Dataset: Green Mark certified buildings metadata from Singapore

Yi Ting, Teo, Matias Quintana, Muhammad Zikry Bin Sabarudin, Charlene Tan, Adrian Chong, Clayton Miller

Department of the Built Environment, College of Design and Engineering

Context

Massive Energy Consumption

Retrofitting current building stock

Technical Guide with examples

No one-size-fits-all solution

Methodology – Web Extraction

Award: Platinum Zero Energy
Certification Year: 2018
GFA: 8525.63
Address: 4 Architecture Drive, Singapore 117356
Postal Code: 117356
District: 5

National University of Singapore, School of Design & Environment, SDE 4

Project Description:

There are three noteworthy aspects of the NZEB_SDE. First, it presents a contemporary view of tropicality, taking climate-responsive design to the next level. Second, in striving for a zero energy target, NZEB_SDE offers an innovative solution to the question of thermal comfort. Finally, the project reframes how things are put together at the drawing board, applying the integrated design process.

Prominent Green Features:

- Estimated energy savings: 292,900kWh/yr;
- Estimated water savings: 6,607m3; ETTV: 39.6W/m2
- First Institute of Higher Learning net-zero energy building in Singapore
- Hybrid ventilation system to provide pre-conditioned air with elevated air speed
- Highly efficient chiller plant system with efficiency of 0.57kW/RT
- With daylight utilisation maximised through architectural

Developer
National University of Singapore

ESD/ESCO/Green Consultant
Surbana Jurong Consultants Pte Ltd/-/-

Architect
Surbana Jurong Consultants Pte Ltd

Structural Engineer
Surbana Jurong Consultants Pte Ltd

M & E Engineer
Surbana Jurong Consultants Pte Ltd

Landscape Consultant
Surbana Jurong Consultants Pte Ltd

Quality Surveyor
Surbana Jurong Consultants Pte Ltd

Main Contractor
Kajima Overseas Asia Pte Ltd

No	Column Name	Info
1	bca_id	BCA ID given from the website. IDs from the old website are numbers while IDs from the new website is an alphanumeric string.
2	building	Name of the building/project.
3	award	Green Mark award rating given to the building.
4	fy	Year the Green Mark award was given.
5	gfa	Gross floor area (GFA) of the building.
6	address	Address of the building.
7	postal_code	Postal code of the building.
8	district	District code where the building is located.
9	developer	Developer for the building.
10	architect	Architect for the building.
11	structural_eng	Structural engineer for the building.
12	me_eng	Mechanical & electrical engineer for the building.
13	land_cons	Land consultant for the building.
14	qs	Quantity surveyor for the building.
15	main_contractor	Main contractor for the building.
16	fac_mgt	Facilities manager for the building.
17	esd_cons	Environmental sustainability design (ESD) consultant for the building.
18	esco_cons	Energy Services Company (ESCO) for the building.
19	green_cons	Green consultant for the building.
20	description	Description of the building.
21	acoustic_cons	Acoustic consultant for the building.
22	facade_cons	Facade consultant for the building.
23	light_cons	Light consultant for the building.
24	green_features	Green features found in the building.

Methodology – Web Extraction

Award: Platinum Zero Energy
Certification Year: 2018
GFA: 8525.63
Address: 4 Architecture Drive, Singapore 117356
Postal Code: 117356
District: 5

National University of Singapore, School of Design & Environment, SDE 4

Project Description:

There are three noteworthy aspects of the NZEB_SDE. First, it presents a contemporary view of tropicality, taking climate-responsive design to the next level. Second, in striving for a zero energy target, NZEB_SDE offers an innovative solution to the question of thermal comfort. Finally, the project reframes how things are put together at the drawing board, applying the integrated design process.

Prominent Green Features:

- Estimated energy savings: 292,900kWh/yr;
- Estimated water savings: 6,607m3; ETTV: 39.6W/m2
- First Institute of Higher Learning net-zero energy building in Singapore
- Hybrid ventilation system to provide pre-conditioned air with elevated air speed
- Highly efficient chiller plant system with efficiency of 0.57kW/RT
- With daylight utilisation maximised through architectural

Developer
National University of Singapore

ESD/ESCO/Green Consultant
Surbana Jurong Consultants Pte Ltd/-/-

Architect
Surbana Jurong Consultants Pte Ltd

Structural Engineer
Surbana Jurong Consultants Pte Ltd

M & E Engineer
Surbana Jurong Consultants Pte Ltd

Landscape Consultant
Surbana Jurong Consultants Pte Ltd

Quality Surveyor
Surbana Jurong Consultants Pte Ltd

Main Contractor
Kajima Overseas Asia Pte Ltd

Award: Gold^{PLUS}
Certification Year: 2016
GFA: 46954.48
Address: 15 to 25 Punggol Field Walk, Singapore 828746 to 828751
Postal Code: 828746
District: 19

Waterwoods

Project Description:

Waterwoods' is a new residential development consisting of 6 blocks of 18-storey executive condominium housing with a total of 373 residential units with 1 basement carpark floor swimming pool landscape deck and communal facilities. The development is located at the junction of Punggol East / Punggol Field Walk

Prominent Green Features:

1. Use of energy efficient inverter air-conditioning system for individual residential units helps to substantially reduce the amount of energy used and increases cost savings for consumers2. Substantial minimization of energy consumption from use of energy efficient lightings in common areas such as the e-deck & landscape areas3. Extensive use of natural landscaping throughout the site encourages greenery usage to reduce heat island effect4. Extensive use of sustainable/ recycled products within the development helps to promote sustainability and stay environmentally friendly5. Use of water efficient fittings for common areas and residential units ensures minimal wastage of water and higher cost savings

Developer
Coral Edge Development Pte Ltd

Facility Management
Goh Soon Lai

Architect
Design Link Architects Pte Ltd

Structural Engineer
P&T Consultants Pte Ltd

M & E Engineer
Bescon Consulting Engineers Pte Ltd

Landscape Consultant
Design Link Architects Pte Ltd

Quantity Surveyor
Langdon & Seah Singapore Pte Ltd

Main Contractor
Greatearth Corporation Pte Ltd

Methodology – Extraction of Keywords

BCA GREEN MARK

GM ENRB: 2017

BCA GREEN MARK FOR EXISTING NON-RESIDENTIAL BUILDINGS

Technical Guide and Requirements

GM ENRB Technical Guide and Requirements

Contents

Criterion	Description of criterion	Points
5.1	Accredited Green Facility Management Companies	1
5.2	ETTV < 40W/m²	1
5.3	Demonstration of Better Air-side Efficiency	2
5.4	Renewable Energy	
	a) Replacement of electricity by on-site renewable energy	6
	b) Purchase of renewable energy from licenced electricity retailers	1
	c) Roof leasing for photovoltaic installation	1.5
5.5	Thermal Comfort with Elevated Air Speed	2
5.6	IAQ Surveillance Audit	2
5.7	Outdoor Airflow Monitoring System	
	a) All precool units (e.g. PAHUs)	1
	b) All AHUs	1
5.8	SGBC or equivalent Certified Air Filters	1
5.9	Indoor Air Quality Trending and Monitoring	
	a) Temperature and relative humidity	1
	b) At least one common indoor air pollutant such as formaldehyde, Total Volatile Organic Compounds (TVOC) or particulate matters	3
5.10	Local Exhaust and Air Purging System	
	a) Local isolation and exhaust systems to remove the pollutants at source such as photocopier room with exhaust system	0.5
	b) Air purging system to replace contaminated indoor air with outdoor fresh air	0.5
5.11	Permanent Measurement and Verification (M&V) for Variable Refrigerant Flow (VRF) Systems	
	a) Power meters installed for VRF system at least for all Condensing Units	1
	b) Provision of permanent measuring instruments for monitoring of energy efficiency performance of VRF condensing units	2

Filtering

Did not consider
- Pre-requisite Requirements
- Section 5.1 to 5.12

Methodology – Extraction of Keywords

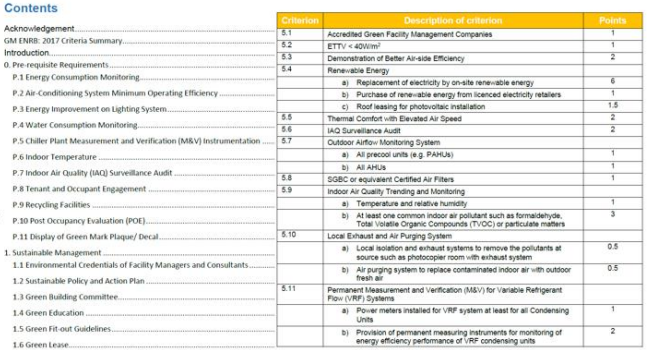
BCA GREEN MARK

GM ENRB: 2017

BCA GREEN MARK FOR EXISTING NON-RESIDENTIAL BUILDINGS

Technical Guide and Requirements

GM ENRB Technical Guide and Requirements



Contents

Criterion	Description of criterion	Points
5.1	Accredited Green Facility Management Companies	1
5.2	ETTV < 40W/m²	1
5.3	Demonstration of Better Air-side Efficiency	2
5.4	Renewable Energy	
	a) Replacement of electricity by on-site renewable energy	6
	b) Purchase of renewable energy from licenced electricity retailers	1
	c) Roof leasing for photovoltaic installation	1.5
5.5	Thermal Comfort with Elevated Air Speed	2
5.6	IAQ Surveillance Audit	2
5.7	Outdoor Airflow Monitoring System	
	a) All precool units (e.g. PAHUs)	1
	b) All AHUs	1
5.8	SGBC or equivalent Certified Air Filters	1
5.9	Indoor Air Quality Trending and Monitoring	
	a) Temperature and relative humidity	1
	b) At least one common indoor air pollutant such as formaldehyde, Total Volatile Organic Compounds (TVOC) or particulate matters	3
5.10	Local Exhaust and Air Purging System	
	a) Local isolation and exhaust systems to remove the pollutants at source such as photocopier room with exhaust system	0.5
	b) Air purging system to replace contaminated indoor air with outdoor fresh air	0.5
5.11	Permanent Measurement and Verification (M&V) for Variable Refrigerant Flow (VRF) Systems	
	a) Power meters installed for VRF system at least for all Condensing Units	1
	b) Provision of permanent measuring instruments for monitoring of energy efficiency performance of VRF condensing units	2

Filtering

Did not consider
- Pre-requisite Requirements
- Section 5.1 to 5.12

Assign keywords to each section

Excluded
- Generic words

Included
- Singular versions
- Addition and removal of hyphens (-)
- Acronyms
- Spacing

	GM Category			
1. Sustainable Management	2. Building Energy Performance	3. Resource Stewardship	4. Smart & Healthy Building	5. Advanced Green Effort
Certified Green Mark AP (FM)/GMFM	ETTV	WELs	occupant comfort	Green Mark Pearl
Certified Green Mark AAP (FM)/ (GMFP)	Envelope Thermal Transfer Value	Water Efficiency Labelling Scheme	Thermal Comfort	Green Mark Occupant-Centric
Singapore Certified Energy Manager (SCEM)	interior lighting	Water Efficient	Temperature Control	Green Mark Occupant Centric
Green Mark AP (FM)	watercooled	Landscape Irrigation	Post Occupancy Evaluation	Hot Water System
Green Mark AAP (FM)	water cooled	Cooling Towers	IAQ	PBT
Green Fit-out	air-cooled	Water monitoring	demand control	Persistent Bio-Cumulative and Toxic
Energy Management Policy	air cooled	Basin	CO2 sensor	Smart Facilities Management
Energy Improvement Plan	Fan Coil Units	WC	carbon dioxide sensor	SFM

List of Keywords

Methodology – Keyword Labelling

GM Category				
1. Sustainable Management	2. Building Energy Performance	3. Resource Stewardship	4. Smart & Healthy Building	5. Advanced Green Effort
Certified Green Mark AP (FM)/GMFM	ETTV	WELs	occupant comfort	Green Mark Pearl
Certified Green Mark AAP (FM)/ (GMFP)	Envelope Thermal Transfer Value	Water Efficiency Labelling Scheme	Thermal Comfort	Green Mark Occupant-Centric
Singapore Certified Energy Manager (SCEM)	interior lighting	Water Efficient	Temperature Control	Green Mark Occupant Centric
Green Mark AP (FM)	watercooled	Landscape Irrigation	Post Occupancy Evaluation	Hot Water System
Green Mark AAP (FM)	water cooled	Cooling Towers	IAQ	PBT
Green Fit-out	air-cooled	Water monitoring	demand control	Persistent Bio-Cumulative and Toxic
Energy Management Policy	air cooled	Basin	CO2 sensor	Smart Facilities Management
Energy Improvement Plan	Fan Coil Units	WC	carbon dioxide sensor	SFM

List of Keywords

Inputted into Labelling Code

Methodology – Keyword Labelling

GM Category				
1. Sustainable Management	2. Building Energy Performance	3. Resource Stewardship	4. Smart & Healthy Building	5. Advanced Green Effort
Certified Green Mark AP (FM)/GMFM	ETTV	WELs	occupant comfort	Green Mark Pearl
Certified Green Mark AAP (FM)/ (GMFP)	Envelope Thermal Transfer Value	Water Efficiency Labelling Scheme	Thermal Comfort	Green Mark Occupant-Centric
Singapore Certified Energy Manager (SCEM)	interior lighting	Water Efficient	Temperature Control	Green Mark Occupant Centric
Green Mark AP (FM)	watercooled	Landscape Irrigation	Post Occupancy Evaluation	Hot Water System
Green Mark AAP (FM)	water cooled	Cooling Towers	IAQ	PBT
Green Fit-out	air-cooled	Water monitoring	demand control	Persistent Bio-Cumulative and Toxic
Energy Management Policy	air cooled	Basin	CO2 sensor	Smart Facilities Management
Energy Improvement Plan	Fan Coil Units	WC	carbon dioxide sensor	SFM

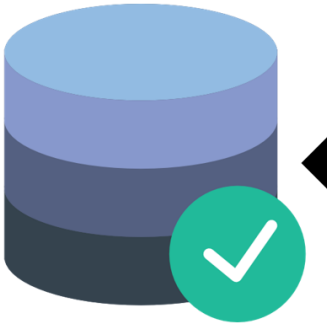
List of Keywords

Inputted into Labelling Code

Examining of keywords in Green Features

feature	category	subcategory
southwest and Northeast oriented	['building energy performance']	['north', 'south', 'northeast', 'southwest']
Energy efficient air conditioning, refrigerator, T5 and LED lighting	['smart & healthy building']	['led']
Use of energy efficient lightings, building system, and equipment.	['building energy performance']	['use of energy efficient']
Use of water efficient fixtures such as taps or water cisterns.	['resource stewardship']	['water efficient', 'cistern']
Provision of landscape greenery, including rooftop gardens and sky terraces where possible.	['sustainable management']	['green', 'landscape', 'rooftop garden', 'sky terrace', 'landscape', 'green']
Promotion of recycling to building users.	['resource stewardship']	['recycling', 'recycling']
Use of pneumatic waste collection system with inverter controller	['resource stewardship']	['waste']
Use of motion sensor lighting at all apartment unit private lift lobby, changing room and commons staircases leading down to basement carpark	['sustainable management', 'smart & healthy building']	['changing', 'motion sensor']
Provision of rooftop garden to clubhouse	['sustainable management']	['rooftop garden']
Collection of AC condensate water for irrigation use	['resource stewardship']	['irrigation']
Collection of rainwater for landscape irrigation use	['sustainable management', 'resource	['landscape', 'landscape', 'landscape irrigation', 'irrigation', 'rainwater']

Labelling of GM Sections to Green Features based on Keywords



Structured Data

Dataset

- 3,583 entries over 17 years
- 1,576 entries with green features and of non-residential nature (~44% of all entries)
- 29 fields including pre-processed fields (i.e. green feature category and simplified primary space type)

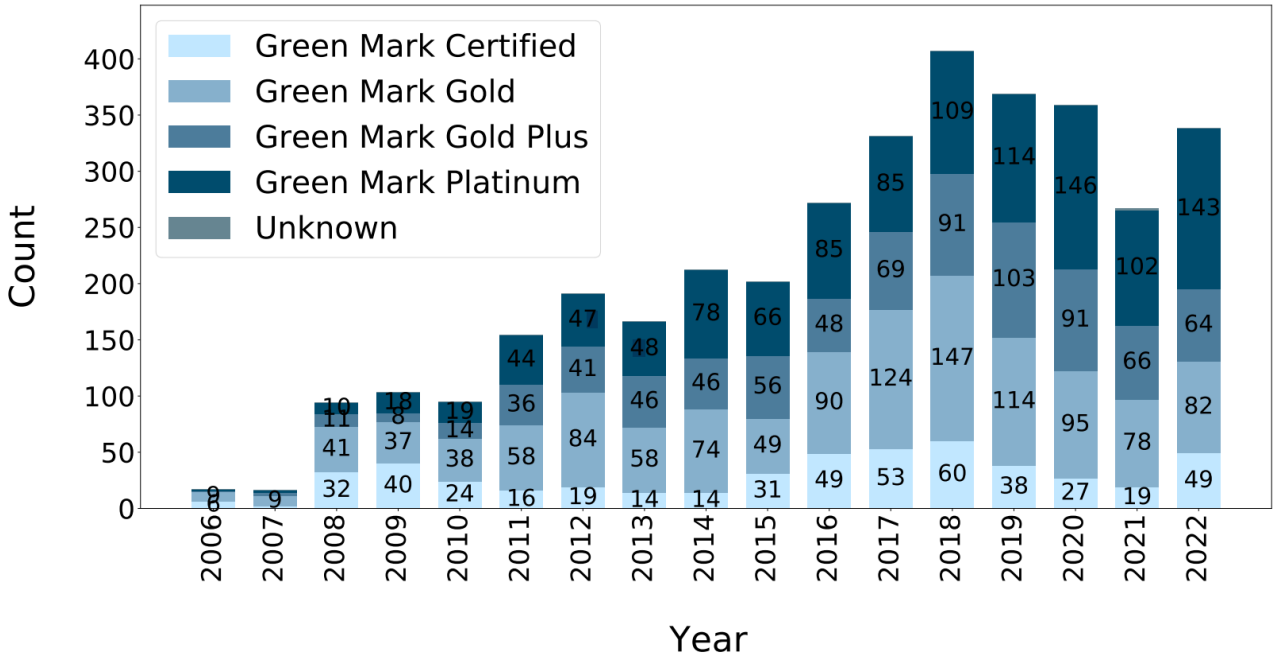


Figure 1: Distribution of GM certifications according to Rating over the years (Data recorded in financial years)

Dataset

- Detailed information about all 29 features can be found on GitHub and Zenodo

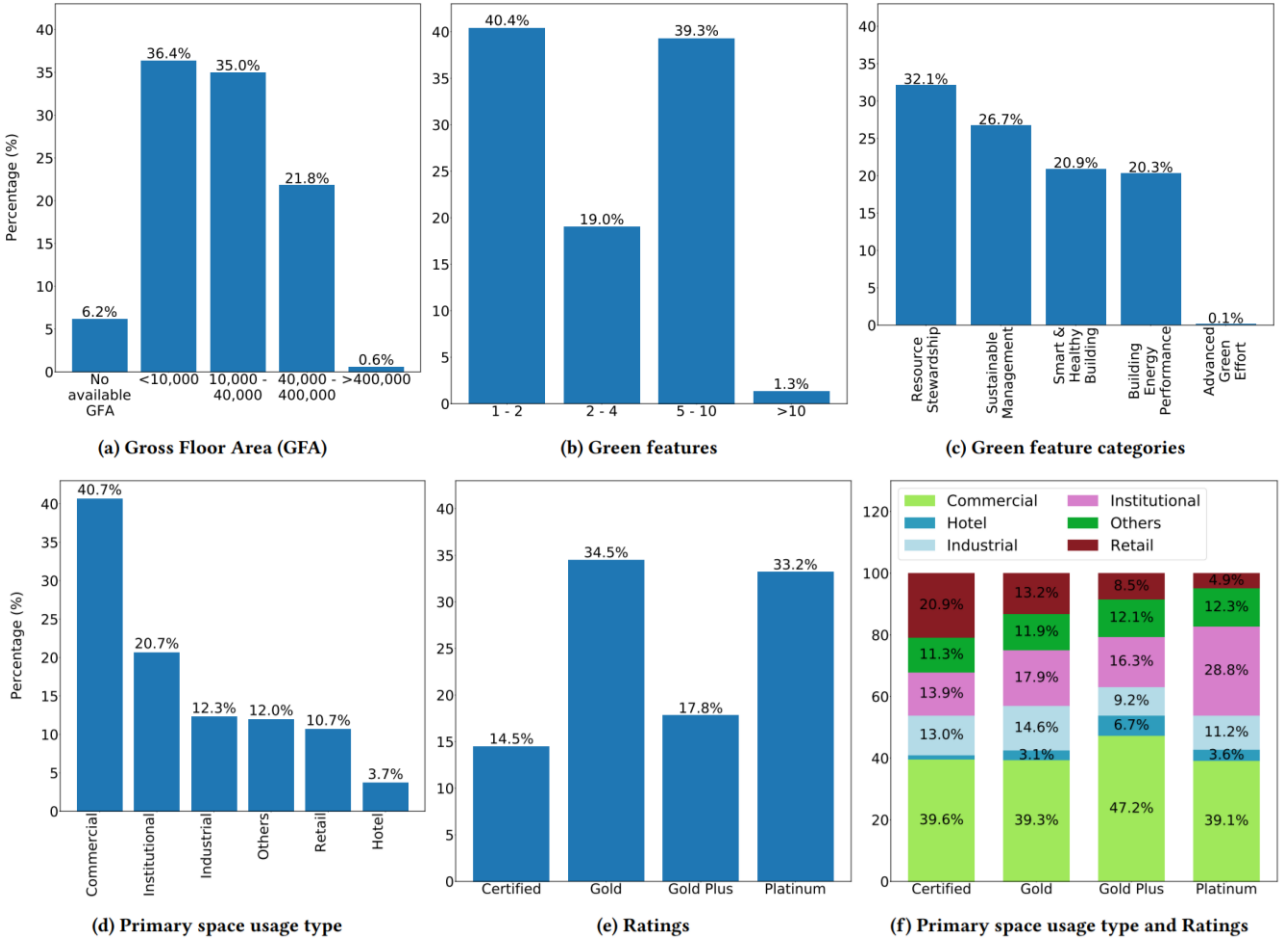


Figure 2: Overview of the main features in the dataset (Gross floor area, Green features, Green feature category, Primary space usage type, and Ratings)

Use Case Background

Overwhelming choices

Old Buildings > New Buildings

Operations Phase : 60-80% of overall lifecycle costs

Use Cases

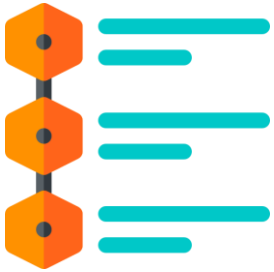
Costs

Energy Consumption

Building Information Modelling (BIM)

BCA GREEN MARK Dataset

Digital Twin

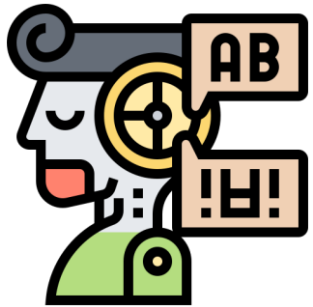


Breakdown of Point System

LEED Data

Use cases

- Data analysis could provide legislators with a better understanding to promote retrofitting strategies
- Legislations can be analysed for insights into the driving force
- Natural Language Processing (NLP) can be used
- Advanced data-driven methods > urban-level decision-making



THANK YOU

This research was funded by the Singapore Ministry of Education (MOE) through the Tier 1 grants: The Internet-of-Buildings (IoB) Platform – Visual Analytics for AI Technologies towards a Well and Green Built Environment (A-0008305-01-00).

t.yiting@nus.edu.sg

clayton@nus.edu.sg

https://budslab.org/

buds lab
building and urban data science

Scan for Github link