Case study on Opportunities to Revise Energy Codes by Data Digitization using a Smart Building Energy Audit Tool with Buildings in Hong Kong

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Case study on Opportunities to Revise Energy Codes by Data Digitization Using a Smart Building Energy Audit Tool With Buildings in Hong Kong

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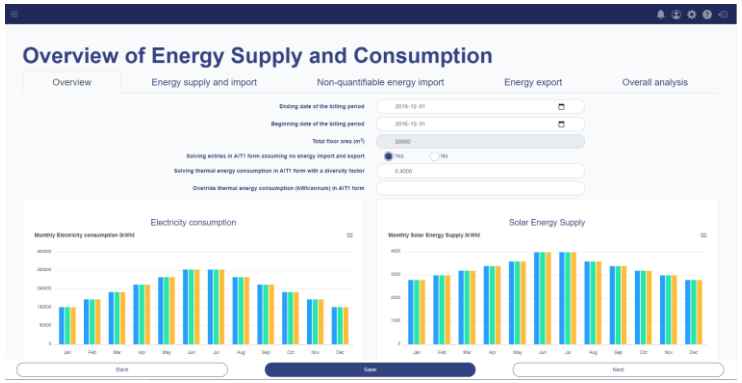
ABSTRACT

Building energy management is crucial to meet carbon neutrality targets between 2050 and 2060. Yet, building energy management standards and codes are struggling to be updated quickly due to misunderstanding from stakeholders outside the

QAC	Rated cooling capacity (W)
QPD	Rated cooling capacity per unit area (W/m^2)
W_{AC}	Rated power consumption of air-conditioning equipment (W)
$W_{lighting}$	Rated power consumption of lighting

About the Research

- This presentation follows the conference paper at International Conference on Applied Energy 2021 with paper ID: 348
- **Why the topic?**
- We have developed a prototype smart energy audit tool (smart610.com) to speed up energy audits with ~250 proof of concept projects between 2019 and 2021
  - Similar to **EnergyStar Home Energy Audit Yardstick** and **AuditTemplate**
  - Generate energy audit documents with a few clicks
- Hong Kong does not have open and detailed energy use databases like CBECS and BPD in the US. Our data only shows EUI of commercial buildings
- We want to see more as energy professionals in HK!



(From smart610.com)

Research Questions

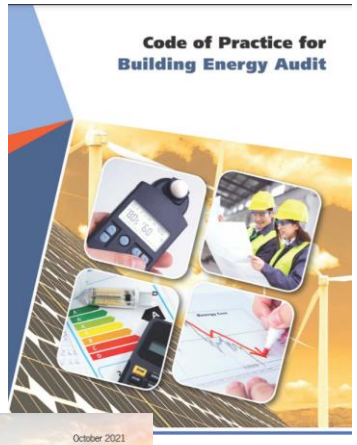
- Based on **actual** building energy audit cases, we want to know if
  - Digital detailed data can help to improve energy codes used in HK
  - How data digitization can help
  - For what aspects the energy codes data digitization can support the energy efficiency improvement

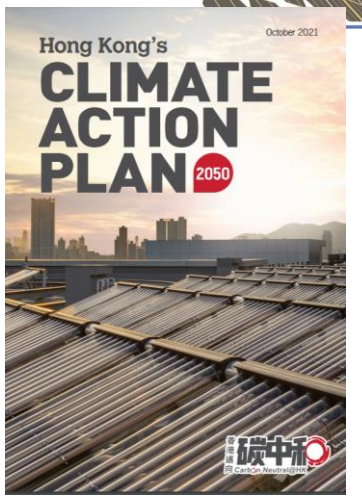
(From smart610.com)

- Significance of the study
  - Not based on simulation data that some stakeholders do not trust
  - Not based on non-domestic data that some stakeholders consider to be irrelevant

Background of Energy Codes and Policies in Hong Kong

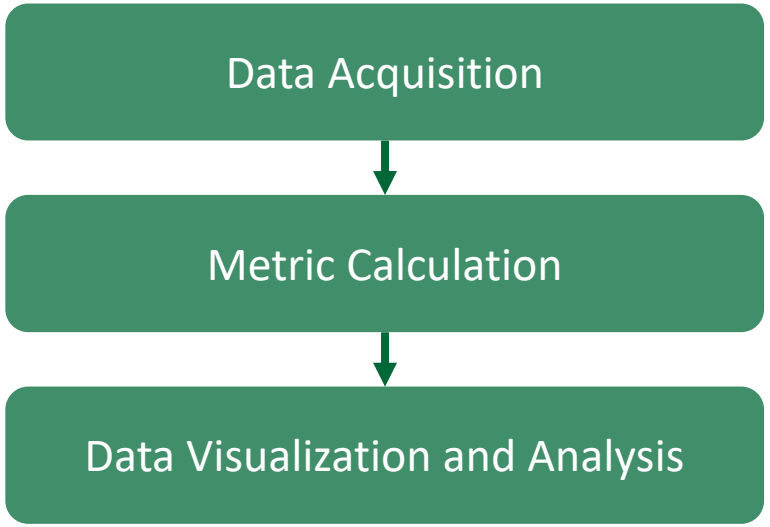
- Hong Kong government regulates energy efficiency of the following building installations through Building Energy Efficiency Ordinance (BEEO)
  - Lighting
  - Heating, Ventilating and Air-Conditioning Equipment
  - Electrical installations (e.g. size of cables)
  - Elevators and lifts
- Energy Codes revised every 3 years to set new limits to parameters such as
  - Lighting Power Density
  - Coefficient of Performance of Air Conditioners and Chillers
- Energy End Use data revised every year to guide the policy direction
- **Hong Kong's Climate Action Plan 2050 to reduce 20 to 40% of building energy consumption**





Methodology

- Data Acquisition
  - Digitize the data of the four types of data entered into the smart energy audit tool for energy audits in Hong Kong
- Metric Calculation, including
  - Lighting Power Density (LPD) of rooms in buildings (against overall LPD)
  - Rated cooling capacity per unit area (QPD)
  - EUI of different types of equipment
- Data Visualization and Analysis
  - Not just on maps but also frequency distribution
  - Comparison with the energy code requirements in HK

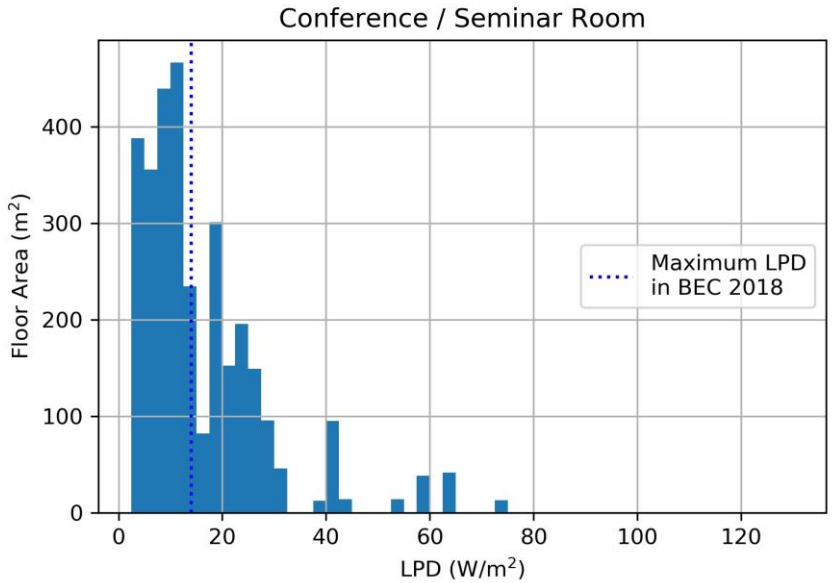


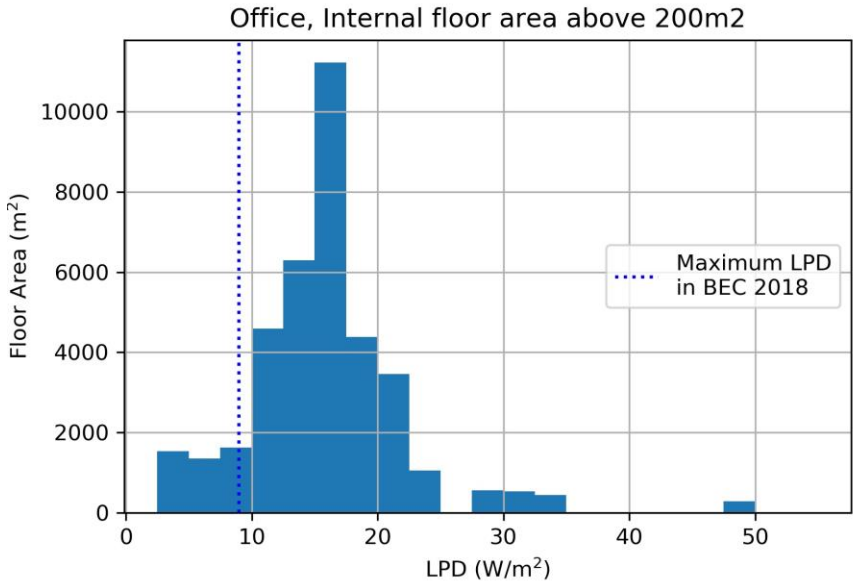
Description of Scenario

- ~250 cases digitized in the trials use of the smart energy audit tool
- With buildings containing offices, restaurants, residential apartments, etc.
- Focus on lighting and air-conditioning equipment
  - Full coverage on CBSI equipment will be future work
- Focus on assessing if the limits in the energy code
  - **Are difficult to execute?**
  - **Are not useful unless we change them dramatically?**

Results on Lighting Equipment

- Lighting Power Density (LPD) comparison with the limits in Code of Practice for Energy Efficiency of Building Services Installation 2018 (BEC 2018)

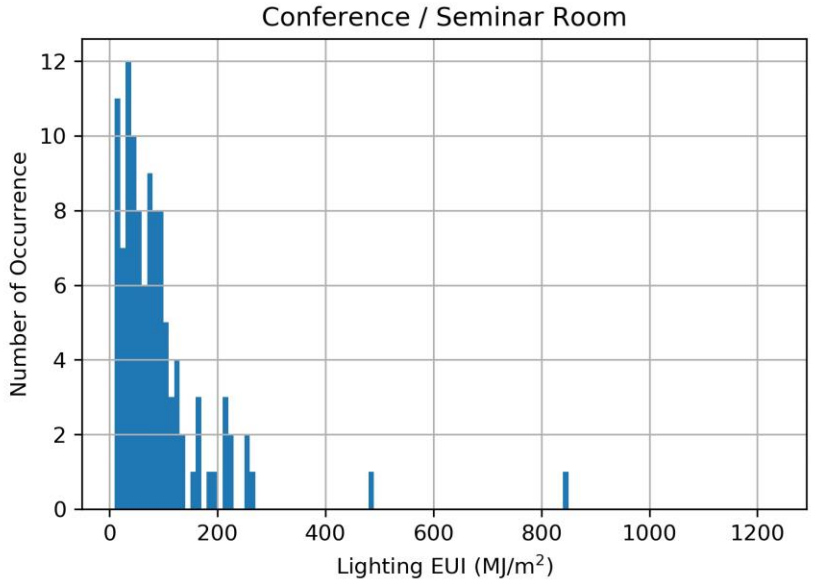


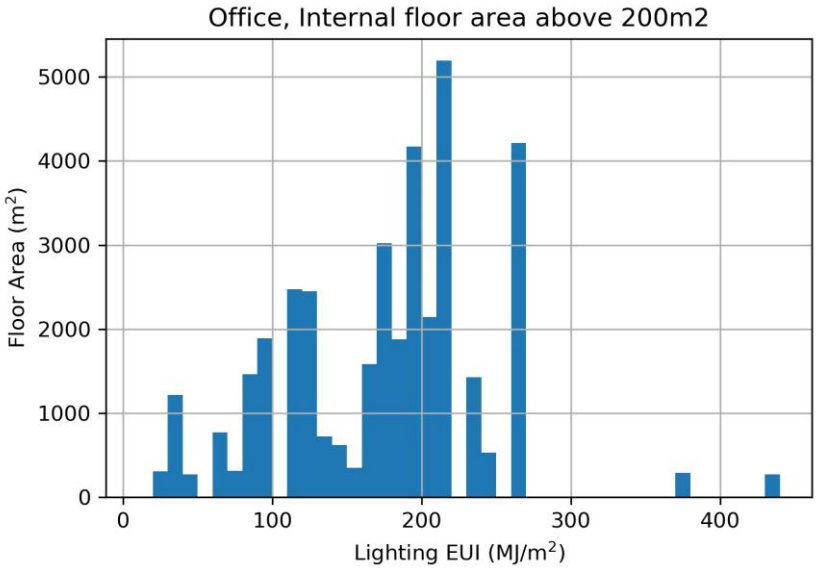


- Significant saving opportunities?

Results on Lighting Equipment

- Lighting Energy Utilization Index (Lighting energy use per floor area)

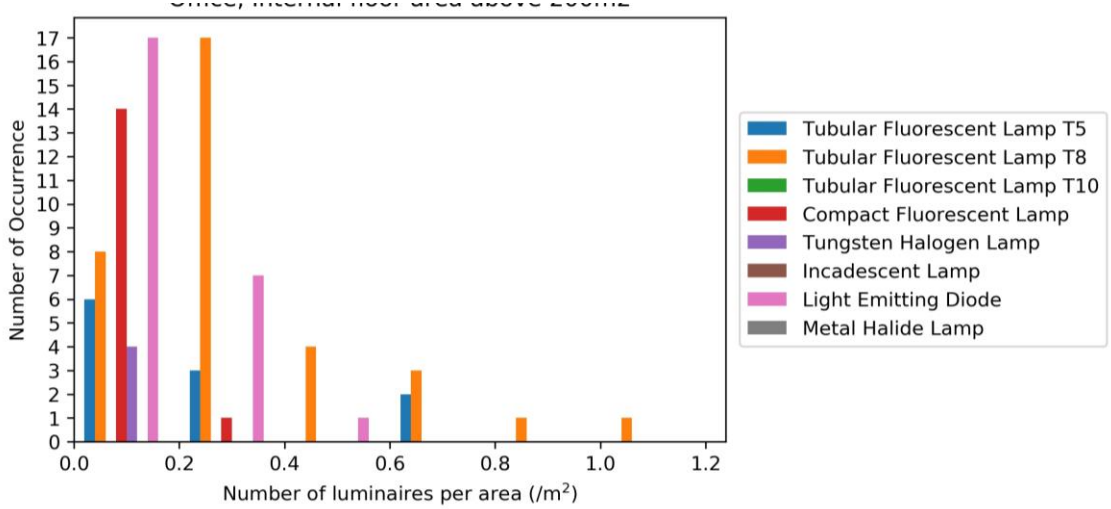




- Relative to EMSD's benchmark (EMSD 2021) for EUI at Grade A office at 480 MJ/m^2, we should further reduce LPD of offices for energy saving!

Results on Lighting Equipment

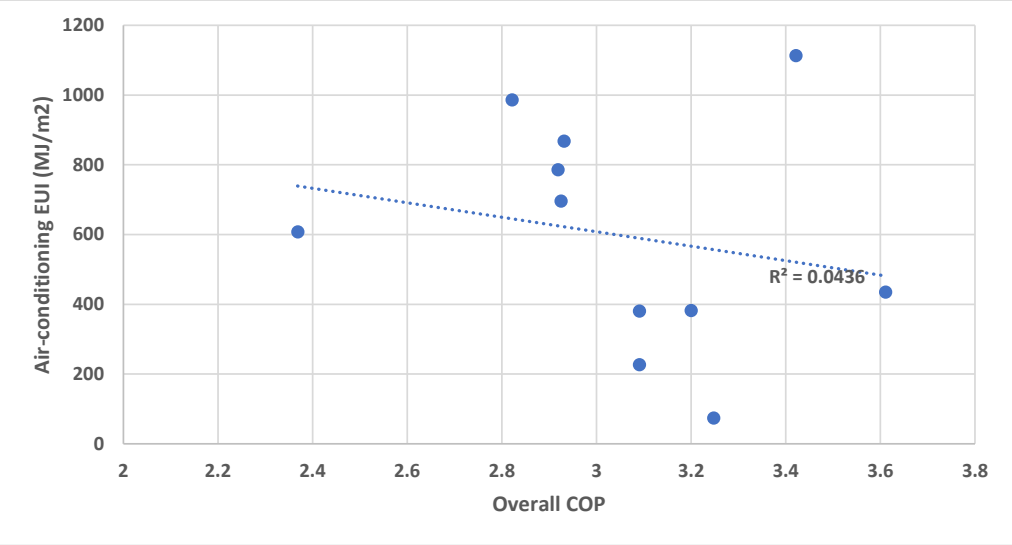
- Lighting equipment use in offices

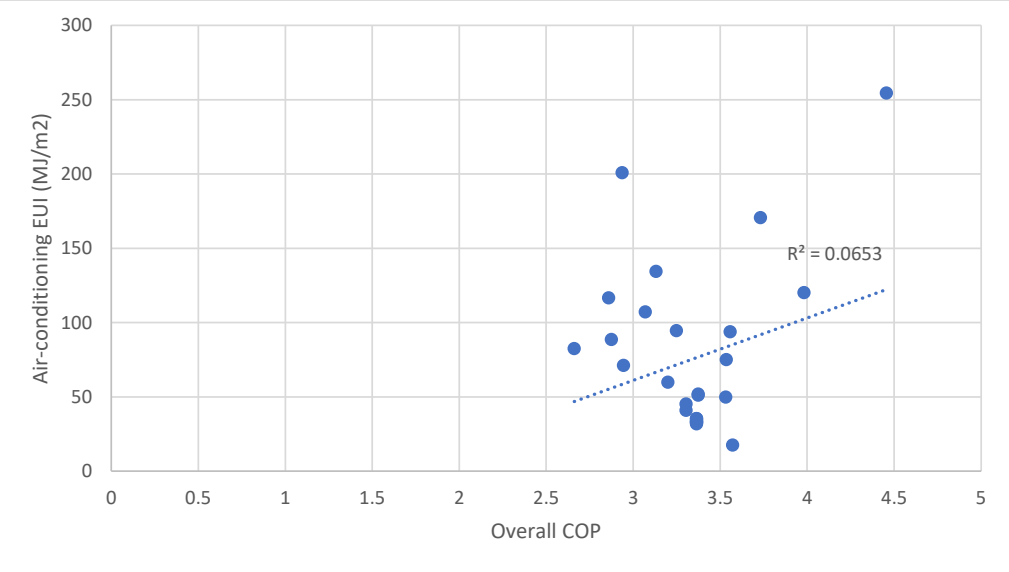


- The reduction is possible by changing to use lighting emitting diode (LED) to replace fluorescent lamps and tubes!
- Reduction of LPD to BEC limit alone can bring 16.1 kg-CO2e/m2 carbon emission reduction in office!

Results on Air-conditioning Equipment

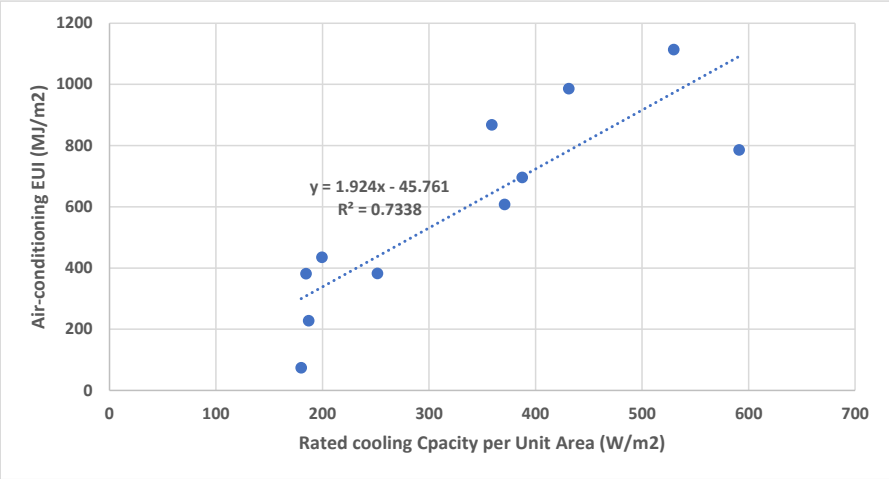
- BEC sets the minimum Coefficient of Performance (COP) of air conditioners and chillers
- We assume that the higher the COP, the lower the energy use density
- Is that the case? Check ones in offices and residential buildings

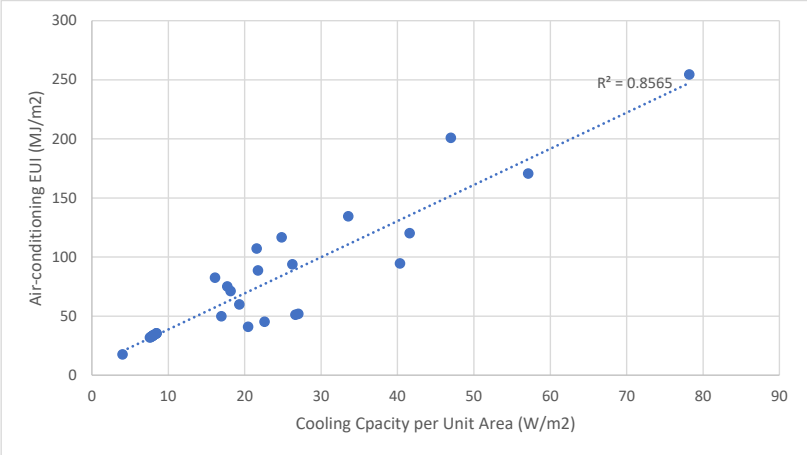




Results on Air-conditioning Equipment

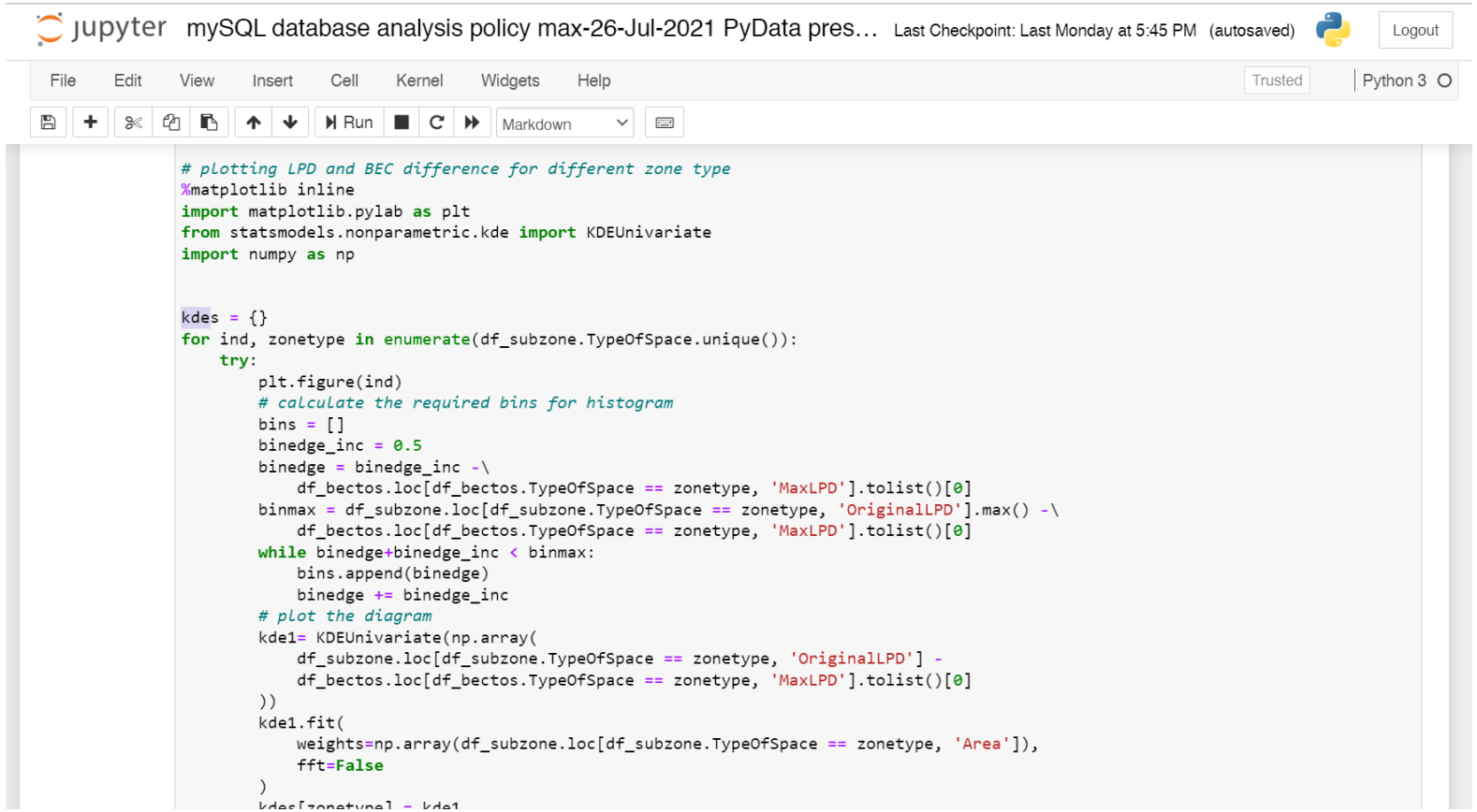
- How about the density of the cooling equipment based on cooling capacity?





- The government assumes typical commercial building's cooling density should be around 117 W/m^2! (LEGCO, 2014)
- If we set offices' cooling density at 300 W/m^2, we can get carbon emission reduction can vary from 14.9 kg-CO2e/m2 to 113.2 kg-CO2e/m2!

Python code demonstration



Using KDEunivariate to turn histograms as frequency distribution functions for further analysis

Conclusions

- We have used ~250 energy audit cases in a smart energy audit tool to get detailed energy use analysis at the equipment end use level

- Data digitization are important to have a better policy direction in Hong Kong through
  - Data-driven energy code revision (i.e. see which limit we can reduce without stakeholder's subjective influence)
  - Equipment energy use assessment (i.e. better cooling density assessment)
  - Carbon emission reduction calculation of each policy changes

Acknowledgements

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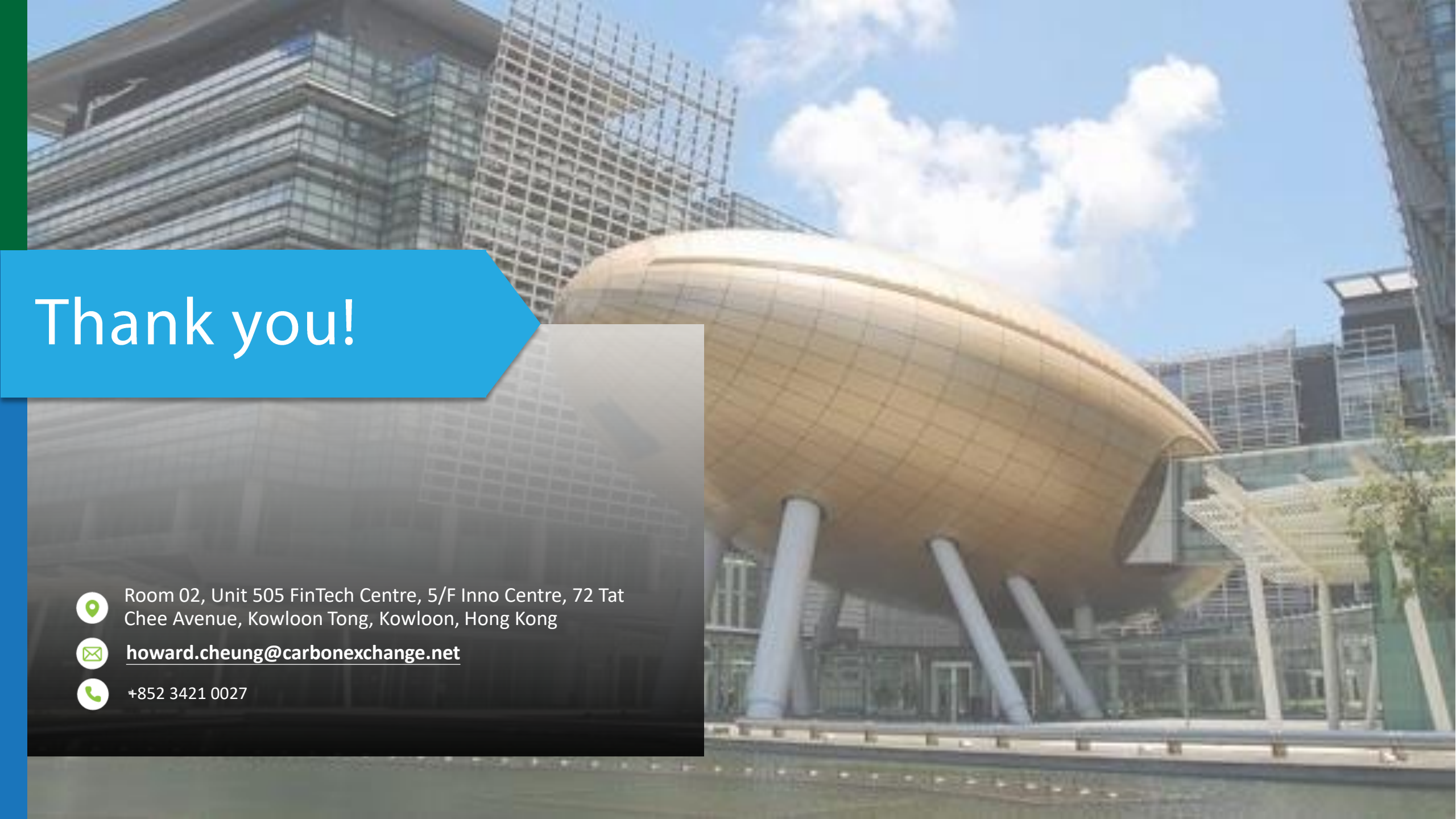

Thank you!

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