# Project 2: Analysis of Air Quality Improvement Strategies

Kyle Heaton, Chris Hoppe, Heather Mello, Shelby Palmer

## Abstract


- Significant smog problems in Hong Kong are linked to many health and economic issues
- "Smog Free Tower" designed by Daan Roosegaarde uses electrostatic precipitation but must be scaled up for significant impact in large cities
- Our team was expected to evaluate implementation, feasibility, scaling issues, and sustainability of these smog towers
- Expected to create a computational model that supports our conclusions about the Smog Free Tower


## Our Approach

- Researched smog free towers, the physics behind them, and values that we would need for our computational model
- Created a computational model to solve for force with different values of tower height and electrostatic plate height
- Used Cotter's method to determine which factor affects the system the most
- Determined the number and location of towers necessary to clear smog

## Physics

- Considered size, concentration, mass, density, and charge of the smog particles
- Height of tower most significant factor

## Assumptions

- Density of smog particles is uniform throughout Hong Kong
- Equal number of positive and negatively charged smog particles
- Volume of buildings is insignificant

## Scaling

- Determined total area of Hong Kong that needed to be covered by the towers
- One tower: 102,857 m^3 of smog but 3 years to clean entire city
- $185,142.86 per 24 m tower
- 100 towers → 111 days → $18,514,286.00 total
- 1000 towers → 11 days → $185,142,860.00 total

## Sustainability

- Cost analysis for maintenance, operation, replacement
- Health costs
- Energy concerns
- Placement concerns involving water, smog density, and world placement

## Conclusion

- Implementation issues
- 100 towers of with height of 24 meters
- Spacing of 5249 m between towers

## Graphical Representation

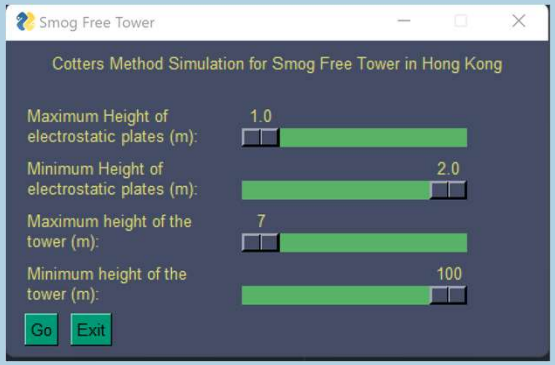


*Figure 1*
*Graphical User Interface created using PySimpleGUI library increase model's accessibility*

Most impactful factor to SMT's efficiency was determined using Cotter's method

**Inputs for Cotters Method**

E-static plate height

**Maximum:** 2.0 m
**Minimum:** 1.0 m

Tower Height

**Maximum:** 100 m
**Minimum:** 7 m

```
The tower height has a sensitivity of 0.9947 and is most impactful
The plate height has a sensitivity of 0.0053 and is least impactful
[Finished in 60.637s]
```


## Acknowledgements

*Dr. Timothy Whalen*


$$\frac{\pi}{6}\rho_{particle}d_{particle}^{3}a_{vert}(t)=\frac{\pi}{6}\left(\rho_{fluid}-\rho_{particle}\right)gd_{particle}^{3}+\frac{1}{2}\rho_{fluid}C_{d}*\left(\frac{\pi}{4}d_{particle}^{2}\right)*v_{vert}^{2}(t)-\frac{q\sigma}{2\pi\varepsilon_{0}}+\frac{q^{2}c(t)}{2\varepsilon_{0}}*\left[2D_{vert}(t)-H\right]$$


*Python guis for humans*. PySimpleGUI. (n.d.). Retrieved April 3, 2022, from https://pysimplegui.readthedocs.io/en/latest/
(www.gov.hk), G. H. K. (2021, December 23). *Govhk: Air Quality in Hong Kong*. GovHK 香港政府一站通. Retrieved April 3, 2022, from https://www.gov.hk/en/residents/environment/air/airquality.htm
*Air Pollution Control Technology fact sheet - US EPA*. (n.d.). Retrieved April 4, 2022, from https://www3.epa.gov/ttncatc1/dir1/fscr.pdf
*Case study: Smog free tower ... - cdn.archilovers.com*. (n.d.). Retrieved April 4, 2022, from https://cdn.archilovers.com/projects/06505a46-61e1-4d28-a371-aa1ce924d3a4.pdf
*The economic consequences of air pollution - GTAP*. (n.d.). Retrieved April 4, 2022, from https://www.gtap.agecon.purdue.edu/resources/download/8318.pdf
*Open Access Proceedings Journal of ... - iopscience.iop.org*. (n.d.). Retrieved April 4, 2022, from https://iopscience.iop.org/article/10.1088/1757-899X/603/3/032100/pdf
World Health Organization. (n.d.). *Who Global Air Quality Guidelines: Particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide*. World Health Organization. Retrieved April 3, 2022, from https://www.who.int/publications/i/item/9789240034228
Zhang, X., & Bo, T. (2020, November 12). *The effectiveness of electrostatic haze removal scheme and the optimization of electrostatic precipitator based on the charged properties of airborne haze particles: Experiment and simulation*. Journal of Cleaner Production. Retrieved April 3, 2022, from https://www.sciencedirect.com/science/article/pii/S0959652620351404
Jenniskens, G. (2017, May 24). Environmental Nano Solutions: Case Study: Smog Free Tower (measurements in an urban environment). ENS Technology.