PM2.5 reduction performance of LEED certified buildings in Thailand

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Abstract. Recently, Thailand has faced more severe PM2.5 problem in winter season due to crop burnings and traffic problems. Nine buildings in Bangkok were examined in order to determine their performances in preventing PM2.5 into their indoor environment. Five buildings are LEED certified buildings and some of these buildings are equipped with higher performance level of air filters. Realtime handheld indoor air meters were used to collect levels of indoor PM2.5 inside the buildings compared to the outside condition. It has been found that LEED certified buildings with high performance filter (MERV13) performed better in preventing PM2.5 comparing to other buildings. However, some non-LEED certified buildings also performed good probably because of inadequate ventilation. High traffic on the ground floors also introduce higher PM2.5 level into the buildings’ common areas.

1. Introduction
The Pollution Control Department (PCD) has monitored and analyzed the data of particulate matters sized 2.5 microns or less (PM2.5) situation in Bangkok and vicinity and found that the PM2.5 level were often more than the standard level at 50 mg/m³ during winter months, from December to April, when high pressure from China arrived at the region and air pollution are trapped according to a temperature inversion effect [1]. The problem has worsened during recent years due to the increase of vehicle number with the popularity of diesel engines and increase of open-air burning activities. According to the Department of Land Transport, there are 10.2 million vehicles accumulated registered in Bangkok at the end of 2018. This number is almost double the total vehicle number at 5.9 million vehicles at the end of 2008. In order to solve this problem, the government has been working on adding more public transportations in the form of sky trains and subways. Ongoing construction of sky train and subway lines are all over the city, in addition, the main source of PM2.5. Other sources of PM2.5 in Bangkok are nearby factories, as well as leaf and weed open-air burning despite law prohibited the activities. Health effects from PM2.5 include increasing in respiratory symptoms i.e. coughing, shortness of breath, tightness of the chest, irritation of the eyes and worsen symptoms for people with heart or lung disease.

People in Thailand, especially Bangkok become aware of the PM2.5 problem at the end of 2018, when PM2.5 levels have been high for several days and affected people’s health. Many schools were shut down for a couple days to let their student stay inside their houses. Many office buildings also concerned and allowed their staffs to work from home during peak PM2.5 level period if their works are permitted. There are questions if the air inside office buildings are good enough for normal activities
during high PM2.5 levels outside. Ensuring good indoor air quality is leading UN'SDG no.3 good health and well-being and UN'SDG no.11 sustainable cities and communities.

Office buildings in Thailand normally have very little measures for air filtration. Thai building codes only requires air-conditioned rooms to have either fresh air intake or exhaust air for 2 m³/h/m² for office spaces, 6 m³/h/m² for meeting rooms and 10 m³/h/m² for toilets. There is no air filter requirement in the law. Therefore, only prefilters are normally installed at AHUs. However, buildings that were pursued green building certifications mostly under LEED by USGBC and TREES by Thai Green Building Institute faced higher requirements for building ventilation using ASHRAE 62.1 standard. There are prerequisite requirements that an adequate amount of fresh outdoor air must be delivered to building regularly occupied spaces and particulate matter filters having a minimum efficiency reporting value (MERV) 6 or more is required at all upstream to cooling coils before air is supplied to an occupied space [2]. In order to gain one more point for LEED 2009 [3], buildings must be designed to minimize and control the entry of pollutants into buildings through three strategies including providing filtration media rated at MERV 13 or higher at all upstream to cooling coils before air is supplied to an occupied space.

Theoretically, LEED certified building should perform better in preventing PM2.5 into its interior spaces compared to typical buildings. In order to investigate how well the indoor air quality of LEED certified buildings are, real-time handheld indoor air meters were used to collect level of PM2.5 inside nine office buildings. Five buildings are LEED certified which are equipped with higher performance level of air filters.

2. Methodology
This research employed case study strategies using cross-sectional measurements, carried out between 24-30 January 2019 to obtain PM2.5 levels. The PM2.5 at outdoor locations in front of the buildings varied each day and each time during the day. The measurement equipment was positioned in the breathing zone, between 3 and 6 feet above the floor. The test occurred during normal occupied hours, with the HVAC system starting at the normal start time and delivering outdoor air at the minimum rate. Each position was sampling 3 times and averaged

2.1. Case Studies
In this article, nine extra-large office buildings (Areas more than 10,000 m²) located in Bangkok were selected and their indoor PM2.5 levels compared and discussed. Three buildings are non-LEED certified (Building A, B, C). The other five buildings are LEED certified project in LEED Core and Shell category (Building D to H) with Building H that did not pursue additional points by adding merv13 filter and only has merv7 air filters. The last building, building I, is also a non-LEED certified building, but it has been rented by a single company and the interior has been certified LEED for Commercial Interior (LEED CI). The details of each buildings are as follows;

| Building | Floor | Areas       | Year | MERV | Ventilation type | LEED certified |
|----------|-------|-------------|------|------|------------------|----------------|
| A        | 34    | 48,000.00   | 1996 | -    | CAV              | -              |
| B        | 44    | 126,020.99  | 1996 | -    | CAV              | -              |
| C        | 30    | 47,398.00   | 1992 | -    | CAV              | -              |
| D        | 35    | 27,000.00   | 2011 | 13   | VAV              | ✓              |
|          |       | (office)    |      |      |                  |                |
| E        | 29    | 70,000.00   | 2015 | 13   | VAV              | ✓              |
| F        |       |             |      | 13   | VAV              | ✓              |
| G        | 35    | 54,329.00   | 2014 | 13   | VAV              | ✓              |
| H        | 12    | 46,190.00   | 2016 | 7    | VAV              | ✓              |
| I        | 23    | 34,235.00   | 2017 | -    | VAV              | ✓ (CI)         |

(7 for LEED CI)
2.2. Measurement equipment

2.2.1. Multi-function Air Quality Detector Model: BR-SMART-126S Brand: BLATN

![Multifunctional air quality detector](image)

Figure 1. Multifunctional air quality detector

- Measuring method: Light scattering
- Measuring range: 0 - 999 µg/m³
- Resolution: 0.1 µg/m³
- Accuracy: ± 10%
- Calibration: Zero cap with 1 count/5 minute (JIS B9921)

3. Results

The PM2.5 at outdoor locations in front of the buildings varied each time and during each day. Figure 2 showed PM2.5 levels outside the buildings compared with indoor common areas at parking, building operation office, lobby, lift lobby and ground floor WC. Figure 3 showed PM2.5 levels outside buildings comparing with indoor office floor areas at closed office, opened office and WC. Indoor PM2.5 concentration level should not exceed 15 µm/m³ as required in LEED Indoor air quality: air testing option.

3.1 Common areas

- Car parking areas are normally naturally ventilated except for building D that the parking is underground and has mechanical ventilation without any filter. Therefore, these areas had either higher or slightly lower PM2.5 level compared to the outside, both in non-LEED and LEED certified buildings.
- Building operation offices are normally closed offices within first floor adjacent to outside or at mechanical floor. Building B, H and I had quite high PM2.5 compared to other buildings.
- Common ground floor areas which are lobbies, lift lobbies, and WC in Building B, E, H and I had PM2.5 level higher than standard.

![PM2.5 level in common areas](image)

Figure 2. PM2.5 level in common areas
3.2 Office floor areas

- Closed and opened offices had low PM2.5 levels in most buildings except for Building B, H and I.
- WC's are normally located in core areas and have exhaust systems drawing indoor air from corridors. The PM2.5 levels were low except for Building B, G, H and I.

![Figure 3. PM2.5 level in office areas](image)

4. Discussion

Indoor PM2.5 can come from numbers of sources, for example, fresh air intake for indoor ventilation, air infiltrations and indoor activities. It has been found that common areas with heavy traffic and high infiltration according to lobby size, location and design could have high PM2.5 level as in Building B, E, H and I. For office floors, filters could play a significant role in reducing PM2.5 into buildings. It can be seen that buildings with pre-filter only and LEED certified building that pursued only prerequisite using MERV7 filter could not control their indoor PM2.5 level under 15 µg/m³. However, building A and C which are non-LEED certified building also had low indoor PM2.5 levels. Further investigation found high CO₂ concentration in these buildings which could indicate inadequate ventilation.

Facing increasingly serious PM2.5 level in Thailand now, buildings should increase their filter performances with caution that it should not interfere with amount of ventilation being introduced to indoor spaces. Care should be taken to reduce space infiltration into office buildings. These requirements i.e. filter performance and filtration test should be included in Thai building codes.

5. Acknowledgement

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References

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