MEBS6020 Sustainable Building Design

http://ibse.hk/MEBS6020/



Practical Examples



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- Bullitt Center, Seattle, USA
- Pixel Building, Melbourne, Australia
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- One Taikoo Place, Hong Kong



Bullitt Center, Seattle, USA

- General information: https://bullittcenter.org/
 - Location: Seattle, Washington, USA
 - New Construction (public and academic buildings)
 - Size: 5,100 sq.m, 6 storeys
 - Market Sector: Private
 - Building Type: Office
 - Delivery Method: Integrated Project Delivery
 - Total Building Cost: \$30 million
 - Completion Date: April 2013

Bullitt Center – the greenest commercial building in the world



(Source: https://www.wbdg.org/additional-resources/case-studies/bullitt-center)

Bullitt Center, Seattle, USA



(Source: https://www.wbdg.org/additional-resources/case-studies/bullitt-center)



Bullitt Center, Seattle, USA

- Evaluation of green features
 - Structure: timber with low embodied carbon
 - High-performance envelope
 - Closed-loop geothermal system & ventilation
 - Radiant floor heating & cooling with passive cooling & natural ventilation
 - Daylight dimming & efficient lighting design
 - Aggressive reduction of plug loads
 - Net-zero water approach

BUILDING LIFE CYCLE

NET ZERO WATER

NET ZERO ENERGY

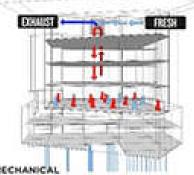
OCCUPANT



250 YEAR STRUCTURE HEAVY TIMBER, CONCRETE & STEEL



RAINWATER COLLECTION 100% DEMAND MET ON SITE 50,000 GALLON DISTERN



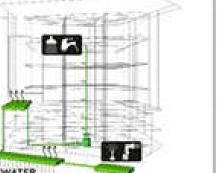
GROUND SOURCE HEAT EXCHANGE RADIANT HEATING/COOLING HEAT RECOVERY AIR SYSTEM



PROGRAM OCCUPANCY PRIVATE USERS ABOVE PUBLIC FOCUS USERS AT GRADE



SO YEAR SKIN HIGH PERFORMANCE ENVELOPE



GREYWATER
TOON TREATMENT ON SITE
EVAPOTRANSPIRATION & INFILTRATION



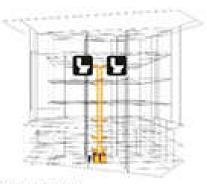
NATURAL VENTILATION NIGHT FLUSH & OPERABLE WINDOWS



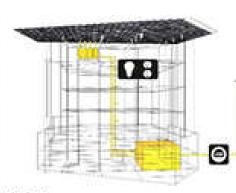
EACH TENANT HAS AN ENERGY BUDGET. UNUSED ENERGY CAN BE TRANSFERRED



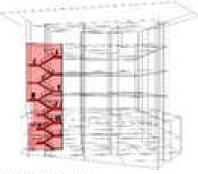
25 YEAR TECHNOLOGY ACTIVE SOLAR CONTROL PHOTOVOLTAICS



WASTE COMPOST NOW TREATMENT ON SITE



ENERGY 100% RENEWABLE ON SITE GRID USED AS BATTERY

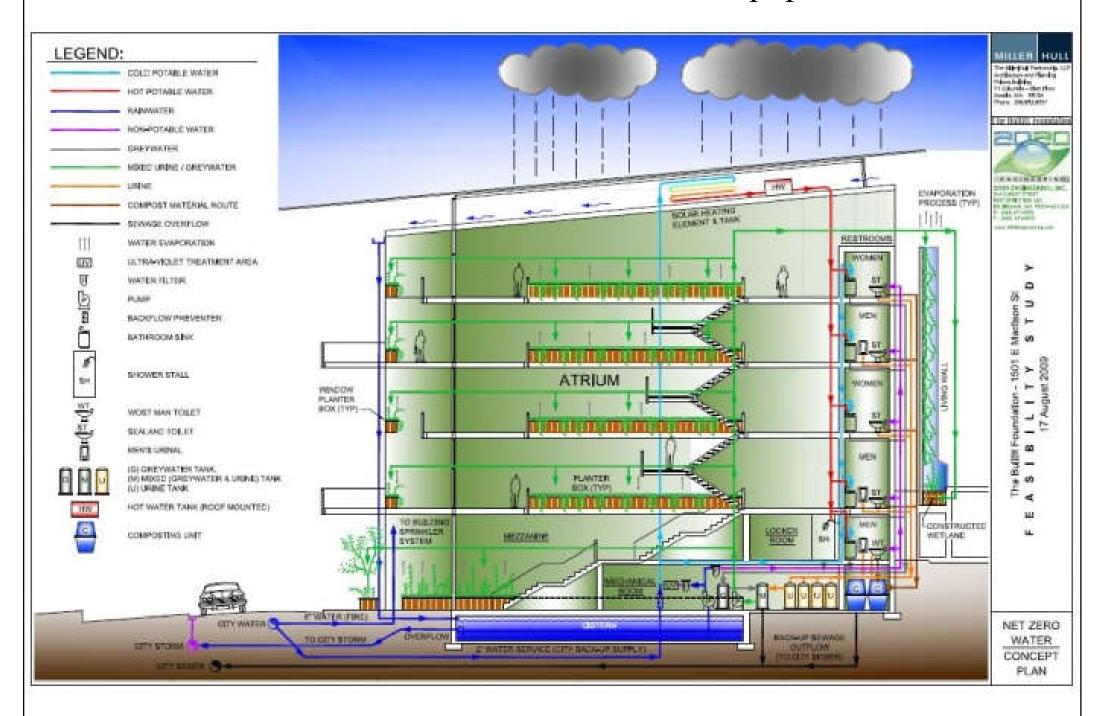


IRRESISTIBLE STAIR
ELEVATOR ALTERNATIVE, HEALTHER
OCCUPANTS, ENGAGEMENT WITH STREET



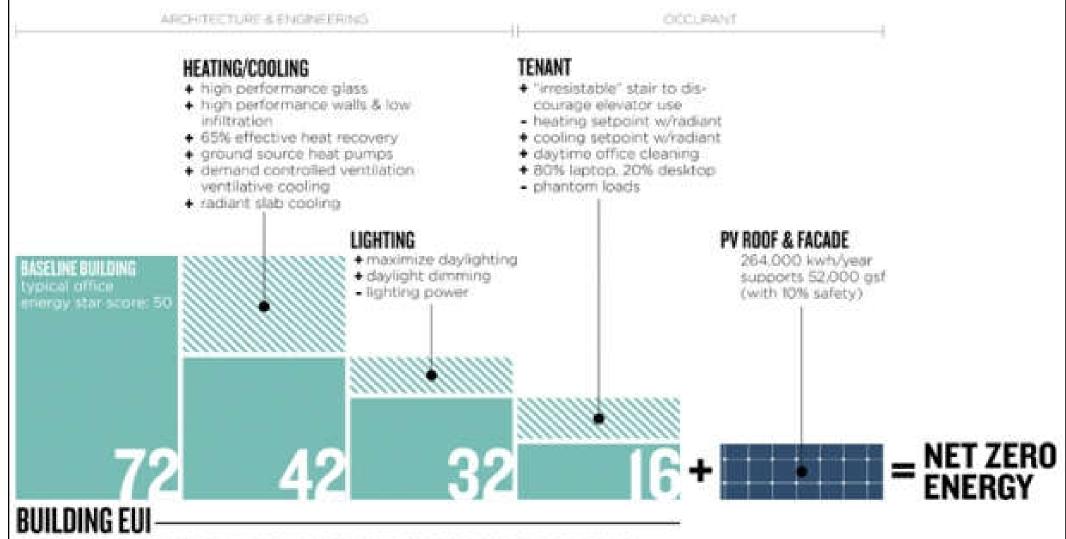
(Source: https://www.solaripedia.com/13/410/6338/bullitt center living building green features by time magazine.html)

Bullit Center: net zero water concept plan



(Source: https://www.solaripedia.com/13/410/6336/bullitt center living building feasibility diagram.html)

Bullit Center: the path to net zero energy



ENERGY USE INTENSITY: ENERGY CONSUMPTION PER FLOOR AREA

THE PATH TO NET ZERO ENERGY

(Source: https://www.solaripedia.com/13/410/6363/bullitt center living building energy use intensity.html)



Bullitt Center, Seattle, USA CENTER

- Further Reading:
 - Living Proof: The Bullitt Center https://bullittcenter.org/wp-content/uploads/2015/08/living-proof-bullitt-center-case-study.pdf
 - Bullitt Center (WBDG case studies) https://www.wbdg.org/additional-resources/case-studies/bullitt-center
 - Bullitt Center Thrives (Seattle, USA) Solaripedia
 http://www.solaripedia.com/13/410/Bullitt+Center+Thrives+%28Seattle

 e%2C+USA%29.html
 - Urban Land Institute (ULI) case study about the Bullitt Center http://uli.org/wp-content/uploads/ULI-Documents/TheBullittCenter.pdf
 - Bullitt Center: Seattle, Wash. HPB Magazine https://www.hpbmagazine.org/bullitt-center-seattle-wash/



Bullitt Center, Seattle, USA CENTER

- Videos:
 - Bullitt Center Tour Produced by the UW IDL (15:31)
 https://youtu.be/BkgRgo3Qaeo
 - Seattle's Bullitt Center: A Green Building Inspiring Visitors (2:35) https://youtu.be/u41E1HsrI-c
 - The Bullitt Center: A Living Building (6:15)
 https://youtu.be/6TvlwAgi-vQ
 - Climate Of Change Bullitt Center (5:19)
 https://youtu.be/2j9wJpiFYto
 - ULI Case Studies: Bullitt Center (6:15)
 https://youtu.be/svg59BlEpVA



BULLIT CENTER

Bullitt Center, Seattle, USA CENTER

- Lessons learned
 - Net-zero energy goal
 - Integrated high-performance based design
 - Safe & secure
 - Productive/healthy
 - Accessible
 - Aesthetic
 - Cost-effective
 - Functional



(Composting units)

Pixel Building, Melbourne, Australia



- General information: https://www.pixelbuilding.com.au/
 - Location: Melbourne, Australia (former Carlton Brewery site)
 - New Construction (commercial offices)
 - Gross floor area 1,136.4 sq.m, 4 storeys
 - Total Building Cost: AUD \$6 million
 - Completion Date: July 2010
 - Project objective: carbon neutral & water balanced

Pixel Building, Melbourne, Australia

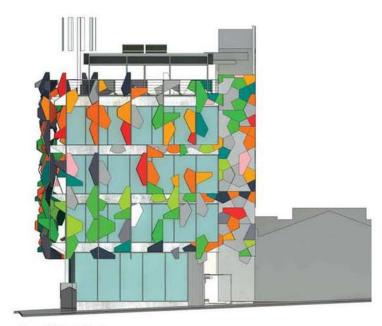


(Source: https://www.pixelbuilding.com.au/greenicon.html)

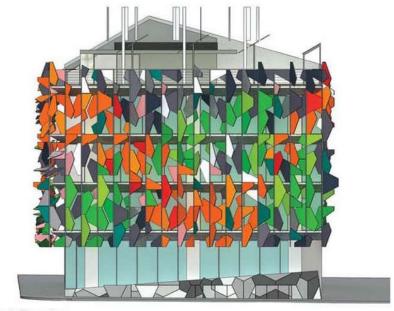
Pixel building – elevations and facades



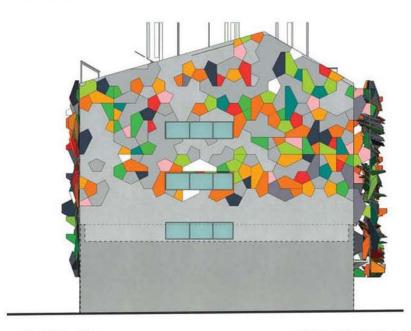




South Elevation



West Elevation



East Elevation

PIXEL

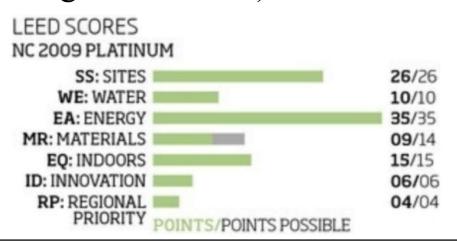
(Source: https://www.livinspaces.net/projects/architecture/pixel-office-building-australia-studio-505/)

Pixel innovations, green features and achievements

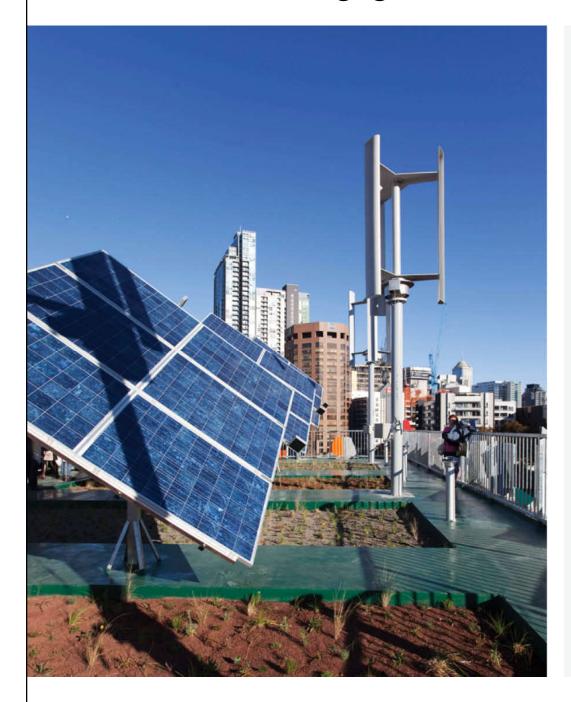
Carbon neutral
Water balanced
Green concrete
Gas fired absorption chillers
Ammonia refrigeration
Chilled structure
Green roof
Photovoltaic & wind power generation
Reed bed water treatment
Reliance on natural daylight
Green concrete
Gas fired absorption chillers
Extensive recycling
Free night cooling
Bio-gas energy
High performance façade

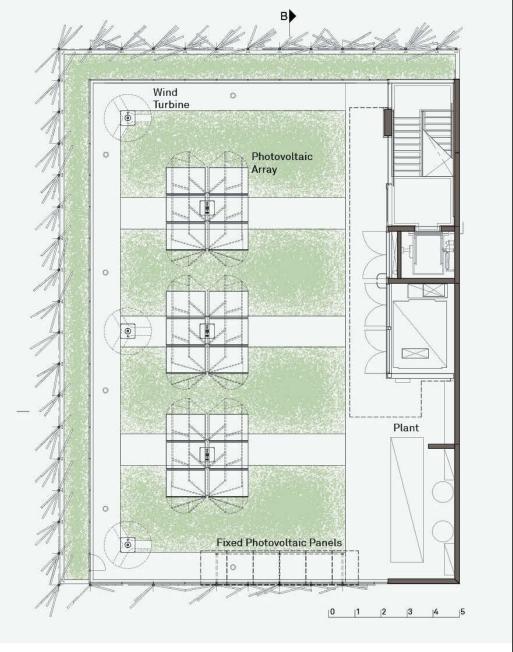
Green building assessment results:

- 6 star Green Star Australia (105 points, full perfect)
- LEED Platinum (105 points, highest rating in the world)
- BREEAM outstanding



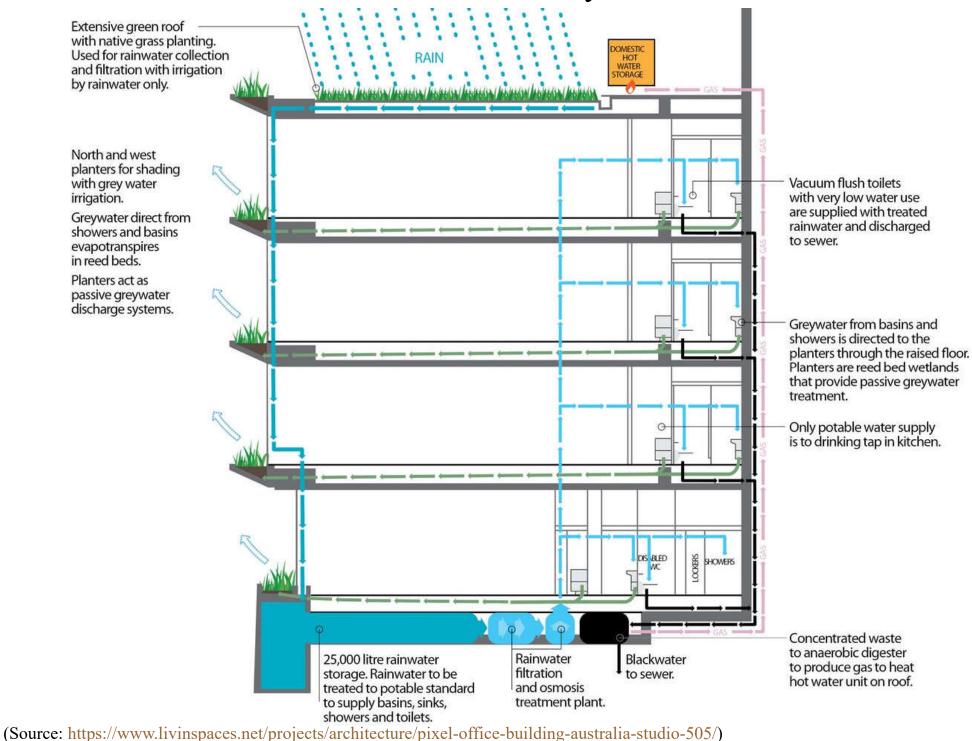
Pixel building: green roof and renewable energy systems

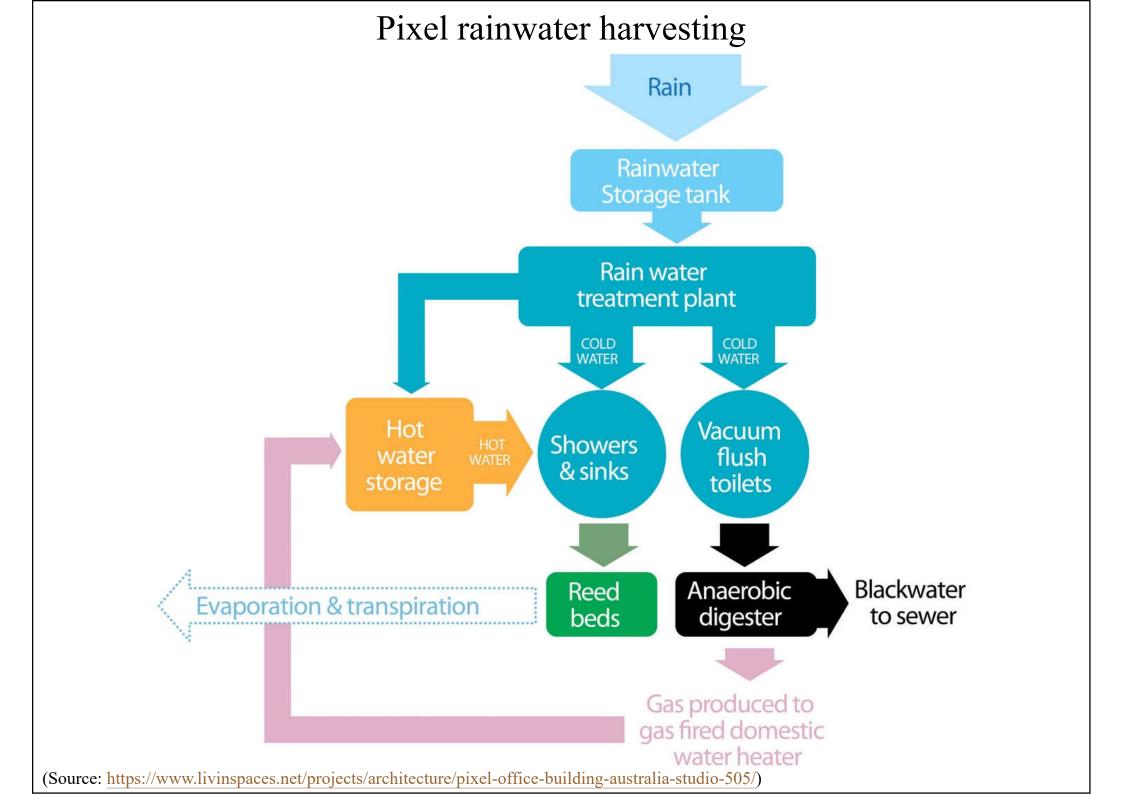




(Source: https://www.db-a.co/work/pixel-building/)

Pixel water cycle





Pixel Building, Melbourne, Australia



- Further Reading:
 - Small Building, Big Picture Pixel
 https://photos.state.gov/libraries/australia/39176/pdf/Pixel.pdf
 - Pixel Office Building in Melbourne by Studio 505
 https://www.livinspaces.net/projects/architecture/pixel-office-building-australia-studio-505/
 - Carbon neutral offices The Pixel Building Case Study https://www.sustainability.vic.gov.au/~/media/resources/documents/ser-vices%20and%20advice/business/srsb%20eeob/srsb%20eeob%20case%20study%20pixel.pdf
 - Videos:
 - Grocon Pixel Building (1:52) https://youtu.be/E0IEOseKV_I
 - Pixel Perfect (1:44) https://youtu.be/TuwemQu6Ls8



Pixel Building, Melbourne, Australia



- Lessons learned
 - Inverter systems for wind turbines are problematic
 - Copper pipe of the bio-gas system was plastic sleeved to enable use with methane
 - Light fittings were adjusted to avoid wrong signal to the DALI lighting control system
 - Vacuum toilets are relatively new & the contract cleaning community has limited experience in cleaning and maintaining them
 - Tracking PV control system were adjusted & time clocks was added to prevent wasting energy

Taipei Public Library, Beitou Branch, Taiwan



- General information:
 - Location: Beitou, Taipei, Taiwan
 - New Construction (library building)
 - Gross floor area 803 sq.m, 3 storeys (1 below grade, 2 above grade)
 - Completion Date: Nov 2006
 - Post-occupancy evaluation (POE) in 2007
 - Taiwan Green Building Label (EEWH) diamond level

Taipei Public Library, Beitou Branch

臺北市立圖書館 北投分館



(Image source: https://architecture-tour.com/world/taiwan/taipei-public-library-beitou-branch/; http://www.taiwangbc.org.tw/tw/modules/news/article.php?storyid=86)

Taipei Public Library, Beitou Branch – indoor environment



(Source: https://architecture-tour.com/world/taiwan/taipei-public-library-beitou-branch/)

Green roof farming and solar photovoltaic (PV) system



Videos: A Visit to Taipei Public Library, Beitou Branch (1:52) https://youtu.be/Q9M7HVXeGKA 臺北市立圖書館北投分館(英文簡介影片) (14:39) https://youtu.be/fyI2d7VWjQ0

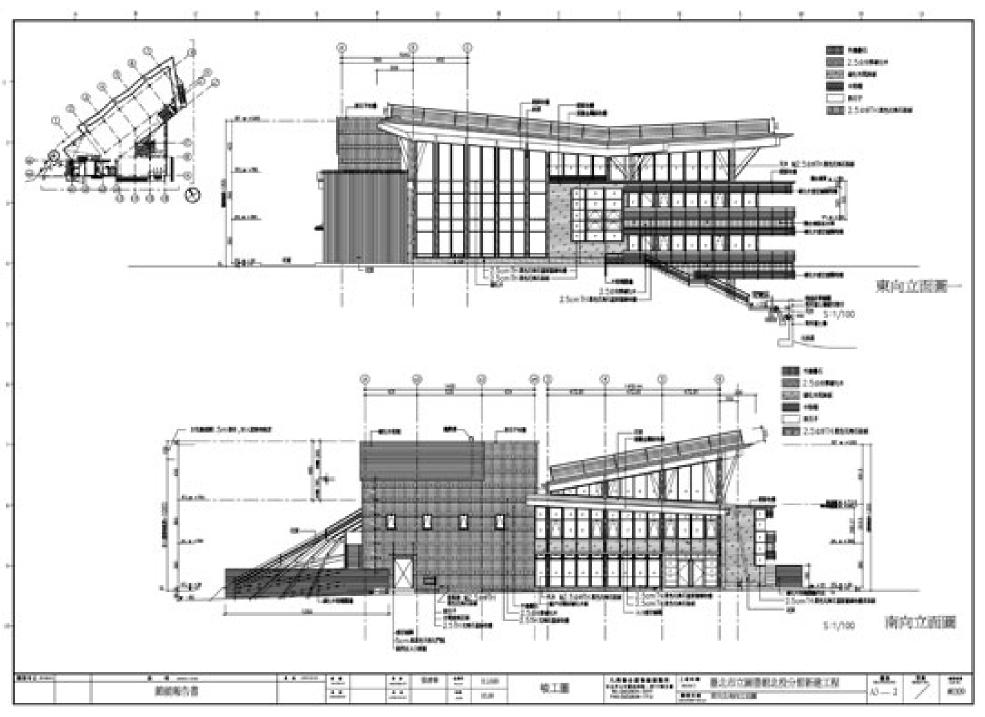


(Source: http://twgbqanda.com/english/e gbt.php?Type=14&menu=e gbt class)

ASHRAE Hong Kong Chapter – Taiwan Study Tour 2007



Taipei Public Library, Beitou Branch – design drawing



Green features of Taipei Public Library, Beitou Branch

- 1. Eco roof (extensive type)
- 2. Variety of garden plants deriving biodiversity from nature
- 3. Multiple layers of greenery on south side, lowering ecological impacts onto surrounding park
- 4. Photovoltaic (PV) modules (16 kW)
- 5. Rainwater recycling system
- 6. Wooden lattice frames with ecromat for greenery cultivation
- 7. Clustered service space modules on west side, enhancing electromechanical efficiency while conserving pipeline kinetics

- 8. Availability of materials recycling area
- 9. Natural lighting and ventilation
- 10. Outdoor reading platforms with wood-tiled boardwalk
- 11. Porous vegetative walls with floral greenery, attracting honeybees & butterflies
- 12. Wood-tiled staircases with living grass on gentle slope

Taipei Public Library, Beitou Branch, Taiwan

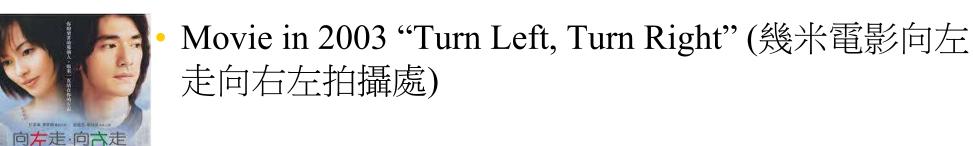


- Further Reading:
 - Green library design and evaluation: the Taipei Public Library, Taiwan https://pdfs.semanticscholar.org/f070/31223fad758af90a83fde31cdc15 5b889d6e.pdf
 - Green Building Label Case Studies http://twgbqanda.com/english/e_gbt.php?Type=14&menu=e_gbt_class
 - 臺北市立圖書館北投分館 (Taiwan GBC case study)(in Chinese) http://www.taiwangbc.org.tw/tw/modules/filelist/download/get/54
 - 台北市立圖書館北投分館 (Taiwan GBC) http://www.taiwangbc.org.tw/tw/modules/news/article.php?storyid=86
 - 台北市立圖書館北投分館 準建築人手札 http://forgemind.net/xoops/modules/news/article.php?storyid=863

Taipei Public Library, Beitou Branch, Taiwan



- Lessons learned
 - Harmony with surrounding natural environment
 - Use of wooden materials & greenery
 - Post-occupancy evaluation & user survey to verify performance & receive feedback
 - Additional benefit to tourist attraction & movie



Obayashi Technical Research Institute, Japan



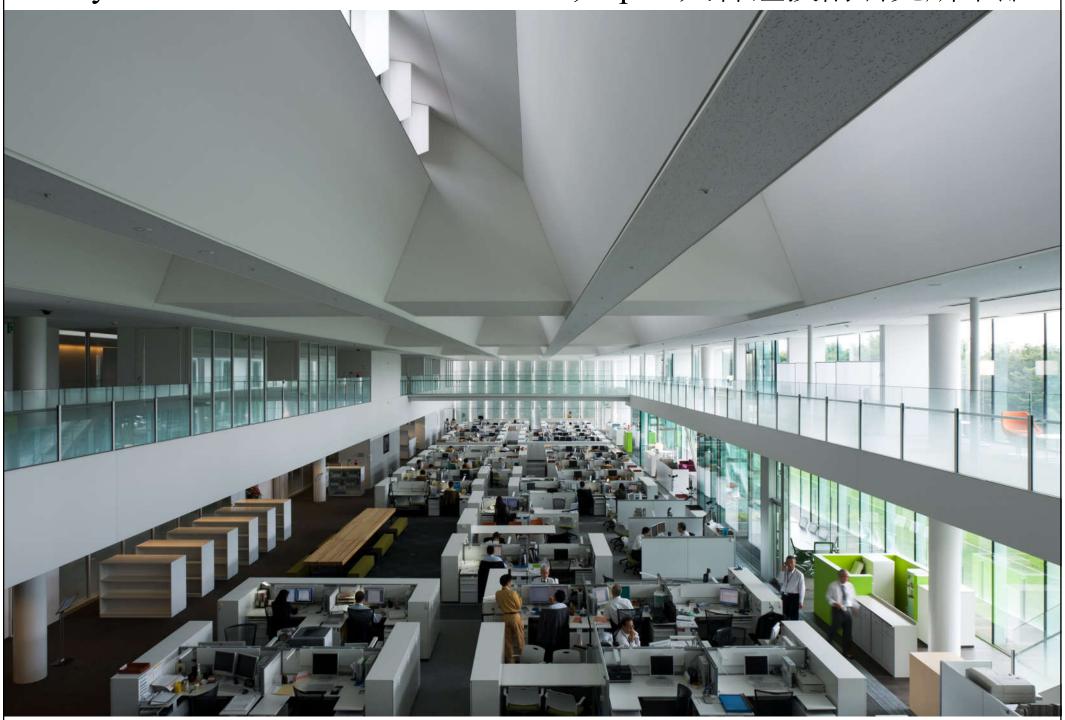
- General information:
 - Location: Kiyose City, Tokyo, Japan
 - New Construction (research offices)
 - Total floor area 5,535 sq.m, 3 floors + 1 penthouse
 - Completion Date: Sep 2010
 - CASBEE 5 star rating (Sustainable, BEE = 7.6)
 - LEED O+M Platinum (95 points)
 - Low carbon, zero energy building

Obayashi Technical Research Institute, Japan 大林組技術研究所本館



(Source: https://www.usgbc.org/projects/techno-station-obayashi-corporation)

Obayashi Technical Research Institute, Japan 大林組技術研究所本館

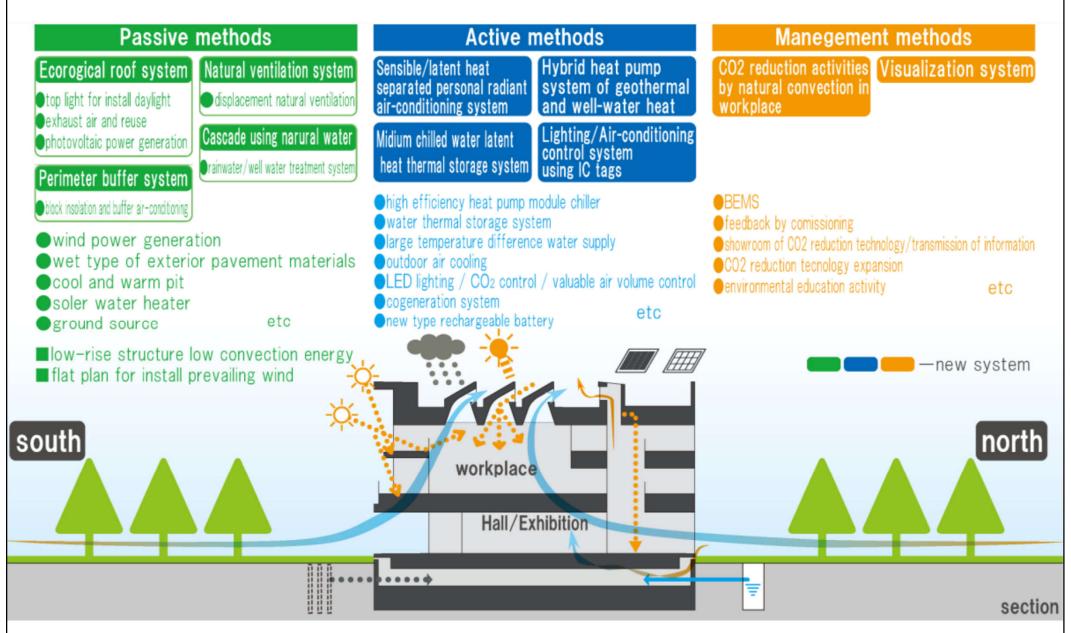


(Source: https://www.usgbc.org/projects/techno-station-obayashi-corporation)

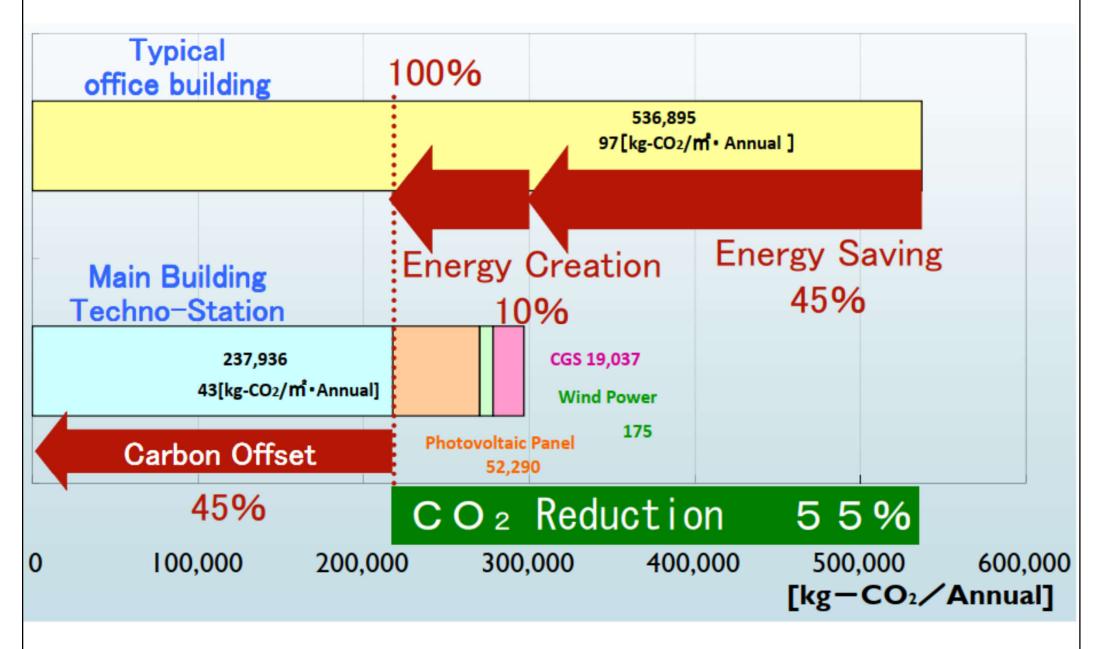
ASHRAE Hong Kong Chapter Japan Study Tour 2018



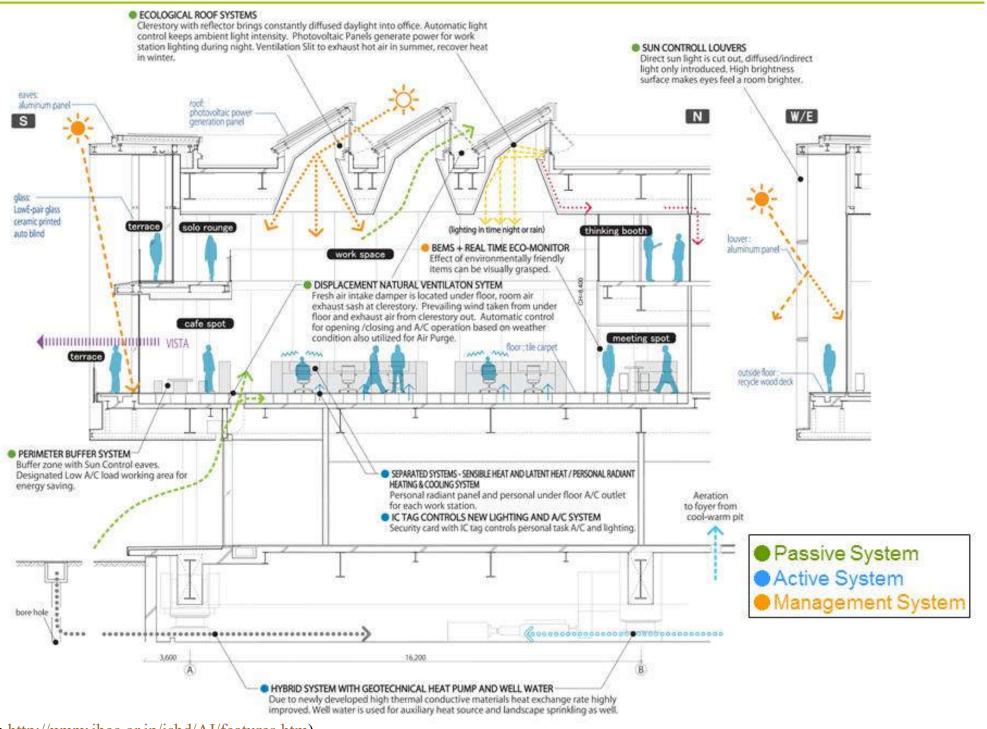
Obayashi Technical Research Institute, Japan Map of technologies of CO₂ reduction



Obayashi Technical Research Institute, Japan CO₂ emission reduction (design value)

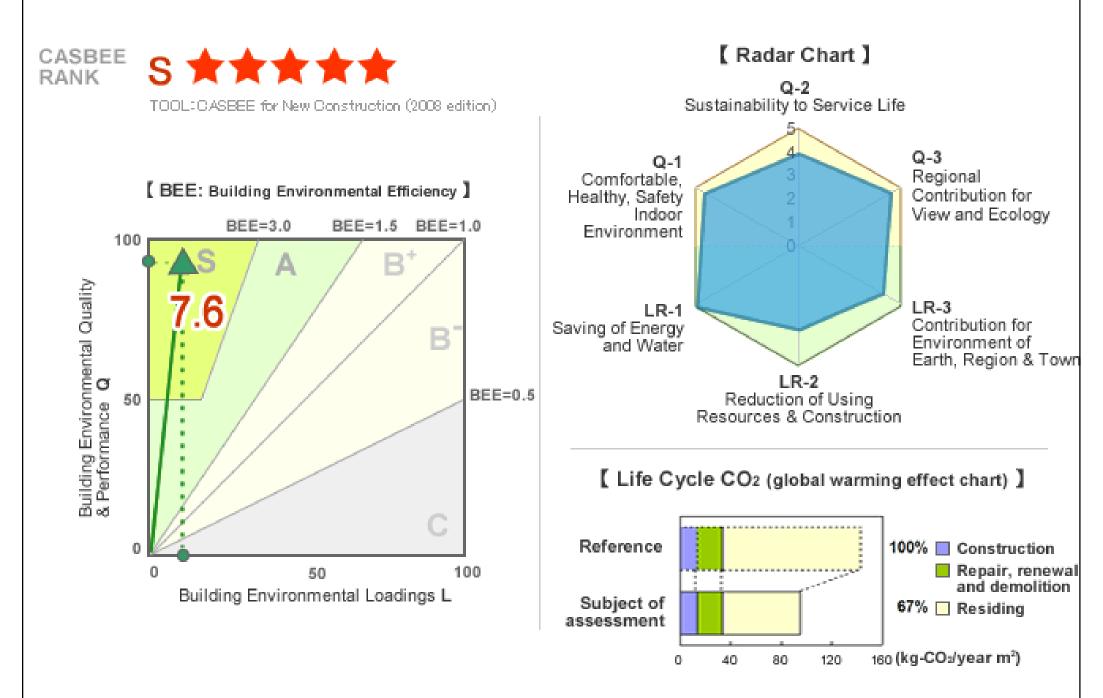


Obayashi Technical Research Institute, Japan 大林組技術研究所本館



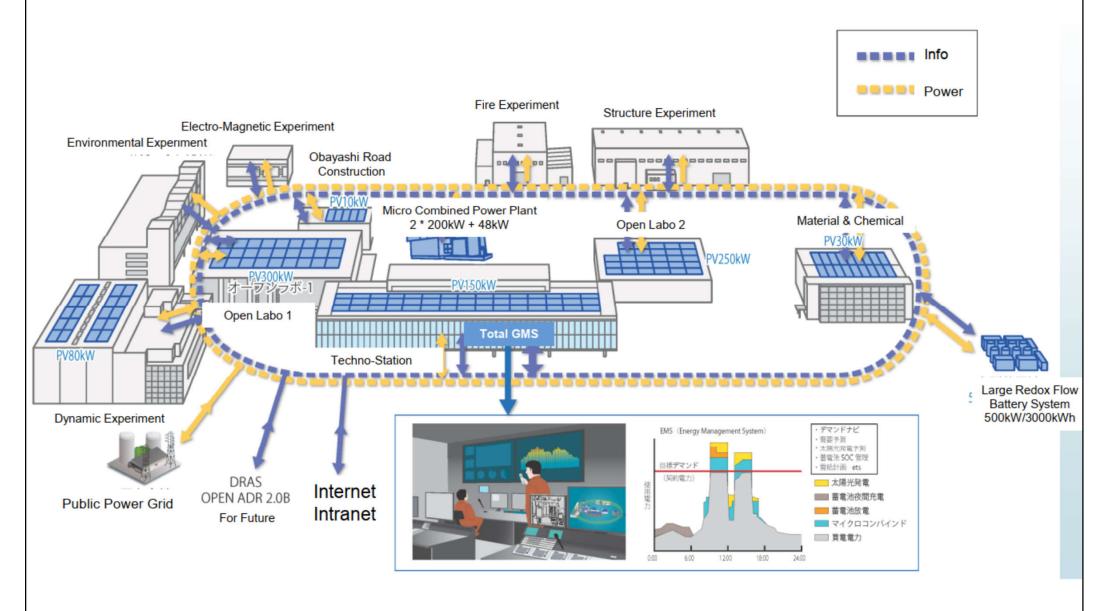
(Source: http://www.ibec.or.jp/jsbd/AI/features.htm)

Obayashi Technical Research Institute, Japan – CASBEE score



(Source: http://www.ibec.or.jp/jsbd/AI/score.htm)

Planning of smart energy grid (with energy generation & storage) in the campus of Obayashi Technical Research Institute



Obayashi Technical Research Institute, Japan



- Further Reading:
 - Japan Sustainable Building Database http://www.ibec.or.jp/jsbd/AI/index.htm
 - Approach to Low Carbon, ZEB and Smart Energy of Obayashi Corporation Technical Research Institute Main Building "TECHNO-STATION"
 - https://www.annex40.net/fileadmin/user_upload/annex40.net/documents/Annex40_Workshop_Nagoya_Onojima.pdf
 - A Low-Carbon Office Building using Innovative Methods and Technologies https://www.irbnet.de/daten/iconda/CIB_DC23290.pdf
- Videos:
 - 大林組 技術研究所 | 大林組 建築設計プロジェクト (2:36) https://youtu.be/EWostZvC470
 - TechnoStation (7:45) https://youtu.be/7YnTM45Rxog

Obayashi Technical Research Institute, Japan



- Lessons learned
 - Intelligent workspace & productivity
 - Design for natural daylight & ventilation
 - Integration of HVAC, hybrid heat pump, geothermal, chilled water storage, radiant cooling & cogeneration systems
 - Approach of zero energy building (ZEB)
 - Planning of smart energy grid for energy generation & storage

EMSD Headquarters, Hong Kong



- General information:
 - Location: Kowloon Bay, Hong Kong
 - Reuse of former HACTL cargo terminal building
 - Completion and in operation since 2005
 - Existing building (offices, workshops, car parks)
 - Gross floor area 74,000 sq.m, 8 storeys
 - Sustainable upgrade of existing buildings
 - Use BIM to enhance building O&M
 - Connection to Kai Tak District Cooling System

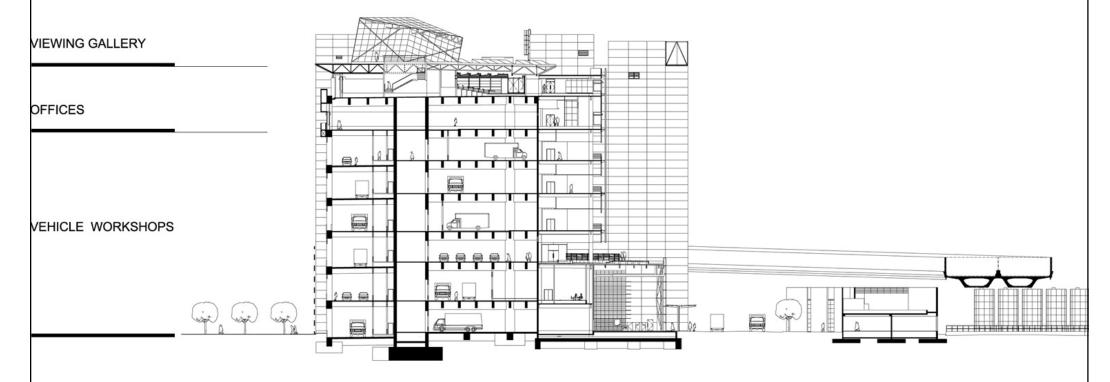
EMSD Headquarters 機電工程署總部大樓



(Source: http://greenbuilding.hkgbc.org.hk/eng/projects/view/24)

Location and layout of the EMSD Headquarters DRAINAGE RESERVE ROOF GARDEN ENTRANCE PLAZA KAI CHEUNG ROAD INTERNATIONAL TRADEMART (Source: https://www.archsd.gov.hk/en/exhibition/new-headquarters-for-the-electrical-and-mechanical-services-department.aspx)

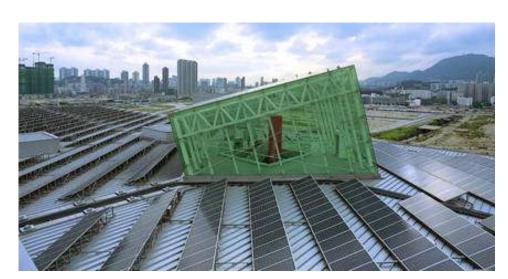
Section plan and transformation of the EMSD Headquarters





(Source: https://www.archsd.gov.hk/en/exhibition/new-headquarters-for-the-electrical-and-mechanical-services-department.aspx)

PV system and interior spaces of the EMSD Headquarters







(Source: https://www.archsd.gov.hk/en/exhibition/new-headquarters-for-the-electrical-and-mechanical-services-department.aspx)

Green features of EMSD Headquarters

- 1. Water-cooled ammonia chiller
- 2. Oil-free magnetic bearing chiller
- 3. Ice thermal storage system
- 4. Displacement ventilation at terminal side
- 5. Daylight & motion sensor for lighting control
- 6. Photovoltaic panels

- 7. Solar hot water system
- 8. Sun pipes (as known as lightpipes)
- 9. Double layer curtain wall
- 10. External façade shading
- 11. Grey water recycling
- 12. Vertical greening
- 13. Water saving sensor tap

Green building assessment results:

- BEAM Plus Existing Buildings v1.2 Platinum (score 84.3)
- BEAM Plus Neighbourhood (Pilot Version) Platinum (score 78.5)

EMSD Headquarters, Hong Kong



- Key success factors for platinum EB rating:
 - 26% lower electricity consumption than similar buildings
 - 30% lower annual water consumption
 - Over 70% of items purchased are now certified as environmentally friendly
 - 22% peak electricity demand reduction
 - 27.6% lighting energy saving in car park
 - 2% annual energy from renewable energy source
 - 87% equipment & appliances are certified with Grade 1 energy label
 - IAQ Good Class for office floors

EMSD Headquarters, Hong Kong



- Key success factors for platinum ND rating:
 - Nearly 9% of publicly accessible open/green space
 - Covered pedestrian pathway leading to piazza
 - Traffic speed is limited to 20 km/hr for complete safety
 - Design fully comply with "Urban Design Guideline"
 - Reduce surface runnoff by about 14%
 - All open spaces achieve thermal comfort by passive design
 - Recycle 35% of grey water for irrigation
 - Over 2% annual energy from renewable energy source
 - Annual electricity consumption reduction of 1,700 MWh
 by connecting Kai Tak District Cooling System

EMSD Headquarters, Hong Kong



- Further Reading:
 - EMSD website https://www.emsd.gov.hk/en/beam_plus_certification/
 - EMSD Headquarters BEAM Plus Online Exhibition http://greenbuilding.hkgbc.org.hk/eng/projects/view/24
 - Transformation of EMSD Headquarters into a Green Building BEAM Plus Online Exhibition http://greenbuilding.hkgbc.org.hk/eng/projects/view/76
 - New Headquarters for the Electrical and Mechanical Services
 Department ArchSD Exhibition
 https://www.archsd.gov.hk/en/exhibition/new-headquarters-for-the-electrical-and-mechanical-services-department.aspx
 - Green Transformation of EMSD Headquarters Building https://www.wsbe17hongkong.hk/_bin/ckfinder/userfiles/files/PDF/Session%206_10_3.pdf
- Video: Electrical and Mechanical Services Department Headquarters 機電工程署總部 (0:30) https://youtu.be/qleCVY3RnV4

EMSD Headquarters, Hong Kong



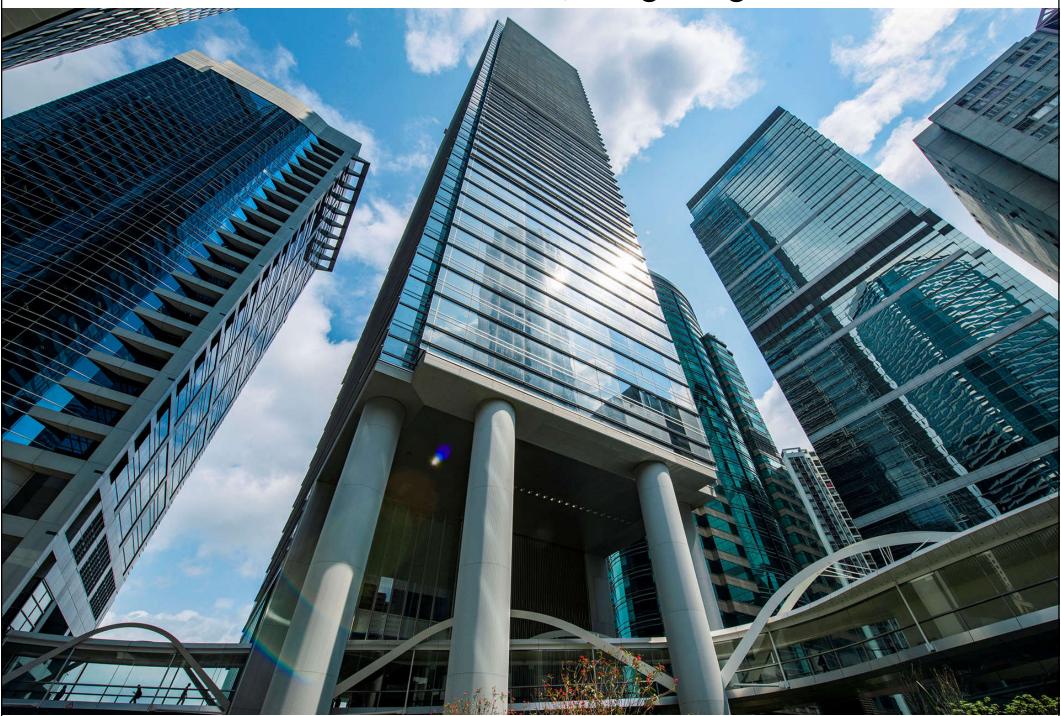
- Lessons learned
 - Reuse of old building structures
 - Sustainable upgrade of existing buildings
 - Promotion of PV systems & technology
 - Potential of BIM for building O&M
 - Advantage of district cooling system
 - Education Path & sharing of experience/knowledge





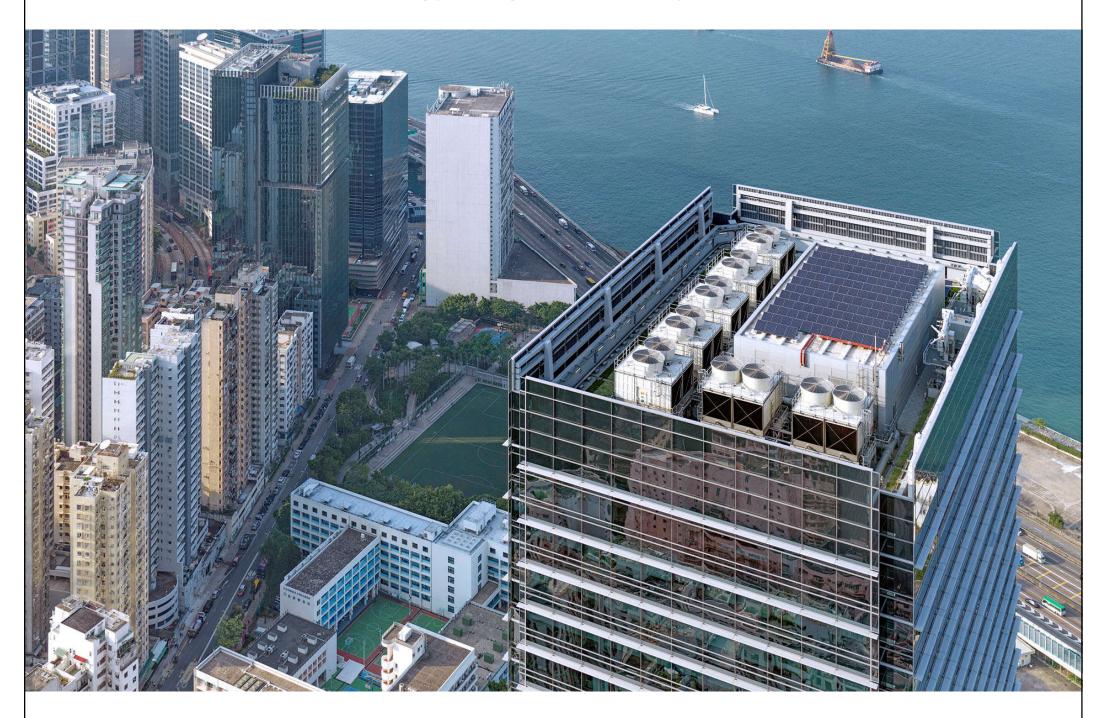
- General information:
 - https://www.taikooplace.com/en/work/onetaikooplace
 - Location: Quarry Bay, Hong Kong
 - New building (commercial office)
 - Completion Year: 2018
 - Gross floor area ~100,000 sq.m, 48 storeys
 - HK\$15 billion redevelopment
 - Swire Properties' Sustainable Development (SD)
 2030 strategy
 - Sustainable demolition & low carbon construction

One Taikoo Place, Hong Kong



(Source: http://greenbuilding.hkgbc.org.hk/eng/projects/view/211)

Solar PV & waste-to-energy tri-generation system at One Taikoo Place



(Source: http://greenbuilding.hkgbc.org.hk/eng/projects/view/211)

Highlight of green elements of One Taikoo Place

1. Renewable Energy

- An integrated solar photovoltaics (PV) system and green roof
- Bio-diesel tri-generation system to supply heating, cooling and electricity. Used cooking oil from tenants is converted into biodiesel by third-party recyclers to power this system

2. Energy Efficiency

- Air handling units with electronically commutated (EC) plug fans
- Highly optimized chiller control system with powerful data analytics
- Energy efficient lighting and control system

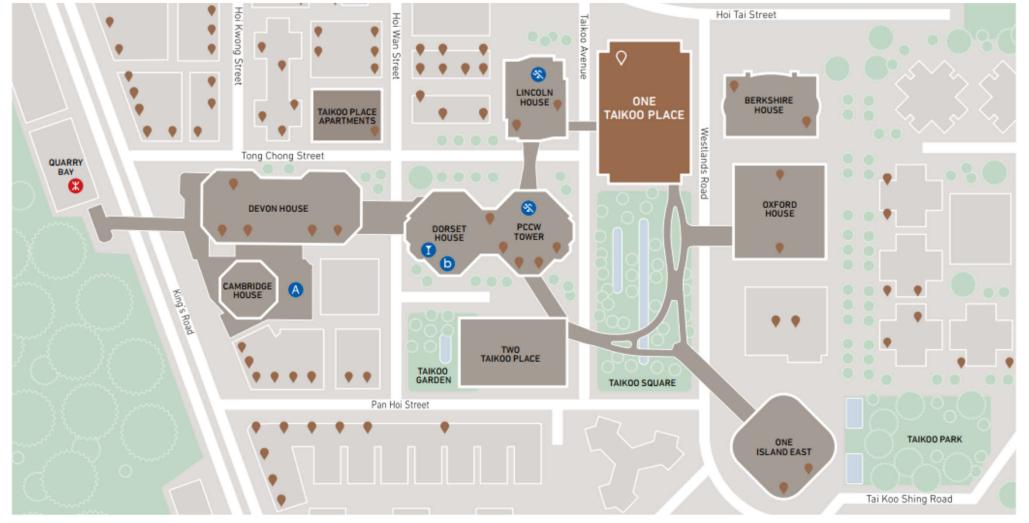
3. Sustainable Water and Wastewater Management

- Harvest rainwater for irrigation and recycle grey water for flushing
- Low-flow sanitary fittings

Green building assessment results:

- BEAM Plus New Buildings v1.2 Platinum (score 86)
- LEED Core & Shell 2009 Platinum (score 91)
- WELL v2 Certification Platinum

Location of One Taikoo Place and surrounding environment



- 1. <u>Connecting Places</u>: Elevated walkways and pedestrian friendly streetscapes enhance existing connections to surrounding buildings and transport hubs.
- 2. <u>Natural Ventilation</u>: Buildings within Taikoo Place have been situated to introduce natural ventilation and cooling breezes.
- 3. <u>Liveability</u>: Green spaces and outdoor seating have been carefully designed & positioned to reduce urban heat island effects.

(Source: https://www.swireproperties.com/en/portfolio/current-developments/taikoo-place-and-cityplaza/taikoo-place/one-taikoo-place.aspx)

Neuron AI smart building system at One Taikoo Place



(Source: https://arupneuron.com/project-reference-one-taikoo-place/)



One Taikoo Place, Hong Kong

- Further Reading:
 - BEAM Plus Online Exhibition http://greenbuilding.hkgbc.org.hk/eng/projects/view/211
 - Performance Synergy from Integrated Design, Construction and Operation. Case Study on a High Performance Grade A Office - Swire One Taikoo Place
 - https://wsbe17hongkong.hk/_bin/ckfinder/userfiles/files/Paper/P_174-181%20Performance%20Synergy.pdf
 - https://www.polyu.edu.hk/af/cesef/wp-content/uploads/2019/12/4.-
 Panel-2_Raymond-Yau-public-version.pdf
 - One Taikoo Place Arup https://www.arup.com/projects/one-taikoo-place
- Video: Transformation of Taikoo Place Our Vision (1:02) https://youtu.be/iy4MrJrJNBk





- American Institute of Architects (AIA) Committee on the Environment (COTE) Top Ten Projects https://www.aiatopten.org/
- BEAM Plus Online Exhibition 綠建環評網上展覽 http://greenbuilding.hkgbc.org.hk/
- Green Buildings (Energizing Kowloon East)
 https://www.ekeo.gov.hk/en/green_map/building/
- Whole Building Design Guide (WBDG) Case Studies <u>https://www.wbdg.org/additional-resources/case-studies</u>
- WorldGBC Online Case Study Library https://www.worldgbc.org/case-study-library