Annex A: Factsheet on Built Environment Innovation Hub @ BCA Braddell Campus

BCA Braddell Campus

1. BCA Braddell Campus[1] prides itself as a living laboratory and an advocate for the key transformation areas (KTAs) under the Built Environment Industry Transformation Map (BE ITM) by showcasing success stories and pushing boundaries of innovation and technology. It provides a dynamic space for test bedding, exploration, and development of cutting-edge technologies by innovators to bring significant contributions to the BE sector. The campus is home to:

    a. BCA Skylab, the world's first high-rise rotatable laboratory for the tropics;
    b. the Academic Tower, a predominantly precast building with high recycled concrete content and exposed cutting-edge installations and technologies, one of the first of its kind in Singapore; as well as
    c. Zero Energy Plus Building (ZEB Plus, a Positive Energy Building).

2. These are joined by two new additions - a 7-storey mid-rise Zero Energy Building (ZEB) and a 16-storey high-rise Super Low Energy Building (SLEB). Collectively, the campus provides experiential learning opportunities for learners and practitioners. The Green Mark Platinum SLEB compound supports decarbonisation efforts by utilising renewable energy from solar panels to meet 25% of the campus' energy needs, one of the highest in Singapore.

3. The BE ITM launched last year sets an ambitious goal of transforming the entire building lifecycle with our industry partners by harnessing emerging technologies and innovations to drive collaboration across various project parties. Hence, it has become increasingly evident that embracing innovation and technology is essential for both individuals and firms. This is also a crucial step in achieving the ultimate aspiration of cultivating a built environment sector that is smart, productive and sustainable, poised to seize global opportunities.

[1] More information on BCA Braddell Campus is at: https://www.bcaa.edu.sg/who-we-are/learning-journeys

Connect: Hub for Collaboration

4. The BEIH @ BCA Braddell Campus (BEIH) is a collaborative space for the industry to connect like-minded individuals, showcase innovative technologies and best practices, augmenting the transfer of ideas and knowledge to accelerate transformation of the Built Environment sector.

5. BEIH's innovative design strategically co-locates BE stakeholders within the value chain comprising consultants, builders to Trade Associations and Chambers (TACs) to form a vibrant community of innovators[2]. This effectively promotes collaborative research, test-bedding and the refinement of in-demand BE solutions such as the novel mixed mode ventilation solution at Level 14, SLEB.

<u>The novel mixed mode ventilation solution @ Level 14, Super Low Energy Building (SLEB)</u>

6. Buildings account for over 20% of Singapore's carbon emissions and we are constantly finding ways to reduce it. Cooling of buildings alone account for 40-50% of energy consumption in building operations. A challenge faced by office buildings is its heavy reliance on air-conditioning due to Singapore's tropical climate, characterised by high temperatures and humidity all year round. Growing demands for air-conditioning are also expected with increasing global temperature brought about by climate change.

7. To reduce a building's cooling energy consumption, BCA has collaborated with the National University of Singapore (NUS), Singapore Institute of Technology (SIT), Kajima Corporation, and Surbana Jurong Consultants Pte Ltd under the Cities of Tomorrow (CoT) R&D programme to explore an incremental approach to cool spaces that uses a combination of natural ventilation from automated windows, elevated air movement from ceiling fans, spot cooling from personal ventilation desks, and background cooling from the air-conditioning and mechanical ventilation (ACMV) system. The aim is to maximise conditions when

[2] More information on co-located partners at BCA Braddell Campus is at: <u>https://www.bcaa.edu.sg/who-we-are/about-us/partners</u>

natural ventilation is desirable and reduce reliance on energy-intensive air-conditioning, thereby contributing to urban sustainability and significantly reducing cooling energy consumption.

8. The team is also developing an occupant-centric sensing and control framework to inform the mixed-mode operation, thereby saving energy while providing a comfortable and healthy indoor environment. The team has conducted experiments assessing occupant thermal comfort across different operational modes and under varying indoor and outdoor conditions. The data from these experiments have been used to establish critical setpoints for switching between the three operating modes, ensuring that the hours of natural ventilation operation are maximized without compromising occupant thermal comfort. Unlike conventional predetermined fixed setpoints, the proposed solution will incorporate occupant feedback to update and adapt these setpoints to ensure continual occupant thermal comfort. Moreover, as collecting actual occupant feedback can be labour intensive in real-world implementation, the team is also exploring transfer learning, a machine learning method, to reduce the data requirement needed to train the machine learning model.

9. For optimal operating mode selection, a comprehensive network of sensors will be installed to provide real-time monitoring of areas such as: (1) indoor air quality, thermal, and noise levels; (2) outdoor weather conditions; (3) occupancy count; (4) occupant feedback via wearables; and (5) rain detection on the façade.

10. Mixed mode ventilation also provides resilience in an uncertain world. For instance, during a haze episode, the high outdoor particulate matter would be detected, signalling the windows to close and switching to an air-conditioned mode of operation. In the event of any pandemic, the ACMV system could also be operated concurrently with windows open to increase ventilation rates and reduce the risk of long-range airborne transmission.

11. During the proof-of-concept experiment, conducted over a two-week period, a 55% cooling energy reduction was achieved in a 45m^2 testbed located at the BE Innovation Hub @ Braddell Campus compared to a similar office located at NUS's

net-zero energy building, SDE4. A full-scale demonstration is set to commence in January 2024 in a sizeable open-plan office space located at Level 14, SLEB which will be occupied by Azendian Solutions, a built environment energy efficient software company. Azendian will be gathering data and collaborating with project stakeholders to fine-tune the design.

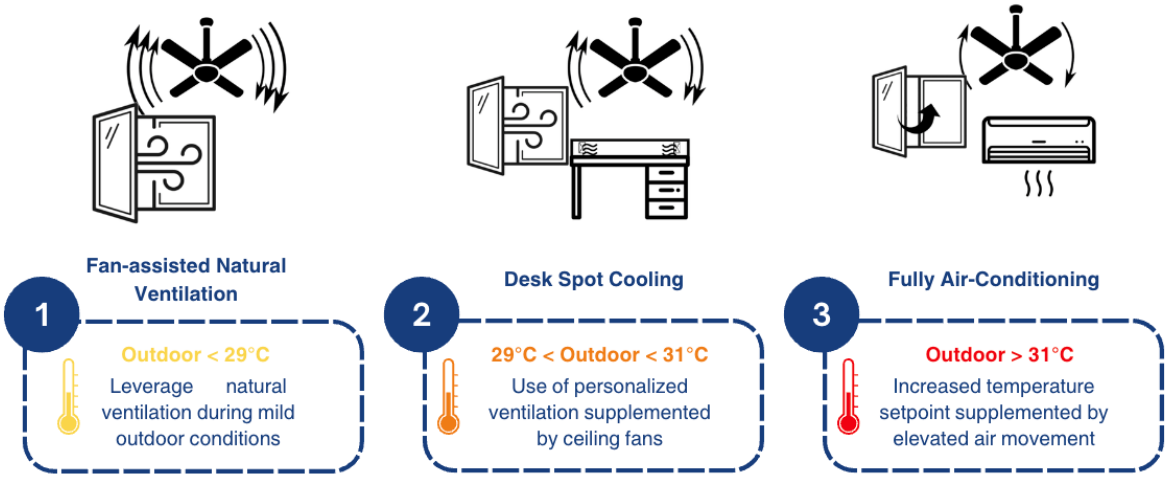

Figure 1. Using mixed-mode ventilation to achieve an incremental approach to cooling.

12. Further, BCA is also bringing together industry partners across the BE value chain locally and globally via the Built Environment Innovation Hub (BEIH) Technology Exchange and Networking Sessions.

<u>Built Environment Innovation Hub (BEIH) Technology Exchange and Networking Sessions</u>

13. The BEIH Technology Exchange and Networking Sessions, initiated in 2022, brings together Innovation & Technology (I&T) ecosystem stakeholders, including leading firms, solution providers, investors and researchers. These events feature technology themes and collaboration opportunities, and are held in partnership with industry associations, accelerators, and innovation catalysts such as Singapore Green Building Council (SGBC), Singapore Contractors Association Limited (SCAL), Tech Onshore MEP-Prefabrication (TOM) Pte Ltd and Hilti.

14. Over the past year, these sessions have gathered more than 300 like-minded innovative proponents across four sessions spanning various technology themes

such as Green Building Technology and Innovations, Prefabricated Mechanical, Electrical and Plumbing (MEP) Systems and Robotics for trade works.

15. With the launch of BEIH, the refreshed campus will serve as a nexus at which the I&T ecosystem converges to explore and apply new innovations for the accelerated transformation of the BE sector. The industry can look forward to more invigorating BEIH Technology Exchange and Networking Sessions to come.

Built Environment Accelerate-to-Market Programme (BEAMP)

16. The Built Environment Accelerate-to-Market Programme (BEAMP)[3] is a multi-agency initiative between the Building and Construction Authority (BCA), Enterprise Singapore, and JTC to support promising innovators as they develop technology solutions. This is to address industry challenges in the built environment based on seven thematic pillars towards a smart, productive and sustainable sector. Each BEAMP cycle consists of two phases – (1) accelerate solution development phase; and (2) market development phase.

17. The BEAMP platform which is in its fourth cycle allow corporates to pose challenge statements and source for new ideas and solutions provided by startups as well as small and medium enterprises (SMEs). To date, BEAMP has supported various partnerships between more than 60 corporates, startups and SMEs, resulting in the development of 44 innovative Built Environment solutions.

18. To accelerate the transformation of the BE sector, the fifth cycle of BEAMP will be launched in the first quarter of 2024 with the continued support of Enterprise Singapore and JTC. The programme will provide additional support for companies to conduct small-scale commercial trials to gain early market traction and build track records to bolster their chances of commercialisation in the wider industry. The support for projects that require accelerated development will also be increased from $30,000 to $50,000.

[3] More information on Built Environment Accelerate-to-Market Programme (BEAMP) is at: https://www.beamp.sg/

Catalyst for Knowledge and Skills Transfer

BCA Academy as Dedicated Continuing Education and Training (CET) Centre for the Built Environment sector

19. With BCA Academy as the dedicated Continuing Education and Training (CET) Centre for the Built Environment sector[4], BCA will be prioritising in-demand and emerging skills in transformative areas to equip industry at all levels with knowledge and cutting-edge skills as we transit towards the refreshed ITM. This includes new skillsets to drive innovation and collaboration in support of integrated platforms and CORENET X. BCA will further develop competencies in enterprise leadership to drive and accelerate value chain transformation.

20. Complementing new formats of training such as Masterclasses and executive dialogues, BCA Academy will be emphasising on tech-enabled pedagogy to promote flexibility and facilitate a more interactive and engaging learning. For example, BCA and Serl.io, the technology partner collaborated to develop an AI Driven Mixed Reality Experiential Learning Platform (AMRAS). AMRAS is a MR authoring tool and digital platform that transforms traditional training workshops into virtual immersive environment. By integrating with head-mounted MR devices such as HoloLens, AMRAS enables learners to interact with 3D digital assets through simulated real-world activities and scenarios, enhancing their learning experience and engagement. Unlike traditional workshop setting, AMRAS provides a cost-effective and efficient solution that eliminates the need for extensive equipment. Learners can also develop practical skills and knowledge in a remote and safe environment.

21. With AMRAS, lecturers can create customised and engaging simulation packages that are tailored to their lessons and areas of training, collect and analyse data to track learners' progress, and identify areas for improvement. This can then be used to inform instructional design decisions and to further tailor learning experiences to better meet the needs of the learners.

[4] More information on BCA Academy as the dedicated Continuous Education and Training (CET) for the Built Environment sector is at: https://go.gov.sg/bca-mr-leadsummit23

SkillsFuture Career Transition Programme (SCTP)

22. The SkillsFuture Career Transition Programme (SCTP) is a Train-and-Place programme which supports mid-careerists in acquiring industry-relevant skills to improve employability and pivot to new sectors or job roles. As part of BCA Academy (BCAA)'s effort to increase the pool of mid-career entrants for forerunner firms, BCAA will be launching a suite of five SCTPs for the Built Environment in areas tabled below by 2023 (See Table 1).

23. These programmes are suitable for both new entrants with non-BE background, and in-service BE personnel. Offered in part-time mode over 9 to 12 months, the programmes will be curated to equip participants with emerging skills and competencies, as well as the technical skills and competencies (TSCs) for the job roles listed below.

	SkillsFuture Career Transition Programme (SCTP)	**Modules**	**Job Roles**
1	SCTP in Digital Delivery (Built Environment)	• Digital Design • Basic Programming for Digital Design • Fundamental Digital Delivery • Advanced Digital Delivery • Workplace Learning	Assistant Specialist (Digital Delivery)
2	SCTP in Sustainable Design (Built Environment)	• Introduction to Digital Building Design • Sustainable Building Design Strategies • Regulatory Requirements • Advanced Digital Design for Sustainable Buildings • Green Building Design Criteria and Green Mark • Workplace Learning	Architectural Assistant
3	SCTP in Computational Design (Built Environment)	• Introduction to Computational BIM • Basic Coding & Programming I • Basic Coding & Programming 2	Assistant Specialist (Digital Delivery)

		• Computational BIM Tool Application 1 • Computational BIM Tool Application 2 • Workplace Learning	
4	SCTP in Smart and Sustainable Facility Management	• Digital Delivery of FM • Planning and Management of Smart FM • Integrated Facility Management • Green Building Design Criteria and Green Mark • Workplace Learning	Assistant Facilities Manager
5	SCTP in Integrated Project Management and Delivery (Built Environment)	• Scope of Work for Project Management in BE sector • Project Management Body of Knowledge in BE sector • Project Management for Productivity Enhancement • Integrated Procurement Management • Contract Administration and Collaborative Contracting • BIM Management • Workplace Learning	Assistant Project Manager

Table 1: Five SCTPs for the Built Environment and corresponding modules and suitable job roles

24. Each SCTP comprises 6-9 months of classroom learning and 3 months' workplace learning. Classroom learning will be mostly conducted in the evenings in modular certificate formats to offer flexibility for in-service personnel to attend.

25. Eligible individuals can receive SkillsFuture course fee funding covering up to 90 percent of the course fees. In addition, they can use their SkillsFuture Credit to offset the out-of-pocket course fees.

Showcase: Exemplifying Innovation and Technology through BEIH

26. BCA Braddell Campus has undergone significant enhancements to further showcase our commitment to align with the key transformation areas (KTAs) set forth in the Built Environment Industry Transformation Map (BE ITM) as shown by the two new buildings, ZEB and SLEB, with a total gross floor area of 27,600 m^2.

The campus' intensification works yielded the following results:

KTA 1: Integrated Planning and Design

27. The project approach on collaborative contracting lays the foundation for a harmonious working environment with shared goals and priorities anchored highly on integrated digitalised work processes. This approach has led to significant improvements, including:
    - 50% reduction in time taken for decisions latencies. For example, the number of Requests for Information (RFIs) were halved compared to our previous Phase 1 project.
    - 40% reduction in redesign and rework schedules by the main contractor when compared to typical projects of similar size.

KTA 2: Advanced Manufacturing and Assembly

28. The project is the first in Singapore to integrate three advanced game-changing construction technologies, Mass Engineered Timber (MET), Advanced Precast Concrete System (APCS) and Prefabricated Prefinished Volumetric Construction (PPVC), in a single project. These technologies are characterised with high levels of offsite prefabrication, shorter onsite construction assembly, improved workmanship and minimal disruption to surroundings. Adopting all three technologies at the same site has facilitated industry-wide comparisons and shared insights into the engineering and management of these innovations, ultimately promoting broader use. The project achievements include:

- Reduced APCS structural floor cycle of 6 days as opposed to the typical 8 to 10 days cycle.
- Reduced PPVC structural floor cycle of 3.5 days as opposed to the typical 8 to 10 days cycle.
- 15% productivity gain, despite disruptions arising from Covid-19 pandemic.
- Up to 80% reduction in onsite manpower.
- Simulations were used to determine the most efficient building form to minimise shadows over the solar photovoltaic roof. The terraced design allowed customisation of PPVC components showcasing the versatility of PPVC for various spatial uses beyond residential applications.

KTA 3: Sustainable Urban Systems

29. The two new buildings are also one of the tallest mid-rise ZEB and high-rise SLEB buildings in Singapore with energy savings expecting to exceed the Green Mark 2015 baseline. This is despite both buildings housing commercial offices and research laboratories, fitted with high-performance equipment, computers and IT peripherals that require considerable power consumption and heat emission. Some key strategies to push the envelope of sustainability in ZEB and SLEB buildings include:
    - Strategic placement of non-air-conditioned ventilated common spaces on lower floors, leveraging the central atrium to create a stack effect. This allows the building to achieve thermal comfort despite 60% of the buildings being naturally ventilated.
    - The use of MET offers high thermal resistance and thermal mass (ability to absorb, store and release heat), contributing to indoor temperature stabilisation.
    - Tapping on existing ACMV system to adopt centralised cooling system to provide higher efficiency and minimise downtime.
    - Extensive usage of passive displacement ventilation resulting in approximately 86% savings in fan energy consumption as compared to conventional systems.
    - Installation of high-efficiency solar photovoltaic panels on the exposed ZEB roof, generating 501MWh of electricity annually, enough to power at least 110

units of 4-room HDB flats per year, with a 20% surplus to meet ZEB's energy demands.

- Further, the new buildings are fitted with an open, scalable and smart Integrated Building Management System (IBMS) which integrates current and future systems to optimise demand control ventilation and building maintenance of mechanical, electrical and plumbing services, housekeeping, security.

30. Both the 7-storey ZEB and 16-storey SLEB are expected to achieve energy savings beyond 46%. This exceeds the minimum 40% Green Mark 2015 baseline requirements.