		

Practical	Difficult to implement since it is related to different organizations in Thailand

Policy Gaps/Challenges and Supports for Adopting Control Technologies

- Policy gaps
  - It is a short-term policy (use on days with high $PM_{2.5}$). Thus, the approach is different from Europe.
  - Insufficient detail of approach (ex. fee, engine standard).
  - Lack of plans or alternative routes for heavy-duty vehicles.
  - People are not adequately informed in advance.
  - Previous pilot project in the Prathumwan area was not as expected (in term of emission reduction)
  - Insufficient public transport in Bangkok area.

- **Challenges and supports needed for adopting air pollution control technologies**
  - Promoting mixed use of land to reduce traveling time, cars that cause less pollution (e.g., electric cars), and alternative forms of transportation (e.g., public transport, biking and walking) (Nikam J. et al., 2021).
  - Need regulations and enforcement to set LEZ with clear details of vehicle information to be allowed in the area. Moreover, public transport needs to be available and coverage.

Electric vehicle

Innovativeness	Medium	Technologies that have been used during 2000 – 2019

Affordability	Medium	The technologies that can be purchased with some supports from the government, but the cost is reducing

Availability	Medium	Electric vehicles are used in Thailand, but the number are still insufficient to solve the $PM_{2.5}$ problem. People in the country are beginning to have knowledge of using technology.

$PM_{2.5}$ reduction potential	Importance of problem	High	Technology helps to reduce and manage $PM_{2.5}$ that emits from transportation sector
	Efficiency of technology	High	The technology has the efficiency to reduce $PM_{2.5}$ at source by over 50%
Assessment	**The technology has high potential to reduce $PM_{2.5}$ in Bangkok**		

Practical	Need more electric boats and vehicles to make price more competitive

Policy Gaps/Challenges and Supports for Adopting Control Technologies

- **Policy gaps**
  - Tax on older vehicles is lower than new vehicles, which promotes the usage of older, inefficient cars (Nikam J. et al., 2021)

Electric Bus in Bangkok

- **Challenges and supports needed for adopting air pollution control technologies**
  - Enforcing policy on vehicular age limit; use economic incentive measures to promote buying newer, more efficient cars (Nikam J. et al., 2021), including EV cars.

Burn Check Application

Innovativeness	High	The technologies that have been used after 2019
Affordability	High	The technologies that can be accessed by everyone
Availability	Medium	The applications (this and others) are used in Thailand with successful story, but it is difficult to expand to solve $PM_{2.5}$ problem. People in the country are beginning to have knowledge of using this technology.
$PM_{2.5}$ reduction potential	Importance of problem	High	Technology helps to reduce and manage $PM_{2.5}$ that emits from agricultural sectors
	Efficiency of technology	Medium	The technology has the efficiency to reduce $PM_{2.5}$ at source by less than 50%
Assessment	**The technology has high potential to reduce $PM_{2.5}$ in Bangkok**		
Practical	Should include technology to make products and fuels from agricultural wastes		

Policy Gaps/Challenges and Supports for Adopting Control Technologies

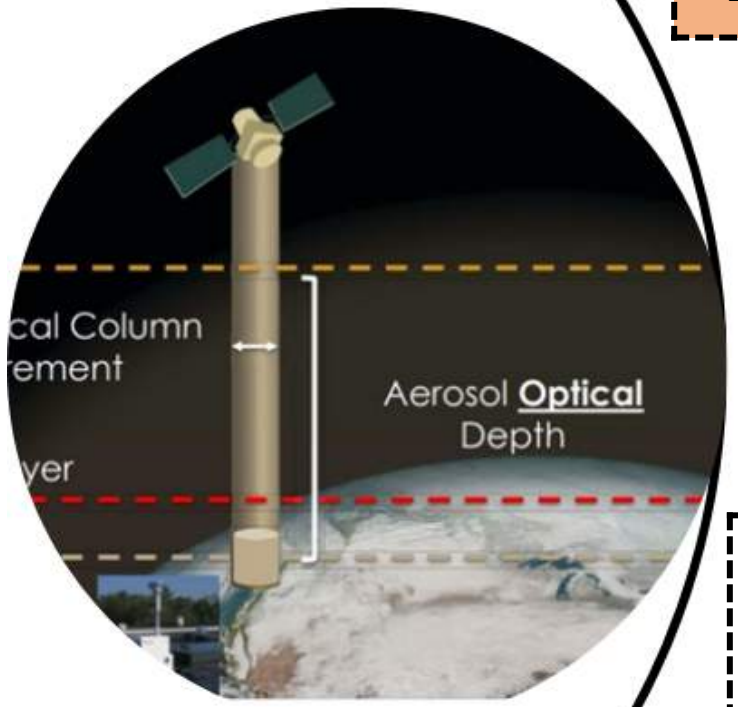
Fire D application

Burn check application
(http://www.burncheck.com/public)

- Policy gaps
  - Lack of public awareness regarding health impacts of haze and open burning (Nikam J. et al., 2021).
  - Majority of the farmlands are leased, leading to a lack of both incentives for investment in alternative farming practices and protection of farmers' rights on financial returns. This leads to a lack of will and capacity to invest in alternative waste management practices (Nikam J. et al., 2021).
  - Burning is the quickest way to get rid of wastes on the field since there is no supporting for agricultural waste management (ex. using for biofuel) in Bangkok.
  - The pilot project has been implemented in the northern region of Thailand, expanding to Bangkok is not currently available.

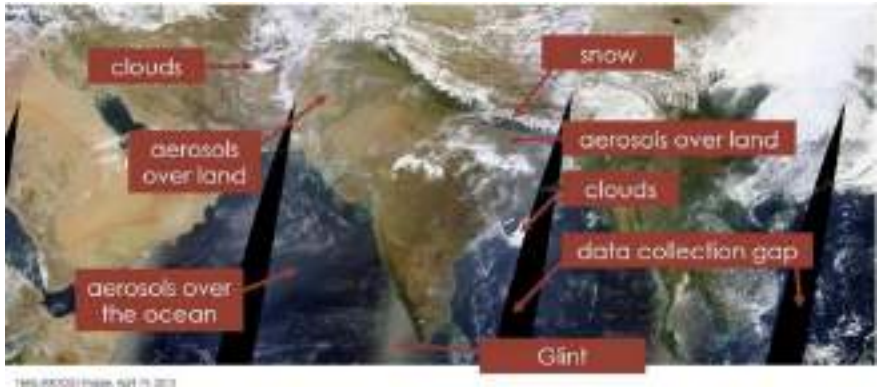
- Challenges and supports needed for adopting air pollution control technologies
  - Increase awareness and technical capacity of the locals (Nikam J. et al., 2021).
  - Introduce the application to the community and providing guidelines and rules for controlling open burning (Nikam J. et al., 2021).
  - Farming is dominated by the older generation; an increase in farmers' incomes would encourage the younger generation, who may have more innovative residue management practices, to be involved (Nikam J. et al., 2021).

Satellite detection for open burning

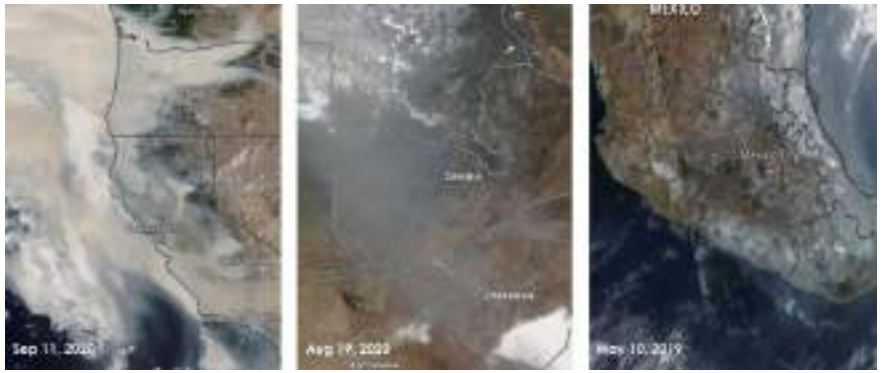


Innovativeness	Low	The technology has been used before 2000
Affordability	High	The technologies that can be accessed by everyone
Availability	Low	Thailand still relies on tools and knowledge from corporate with other countries for data analysis, tool development, and effort to adapt technology to use in the country
$PM_{2.5}$ reduction potential	Importance of problem: High	Technology helps to reduce and manage $PM_{2.5}$ that emits from agricultural sectors
	Efficiency of technology: Medium	The technology has the efficiency to reduce $PM_{2.5}$ at source by less than 50%
Assessment	**The technology has high potential to reduce $PM_{2.5}$ in Bangkok**	
Practical	Should explore new satellite, such as GEMS satellite to get better data	

Policy Gaps/Challenges and Supports for Adopting Control Technologies



Visible Smoke from Fires detect by MODIS



Visible Smoke from Fires detect by VIIRS

- **Policy gaps**
  - Lacking framework that enables multi-sectoral collaboration (Nikam J. et al., 2021), and central database for air quality management. There are still some gaps to manage fire after detection.
  - Most fires happen outside Bangkok, but the cooperation among different provinces and organizations are not clear.

- **Challenges and supports needed for adopting air pollution control technologies**
  - Developing database for $PM_{2.5}$ management which include online data from different organization, such as monitoring data from PCD and BMA, hotspots from GISTDA, name and contact number of the community by BMA and metropolitan provinces.

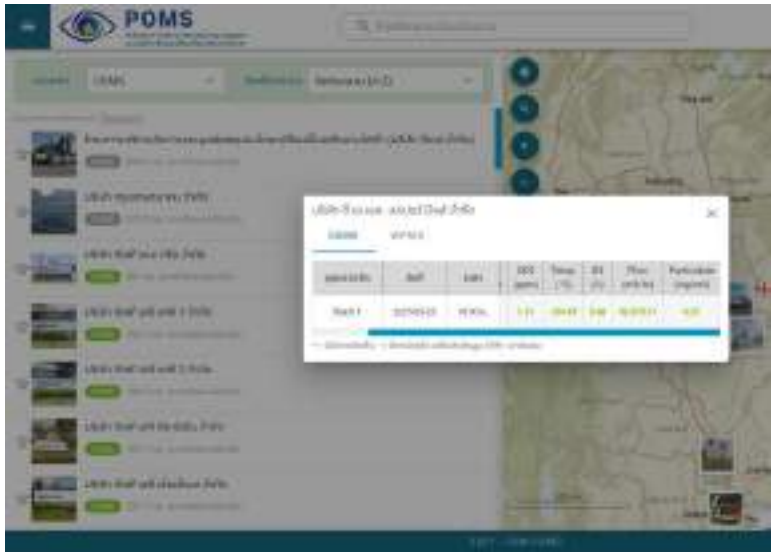
Technologies with Medium Potential to Reduce $PM_{2.5}$ in Bangkok

Continuous Emission Monitoring Systems

Innovativeness	Medium	The technologies that have been used during 2000 – 2019
Affordability	Low	The technologies that can be purchased by only private sector and government
Availability	Medium	The technology is used in Thailand, but their quantity is still insufficient to solve the $PM_{2.5}$ problem. People in the country are beginning to have knowledge of using technology, but it is not enough to enable the development and production of devices for use in Thailand
$PM_{2.5}$ reduction potential	Importance of problem	Medium	Technology helps to reduce and manage $PM_{2.5}$ that emits from industrial sectors
	Efficiency of technology	Low	The device used for the measurement and monitoring of $PM_{2.5}$ levels
Assessment	**The technology has medium potential to reduce $PM_{2.5}$ in Bangkok**		
Practical	Should include “Smart Boiler” with IoT and cleaner crematorium and waste incinerator		

Policy Gaps/Challenges and Supports for Adopting Control Technologies

Component of CEMs



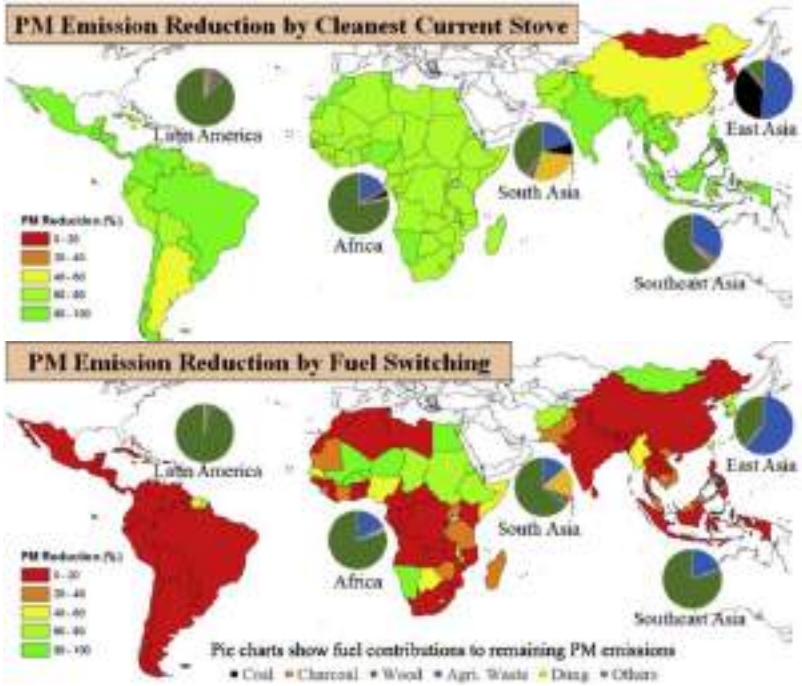
Source: Thai DIW (2023)

- Policy gaps
  - The measure is insufficient to inspect and control the factories that are not under the Department of Industrial Works (small factory or community business).
  - Shortage of industrial emissions data collection or measurement due to lack adequate air quality planning (Nikam J. et al., 2021).
  - Lacking public participation in the inspection and monitoring of industrial air emissions due to lack of awareness and available data (Nikam J. et al., 2021).
- **Challenges and supports needed for adopting air pollution control technologies**
  - Regularly updating and publishing information on air quality conditions on an open-sourced website, through a Pollutant Release and Transfer Register (PRTR) process; collect data from stakeholders, rather than local leaders, for more accurate and community centric information (Nikam J. et al., 2021).
  - Enabling public access to information about emissions through a PRTR process (Nikam J. et al., 2021).
  - Working with community to control emission from small industries (possible to use some simple technologies for monitoring emission, ex. Ringelmann Smoke Chart)

Cleaner cooking

Innovativeness	Low	The technology has been used before 2000
Affordability	High	The technologies that can be purchased by everyone
Availability	High	The number of devices within Thailand is sufficient to solve the $PM_{2.5}$ pollution problem. Moreover, there are several companies in Thailand capable of developing and producing the devices on their own.
$PM_{2.5}$ reduction potential	Importance of problem: Low	Technology helps to reduce and manage $PM_{2.5}$ that emits from residential sector
	Efficiency of technology: High	The technology has the efficiency to reduce $PM_{2.5}$ at source by over 50%
Assessment	**The technology has medium potential to reduce $PM_{2.5}$ in Bangkok**	
Practical	Difficult to implement since it is related to local preferences and limitations.	

Policy Gaps/Challenges and Supports for Adopting Control Technologies

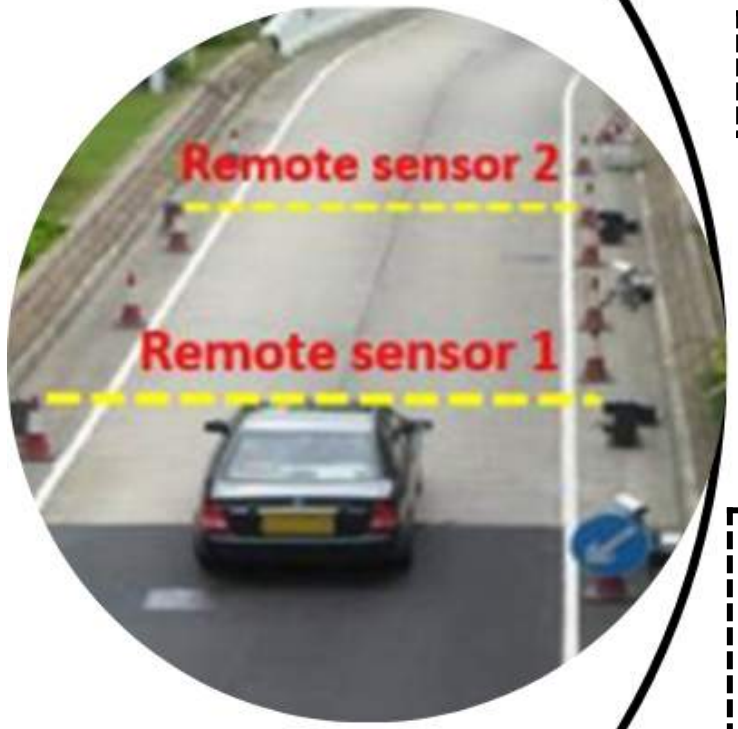


Source: Winijkul (2016)

- **Policy gaps**
  - No control of pollution from the residential sector and street food.

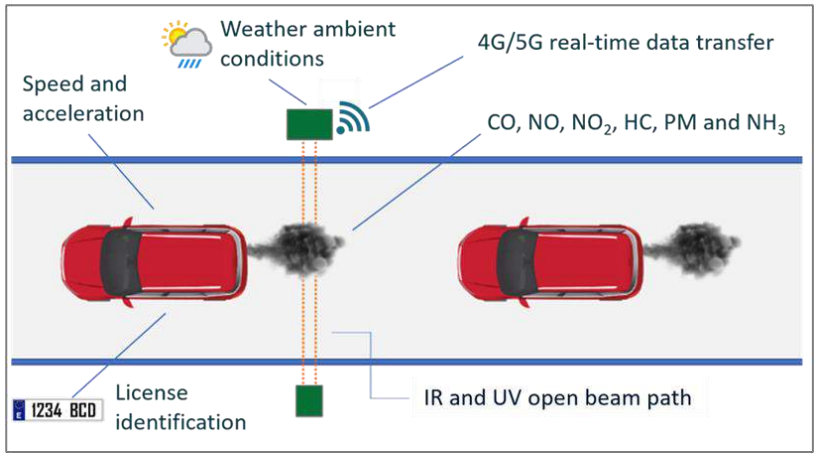
- **Challenges and supports needed for adopting air pollution control technologies**
  - Street food is highly linked with local practices, and the income of the local people which is difficult to regulate by policy.

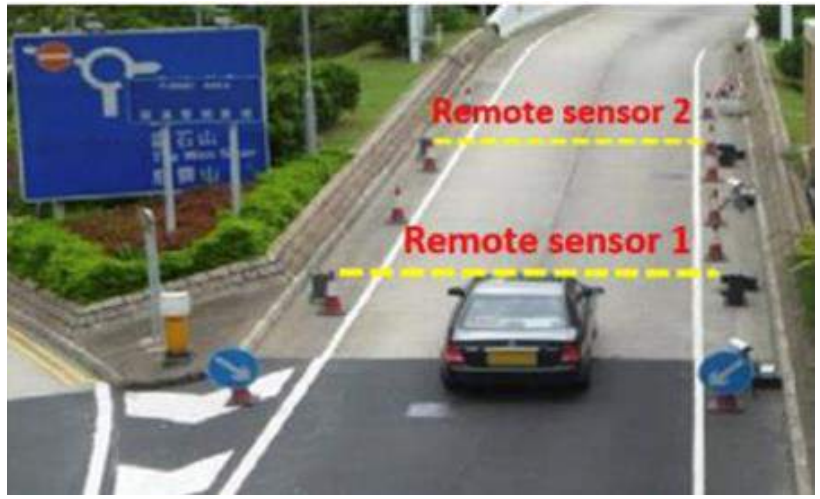
Remote Sensing for vehicles



Innovativeness	Medium	The technology has been used during 2000 – 2019
Affordability	Low	The technologies that can be purchased by only private sector and government
Availability	Low	Technology is still not available to be used in Thailand, but it is available and used in other countries. Thailand still relies on tools and knowledge from corporate with other countries for data analysis, tool development, and effort to adapt technology to use in the country
$PM_{2.5}$ reduction potential	Importance of problem	High	Technology helps to reduce and manage $PM_{2.5}$ that emits from transportation sectors
	Efficiency of technology	Low	The device used for the measurement and monitoring of $PM_{2.5}$ levels
Assessment	**The technology has medium potential to reduce PM2.5 in Bangkok**		
Practical	Should be used in Thailand, but the cost is high for government		

Policy Gaps/Challenges and Supports for Adopting Control Technologies





- **Policy gaps**
  - Technology is not available for the CCTV to detect black smoke, and current roadside inspection can only cover small vehicle population.

- **Challenges and supports needed for adopting air pollution control technologies**
  - Technology transfer of the remote sensing for vehicle inspection and data analysis are necessary since this is lacking in Thailand.
  - Funding to support procurement and maintenance of the equipment

Technologies with Low Potential to Reduce $PM_{2.5}$ in Bangkok

Low-cost Sensor

Innovativeness	Medium	The technologies that have been used during 2000 – 2019

Affordability	High	The technologies that can be purchased by everyone

Availability	High	Many devices are available in Thailand. Moreover, there are several companies in Thailand capable of developing and producing the devices on their own

$PM_{2.5}$ reduction potential	Importance of problem	Low	Technology helps to raise awareness and identify air pollution problem.
	Efficiency of technology	Low	The device used for the measurement and monitoring of $PM_{2.5}$ levels, not to reduce emission.
Assessment	**The technology has low or no potential to reduce $PM_{2.5}$ in Bangkok**		

Practical	Should be certified by USEPA, and follow the standard method to calculate Air Quality Index

Policy Gaps/Challenges and Supports for Adopting Control Technologies

Sensor for All developed by Chulalongkorn University

Dust boy developed by Chiang Mai University

- Policy gaps
  - Insufficient air quality monitoring (Nikam J. et al., 2021) – not for the case of Bangkok.
  - Official monitoring station is costly.
  - Sensor quality varies largely. This may lead to panicking of the community.

- Challenges and supports needed for adopting air pollution control technologies
  - Creating website and reporting format to avoid confusion between measurement values obtained from low-cost sensors and official monitoring stations.
  - Providing guidelines for quality control and usage of low-cost sensors.

Summary of Technology Assessment for Air Pollution Control in Bangkok

Technologies	Rank						Practical: Comments on the potential for success in implementation in Bangkok (Report and interviews and personal communication) *
	Innovativeness (Operation year)	Affordability	Availability	$PM_{2.5}$ reduction potential			
				Importance of problem	Efficiency of technology	Score	
Low-cost sensor	2012 (Dye T., 2023)	High	High	Low (1)	M (1)	**2**	Should be certified by USEPA, and follow the standard method to calculate Air Quality Index.
Diesel Particulate Filter (DPF)	1981 (Majewski, 2020)	Medium	Medium	High (3)	S: up to 90% (3)	**6**	Need financial supports from government to implement. This should be options for fleet owner, not individual.
Low Emission Zone	1990 (Jens M et al., 2019)	High	Medium	High (3)	S: depend on the location (2)	**5**	Difficult to implement since it is related to different organizations in Thailand.
Electric vehicle	2010 (Matulka R., 2014)	Medium	Medium	High (3)	S: 100% (3)	**6**	Need more electric boats and vehicles to make price more competitive.
CEMs	2001 (Leungsakul S., 2021)	Low	Medium	Medium (2)	M (1)	**3**	**Should include "Smart Boiler" with IoT and cleaner crematorium and waste incinerator.**
Cleaner cooking	1973 (PTT, 2023)	High	High	Low (1)	S: 95% (3)	**4**	Difficult to implement since it is related to income of people (street food).
Burn check Application for open burning	2021 (Haze Free Thailand, 2021)	High	Medium	High (3)	S: depend on the location (2)	**5**	**Should include technology to make products and fuels from agricultural wastes.**
Satellite detection for open burning	1999 (Channarong J. et al., 2022)	Low	High	High (3)	S: depend on the location (2)	**5**	Should explore new satellite, such as GEMS satellite to get better data.
Remote Sensing for vehicles	2000 (Huang et al., 2018)	Low	Low	High (3)	M (1)	**4**	Should be used in Thailand, but the cost is high for government.

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THANK YOU

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