Call Topic 1: Adaptive Air-conditioning & Mechanical Ventilation for the Tropics

1. Background

1.1 In Singapore's tropical climate, Air-Conditioning and Mechanical Ventilation (ACMV) plays an important role in ensuring building occupants' thermal comfort. As air-conditioning is energy intensive, typically responsible for 40 to 60% of the total building electricity, it is imperative to drive energy efficiency and sustainability so as to support the ambitious targets of Singapore's Green Plan and Green Building Masterplan to achieve 80% improvement in energy efficiency for best-in-class green building by 2030.

1.2 With the rising concern on the impact of indoor air quality to occupant's health, well-being and productivity, raising outdoor air provision has been widely accepted as an effective means to improve indoor environments. However, with the hot and humid climatic condition, the energy required for conditioning the outdoor air, i.e. cleaning, cooling and dehumidifying, is usually high through the whole year[1] . This challenge has been further aggravated by the rising ambient temperature, more frequent hot spells, and potential threats of haze, etc.

1.3 In addition to challenges from the outdoor air, there are several internal factors that should be addressed in order to respond to external variations effectively and efficiently. Today, building ACMV systems are designed to cater to the most unfavourable days or hours of the year under the full occupancy condition. This has posed challenges and potentially caused inefficiencies in operation, as most of the time buildings are operated under part-load conditions with rigid setting of space condition. To achieve energy efficiency, an adaptive air-conditioning system that can monitor the occupancy conditions and adjust its operation accordingly would be necessary. This is particularly relevant in the face of the rising demand of work-from-home and co-working spaces for which the part-loading conditions in workplaces would be more serious.

2. Objectives and Scope of Call for Proposals

2.1 This call aims to develop adaptive ACMV solutions/technologies, that can adjust to different conditions (e.g. weather conditions, usage and occupancy changes, etc.) for the various building types of commercial buildings in the tropics.

2.2 The objectives and scope of the project are to:

a) Review and identify the key performance factors including ACMV efficiency in various outdoor and indoor conditions.
b) Develop an adaptive air-conditioning system that can adjust to different conditions (e.g. weather conditions, occupancy changes, etc.) in an efficient manner.
c) The solution requires to be compact, durable, cost effective and low maintenance.
d) Evaluate the effectiveness of the solution including energy efficiency, Indoor Air Quality (IAQ), and thermal comfort performance.

2.3 Some of the possible solutions (non-exhaustive) are listed below:

- Innovation in mechanical components that can take quick action for flexible adjustments of cooling power and broader high-efficiency band under part load condition.

[1] Rim D, Schiavon S, Nazaroff WW, Energy and Cost Associated with Ventilation Office Buildings in a Tropical Climate. PLos ONE 10(3): e0122310. doi: 10.1371/journal.pone.0122310; 2015.

- Innovation in sensing technologies (e.g. IoT based digital solutions) to more accurately sense the room thermal condition felt by occupants and change in activity level for control and monitor the system efficiency and health under the fluctuating conditions.
- ACMV solutions to allow for raised indoor temperature set point without compromising cooling and dehumidification efficacy and be able to take quick adaption to variation of occupancy pattern and weather condition.
- Resilient building ventilation and air conditioning solutions to provide adequate clean fresh air and effective air movement pattern to protect building occupants in an energy efficient manner under the post-pandemic operation.

2.4 The project should achieve 20% more energy saving than existing best-in-class technologies for air-conditioning systems commonly used by Green Mark Platinum buildings, with satisfactory thermal comfort and IAQ.

2.5 The project will be split into two phases. Phase 2 will be contingent on phase 1 being successful.

Phase 1: Proof of Concept (POC)

i. Development of a working prototype of the air-conditioning system with flexible capacity for office and/or other building types; and
ii. Test-bedding the technologies in the translational facilities in BCA Braddell Campus (see Annex A) or other labs to achieve energy saving target, thermal comfort and indoor air quality under different possible thermal conditions representing Singapore climate environment.

Phase 2: Performance Validation

i. The developed prototypes should be tested in a high-fidelity testbed environment, such as the translational facilities in BCA Braddell Campus (see Annex A), and/or
ii. The developed solutions should be demonstrated in an operational environment in an actual building as part of the deliverables.

3. Funding Support:

3.1 The Call for Proposals offers funding support up to S$800,000 (including indirect costs). Proposals seeking more than S$800,000 will need to provide strong justifications.

3.2 This Call for Proposals offers funding support for a period up to 2 years.

Call Topic 2: Advanced Integrated Control Solutions for ACMV & Lighting

1 Background

1.1 To achieve Super Low Energy (SLE) Buildings, it is crucial to adopt a system approach that can drive optimum overall performance by effectively coordinating multiple systems, including ACMV, lighting, window/glass, etc. With the advances of control technologies (e.g. dimmable and spectrum tuneable lighting) and change of user behaviours (e.g. aging population, paperless offices), Internet Of Things (IOT) based smart control devices/methods are becoming prevalent for individual systems and help achieve energy savings, such as smart lighting, smart glass, data driven chiller operation, etc. However, there is opportunity to achieve further energy savings and non-energy benefits, by integrating multiple smart systems to allow data interchange and system cooperation.

1.2 For example, lighting sensors today have been used to provide occupancy information and adjust lighting energy consumption. This occupancy information can also be used by smart air-conditioning system to adjust air dampers and valves to reduce energy when occupancy is reduced. Another example is there is a lack of integration of artificial light and daylight and potentials for energy savings. On one hand, introducing more daylight can help to reduce the energy consumed by artificial lighting. On the other hand, it can increase the building cooling load, resulting in more energy consumed by the cooling system. The efficient utilization of daylight will not only affect the interior environment and the occupants' well-being, but also has a direct impact on the building energy performance.

2 Objectives and Scope of Call for Proposals

2.1 To harness the maximized benefits of integrated system, this project will:

a) Review existing control and optimisation strategies for lighting and air conditioning;
b) Study the integration of lighting and air-conditioning to develop innovative control strategies to maximise the total energy performance of lighting and air-conditioning;
c) Study the daylight use and optimally balance the lighting energy performance and cooling load, occupants' behaviour and total energy consumption;
d) Develop evaluation methodologies for the smart lighting solutions with daylight integration to enable performance benchmarking and thus encourage the innovation to further push the boundary of energy efficiency of lighting systems;
e) Establish innovative measurement and verification (M&V) tools to quantify and qualify the benefits of energy-efficient smart solutions in a simple, credible, and cost-effective way; and
f) Testbed the integrated smart solutions under different possible climate environment that emulate tropical daylighting conditions as well as at various real-world mock-ups (See Annex A).

2.2 Some of the possible solutions (non-exhaustive) are listed below:

- Integrated and coordinated control of different systems (e.g. daylighting with dynamic façade, lighting, air-conditioning) not only at the information level (e.g., sharing of sensor data or dashboard display) but at the system dynamics level to achieve optimal performance.

- Real-time optimisation for system dynamics to cater for transient disturbances (weather conditions, occupancy, activity level) and comprehensive performance.
- Lighting source with predictive control function (e.g. IoT based) to adjust the spectrum, intensity and optical distributions of light to provide visual comfort in an energy efficient manner.

2.3 The project should achieve at least 20% improvement in energy efficiency than the existing best-in-class lighting and control technologies commonly used by Green Mark Platinum buildings (taking the air conditioning system into consideration) to maintain a targeted optimal operational Lighting Power Density (LPD) for occupancy visual comfort

2.4 The project will be split into two phases. Phase 2 will be contingent on phase 1 being successful.

Phase 1: Proof of Concept (POC)

i. Development of a working prototype of an integrated smart control system for office and/or other building types; and
ii. Test-bedding the technologies in the translational facilities in BCA Braddell Campus (see Annex A) or other labs to achieve energy saving target, and visual comfort under different possible exposure of Singapore climate environment.

Phase 2: Performance Validation

i. The developed prototypes should be tested in a high-fidelity testbed environment, such as the translational facilities in BCA Braddell Campus (see Annex A), and/or

ii. The developed solutions should be demonstrated in an operational environment in an actual building as part of the deliverables.

3 Funding Support

3.1 The Call for Proposals offers funding support up to S$600,000 (including indirect costs).

3.2 This Call for Proposals offers funding support for a period up to 2 years.

Annex A: Translational Facilities in BCA Academy

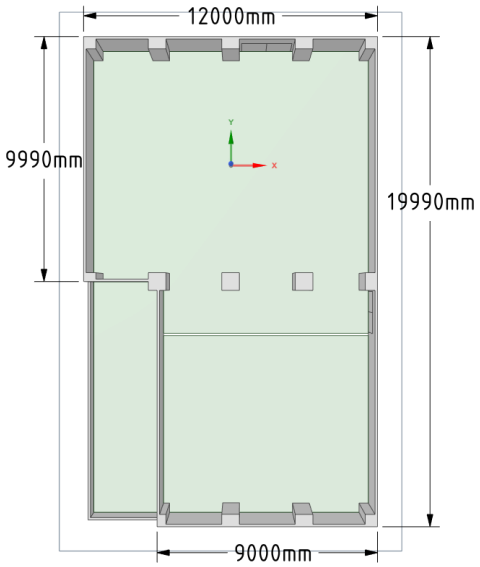

Figure 1 Co-innovation Space (level 16)

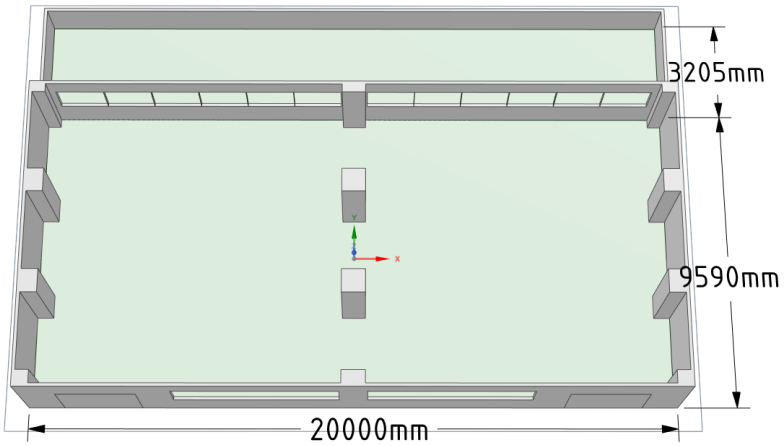

Figure 2 Multi-purpose Testbed Space (level 16)