ASIA CLEAN ENERGY FORUM 2020

15-19 June 2020

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

16 June 2020

"Energy End-Use Trilemma - Energy Efficiency, Thermal Comfort and Productivity - Post-COVID-19"

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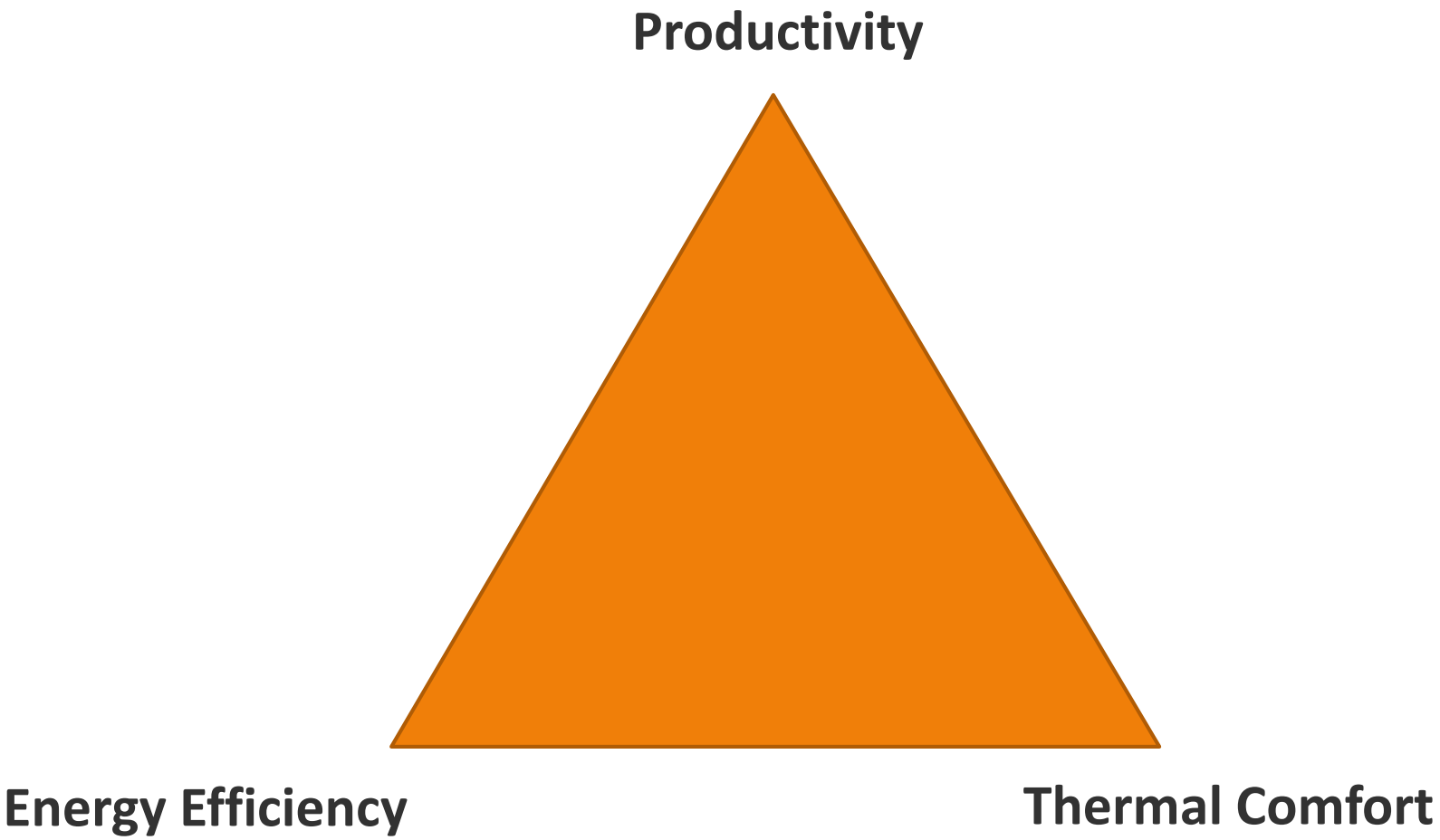
Energy End-Use Trilemma in the Time of COVID-19



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:

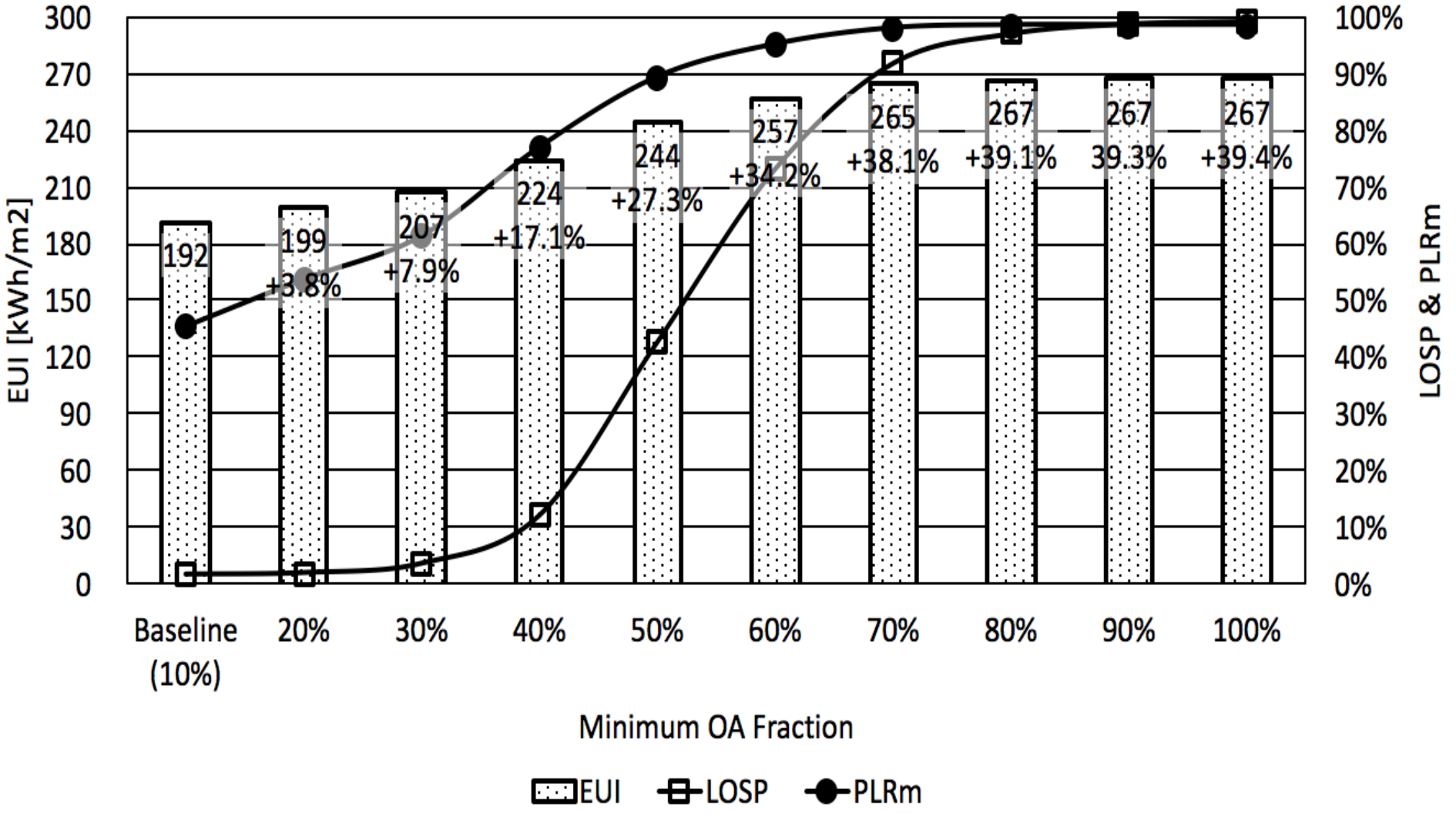
$$LOSP = \frac{\int_{\tau_1}^{\tau_2} uh(t)dt}{\int_{\tau_1}^{\tau_2} dt}, uh(t) = \begin{cases} 1, & if \left|T_{setpoint} - T_{indoor}\right| > 0.5\ ^{\circ}\mathrm{C} \\ 0, & if \left|T_{setpoint} - T_{indoor}\right| \leq 0.5\ ^{\circ}\mathrm{C} \end{cases}$$

- Mean Part Load Ratio:

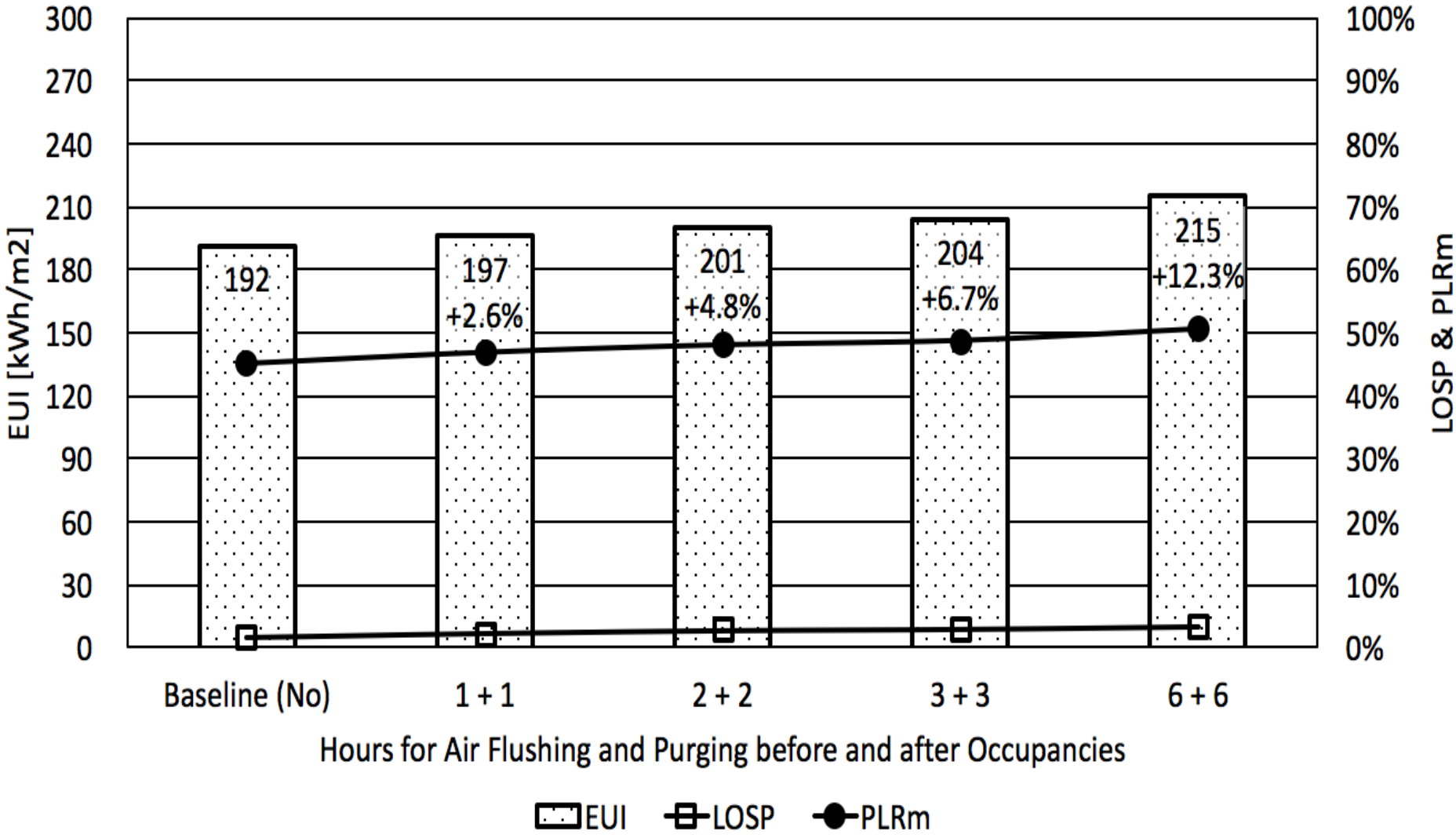
$$PLR_m = \frac{\int_{\tau_1}^{\tau_2} PLR(t)dt}{\int_{\tau_1}^{\tau_2} dt}$$

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.

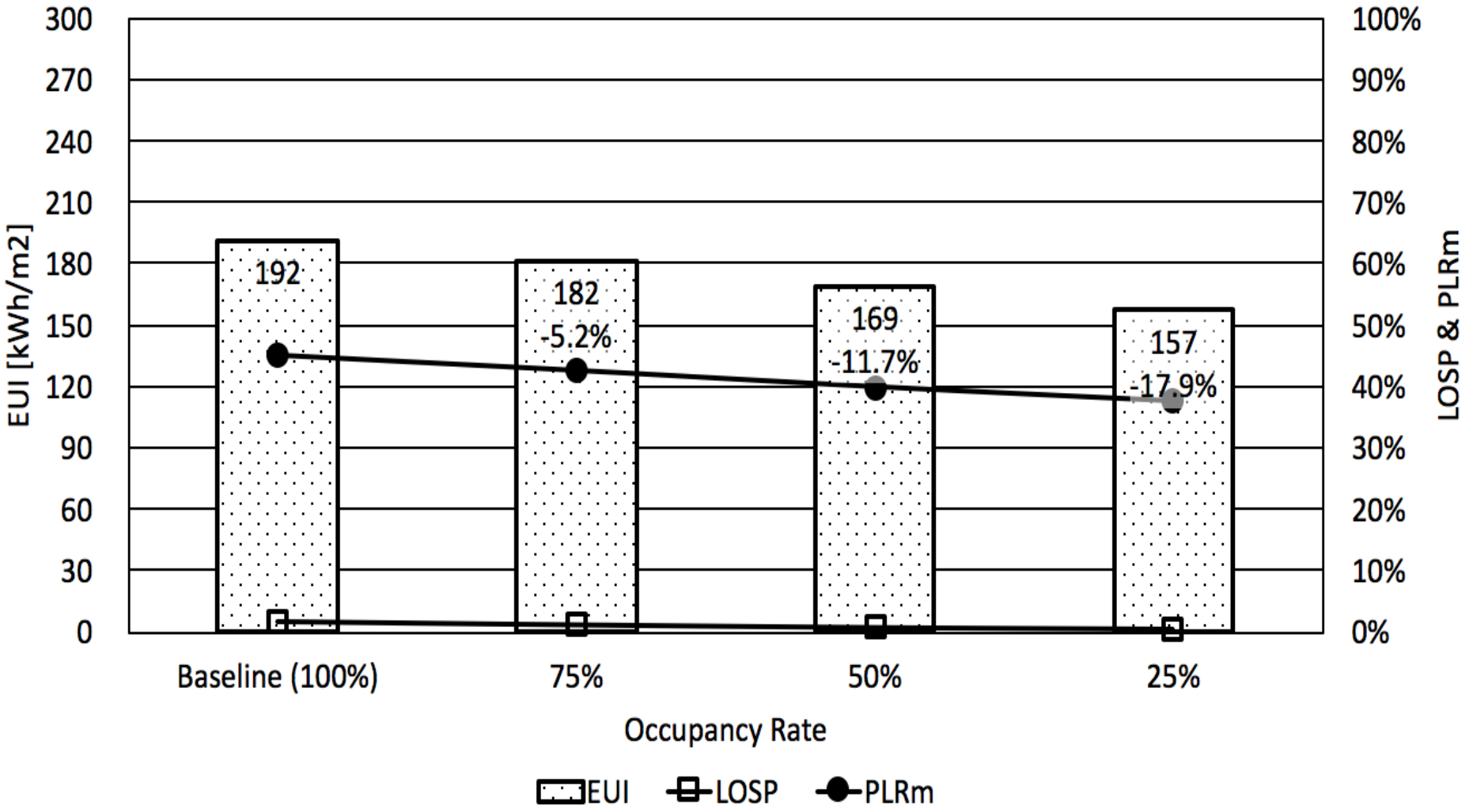
OA Fraction


300
270
240
210
180
150
120
90
60
30
0
EUI [kWh/m2]
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
LOSP & PLRm
192
199
+3.8%
207
+7.9%
224
+17.1%
244
+27.3%
257
+34.2%
265
+38.1%
267
+39.1%
267
39.3%
267
+39.4%
Baseline (10%)
20%
30%
40%
50%
60%
70%
80%
90%
100%
Minimum OA Fraction
EUI
LOSP
PLRm

Air Flushing and Purging before and after Occupancies

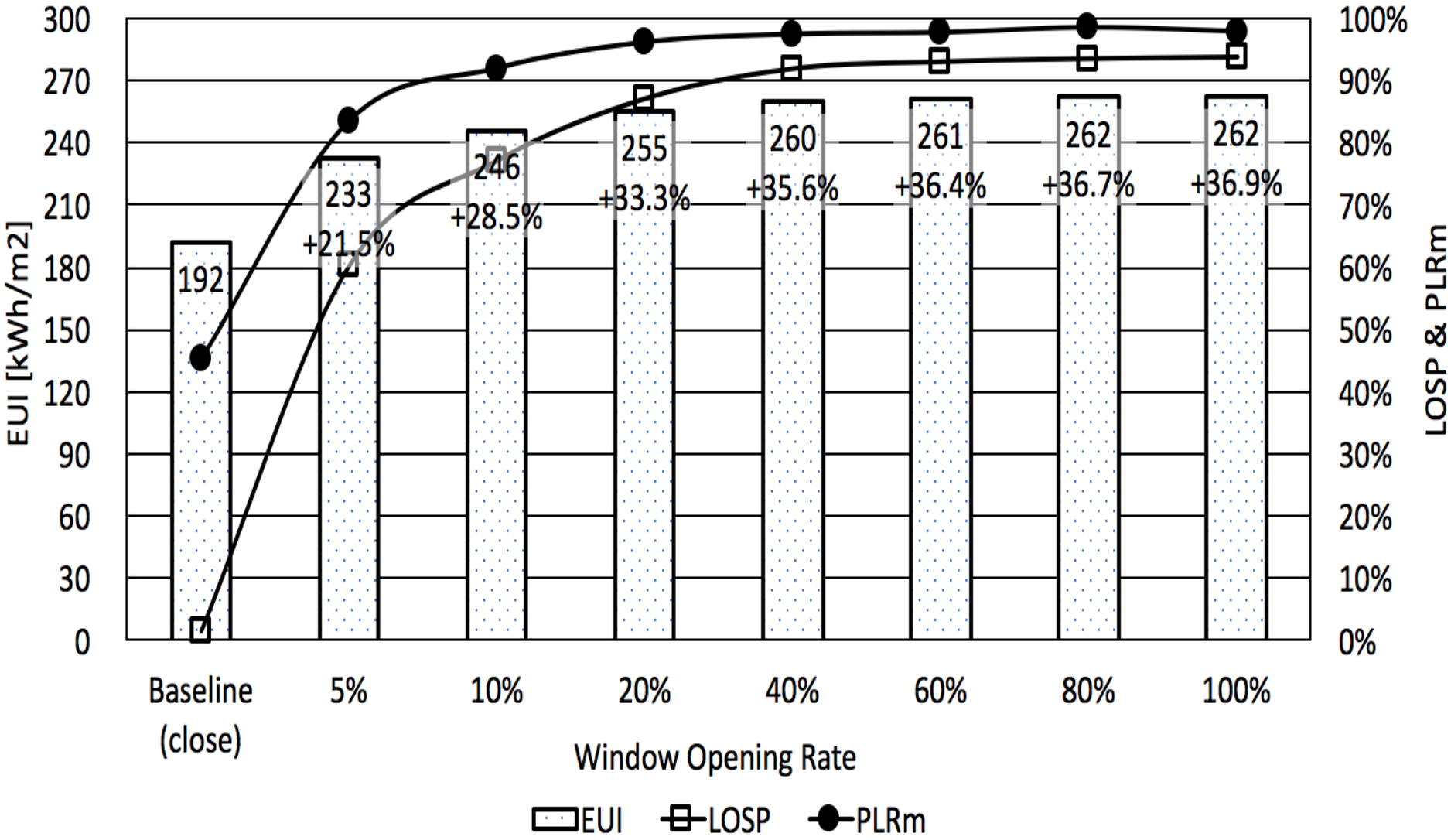


Occupant Density



Baseline occupant density: open office 18 m^2/person; enclosed office 15 m^2/person

Window Opening Rate



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

Key Findings

- **Influence of Parameters**

OA fraction > occupant density > 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

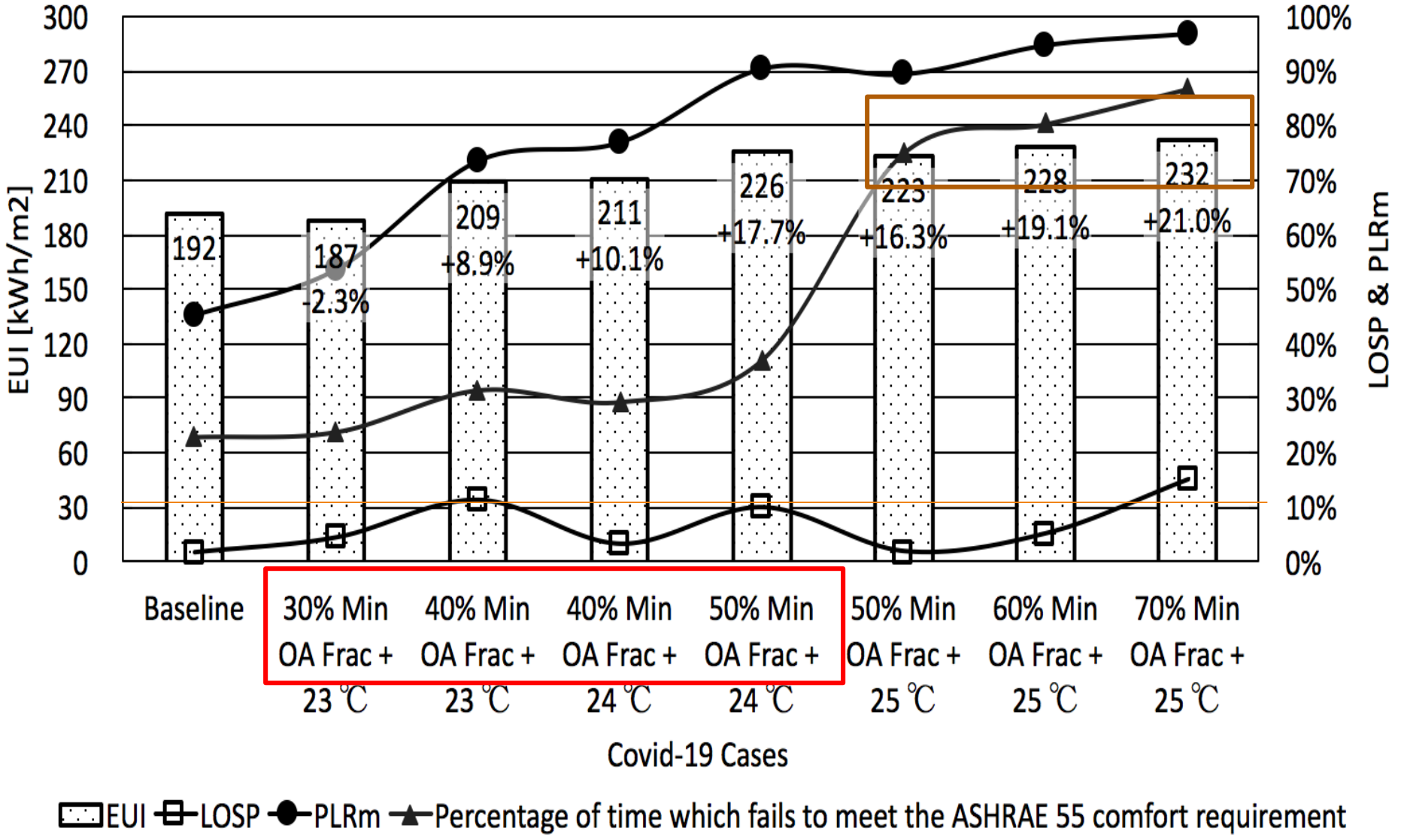
- *COVID-19 case:*

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

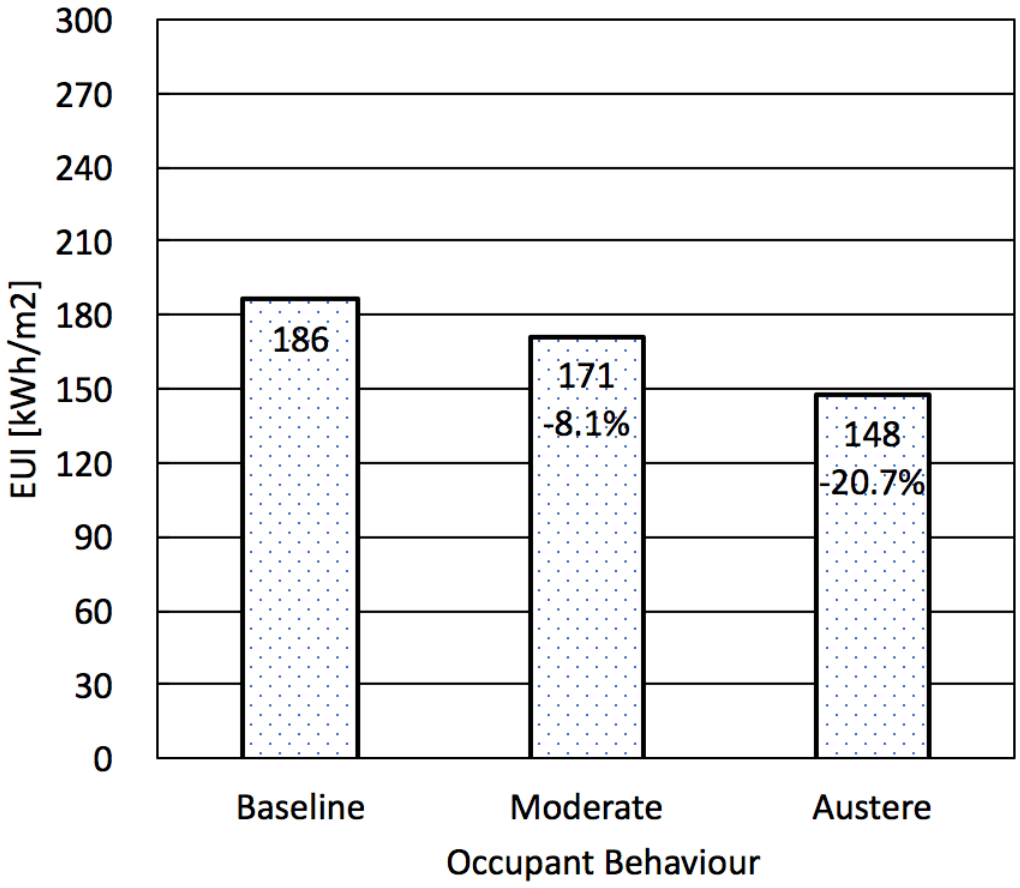


ASHRAE Standard 55: Thermal environmental conditions for human occupancy

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 ℃, increase it to 24 ℃. 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**

Source: He Zhiyuan, A Framework for Estimating the Energy-saving Potential of Occupant Behaviour Improvement in Tropical Buildings

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