Track 5.1: COVID-19 and the Energy Sector: Technical Perspectives and Opportunities

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Energy End-Use Trilemma in the Time of COVID-19
Making Safe – the Must Do’s

- *Safe entry*
- *Contact tracing*
- *Social distancing*
- *Workplace zoning*
- *Work alternation and shifts - reduced occupancy*
- *No cross-contamination*
- *Indoor air dilution – purging with fresh air*
- *Occupant behaviour check – windows and thermostats*
Parameters of Interest*

- Outdoor air (OA) fraction of the supply air flow [10%-100%]
- Hours for air flushing and purging before and after occupancies [0 hour – entire night]
- Occupant density [25%-100%]
- Window opening rate [fully close – 100% open]
- Occupant behaviour [baseline, moderate, austere]

*“Guidance note on building air-conditioning and mechanical ventilation (MVAC) operations amid covid-19 situation”, BCA
Performance Indicators

• Energy Use Intensity:

$$EUI = \frac{E_t}{A_t}$$

• Lost of Set-Point Probability:

$$LOS\bar{P} = \frac{\int_{\tau_1}^{\tau_2} u_h(t)dt}{\int_{\tau_1}^{\tau_2} dt}, u_h(t) = \begin{cases} 1, & \text{if } |T_{setpoint} - T_{indoor}| > 0.5 \degree C \\ 0, & \text{if } |T_{setpoint} - T_{indoor}| \leq 0.5 \degree C \end{cases}$$

• Mean Part Load Ratio:

$$PLR_m = \frac{\int_{\tau_1}^{\tau_2} PLR(t)dt}{\int_{\tau_1}^{\tau_2} dt}$$

$E_t$: total building energy consumption; $A_t$: total building floor area; LOSP and $PLR_m$ are based on the 3000 operating hours of the cooling system.
OA Fraction

![Graph showing the relationship between OA Fraction and various metrics such as EUI, LOSP, and PLRm.]
Air Flushing and Purging before and after Occupancies

![Graph showing EUI, LOSP, and PLRm metrics for different occupancy hours.](image)
Baseline occupant density: open office 18 m²/person; enclosed office 15 m²/person
Window Opening Rate

Natural Ventilation Model: EnergyPlus “Zone Ventilation: Wind and Stack Open Area”
Key Findings

• Influence of Parameters

\( \text{OA fraction} > \text{occupant density} > \text{air flushing hours} \)

• Window opening when AC is on is not recommended from the perspective of energy saving and thermal comfort.
COVID-19 Case Study

• **COVID-19 case:**
  
i. 2+2 hours for air flushing and purging
ii. 50% occupant density
iii. No window opening

• **OA fraction varies to keep the LOSP smaller than 10%**

• **Measure to reduce LOSP: increase set-point temperature**
COVID-19 Case Study

ASHRAE Standard 55: Thermal environmental conditions for human occupancy

EUI [kWh/m²]

LOS & PLRm

Covid-19 Cases

- Baseline
- 30% Min OA Frac +
- 40% Min OA Frac +
- 40% Min OA Frac +
- 50% Min OA Frac +
- 50% Min OA Frac +
- 60% Min OA Frac +
- 70% Min OA Frac +

Percentage of time which fails to meet the ASHRAE 55 comfort requirement
Recommendations on COVID-19 Case Study

• Window opening when AC is on is not recommended

• Regarding the OA fraction, if the system is not designed as a dedicated outdoor air system (DOAS), the system capacity could be insufficient to handle 100% fresh air. Facility personnel can adjust the OA damper to ensure that the cooling system is not overloaded and thermostat set-point can be reached

• If the normal set-point is lower than 24 °C, increase it to 24 °C. This will allow the mechanical ventilation and air conditioning (MVAC) system to supply more fresh air and ensure satisfactory thermal comfort

• Promote an energy-saving behaviour during this period. More zones would be unoccupied than normal case. So, turn off the lights when leaving; utilise daylight; turn off unused appliances; lock, isolate and switch off some unused auxiliary zones
Energy-Saving Measures: Occupant Behaviour Improvement

- Light use: off lights when unoccupied
- Daylight use: off lights when there is enough daylight
- Appliance use: switch off the unused appliances
- Thermostat adjustment: increase set-point
- Other measures: lock and switch off some unused auxiliary zones

Engineering Focus

- Reduce solar transmission - Increase building envelope thermal performance
- Reduce temperature lift of chillers - Increase ventilation flow rate
- Reduce fresh air sensible heat load - Increase fresh air treatment
- Reduce human interference - Increase smart machine intervention
- Reduce loss of probability that load is not met - Increase set-point temperature
- Reduce energy consumption – Increase renewable energy capture
Thank you for your attention