MEBS6020 Sustainable Building Design

http://ibse.hk/MEBS6020/

Practical Examples

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Contents

- Bullitt Center, Seattle, USA
- Pixel Building, Melbourne, Australia
- Taipei Public Library, Beitou Branch, Taiwan
- Obayashi Technical Research Institute, Japan
- EMSD Headquarters, Hong Kong
- 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

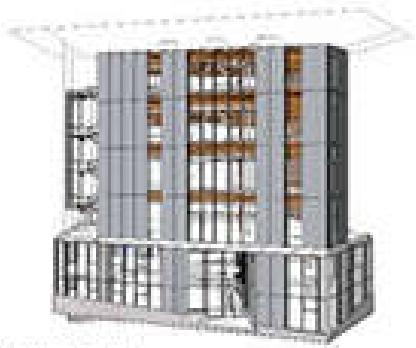
(Source: https://www.wbdg.org/additional-resources/case-studies/bullitt-center)

Bullitt Center, Seattle, USA

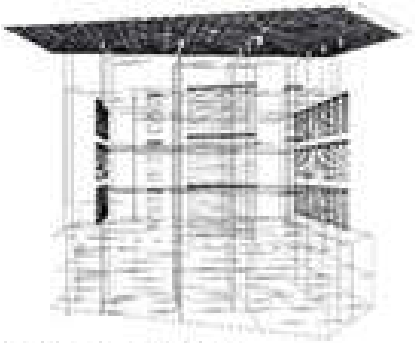
- Evaluation of green features
  - Structure: timber with low embodied carbon
  - High-performance envelope
  - Closed-loop geothermal system & ventilation
  - Radiant floor heating & cooling with passive cooling & natural ventilation
  - Daylight dimming & efficient lighting design
  - Aggressive reduction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

BUILDING LIFE CYCLE

250 YEAR STRUCTURE
HEAVY TIMBER, CONCRETE & STEEL

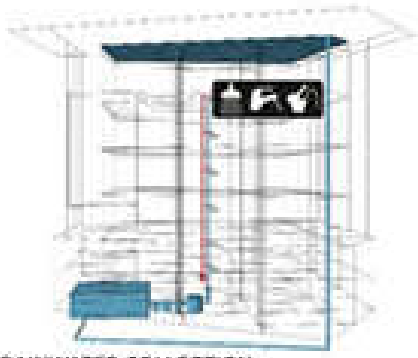


50 YEAR SKIN
HIGH PERFORMANCE ENVELOPE

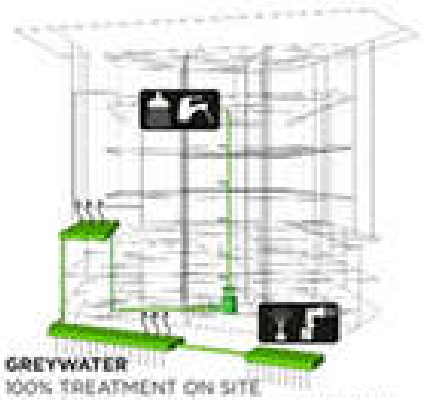


25 YEAR TECHNOLOGY
ACTIVE SOLAR CONTROL
PHOTOVOLTAICS

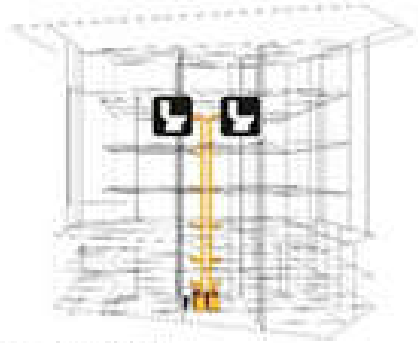
NET ZERO WATER



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

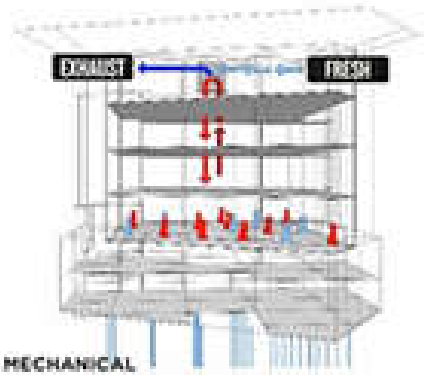


GREYWATER
100% TREATMENT ON SITE
EVAPOTRANSPIRATION & INFILTRATION

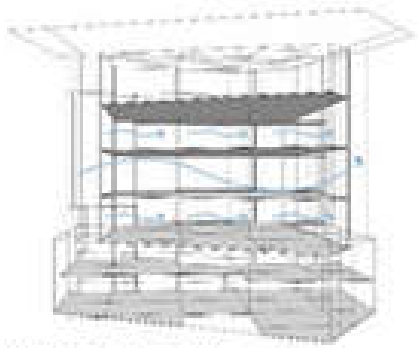


WASTE COMPOST
100% TREATMENT ON SITE

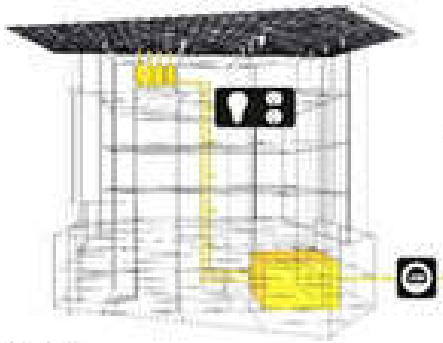
NET ZERO ENERGY



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



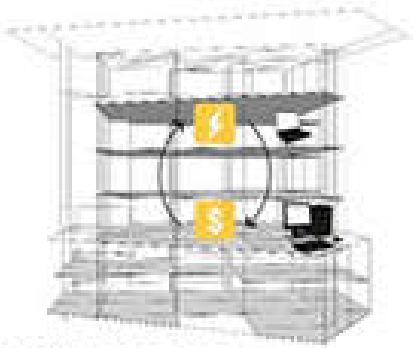
NATURAL VENTILATION
NIGHT FLUSH & OPERABLE WINDOWS



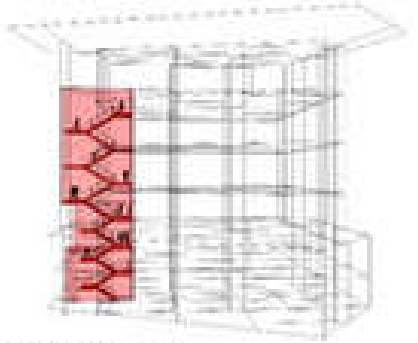
ENERGY
100% RENEWABLE ON SITE
GRID USED AS BATTERY

OCCUPANT

PROGRAM
OCCUPANCY
PRIVATE USERS ABOVE, PUBLIC FOCUS
USERS AT GRADE

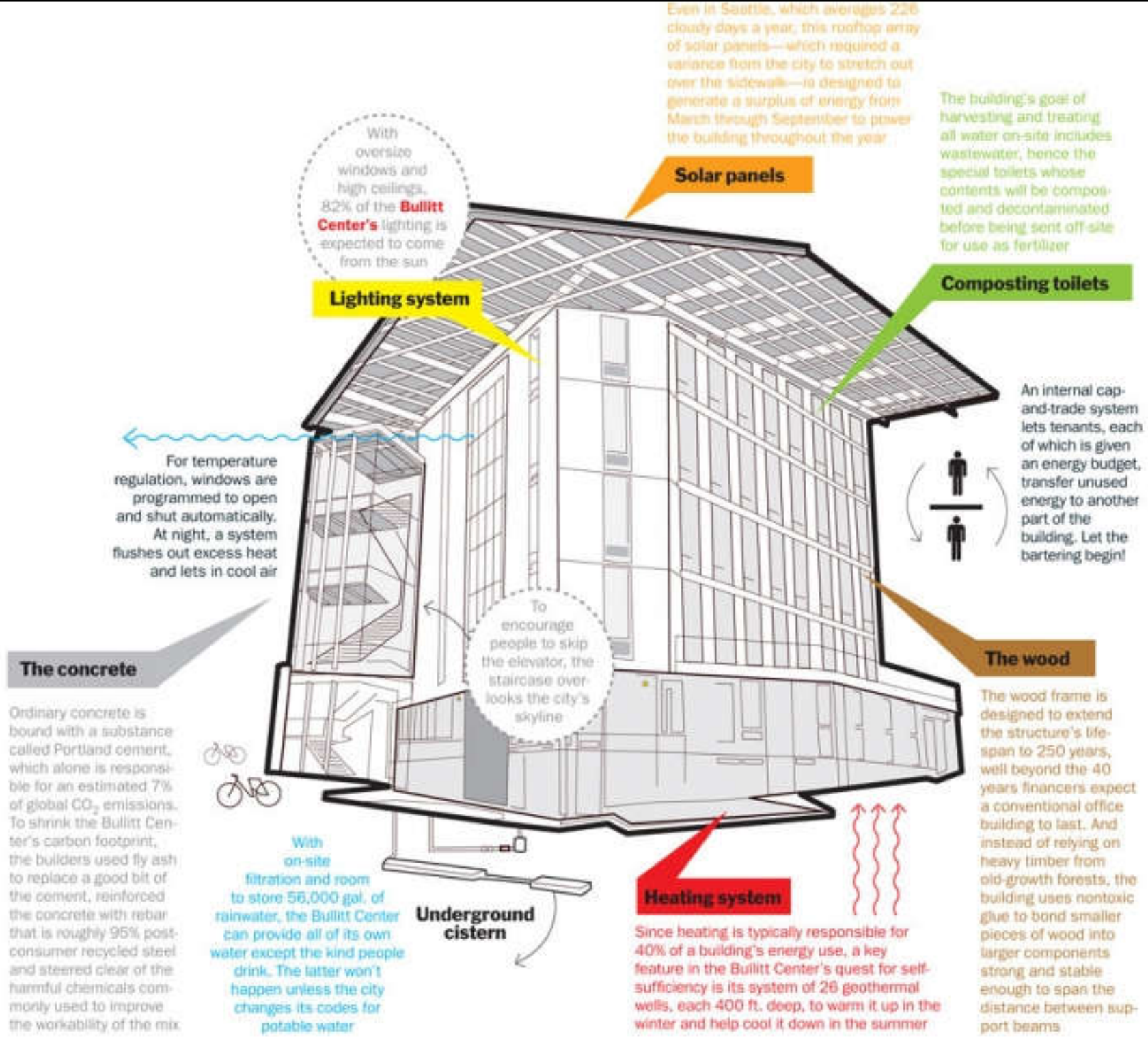


INTERNAL CAP & TRADE
EACH TENANT HAS AN ENERGY BUDGET,
UNUSED ENERGY CAN BE TRANSFERRED



IRRESISTIBLE STAIR
ELEVATOR ALTERNATIVE, HEALTHIER
OCCUPANTS, ENGAGEMENT WITH STREET

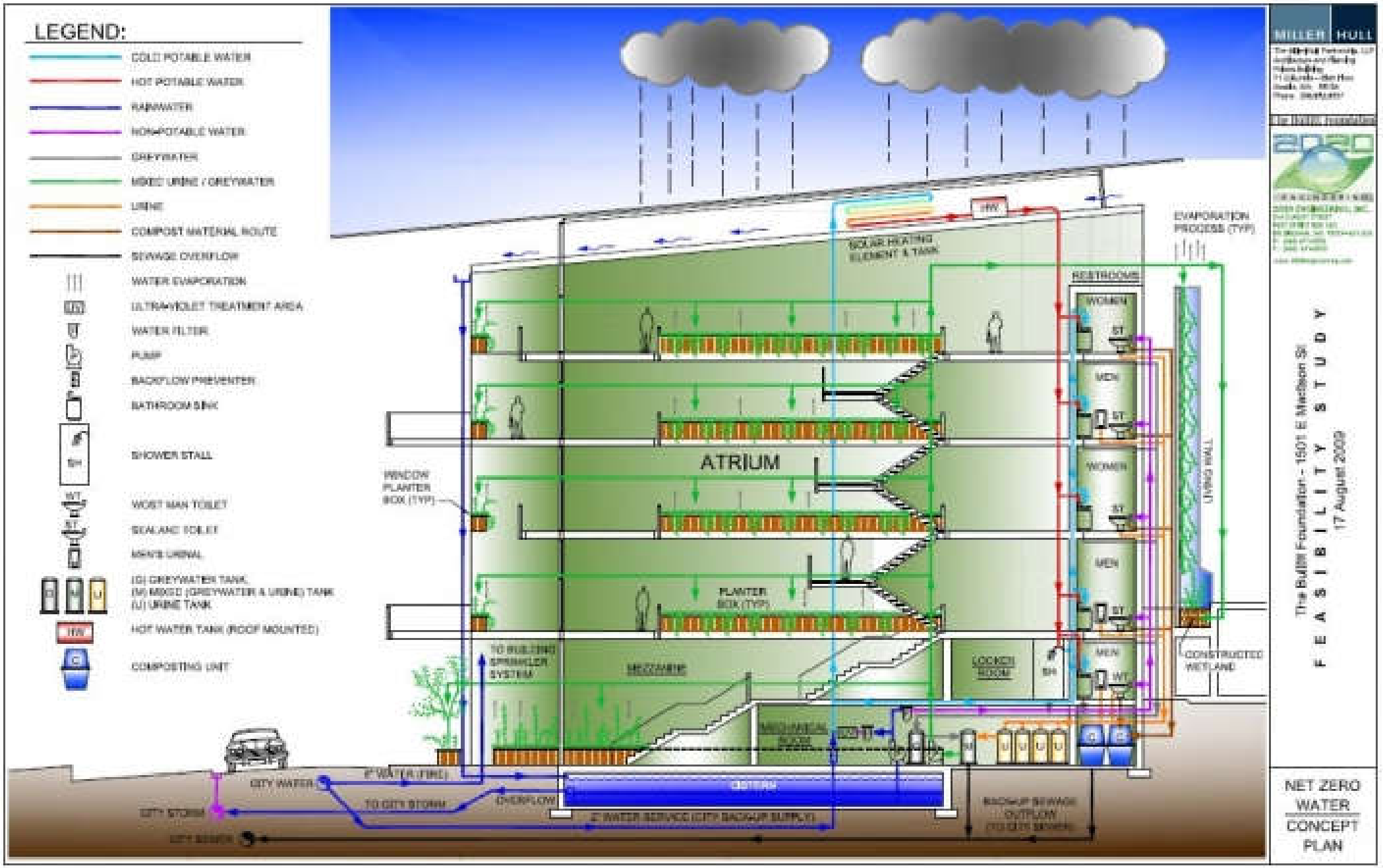
(Source: https://www.wbdg.org/additional-resources/case-studies/bullitt-center)



Green building features of Bullit Center

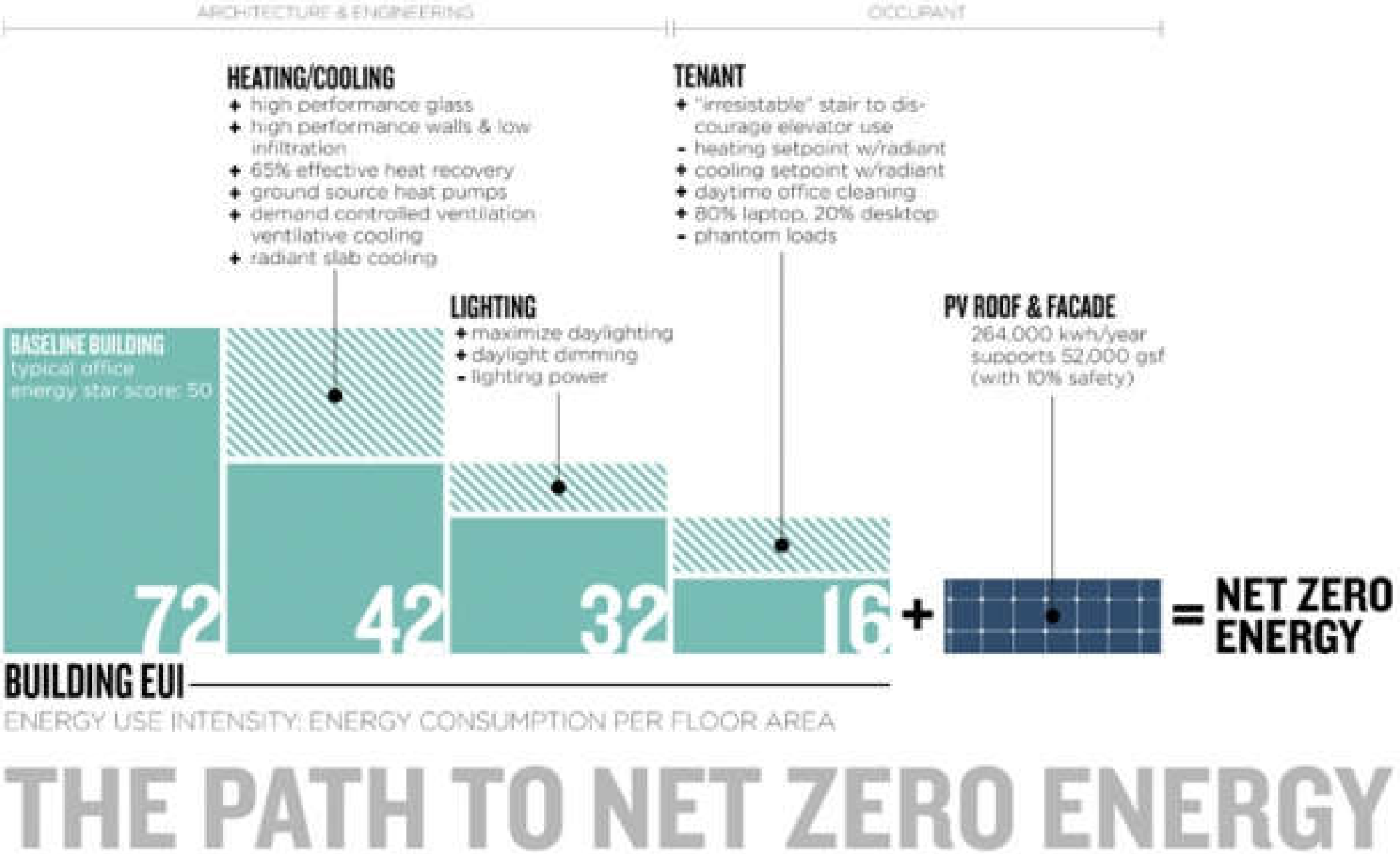
(Source: https://www.solaripedia.com/13/410/6338/bullitt_center_living_building_green_features_by_time_magazine.html)

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



(Source: https://www.solaripedia.com/13/410/6363/bullitt_center_living_building_energy_use_intensity.html)

Bullitt Center, Seattle, USA

- 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%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

- 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

Bullitt Center, Seattle, USA

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

(Composting units)

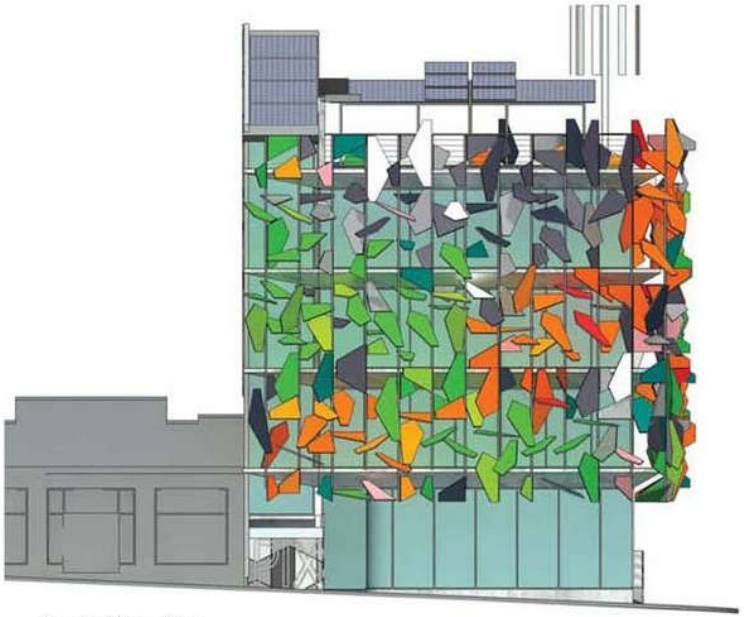
Pixel Building, Melbourne, Australia

- 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

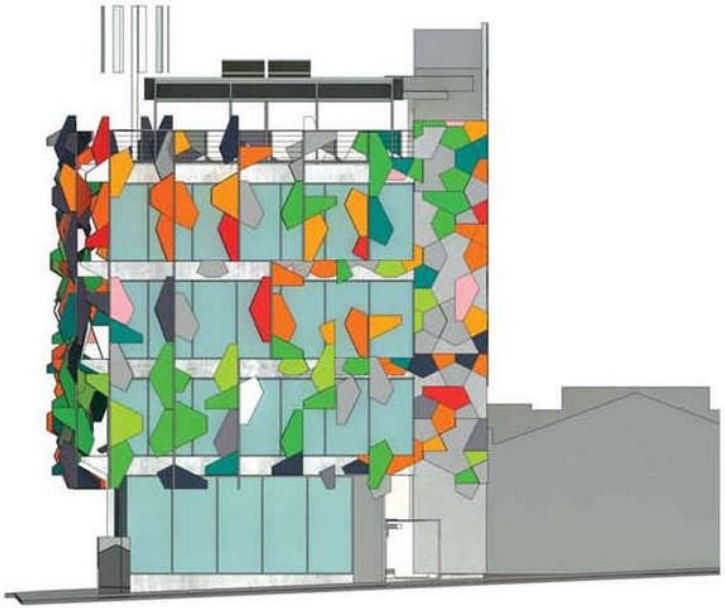
(Source: https://www.pixelbuilding.com.au/greenicon.html)

Pixel building – elevations and facades

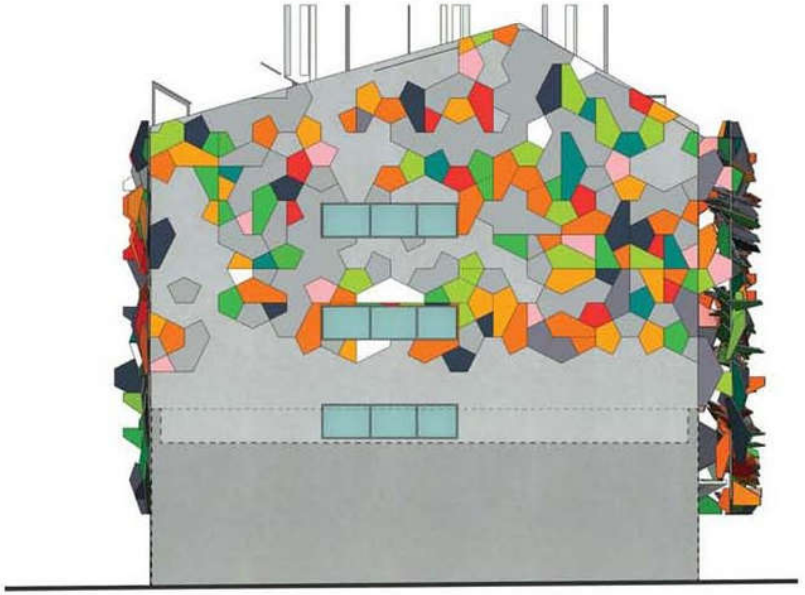


North Elevation

West Elevation



South Elevation



East Elevation

PIXEL

505 studio

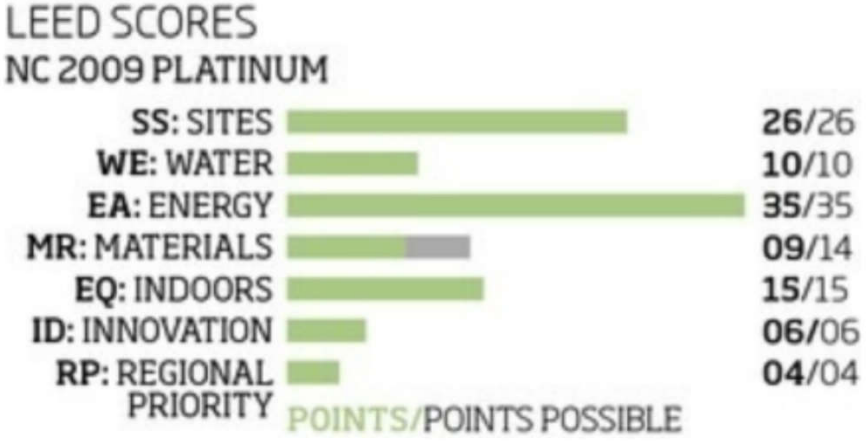
(Source: https://www.livinspaces.net/projects/architecture/pixel-office-building-australia-studio-505/)

Pixel innovations, green features and achievements

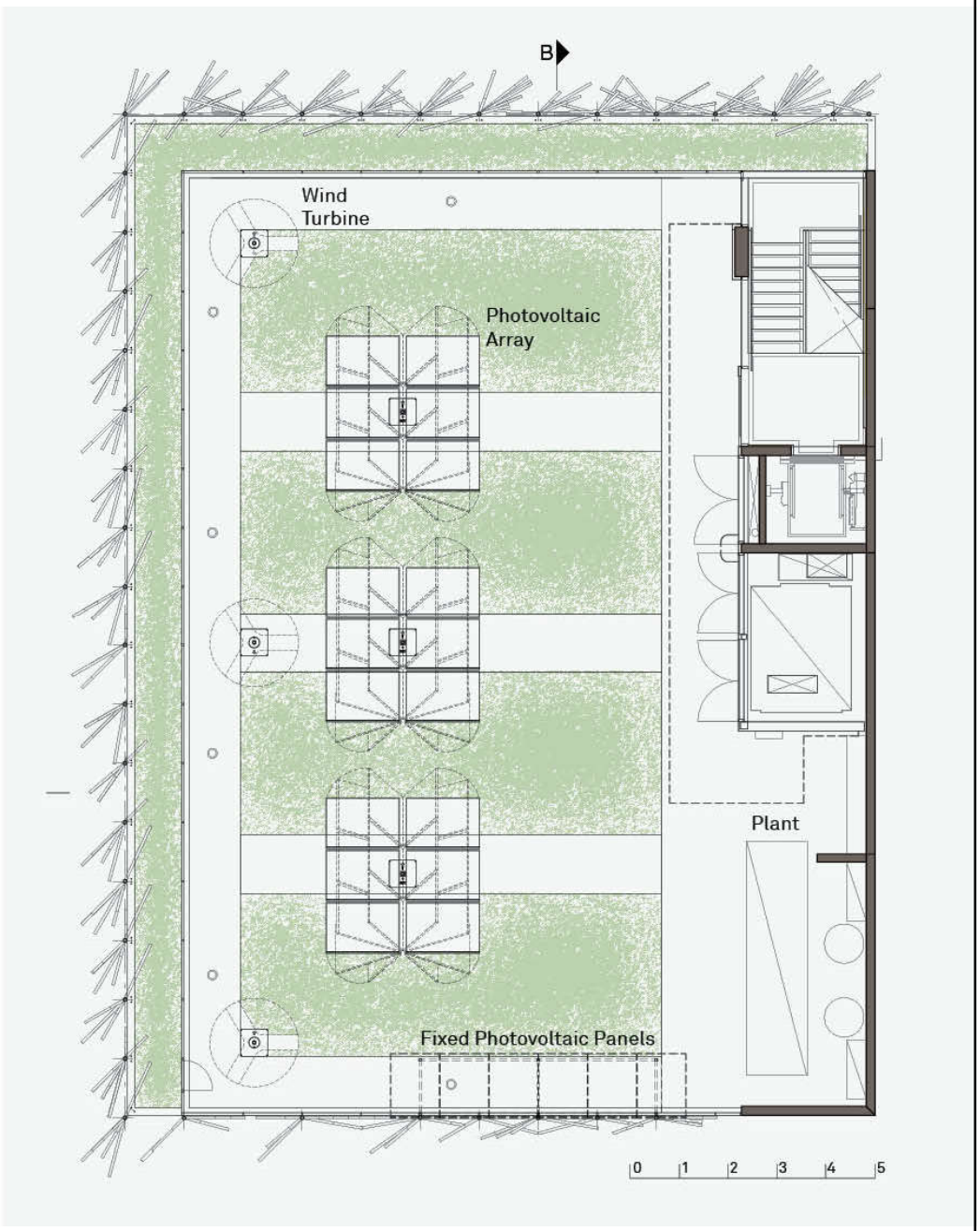
Carbon neutral	Reliance on natural daylight
Water balanced	Green concrete
100% fresh air system	Gas fired absorption chillers
Ammonia refrigeration	Extensive recycling
Chilled structure	Free night cooling
Green roof	Bio-gas energy
Photovoltaic & wind power generation	High performance façade
Reed bed water treatment	

Green building assessment results:

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

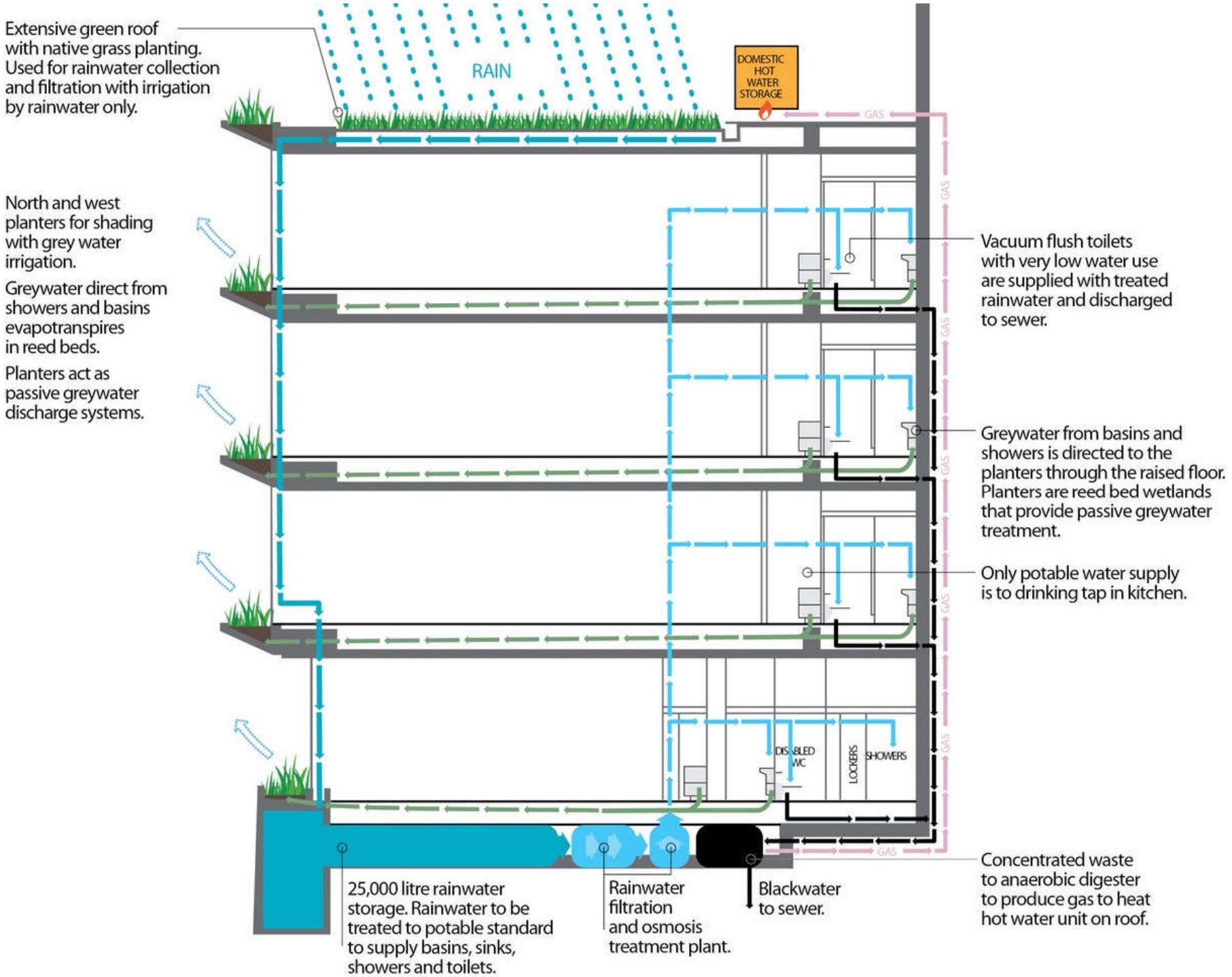


Pixel building: green roof and renewable energy systems



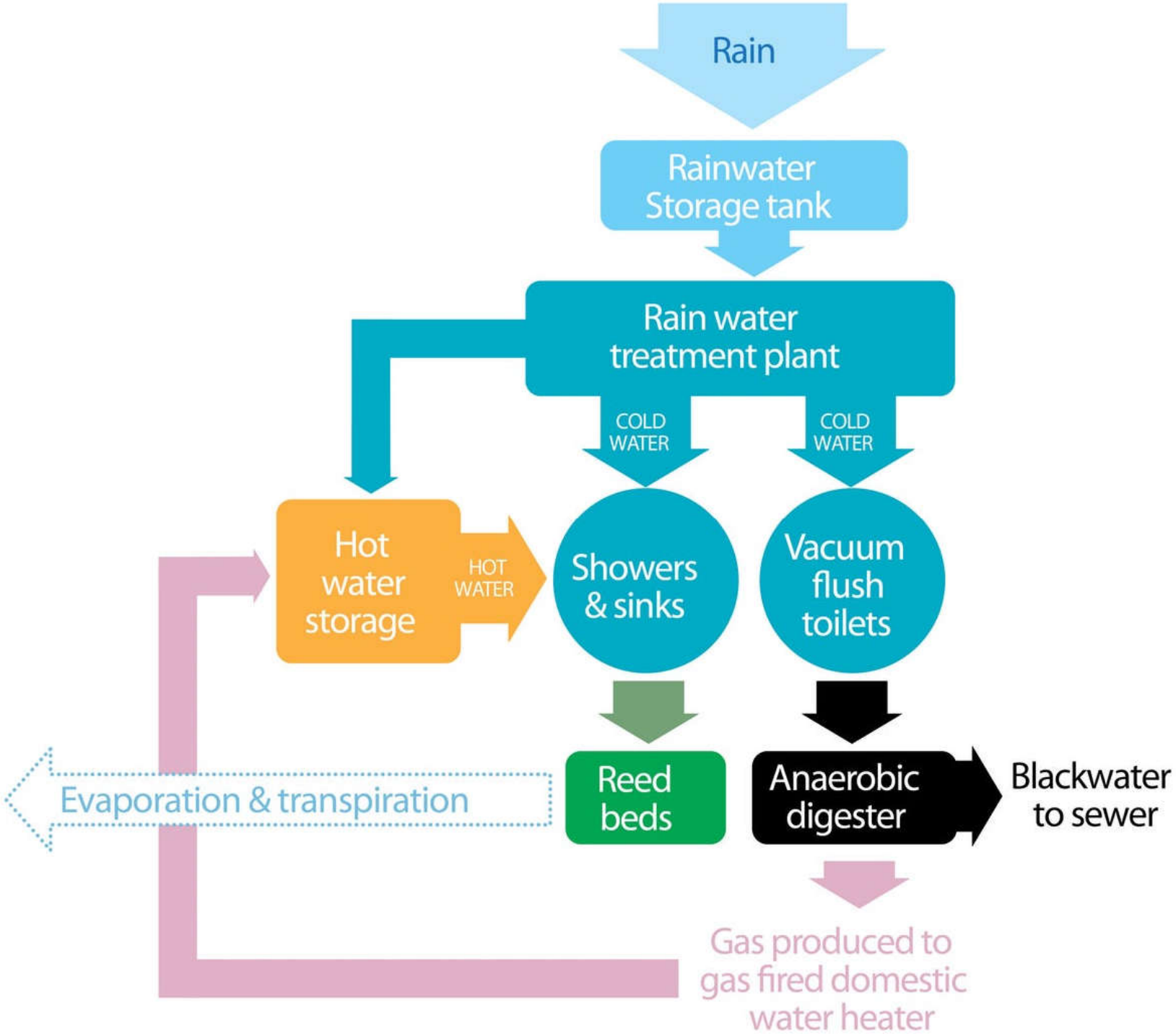
(Source: https://www.db-a.co/work/pixel-building/)

Pixel water cycle



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

Pixel rainwater harvesting



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

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/services%20and%20advice/business/srsb%20eeob/srsb%20eeob%20case%20studies/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/)

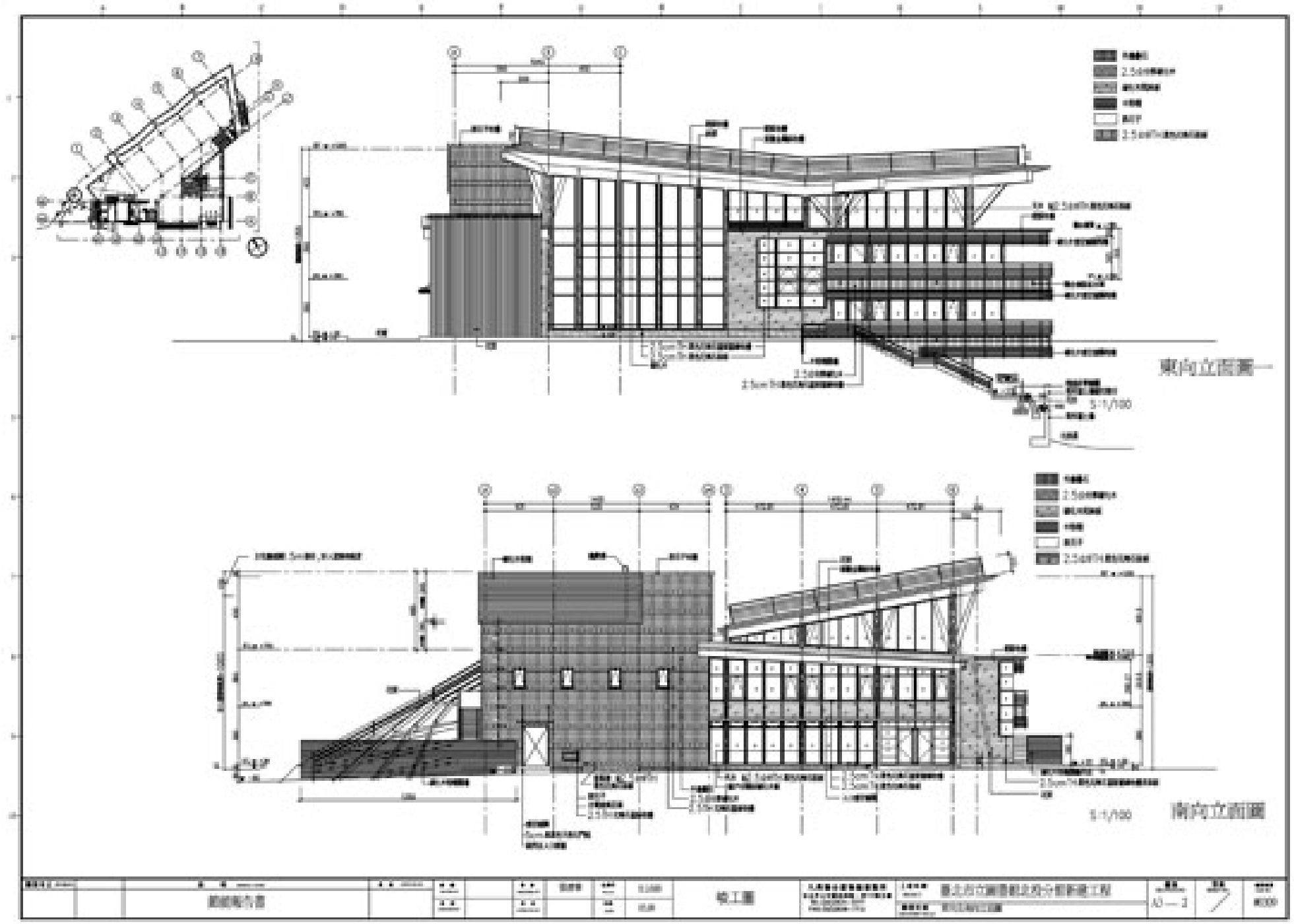
Green roof farming and solar photovoltaic (PV) system

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



(Source: http://forgemind.net/xoops/modules/news/article.php?storyid=863)

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

(Source: Green library design and evaluation: the Taipei Public Library, Taiwan
https://pdfs.semanticscholar.org/f070/31223fad758af90a83fde31cdc155b889d6e.pdf)

Taipei Public Library, Beitou Branch, Taiwan

- Further Reading:
  - Green library design and evaluation: the Taipei Public Library, Taiwan https://pdfs.semanticscholar.org/f070/31223fad758af90a83fde31cdc155b889d6e.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
    - Movie in 2003 “Turn Left, Turn Right” (幾米電影向左走向右左拍攝處)

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

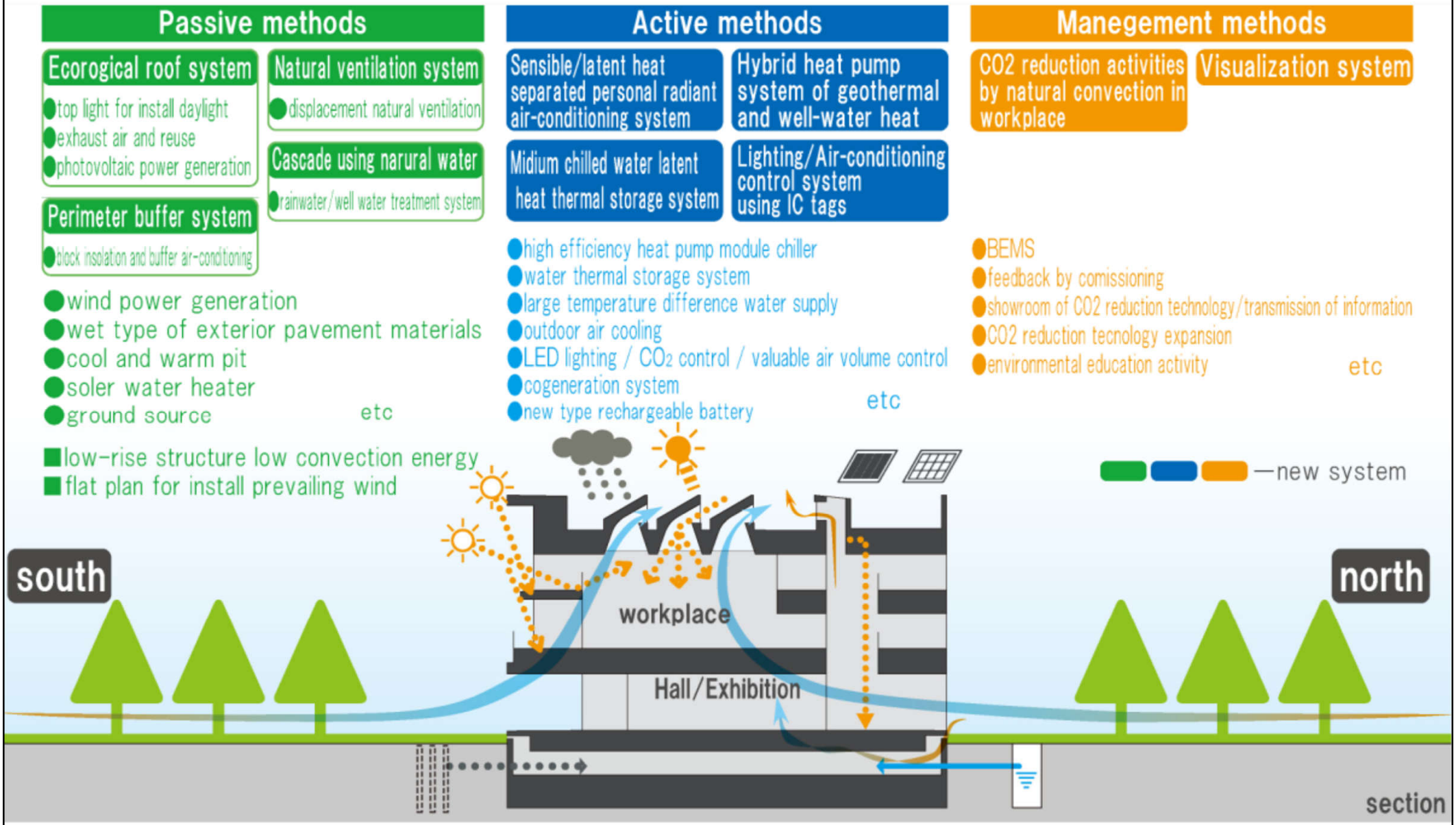
(Source: https://www.usgbc.org/projects/techno-station-obayashi-corporation)

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)

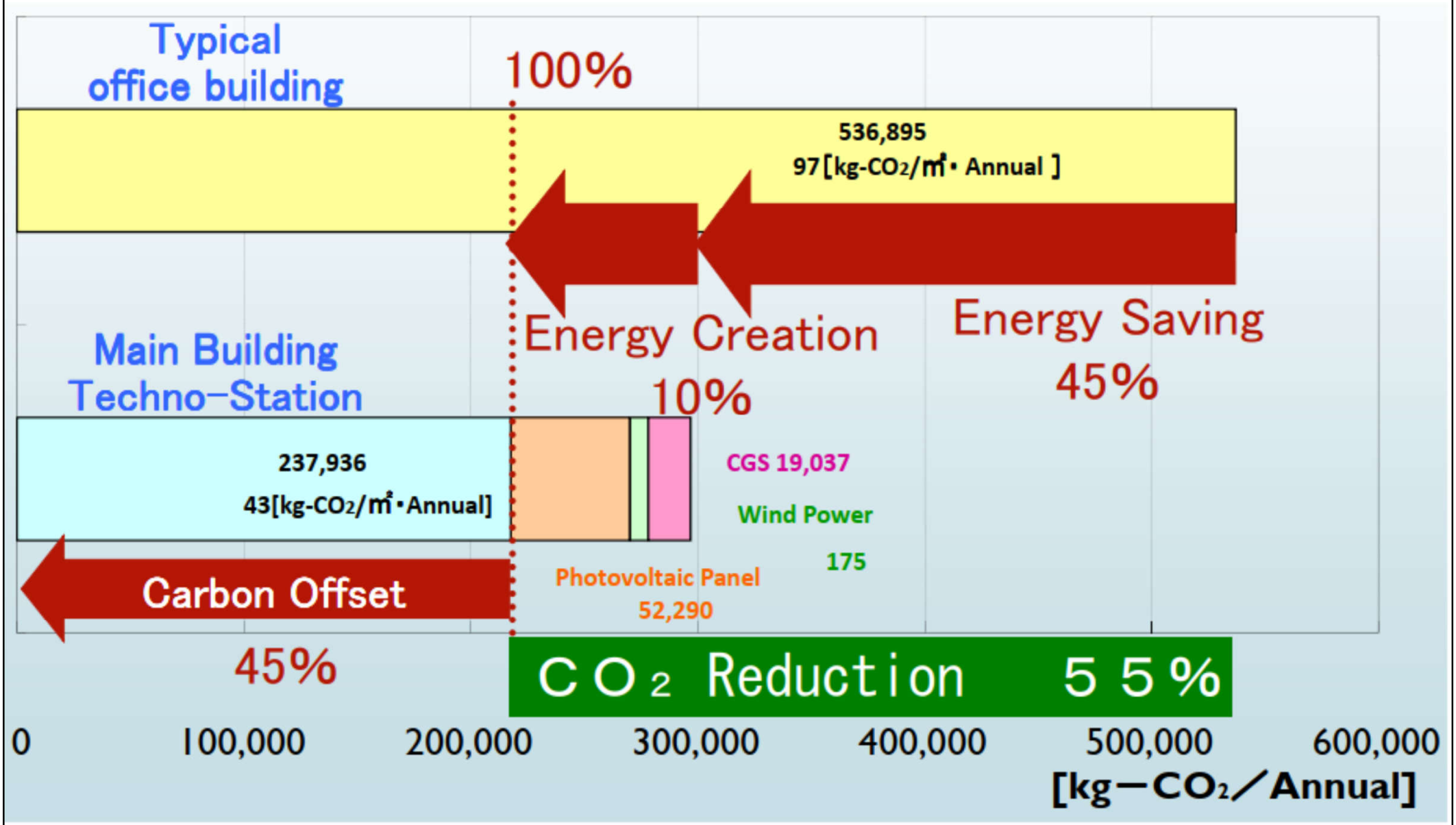
ASHRAE Hong Kong Chapter Japan Study Tour 2018

Obayashi Technical Research Institute, Japan
Map of technologies of CO_2 reduction



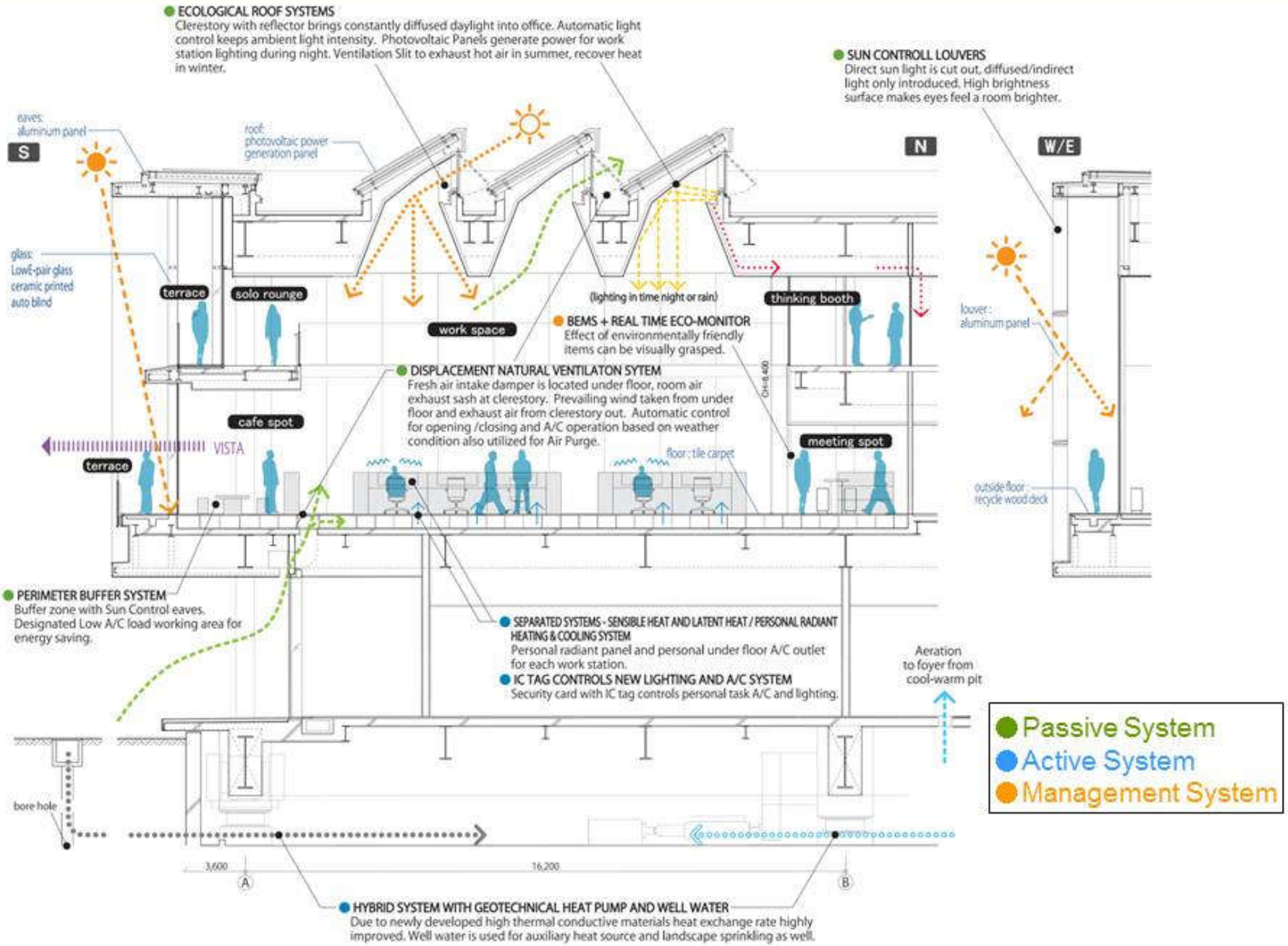
(Source: https://www.annex40.net/fileadmin/user_upload/annex40.net/documents/Annex40_Workshop_Nagoya_Onojima.pdf)

Obayashi Technical Research Institute, Japan
CO_2 emission reduction (design value)



(Source: https://www.annex40.net/fileadmin/user_upload/annex40.net/documents/Annex40_Workshop_Nagoya_Onojima.pdf)

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



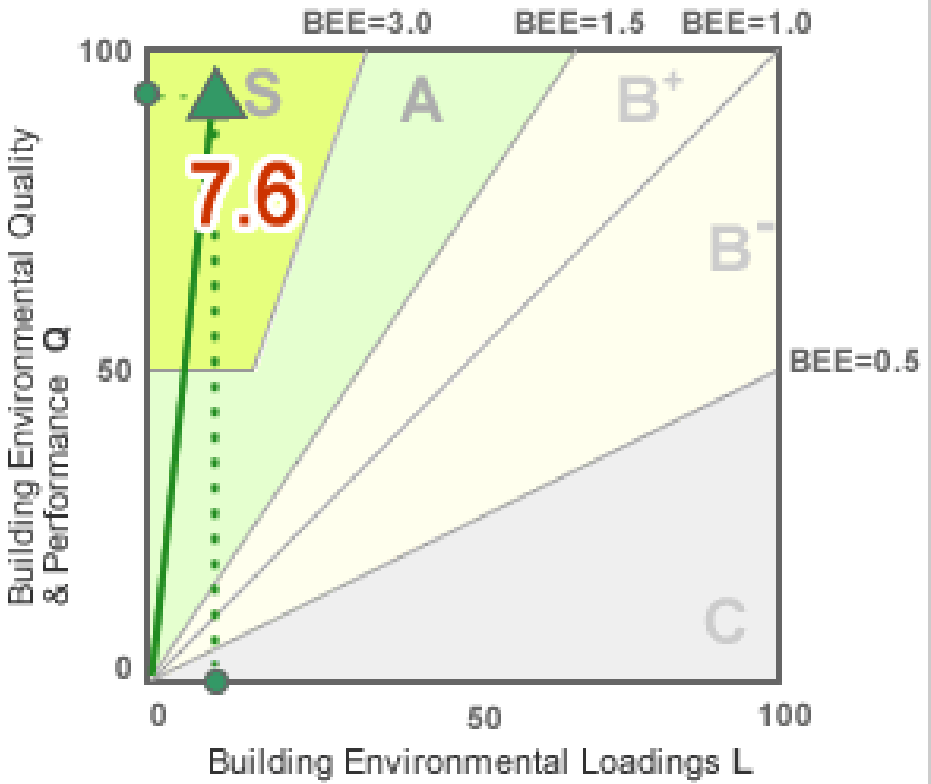
(Source: http://www.ibec.or.jp/jsbd/AI/features.htm)

Obayashi Technical Research Institute, Japan – CASBEE score

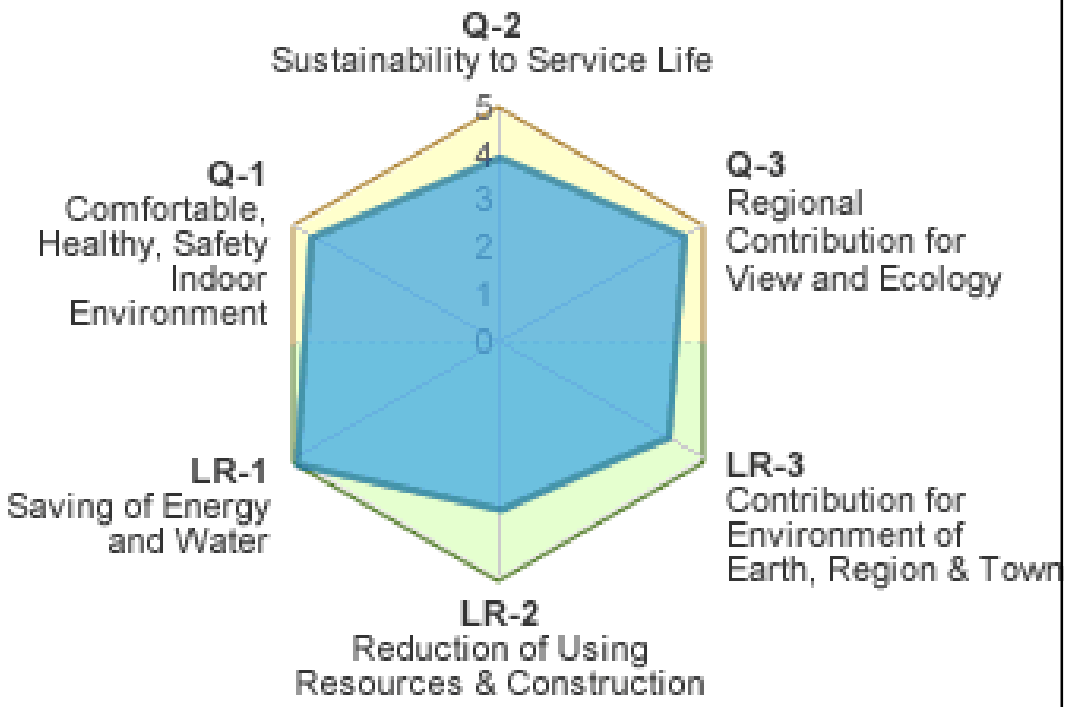
CASBEE RANK **S** ★★★★★

TOOL: CASBEE for New Construction (2008 edition)

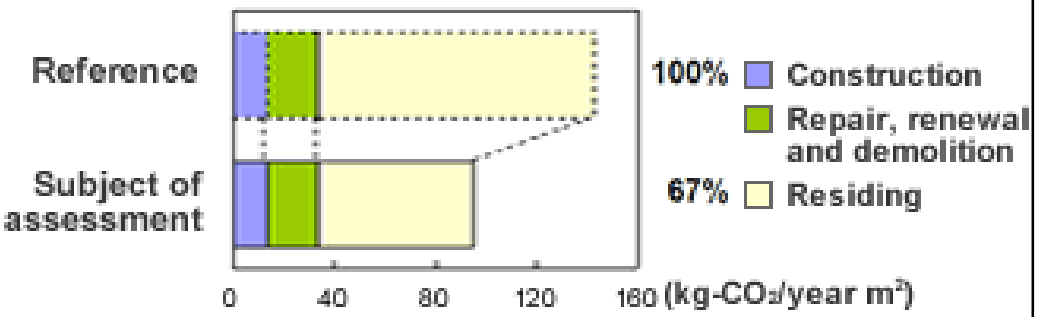
【 BEE: Building Environmental Efficiency 】



【 Radar Chart 】

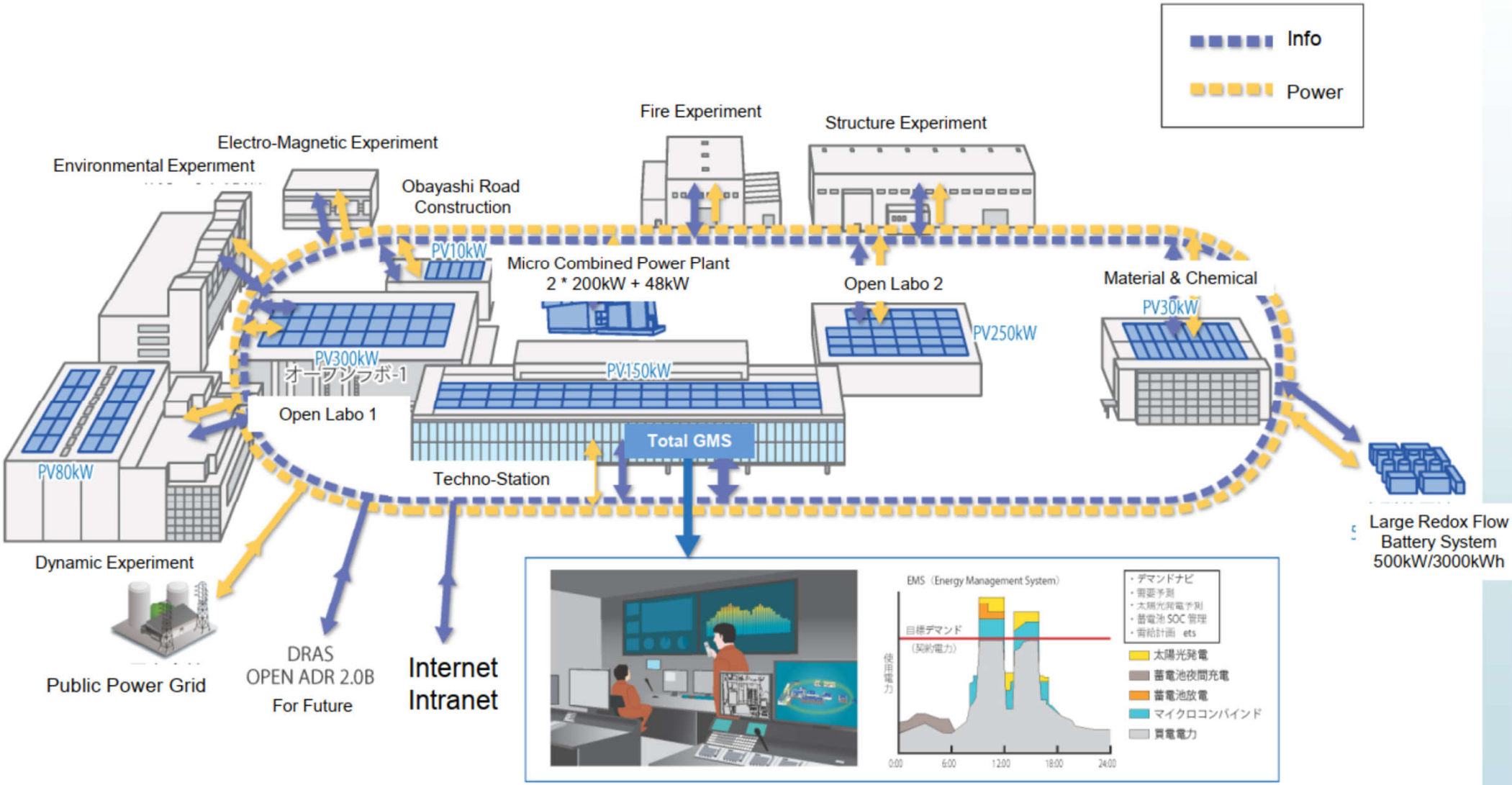


【 Life Cycle CO_2 (global warming effect chart) 】



(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



(Source: https://www.annex40.net/fileadmin/user_upload/annex40.net/documents/Annex40_Workshop_Nagoya_Onojima.pdf)

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/EWostZvC47o
  - 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

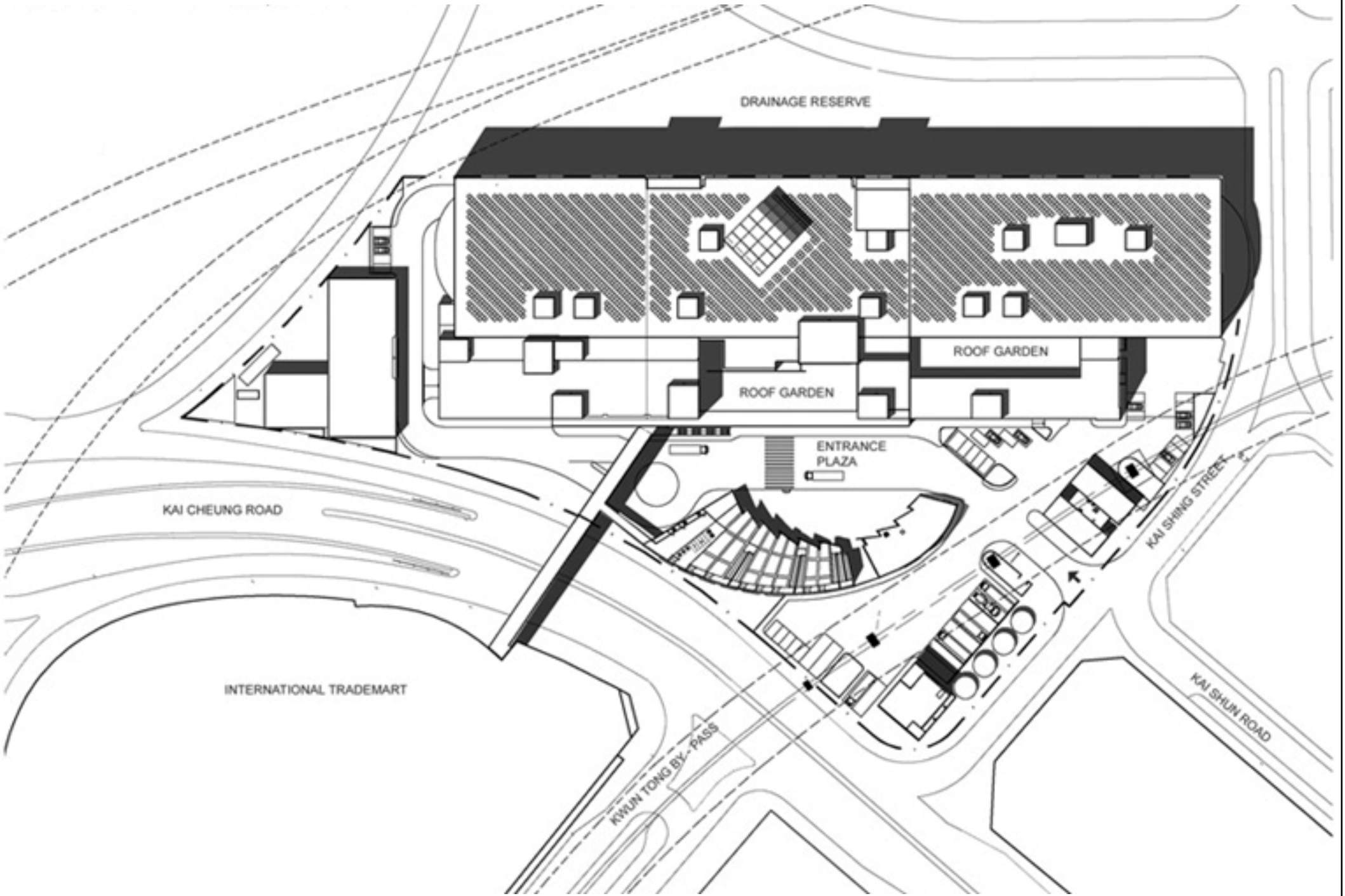
EMSD Headquarters, Hong Kong

- 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

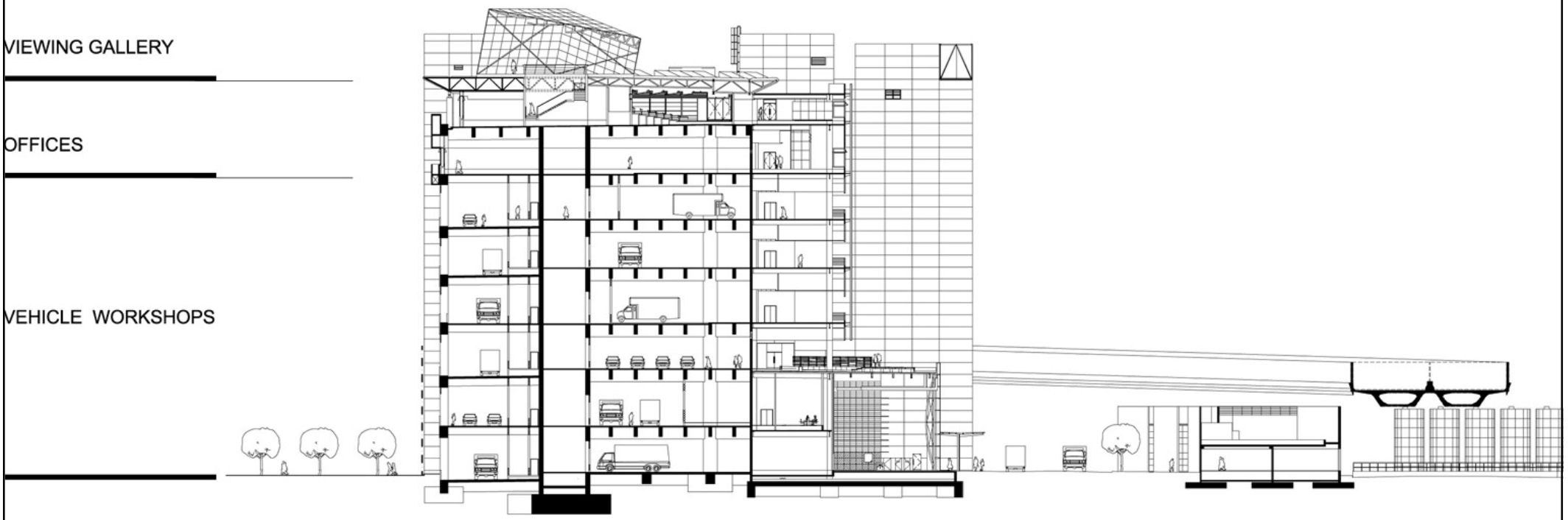
(Source: http://greenbuilding.hkgbc.org.hk/eng/projects/view/24)

Location and layout of the EMSD Headquarters



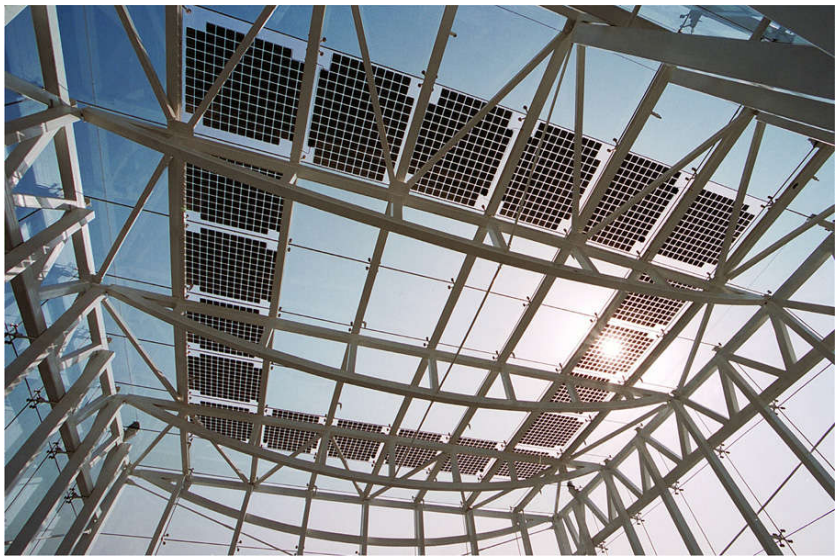
(Source: https://www.archsd.gov.hk/en/exhibition/new-headquarters-for-the-electrical-and-mechanical-services-department.aspx)

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 light-pipes) 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)

(Source: http://greenbuilding.hkgbc.org.hk/eng/projects/view/24; https://www.emsd.gov.hk/en/beam_plus_certification/)

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

One Taikoo Place, Hong Kong

- 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

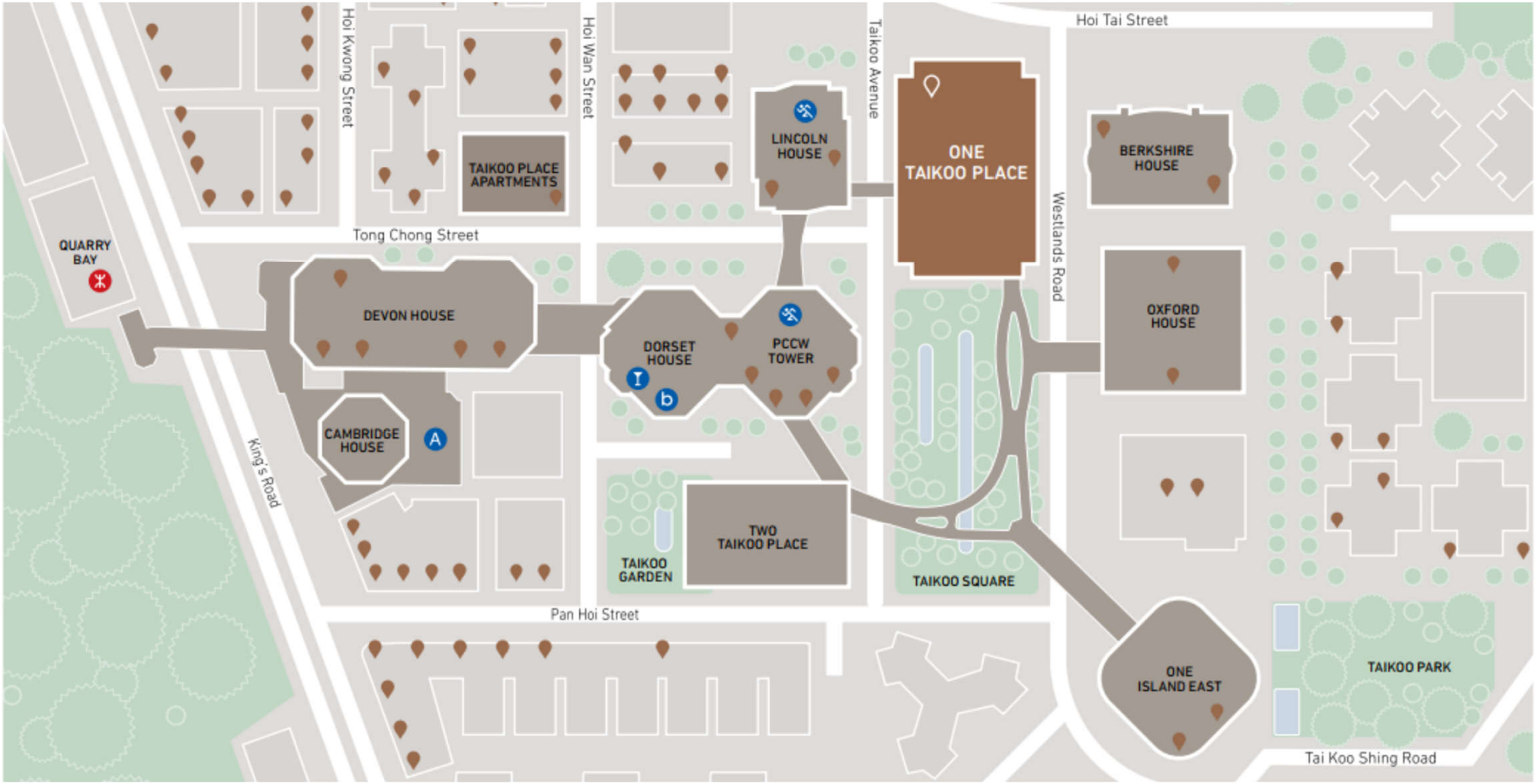
• Low-flow sanitary fittings

Green building assessment results:

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

(Source: https://www.polyu.edu.hk/af/cesef/wp-content/uploads/2019/12/4.-Panel-2_Raymond-Yau-public-version.pdf)

Location of One Taikoo Place and surrounding environment



1. Connecting Places: Elevated walkways and pedestrian friendly streetscapes enhance existing connections to surrounding buildings and transport hubs.
2. Natural Ventilation: Buildings within Taikoo Place have been situated to introduce natural ventilation and cooling breezes.
3. Liveability: 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

Useful Websites

- 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
  https://www.wbdg.org/additional-resources/case-studies
- WorldGBC Online Case Study Library
  https://www.worldgbc.org/case-study-library