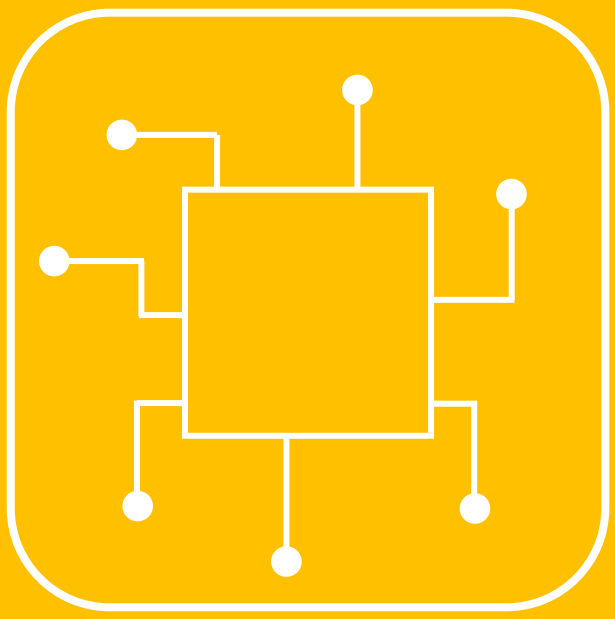

Green Mark 2021

In

Intelligence

Revision Log

Revision	Description	Effective Date
R1	1st Version	1/11/2021

Contents

Revision Log 2

IN1 Integrated 4

IN1.1 Digital Life Cycle 4

(i) Project Information Model (PIM) developed in accordance with Singapore Common Data Environment (CDE) Data Standard 4

(ii) Use of spatial model co-ordination platform based on Project Information Model (PIM) for spatial analysis 5

(iii) Digital building commissioning, performance and defect co-ordination platform based on Project Information Model (PIM) 8

IN1.2 Common Data Environment 9

(i) Performance Dashboard to monitor building assets' performance and operations 9

(ii) Data Management and Integration (Interoperability) with a platform based on an open protocol 10

(iii) Data Accessibility and Security 11

IN1.3 Voluntary Disclosure of Building Energy Performance Data 12

(i) Share basic information 12

(ii) Share additional information 13

IN2 Data Driven 14

IN2.1 Asset Information Model 14

(i) Development and handover of an accurate spatial model of the building or asset 14

(ii) Physical and virtual Asset Information tagging system 14

(iii) Adoption of a common international standard for asset ontology 15

IN2.2 Digital Twins 16

(i) Asset Digital Twin 16

(ii) System Digital Twin 17

(iii) Process Digital Twin 18

IN3 Responsive 20

IN3.1 Real Time Performance 20

(i) Energy – Measurement, trend and analysis of energy consumption and efficiency of key systems to facilitate real time performance optimisation 20

(ii) Health & Comfort – Provision of permanent calibrated quality monitoring system with zonal controls 21

(iii) Space – Monitoring of space utilisation for optimisation of building systems 22

IN3.2 User Experience 23

IN3.3 Data Ethics 24

Intelligence - Innovation 25

Acknowledgements: 26

IN1 Integrated

A maximum of 5 points can be scored across IN 1 Integrated section.

IN1.1 Digital Life Cycle

Integrated Digital Delivery (IDD) is the use of digital technologies with a Project Information Model (PIM) to integrate work processes and connect stakeholders throughout the design, construction, operation, and retrofitting of the whole building life cycle. Digital life cycle involves the use of PIM to integrate planning, design, construction, retrofit and operational activities with adequate levels of definition of geometry and facility information.

(i) Project Information Model (PIM) developed in accordance with Singapore Common Data Environment (CDE) Data Standard

Assessment Criteria

IN1.1 Digital Life Cycle		**New Buildings**	**Existing Buildings**
(i)	PIM developed in accordance with Singapore Common Data Environment (CDE) Data Standard that align with the Principles of ISO 19650-2018	2 Points	2 Points

The Project Information Model (PIM) should include the standardisation of the model element names, and specification of the element attributes or parameters to allow consistency and clarity in the communication of information between project members.

Documentation Requirements

At Design stage (New Buildings) / Pre-retrofit stage (Existing Buildings):

- PIM Plan (BIM Execution Plan [BEP]) including the requirements for the model content to follow CDE Data Standard for project team to deliver

At Verification stage (New Buildings & Existing Buildings):

- Schedule/report of asset information following CDE Data Standard

Guidance Notes

The PIM can be formulated in multiple formats, such as a BIM model with the building and asset geometrical information, or database technologies to store project information. Where two or more formats are used for PIM, specific identifiers shall be used for the shared items to ensure connectivity.

The PIM shall contain the information required by the facility/asset owners to manage their assets. Examples of requirements for Model Elements, Parameters, Data Type and Units can be found in the CDE Data Standard – Section 9.1 (see Figure 1). The PIM shall also be sufficiently developed and detailed for purposes of co-ordination, environmental simulations, statutory submissions, tender and construction documentation as well as forming the basis for conversion into Asset Information Models (AIM).

MAIN ELEMENT	SUB-ELEMENT*	ELEMENT NAME: • IFC • ARCHICAD *(A)* • REVIT *(R)*	DISCIPLINE	PARAMETERS (GENERIC TERMS)	PARAMETER DATA TYPE	UNIT
Equipment (Primary)		• Ifc - varies • Equipment/Object *(A)* • Mechanical Equipment/Electrical Equipment/Plumbing Fixture *(R)*	Architecture, MEP	Type	Text	N.A.
				Description	Text	N.A.
				System	Text	N.A.
				Overall Height, Width, Length	Number	mm
				Capacity *(for Chillers, Cooling Towers, AHUs, Pumps, FCUs, Heat Exchangers)*	Number	kW/kg/litres
				Location	Text	N.A.
				Manufacturer	Text	N.A.
				Model Number	Text	N.A.
				Electrical Panel Name *(not applicable for plumbing fixtures)*	Text	N.A.
				Electrical Panel Circuit *(not applicable for plumbing fixtures)*	Text	N.A.
				Asset Code	Text	N.A.
				Barcode/QR Code	Text	N.A.
				Installation Date	Date	dd/mm/yyyy
				Warrantor	Text	N.A.
				Warranty Description	Text	N.A.
				Warranty Duration	Number	years

Figure 1: Requirements for Model Elements, Parameters, Data Type and Units

References

- *ISO 19650–1 Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) - Information management using building information modelling - Part 1: Concepts and principles*
- *ISO 19650-2 Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) - Information management using building information modelling - Part 2: Delivery phase of the assets*
- *CDE Data Standard defines what information is required for a building project and how it can be structured to facilitate sharing and collaboration among project team members using a Common Data Environment*

(ii) Use of spatial model co-ordination platform based on Project Information Model (PIM) for spatial analysis

Assessment Criteria

IN1.1 Digital Life Cycle		**New Buildings**	**Existing Buildings**
(ii)	Use of spatial model co-ordination platform based on PIM for spatial analysis including:		*(for areas of new construction/ additions and alterations)*
	a. Identifying system clashes through an automatic model checking tool	1 Point	1 Point
	b. Spatial analysis for effective construction, maintenance and future alteration or replacement.	1 Point	1 Point

(a) Identifying system clashes through an automatic model checking tool

The use of BIM clash detection process to model building and facility elements, equipment access and working spaces as “3D volumes” or “reserved box” can help to avoid clashes between different disciplines and to accurately allocate maintenance space for mechanical equipment.

Points shall be awarded for clash-checking between different disciplines, modelling equipment access and working space of key mechanical equipment (e.g. Chillers, AHU).

(b) Spatial analysis for effective planning, design, construction, maintenance and future replacement

New development projects should involve the facilities management (FM) team throughout the key design and construction stages to provide insights on space requirements for maintenance and future replacement works.

Points shall be awarded for the use of PIM to solve issues in space requirements for maintenance or other space-related issues in the building operation process.

Documentation Requirements

At Design stage (New Buildings) / Pre-retrofit stage (Existing Buildings):

- BIM Execution Plan (BEP) showing the key spatial provisions made to meet the clash detection requirement.
- Meeting notes, correspondences with facility management team reflecting their involvement and inputs during the meeting sessions

At Verification stage (New Buildings & Existing Buildings):

- Clash report and/or animation to show the spatial issues from the clashes detected are checked and resolved
- As-built drawing/model showing the space requirements are fulfilled.

Guidance Notes

An example of how space requirements for equipment access and maintenance work are modelled in BEP can be found in **Error! Reference source not found.**.

Figure 2: Model Maintenance Space (Image Courtesy of SIT)

The spatial analysis can be performed through visualisation or animation tools as shown in and .

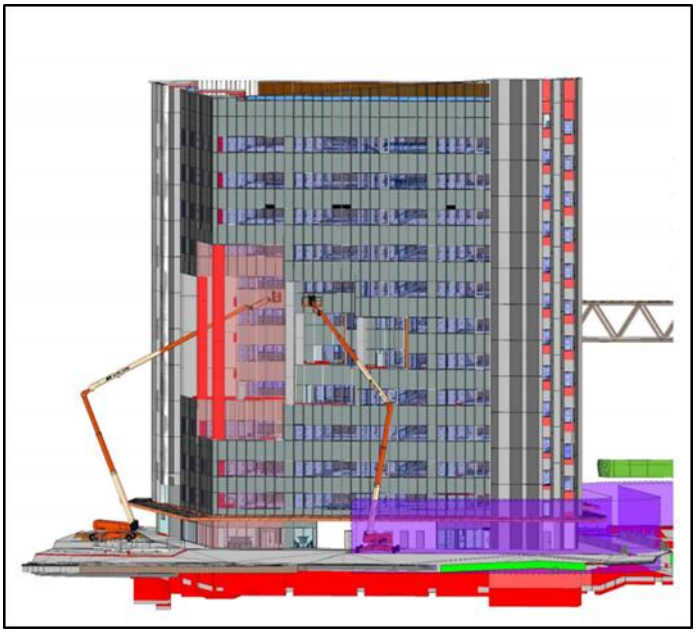

Figure 3: Maintenance Study using Boom Option (Image Courtesy of SIT)

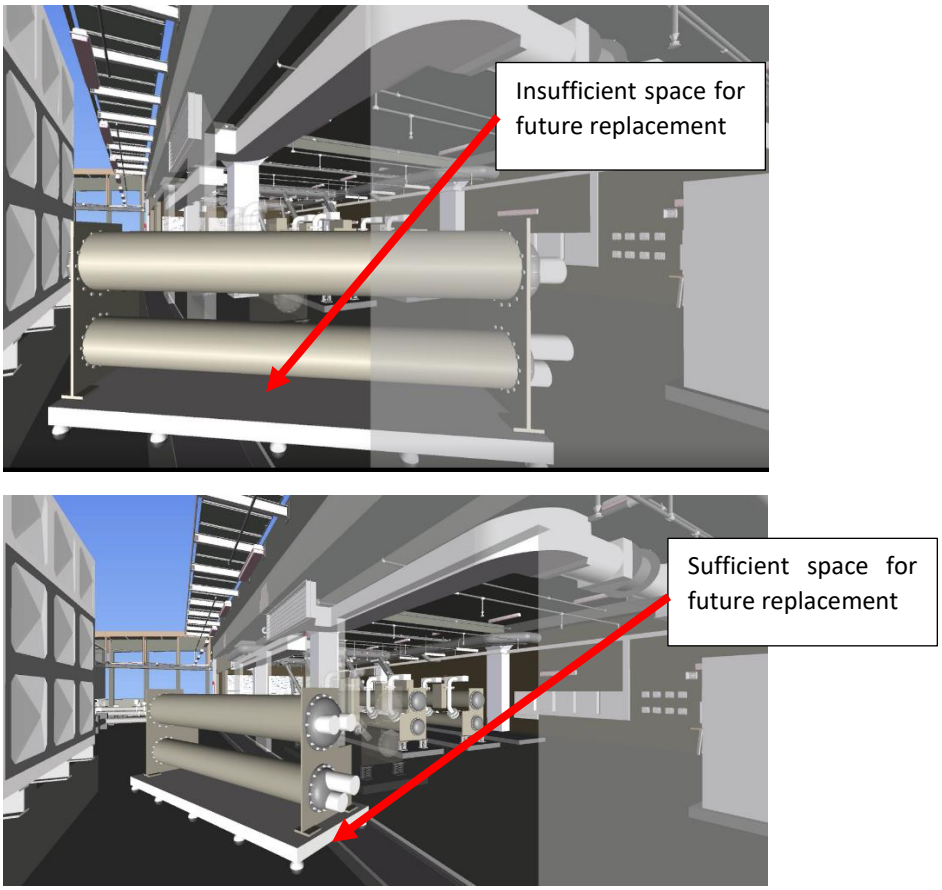

Figure 4: Using Animation to Perform Spatial Analysis for Future Replacement (Image Courtesy of BCA Academy)

(iii) Digital building commissioning, performance and defect co-ordination platform based on Project Information Model (PIM)

To ensure that the building or assets are operationally ready for handover, a digital platform could be used to manage the commissioning processes as well as track defects and the corresponding rectifications.

Assessment Criteria

IN1.1 Digital Life Cycle		**New Buildings**	**Existing Buildings**
(iii)	Digital building commissioning, performance and defect co-ordination platform based on PIM to track, co-ordinate and manage the commissioning of systems and the tracking of defects and their rectification	1 Point	1 Point

Documentation Requirements

At Design stage (New Buildings) / Pre-retrofit stage (Existing Buildings):

- Tender specifications stating the use of digital platform to track, co-ordinate, and manage the commissioning of systems and tracking of defects and their rectifications

At Verification stage (New Buildings & Existing Buildings):

- Screenshots and pictures showing the implementation of the platform onsite
- Activity logs from the digital platform

Guidance Notes

An example of the digital platform as shown in Figure 5.

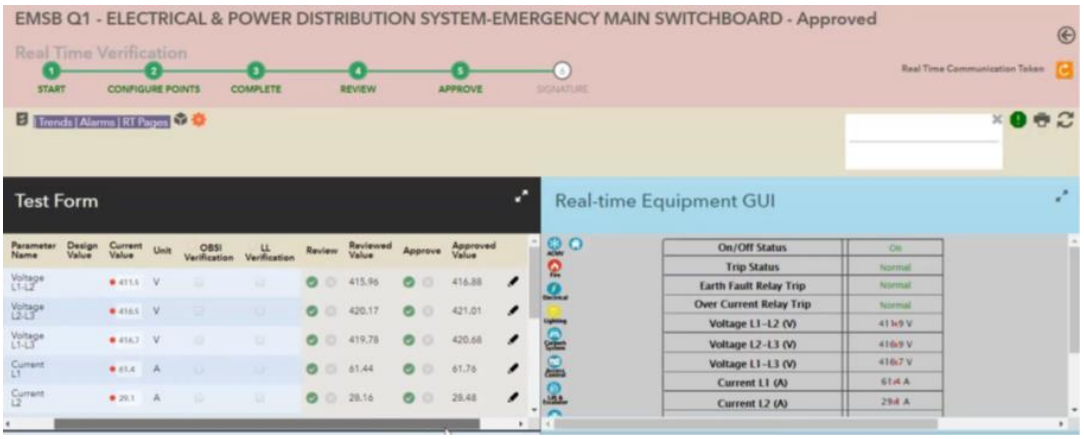

Figure 5: Digital Commissioning (Image Courtesy of Eutech Cybernetics)

IN1.2 Common Data Environment

The use of a common data environment (CDE), which is a single source of information to collect, manage, and disseminate information can facilitate collaboration between project team members and helps avoid duplication and mistakes. With increasing specialisation and isolation of technologies and processes, systems often operate in silos and result in incoordination that lead to wastage in time, materials and manpower. To address these silos, a Common Data Environment for Asset Information Management (CDE for AIM) solution and workflow should be established for managing information during operational stage of the assets. A CDE shall be a combination of workflow and information storage solutions, to support the information management process for the asset(s)[1].

(i) Performance Dashboard to monitor building assets' performance and operations

Having a single dashboard reduces the need to switch between screens from different systems. With the increasing amount of operational data collected from multiple systems and facilities, facility managers should combine and simplify the metrics on a single dashboard in order to gain insight on the building's performance and operations.

Assessment Criteria

IN1.2 Common Data Environment (CDE)	**New Buildings**	**Existing Buildings**
(i) Performance dashboard to monitor the different aspect of building assets' performance and operations from a single dashboard built on top of the CDE.	1 Point	2 Points

Points shall be awarded for the use of a single extensible dashboard that covers at least energy and water systems. Two types of performance dashboard that shall be developed where possible:

- Operational dashboard: sets of measures used to guide facility operations, usually in real time such as equipment status and work order status.
- Managerial dashboard: sets of metrics which may use data from multiple operational systems such as maintenance cost per sqm and energy use per occupant.

Documentation Requirements

At Design stage (New Buildings) / Pre-retrofit stage (Existing Buildings):

- Tender specifications stating the adoption of a CDE with the performance dashboard during the operational stage of the assets (if there is no such platform available).
- Illustrations of the building assets' operational and managerial dashboard of the existing implementation (if the CDE is already available).

At Verification stage (New Buildings & Existing Buildings):

- Screenshots and photos showing the performance dashboard of the implementation

Guidance Notes

The Common Energy Dashboard data requirements set the requirements for building energy efficiency aspect under CDE. The copy of CED data requirements can be found here.

Examples of operational and managerial dashboards are shown in .

[1] Following ISO 19650-3 Clause 5.1.9

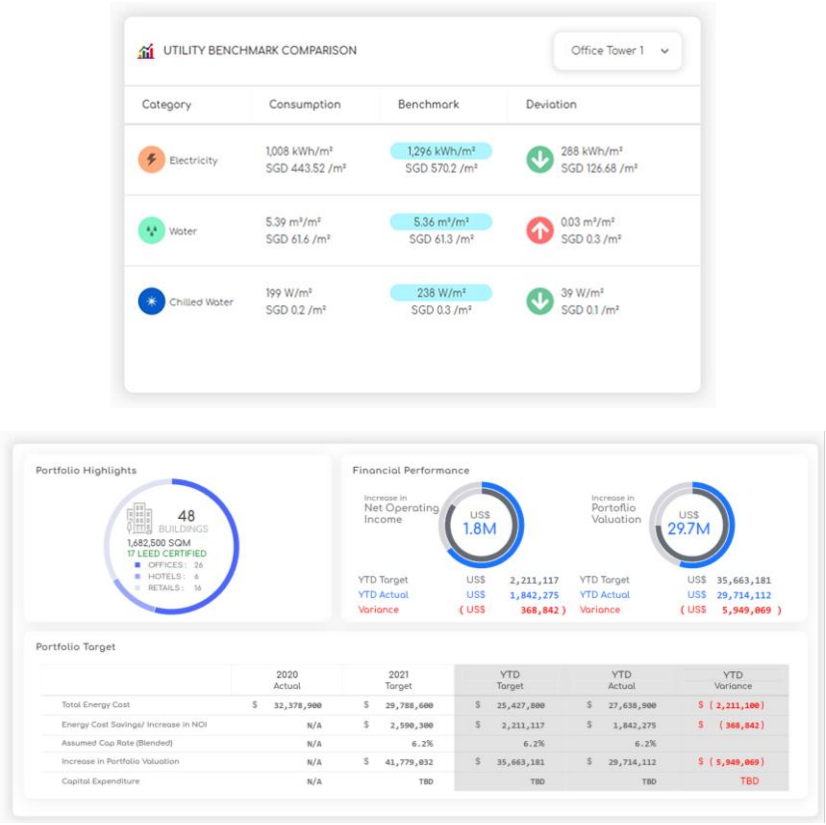

Figure 6: Operational & Managerial Dashboard (Image Courtesy of Eutech Cybernetics)

(ii) Data Management and Integration (Interoperability) with a platform based on an open protocol

A data management and integration platform enable building owner or facility managers to be better steward of their asset by providing a holistic and fact-based approach for decision making. Building owner/operator is encouraged to adopt platforms with open protocol connectivity such as BACnet, OPC, or REST API to all their system/sub-system providers to allow ease of data management and analytics during operational stage of the assets.

Assessment Criteria

IN1.2 Common Data Environment (CDE)		**New Buildings**	**Existing Buildings**
(ii)	Data Management and Integration with a platform that connects and manages asset and facility data, operational data, and real-time equipment data extracted from different sub-systems based on an open protocol (e.g. OPC, BACNET, MODBUS, DLMS, published REST/SOAP APIs and etc.)	1 Point	2 Points

Documentation Requirements

At Design stage (New Buildings) / Pre-retrofit stage (Existing Buildings):

- Tender specifications stating the connectivity of various facilities management (FM) systems/sub-systems and data to the CDE platform with open protocol.

At Verification stage (New Buildings & Existing Buildings):

- System write up on the various FM digital solutions which are integrated through the CDE with open protocol
- Screenshots and photos showing the implementation

Guidance Notes

For examples of different open protocol systems, please refer to .

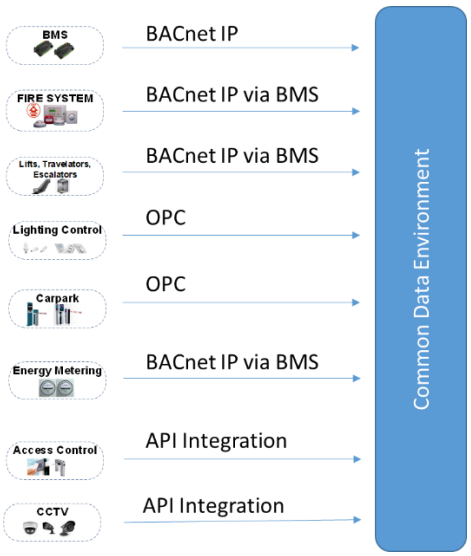

Figure 7: Examples for Integration of systems/sub-systems to a CDE platform

(iii) Data Accessibility and Security

Integration of asset information can enable an effective way of collaboration, but it also brings increased risk of security breaches with widening access to asset information. It is important to incorporate appropriate security and security minded principles in the service contracts and security requirements of the CDE for AIM. Refer to the Cybersecurity Certification Guide published by the Cyber Security Agency of Singapore (CSA) for more information.

Assessment Criteria

IN1.2 Common Data Environment (CDE)		**New Buildings**	**Existing Buildings**
(iii)	Data Accessibility and Security - information stored in the CDE platform can be accessed by facilities teams in a secured manner to facilitate operation and maintenance activities from anywhere and anytime.	0.5 Point	1 Point

Documentation Requirements

At Design stage (New Buildings) / Pre-retrofit stage (Existing Buildings):

- Tender specifications stating the requirement of cybersecurity considerations for the CDE for AIM platform

At Verification stage (New Buildings & Existing Buildings):

- Security certification/accreditation of the CDE for AIM solutions (e.g. Common Criteria)

IN1.3 Voluntary Disclosure of Building Energy Performance Data

Projects that share non-sensitive information and data related to building energy performance to the Super Low Energy Building (SLEB) Smart Hub [2] on a voluntary basis would enable dynamic energy performance benchmarking and Green Mark energy data reporting in a smart and automatic way. Providing building energy performance data terms with clear definitions and standardised formats in accordance to the Common Energy Dashboard (CED) data requirements can facilitate data interoperability with SLEB Smart Hub.

(i) Share basic information

Assessment Criteria

IN1.3 Voluntary Disclosure of Building Energy Performance Data	New Buildings	Existing Buildings
(i) Share basic information – follow Common Energy Dashboard (CED) data requirements to share basic information and data.	0.5 Point *For Non-Residential buildings only*	0.5 Point *For Non-Residential buildings only*

Documentation Requirements

At Design stage (New Buildings) / Pre-retrofit stage (Existing Buildings):

- The commitment letter with the data fields to be shared with SLEB Smart Hub

At Verification stage (New Buildings & Existing Buildings):

- Required data sets of basic information, visualised at SLEB Smart Hub. Data can be shared either by providing excel/csv files or sending data through APIs to the SLEB Smart Hub. For the monthly consumption data, the applicant shall share at least 12 consecutive months of data.

Guidance Notes

Building operators can refer to the provided user interface (UI) design template to visualise their building's energy performance consistent to Green Mark nomenclature, and thus save the cost in developing such energy information dashboard. More information on the Common Energy Dashboard data requirements and user interface design template can be found here.

This note also applies for IN1.3(ii).

[2] Super Low Energy Building (SLEB) Smart Hub (www.sleb.sg) is Singapore's first digital knowledge centre for green buildings in the region, feature-filled with smart analytic tools, datasets, a directory and also the largest green building database in Singapore.

(ii) Share additional information

Assessment Criteria

IN1.3 Voluntary Disclosure of Building Energy Performance Data	New Buildings	Existing Buildings
(ii) Share additional information – follow Common Energy Dashboard (CED) data requirements to share basic information and data.	1 Point *For Non-Residential buildings only*	1 Point *For Non-Residential buildings only*

Documentation Requirements

At Design stage (New Buildings) / Pre-retrofit stage (Existing Buildings):

- The commitment letter with the data fields to be shared with SLEB Smart Hub

At Verification stage (New Buildings & Existing Buildings):

- Required data sets of additional information, visualised at SLEB Smart Hub. Data can be shared either by providing excel/csv files or sending data through APIs to the SLEB Smart Hub. For the monthly consumption data, the applicant shall share at least 12 consecutive months of data.

Guidance Notes

Refer to note in IN 1.3 (i) for more information.

IN2 Data Driven

A maximum of 5 points can be scored across IN 2 Data Driven section.

IN2.1 Asset Information Model

The Asset Information Model (AIM) is defined as a federated information model which can include structured information (e.g. geometrical models, schedules and databases) and unstructured information (e.g. documentation, video clips and sound recordings)[3]. Projects are encouraged to use integrated platforms to develop an up-to-date operational AIM for purposes of asset tagging, co-ordination, maintenance, etc. The AIM is to be managed within a Common Data Environment (CDE) as the single source of asset information.

(i) Development and handover of an accurate spatial model of the building or asset

To encourage the generation of digital asset information of the built physical assets and digitally hand over as-built records, manufacturers' specifications & warranties, testing / commissioning reports, and O&M manuals

Assessment Criteria

IN2.1 Asset Information Model		**New Buildings**	**Existing Buildings**
(i)	Development and handover of an accurate spatial model of the building or asset which is complete, fully up-to-date and inclusive of renovations that would impact building services or layout alterations.	1 Point	1 Point

Documentation Requirements

<u>At Design stage (New Buildings) / Pre-retrofit stage (Existing Buildings):</u>

- Tender specifications for the AIM including digital handover requirements

<u>At Verification stage (New Buildings & Existing Buildings):</u>

- Photos / screenshots and documents showing the implementation of digital handover

(ii) Physical and virtual Asset Information tagging system

Assessment Criteria

IN2.1 Asset Information Model		**New Buildings**	**Existing Buildings**
(ii)	Physical and virtual asset information tagging system aligned with common data environment that allows for tracking of maintenance work, repairs, refurbishments or upgrades, replacement, decommissioning, risk assessments, and performance evaluations of the physical asset to be captured.	1 Point	2 Points

Assets are to be tagged with a barcode / QR code / RFID. Asset tagging shall at least cover the following systems:

- ACMV system – include Chiller plant, Air distribution (AHU/FCU), Mechanical Ventilation Fans (i.e. Toilet, Carpark and Kitchen exhaust fans) where applicable
- Electrical System main equipment - include Main HT/LT Switchboard, Sub-board and Distribution Board

[3] From ISO 19650-1 (Clause 4.1) and ISO 19650-3 (Clause 5.1.11)

Documentation Requirements

At Design stage (New Buildings) / Pre-retrofit stage (Existing Buildings):

- Tender specifications of the AIM capturing the asset tagging requirements

At Verification stage (New Buildings & Existing Buildings):

- Photos / BMS screenshots showing the implementation of asset information tagging

(iii) Adoption of a common international standard for asset ontology

Asset ontology is an extensible dictionary of terms and concepts in and around buildings, a set of relationships for linking and composing concepts together, and a flexible data model permitting seamless integration of asset ontology with existing tools and databases. Asset Ontology helps to standardise semantic descriptions of the physical, logical and virtual assets in buildings and the relationships between them.

Assessment Criteria

IN2.1 Asset Information Model		**New Buildings**	**Existing Buildings**
(iii)	Adoption of a common international standard for asset ontology. For example, Brick Schema or Project Haystack.	1 Point	1 Point

The asset ontology shall have the following modelling support:

- ACMV / Sensor systems
- Lighting systems
- Electrical systems
- Plumbing and Sanitary systems
- Fire protection system
- Vertical transportation system
- Security system
- Spatial Information
- Control & operational relationship
- Formal Definitions

Documentation Requirements

At Design stage (New Buildings) / Pre-retrofit stage (Existing Buildings):

- Tender specifications capturing the type of asset Ontology and implementation requirements in terms of completeness, usability, consistency and future extension.

At Verification stage (New Buildings & Existing Buildings):

- Schematic web structure showing the digital representation of a building that adheres to the Committed Asset Ontology.

Guidance Notes

Please refer to the *Bricks Schema for Common Energy Dashboard* for examples on building energy efficiency aspects of asset ontology or refer to .

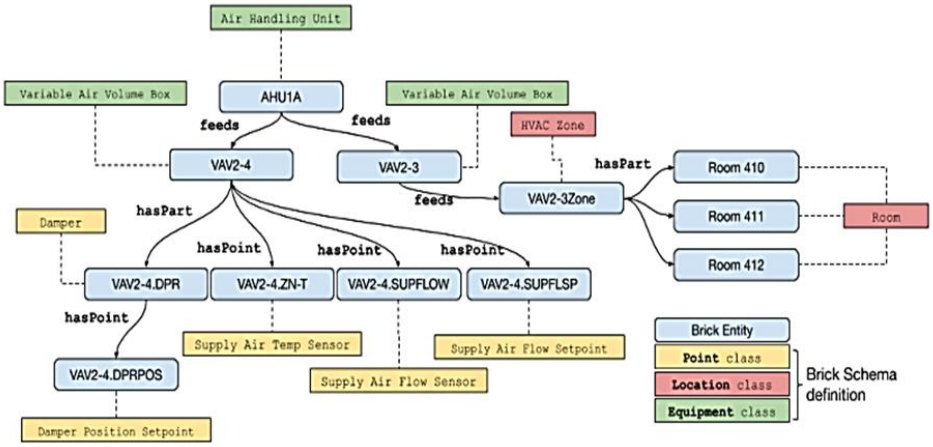

Figure 8: Asset ontology following Brick Schema

References

- ISO 19650-3:2020 Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) — Information management using building information modelling — Part 3: Operational phase of the assets

- PAS 1192-3 (withdrawn) – however provides a good guide on specifying how an Asset Information Model (AIM) should be created and how that model should be used and maintained through the life of the asset up to final disposal. It applies to direct capital works, existing assets and acquired assets and to both building and infrastructure assets.

- Asset information model AIM - Designing Buildings Wiki

IN2.2 Digital Twins

A digital twin is an integration between virtual representation of asset/system/process and real-world system. It is designed to monitor and optimise its functionality through feedback from both simulated and real-world systems. More information on Digital Twins can be found at Smart Cities Council – Data Leadership Guidance Note.

(i) Asset Digital Twin

The asset digital twin is a key tool that can assist the facility management team on daily operation and maintenance and on space planning.

Assessment Criteria

IN2.2 Digital Twins		New Buildings	Existing Buildings
(i)	Asset Digital Twin – the digital twin of the building assets assists the facility management team to deliver efficient daily operation and maintenance, and to better plan and organize alteration of internal spaces and functions.	2 Points	2 Points

Points shall be awarded for the development of an asset digital twin that can properly simulate the asset in its working context and store asset-related information such as product and individual system technical parameters, allowing for predictive maintenance, purchase and installation records and maintenance records. 0.5 points can be awarded per high impact asset, and 0.25 points can be awarded per low impact asset.

Documentation Requirements

At Design stage (New Buildings) / Pre-retrofit stage (Existing Buildings):

- Tender specifications capturing the asset digital twin requirements

At Verification stage (New Buildings & Existing Buildings):

- Photos / screenshots showing the asset digital twin implementation
- Activity logs from the digital platform

(ii) System Digital Twin

The system digital twin optimises system performance and efficiency to best serve the needs of building occupants. For example, a system digital twin of an electrical network can simulate the core behaviour of the system — energy generation, storage and consumption — together with human inputs to the system, as well as the capacity to deal with unexpected occurrences.

Assessment Criteria

IN2.2 Digital Twins		**New Buildings**	**Existing Buildings**
(ii)	System Digital Twin – detailed model based on operational data of individual systems to deep dive into its performance, conduct virtual stress tests and detailed analytics.	3 Points	3 Points

Points shall be awarded for the development of digital twins for individual systems i.e. 1.5 points can be awarded if a digital twin of air conditioning system is built up to facilitate optimization, 0.25 points can be awarded if digital twin is built up for lighting system or mechanical ventilation system. Points for other systems shall be awarded in accordance to its impact.

Documentation Requirements

At Design stage (New Buildings) / Pre-retrofit stage (Existing Buildings):

- Tender specifications capturing the system digital twin requirements

At Verification stage (New Buildings & Existing Buildings):

- Photos or screen shot showing the system digital twin implementation
- Activity logs from the digital platform

Guidance Notes

For an example of a digital twin of a building system, please refer to Figure 9.

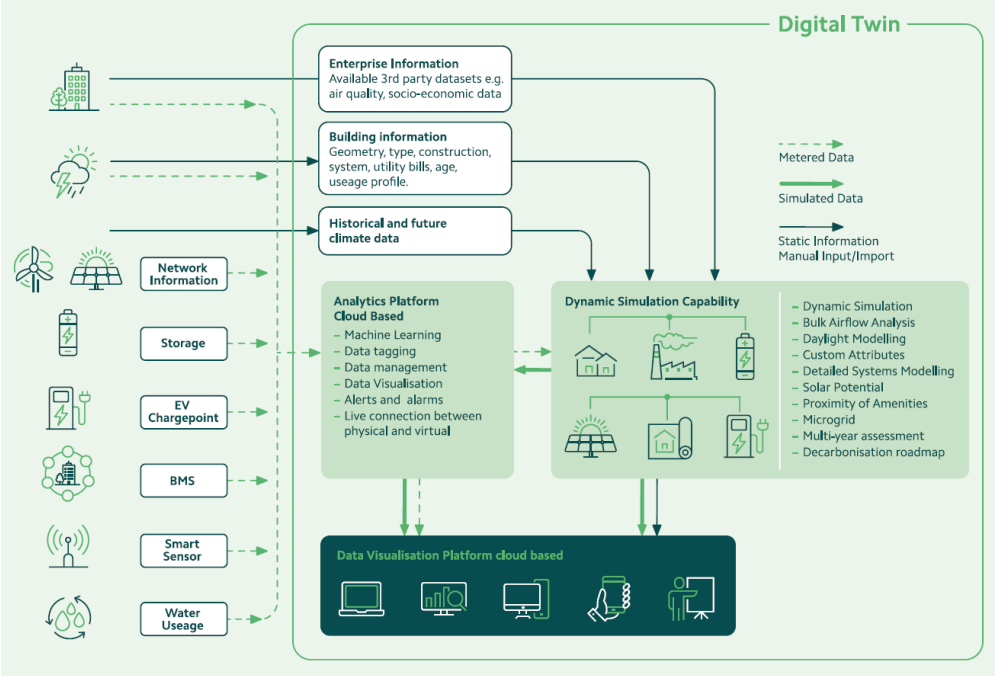

Figure 9: Digital Twin of building system (Image Courtesy of Integrated Environmental Solutions)

(iii) Process Digital Twin

The process digital twin facilitates optimisation of operations to best serve the needs of building occupants by modelling processes and scenarios to find the optimum solution using actual and simulated data. For example, when a fire alarm is triggered, the virtual model would be able to pinpoint the specific fire alarm that went off and show all equipment close to the incident site. The FM personnel can view the status of other fire alarms nearby, access room booking information to notify points-of-contact and review CCTV footage to verify the incident. Once verified that it is not a false alarm, the FM personnel is able to shut down the equipment at the incident site as required by the standard operating procedure.

Assessment Criteria

IN2.2 Digital Twins		**New Buildings**	**Existing Buildings**
(iii)	Process Digital Twin – To model processes and scenarios to find the optimum solution based on actual and simulated data.	1 Point	1 Point

0.25 points will be awarded per digital twin built for each process type. Processes include building users' movements, production processes in factories and labs, maintenance processes, event processes (such as fire or emergency events)

Documentation Requirements

At Design stage (New Buildings) / Pre-retrofit stage (Existing Buildings):

- Tender specifications capturing the process digital twin requirements

At Verification stage (New Buildings & Existing Buildings):

- Photo or screen shot showing the process digital twin implementation
- Activity logs from the digital platform

Guidance Notes

For an example of a digital twin of a building process type, please refer to Figure 10.

Figure 10: Digital Twin of a process (Image Courtesy of Eutech Cybernetics)

IN3 Responsive

A maximum of 5 points can be scored across IN 3 Responsive section.

IN3.1 Real Time Performance

Projects are encouraged to utilise a network of sensors, data transmission infrastructure and building management (control) system to facilitate responsive building operations, to ensure the indoor built environment promotes the health and wellbeing of building occupants whilst operating the systems with high efficiency.

(i) Energy – Measurement, trend and analysis of energy consumption and efficiency of key systems to facilitate real time performance optimisation

Assessment Criteria

IN3.1 Real Time Performance		**New Buildings**	**Existing Buildings**
(i)	Energy - Breakdown of energy consumption by system, such as air conditioning, lighting, ventilation, transportation, receptacle loads, and efficiency metrics tracking and analytics for real time optimisation.	1 Point *For Non-Residential buildings only*	1 Point *For Non-Residential buildings only*

Points shall be awarded where the key systems, such as chiller plant, fresh air processing supply, air distribution system, lighting system, mechanical ventilation system, and plug/ process loads where applicable, can:

1) Measure and monitor the energy consumption of all key systems to allow building operators and owners to view the energy performance of building from building level to system level

2) Calculate and indicate the efficiency of each system with real time data and benchmarked with design value to facilitate optimization

3) Use of statistical data insights retrieved from multiple data sources (e.g. occupancy data, CO2 concentration data, etc) to optimise and reduce energy usage.

4) provide a control logic for auto optimisation of systems.

Where the system is not fully developed to cover all the systems, 0.5 point can be scored for covering the air conditioning system, 0.25 point for covering lighting or mechanical ventilation systems.

Measurement devices like sensors for subsystems with remote capability shall be provided and linked to the monitoring system (BMS). Real time performance optimization shall fully utilize the available sensors and performance indicators to ensure the system is performing at its utmost energy efficiency.

Documentation Requirements

At Design stage (New Buildings) / Pre-retrofit stage (Existing Buildings):

- Monitoring and control (optimisation) method statement – what the system does and how
- Sub-system equipment specification
- Power meter and current transducer specification
- The remote capability and link to a BMS/EMS system
- Single line diagram showing the location of the power meters and sensors
- Design of the main switchboards and power distribution boxes
- Location of system performance related sensors and specification
- Control logic description and parameters.

At Verification stage (New Buildings & Existing Buildings):

- System description, including the monitoring and optimisation capabilities and logic.
- BMS or supervisory control and data acquisition display of meter readings and trends
- Commissioning report of the sub-metering system
- Screenshot or real time display on energy consumption breakdown and efficiency tracking of key systems

(ii) Health & Comfort – Provision of permanent calibrated quality monitoring system with zonal controls

Indoor environment parameters shall be measured in real time and used for zonal control of the AC and ventilation system to facilitate a healthy indoor environment for building users and occupiers.

Assessment Criteria

IN3.1 Real Time Performance		**New Buildings**	**Existing Buildings**
(ii)	Health & Comfort – Provision of permanent calibrated air quality monitoring system with zonal controls	1 Point *For Non-Residential buildings only*	1 Point *For Non-Residential buildings only*

Points shall be awarded when the air-conditioning / mechanical ventilation system can be controlled with real time measurement of the indoor environment parameters, including temperature, relative humidity, CO2, formaldehyde (or TVOC), and PM2.5 for all the major occupied spaces. For projects where the system doesn't cover all the major occupied spaces, points awarded shall be prorated basing on percentage area of coverage.

Documentation Requirements

At Design stage (New Buildings) / Pre-retrofit stage (Existing Buildings):

- Method statement covering parameters monitored, data trending, action thresholds and system actions
- Sensor specification and design location
- Specification on the control logic and response
- Requirement on calibration frequency (recommended annual calibration, depending on sensor type)

At Verification stage (New Buildings & Existing Buildings):

- BMS or supervisory control and data acquisition display of meter readings
- Calibration report of the environmental sensors
- Screenshot or real time display on indoor environmental parameters, and system actions.

(iii) Space – Monitoring of space utilisation for optimisation of building systems

As occupancy and space utilisation changes within the premise, the building and its systems shall adjust their operations to meet current demand while continuing to perform at high efficiency levels. This is to avoid wastage in manner of overproviding for non-occupied spaces or spaces with low utility rate.

Assessment Criteria

IN3.1 Real Time Performance		**New Buildings**	**Existing Buildings**
(iii)	Space – Monitoring of space utilisation for optimisation of building systems that cater for the changes in occupancy and space usage	1 Point *For Non-Residential buildings only*	1 Point *For Non-Residential buildings only*

Points shall be awarded where all the major energy consuming systems are controlled with occupancy data gathered at building level or tenant level or space level. This includes controls for lift/elevator group, zonal thermostat set points, zonal lighting system, provisions for mechanical ventilation in carparks, directional signage, room booking availability and partial building or infrastructure (e.g. carpark) shutdown, etc. The coverage for individual systems shall be at least 80% to be accorded points. For projects where the system does not cover all the major occupied spaces, points awarded shall be prorated basing on percentage area of coverage.

Occupancy sensors should be deployed at spaces which are not usually occupied. Zonal occupancy monitoring system should also be installed at each floor and at every tenanted space.

Documentation Requirements

At Design stage (New Buildings) / Pre-retrofit stage (Existing Buildings):

- Method statement for occupancy and space monitoring, and its integration into systems for spatial optimisation, including
    - System controls (environmental system, movement systems, room booking and allocation systems, car park systems
    - Data analysis and logging
    - Identification of under utilised space, allowing for investigations
- Sensor specification and calibration frequency

At Verification stage (New Buildings & Existing Buildings):

- Screenshots of spatial optimisation system, control logic and data analytics reports
- Calibration report of the environmental sensors

IN3.2 User Experience

The collection of feedback from building occupants and visitors on user experience in a digital format can help building operators to easily collate and analyse the feedback to gather insights on the expectation of the desired indoor environment. Building operators can adjust the building systems to better serve the need of their occupants and visitors.

Assessment Criteria

IN3.2 User Experience	**New Buildings**	**Existing Buildings**
Proactive collection and use of data to understand, track and manage the user experience within the building to improve performance including: • Use patterns. • Comfort (thermal, visual, aural and olfactory, including locational information) • Service requests and time for resolutions For the following groups: (i) Building Occupants (ii) Visitors	 1 Point 0.5 Point	 1 Point 0.5 Point

Points shall be awarded in the utilisation of a digital user feedback platform capable in gathering the feedback from building occupants and visitors to facilitate responsive operation of building and its system and better operate according to user expectations. The collected data shall be able to record service requests and times for resolutions, to gather feedback on preferred thermal visual aural and olfactory, and spatial comfort and derive insight on use expectations. With the digitalized data, the user experience shall be continuously enhanced via adjustments of operations.

Documentation Requirements

<u>At Design stage (New Buildings) / Pre-retrofit stage (Existing Buildings):</u>

- Design proposal and requirements on feedback collection platform
- Design requirement on capability of system to be adjustable and operational guide on system adaption

<u>At Verification stage (New Buildings & Existing Buildings):</u>

- Screenshots of the digital feedback collection platform
- Protocol to gather, analyse the collected feedback, and adjust the systems

IN3.3 Data Ethics

To ensure data related practices including but not limited to collecting, generating, analysing and utilising the data are under established protocols to avoid potential adverse impact on people and society. The data ethics plan lays out the set of key principles and processes that guide the ethical collection, processing, analysis, and application of data.

Assessment Criteria

IN3.3 Data Ethics	New Buildings	Existing Buildings
A data ethics plan shall be detailed for the building that identifies the various opportunities for the collection, analysis and use of data as well as a risk register that looks at the following risks and how they will be managed and mitigated. a) Personal Privacy b) Risks including data governance, monetarisation of data and data permissions c) Workforce transitioning d) Transparency e) Data bias and data quality	2 points (1 point for addressing items a and b, and 1 point for items c, d and e)	2 points (1 point for addressing items a and b, and 1 point for items c, d and e)

The project team shall consider the risks that technologies deployed in the building present to the environment, society, and governance. This includes the understanding of data bias, privacy protection and the right to be forgotten.

Documentation Requirements

At Design stage (New Buildings) / Pre-retrofit stage (Existing Buildings):

- Data ethics plan covering protocol on collecting, processing, analysing and applying the data.

At Verification stage (New Buildings & Existing Buildings):

- Data ethics plan and documentation on cases how data was collected and processed with the protocol set up.

References

- Crossing the Threshold, A primer for sustainable digitalisation in real estate and cities
- Global trends in Data Capture and Management in Real Estate and Construction (RICS)
- The use and value of commercial property data
- Artificial Intelligence: What it means for the built environment

Intelligence - Innovation

A maximum of 3 points can be scored across the Innovation and Smart Products section. Points scored in this section can add to the overall score for the Intelligence Section, capped at 15 points in total.

Assessment Criteria

Intelligence - Innovation	New Buildings	Existing Buildings
Projects can demonstrate substantial performance to a specific Intelligence indicator or outcome, where innovation points can be awarded on a case by case basis. Points shall be awarded based on the strength of evidence of benefits and potential impact.	2 Points	2 points

Points are awarded on a case by case basis, according to the potential impact and coverage shall be at least 50%. For high impact items, 0.5 point is awarded. For low impact items, 0.25 point is awarded. For example, for energy storage systems equipped with smart coordination to work with intermittent generation sources (e.g. Photovoltaics), up to 1 point shall be awarded.

Documentation Requirements

At Design stage (New Buildings) / Pre-retrofit stage (Existing Buildings):

The project team is to submit a concise summary that articulates:

- The nature of the environmental benefit of their intervention
- Justify the impact of the intervention through detailed calculations and comparisons with industry norms
- Substantiate the calculations and comparisons with evidence and data

At Verification stage (New Buildings & Existing Buildings):

- Details of the implemented intervention including measurements and monitoring of the environmental performance and lessons learnt if the intervention does not perform as expected

Guidance Notes

Projects can innovate to go above and beyond to attain exceptional Intelligence outcomes as intended in one or more criterion or demonstrate unique solutions to enhance other aspects of Intelligence not specified in the criteria. Innovations will be considered on a case by case basis.

Some examples, include, but not limited to:

- Use of Singapore Green Building Council certified smart building products or product with equivalent certification that allows integration with the Common Data Environment (CDE). Where 0.25 point shall be awarded for each smart product used that is certified by Singapore Green Building Council or other equivalent certification entities. The coverage rate shall be at least 50% of the applicable areas.

Acknowledgements:

Mr. Zhang Xiangjing GMAP	Building and Construction Authority
Mr. Jusuf Anggono	Building and Construction Authority
Dr. Jin Guang Yu GMAP	Building and Construction Authority
Mr. Tan Kee Wee	Building and Construction Authority
Ar Benjamin Towell GMAAP	Building and Construction Authority