



Practical Examples



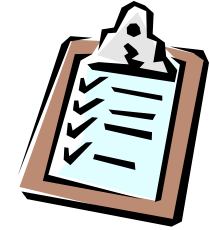
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Contents



- 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



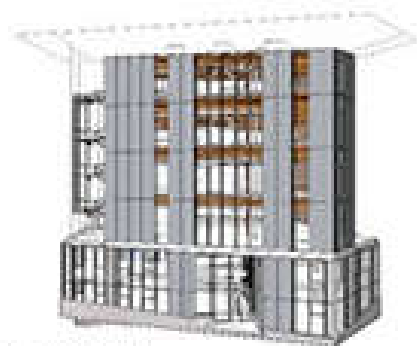
Bullitt Center, Seattle, USA

- 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

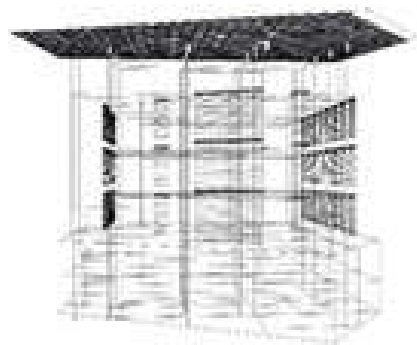
BUILDING LIFE CYCLE



250 YEAR STRUCTURE
HEAVY TIMBER, CONCRETE & STEEL

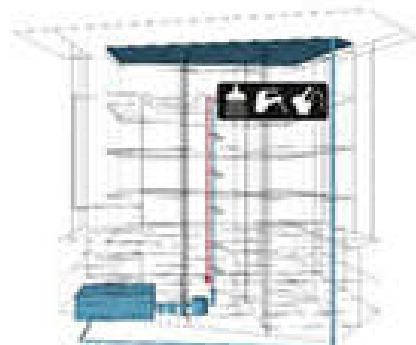


50 YEAR SKIN
HIGH PERFORMANCE ENVELOPE

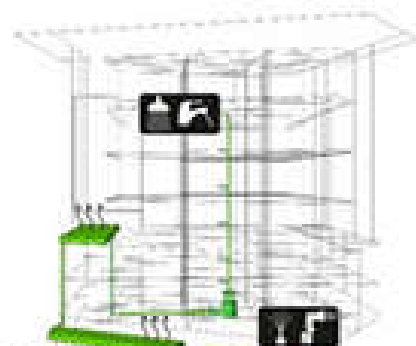


25 YEAR TECHNOLOGY
ACTIVE SOLAR CONTROL
PHOTOVOLTAICS

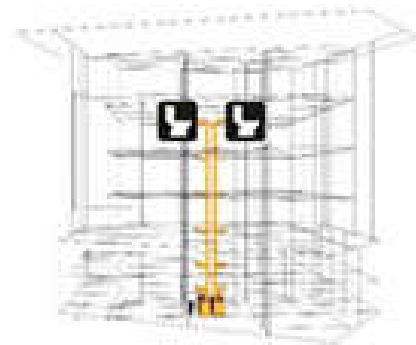
NET ZERO WATER



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

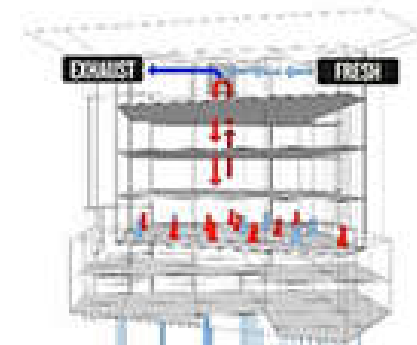


GREYWATER
100% TREATMENT ON SITE
EVAPOTRANSPIRATION & INFILTRATION

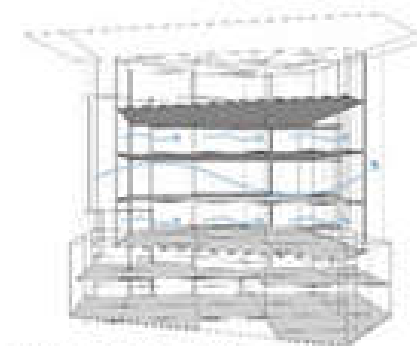


WASTE COMPOST
100% TREATMENT ON SITE

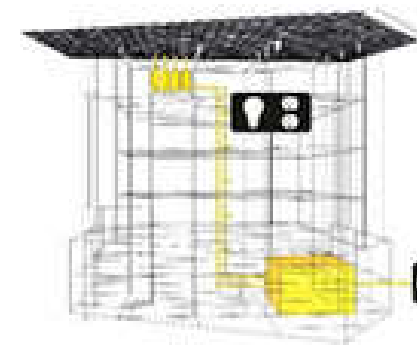
NET ZERO ENERGY



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

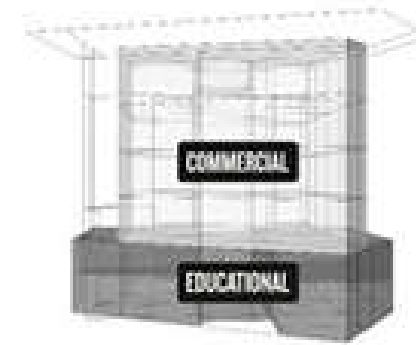


NATURAL VENTILATION
NIGHT FLUSH & OPERABLE WINDOWS

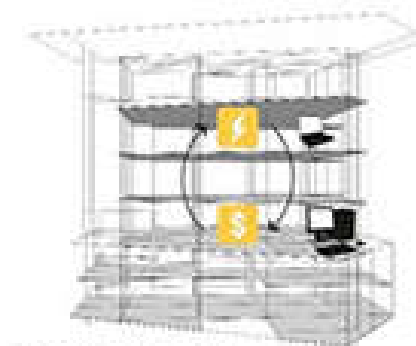


ENERGY
100% RENEWABLE ON SITE
GRID USED AS BATTERY

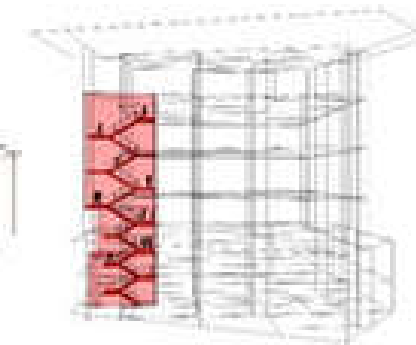
OCCUPANT



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

Even in Seattle, which averages 226 cloudy days a year, this rooftop array of solar panels—which required a variance from the city to stretch out over the sidewalk—is designed to generate a surplus of energy from March through September to power the building throughout the year.

The building's goal of harvesting and treating all water on-site includes wastewater, hence the special toilets whose contents will be composted and decontaminated before being sent off-site for use as fertilizer.

With oversized windows and high ceilings, 82% of the Bullitt Center's lighting is expected to come from the sun.

Solar panels

Lighting system

Composting toilets

For temperature regulation, windows are programmed to open and shut automatically. At night, a system flushes out excess heat and lets in cool air.

An internal cap-and-trade system lets tenants, each of which is given an energy budget, transfer unused energy to another part of the building. Let the bartering begin!



To encourage people to skip the elevator, the staircase overlooks the city's skyline.

The wood

The wood frame is designed to extend the structure's lifespan to 250 years, well beyond the 40 years financiers expect a conventional office building to last. And instead of relying on heavy timber from old-growth forests, the building uses nontoxic glue to bond smaller pieces of wood into larger components strong and stable enough to span the distance between support beams.

The concrete

Ordinary concrete is bound with a substance called Portland cement, which alone is responsible for an estimated 7% of global CO₂ emissions. To shrink the Bullitt Center's carbon footprint, the builders used fly ash to replace a good bit of the cement, reinforced the concrete with rebar that is roughly 95% post-consumer recycled steel and steered clear of the harmful chemicals commonly used to improve the workability of the mix.



With on-site filtration and room to store 56,000 gal. of rainwater, the Bullitt Center can provide all of its own water except the kind people drink. The latter won't happen unless the city changes its codes for potable water.

Underground cistern

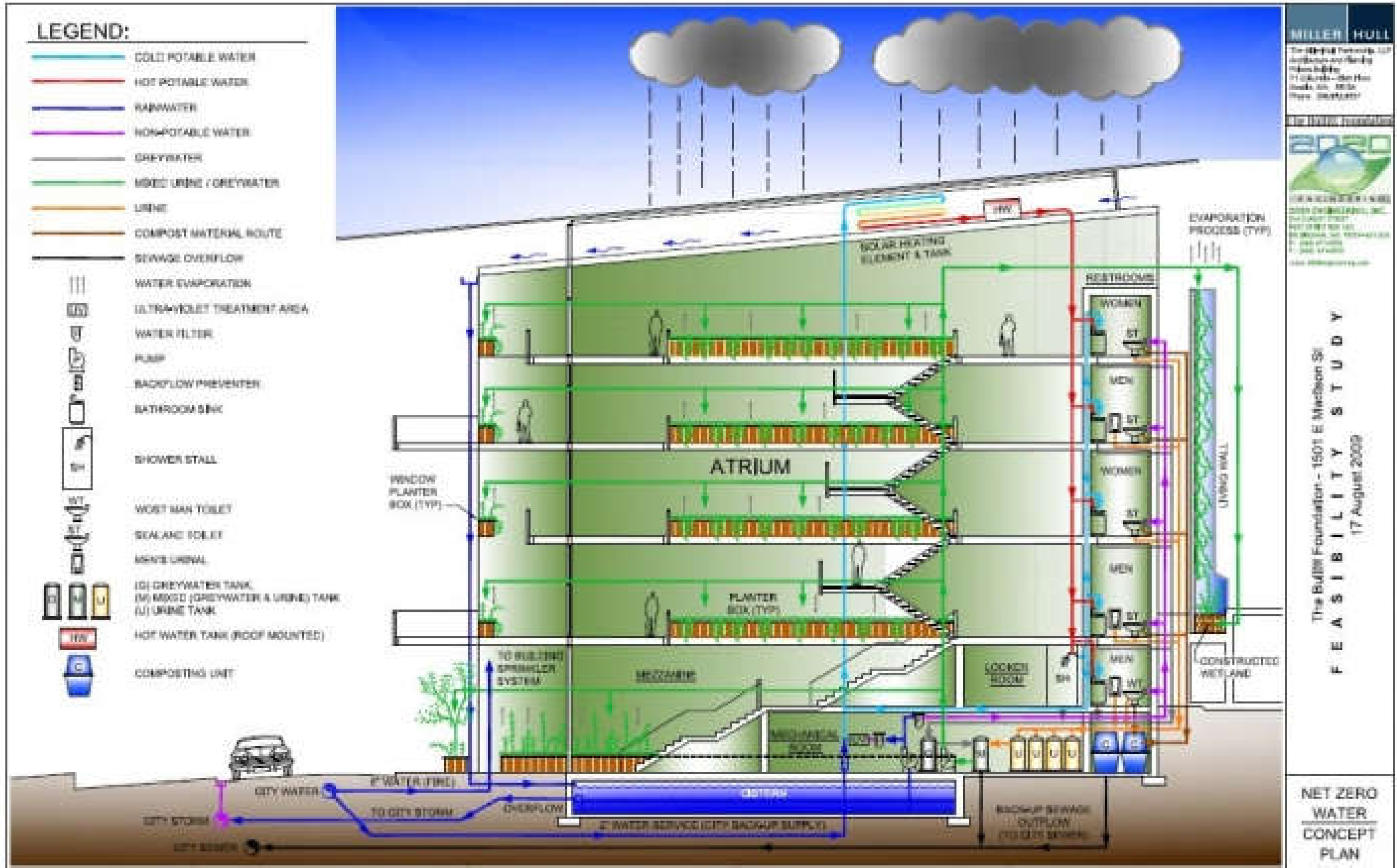
Heating system

Since heating is typically responsible for 40% of a building's energy use, a key feature in the Bullitt Center's quest for self-sufficiency is its system of 26 geothermal wells, each 400 ft. deep, to warm it up in the winter and help cool it down in the summer.



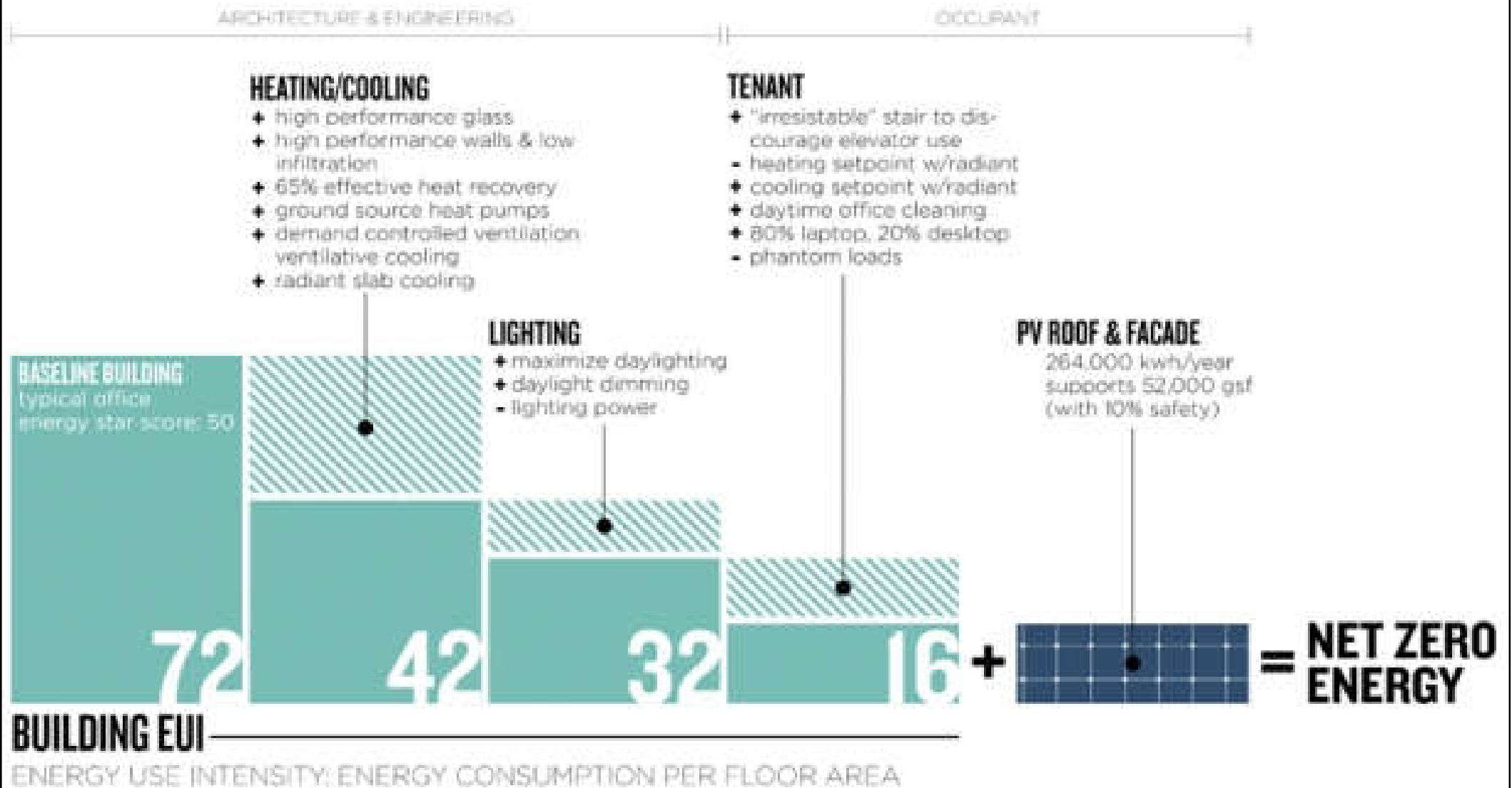
Green building features of Bullitt Center

Bullitt Center: net zero water concept plan



(Source: https://www.solaripedia.com/13/410/6336/bullitt_center_living_building_feasibility_diagram.html)

Bullitt Center: the path to net zero energy



THE PATH TO NET ZERO ENERGY

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

PIXEL

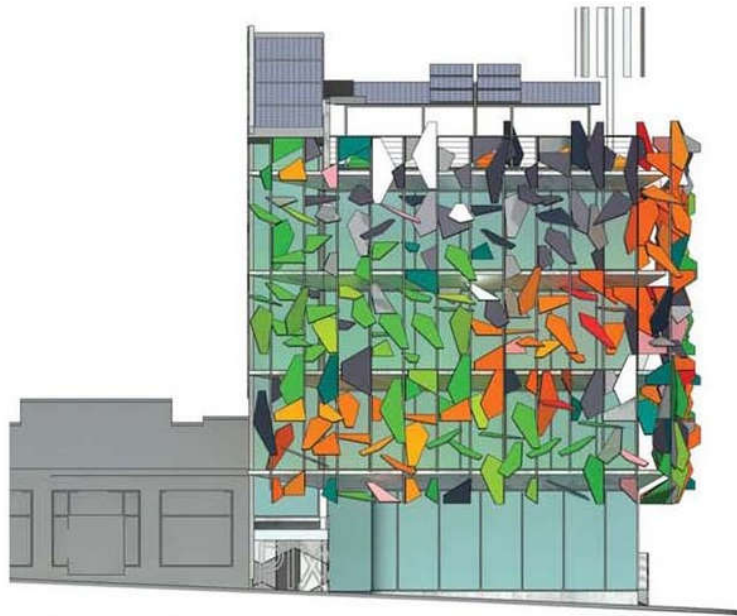
- General information: <https://www.pixelbuilding.com.au/>
 - Location: Melbourne, Australia (former Carlton Brewery site)
 - New Construction (commercial offices)
 - Gross floor area 1,136.4 sq.m, 4 storeys
 - Total Building Cost: AUD \$6 million
 - Completion Date: July 2010
 - Project objective: carbon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

Pixel Building, Melbourne, Australia



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

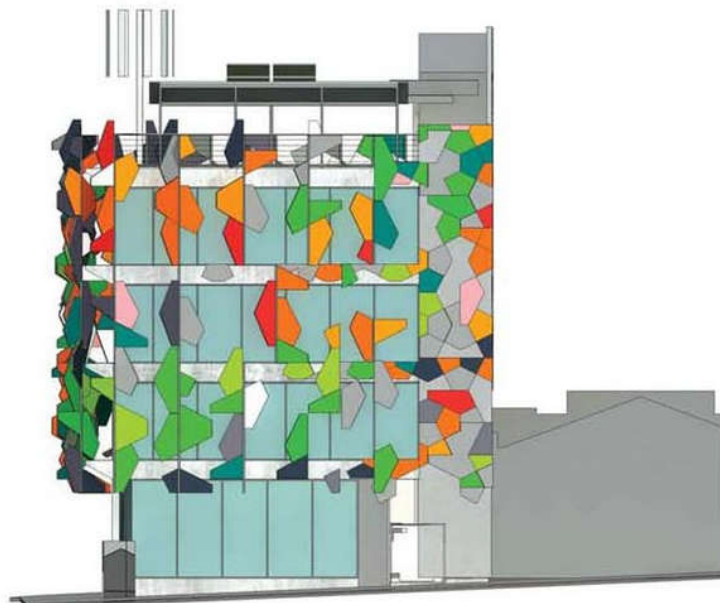
Pixel building – elevations and facades



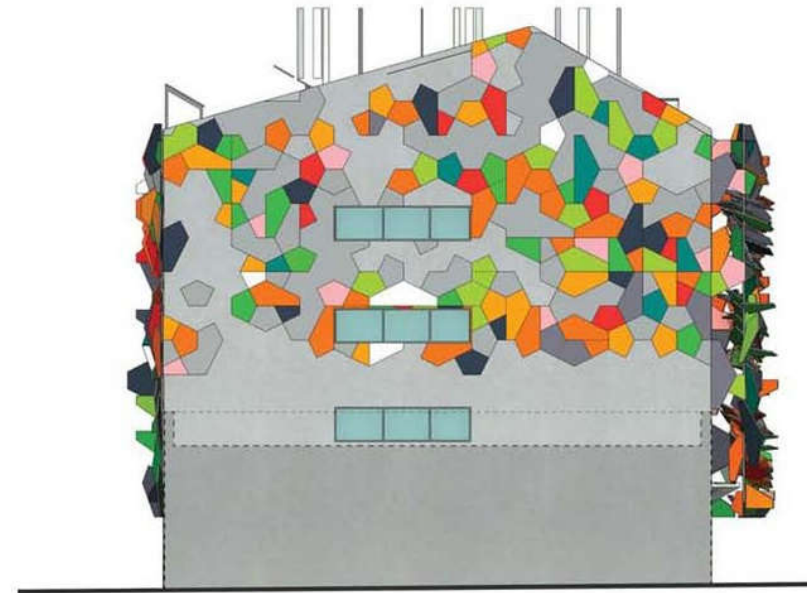
North Elevation



West Elevation



South Elevation



East Elevation

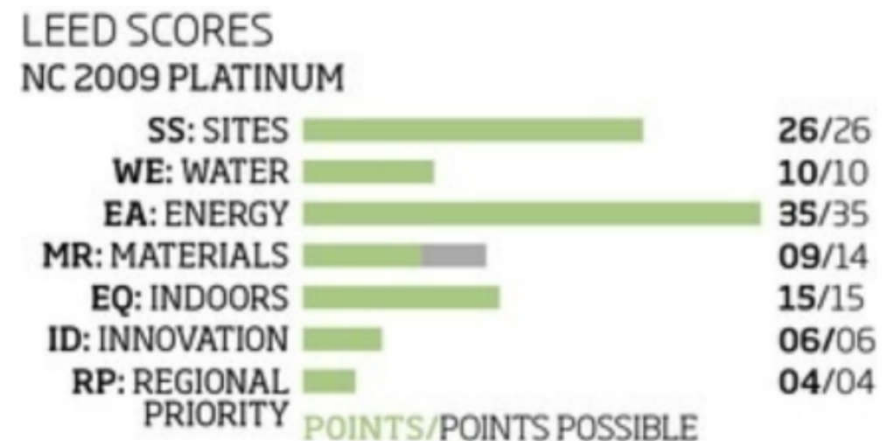
Pixel innovations, green features and achievements

Carbon neutral
Water balanced
100% fresh air system
Ammonia refrigeration
Chilled structure
Green roof
Photovoltaic & wind power generation
Reed bed water treatment

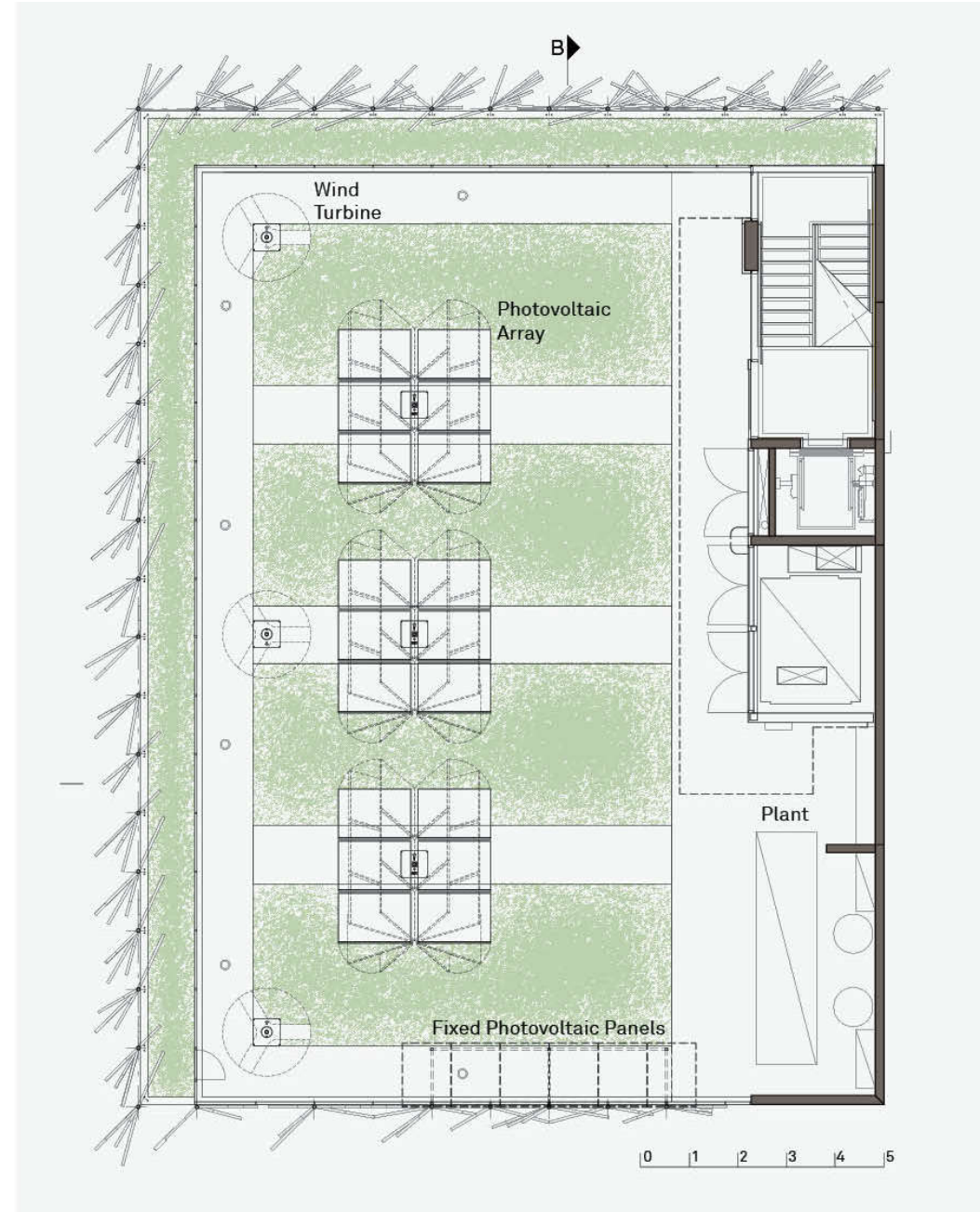
Reliance on natural daylight
Green concrete
Gas fired absorption chillers
Extensive recycling
Free night cooling
Bio-gas energy
High performance façade

Green building assessment results:

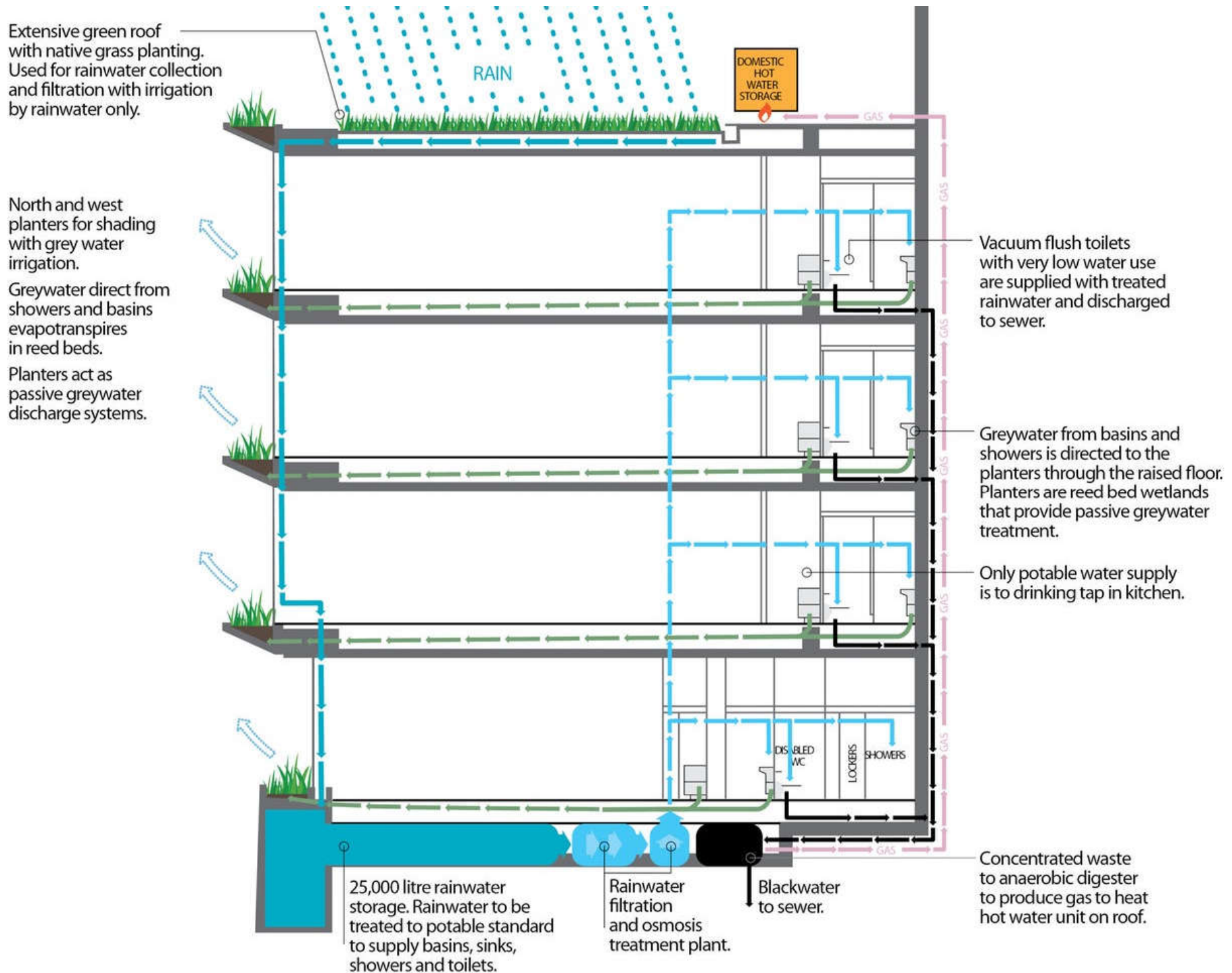
- 6 star Green Star Australia (105 points, full perfect)
- LEED Platinum (105 points, highest rating in the world)
- BREEAM outstanding



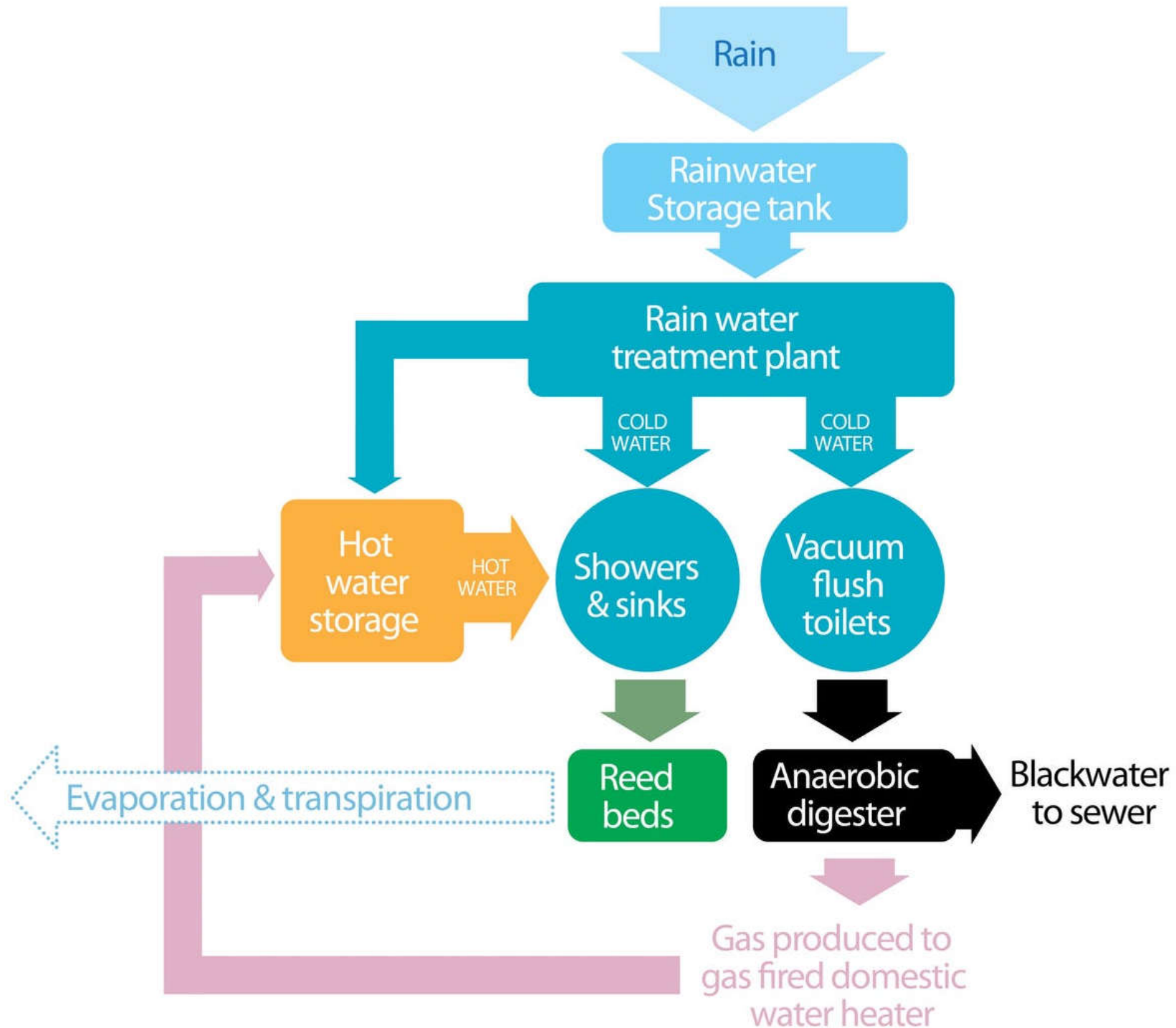
Pixel building: green roof and renewable energy systems



Pixel water cycle



Pixel rainwater harvesting



Pixel Building, Melbourne, Australia

PIXEL

- 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/>

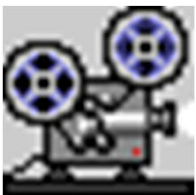
- Carbon neutral offices - The Pixel Building Case Study

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

PIXEL

- 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/Q9M7HVVXeGKA>
臺北市立圖書館北投分館(英文簡介影片) (14:39) <https://youtu.be/fyI2d7VWjQ0>

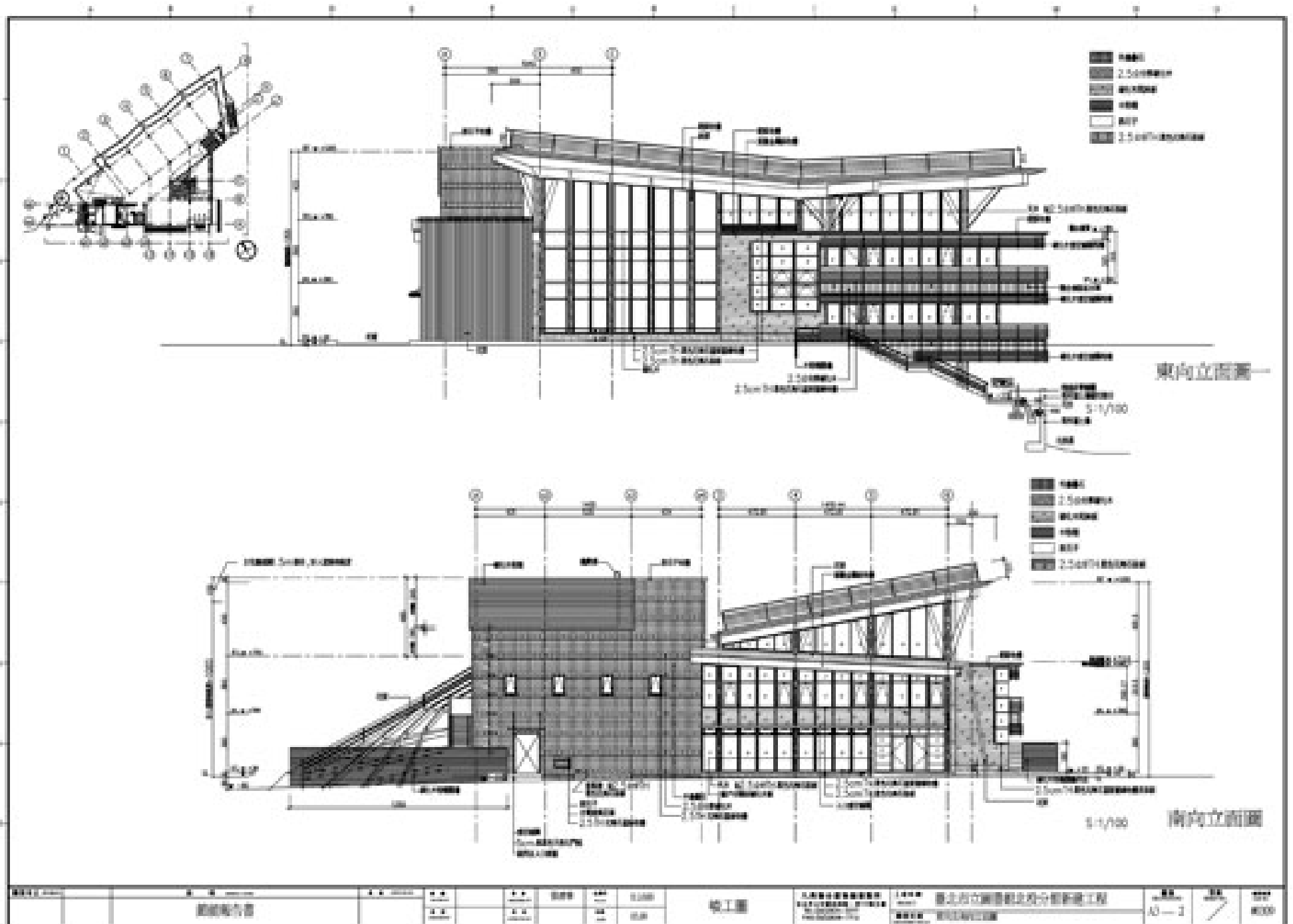
(Source: http://twgbqanda.com/english/e_gbt.php?Type=14&menu=e_gbt_class)



ASHRAE Hong Kong Chapter – Taiwan Study Tour 2007



Taipei Public Library, Beitou Branch – design drawing



Green features of Taipei Public Library, Beitou Branch

- | | |
|---|--|
| <ol style="list-style-type: none">1. Eco roof (extensive type)2. Variety of garden plants deriving biodiversity from nature3. Multiple layers of greenery on south side, lowering ecological impacts onto surrounding park4. Photovoltaic (PV) modules (16 kW)5. Rainwater recycling system6. Wooden lattice frames with ecromat for greenery cultivation7. Clustered service space modules on west side, enhancing electromechanical efficiency while conserving pipeline kinetics | <ol style="list-style-type: none">8. Availability of materials recycling area9. Natural lighting and ventilation10. Outdoor reading platforms with wood-tiled boardwalk11. Porous vegetative walls with floral greenery, attracting honeybees & butterflies12. 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/f070/31223fad758af90a83fde31cdc155b889d6e.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



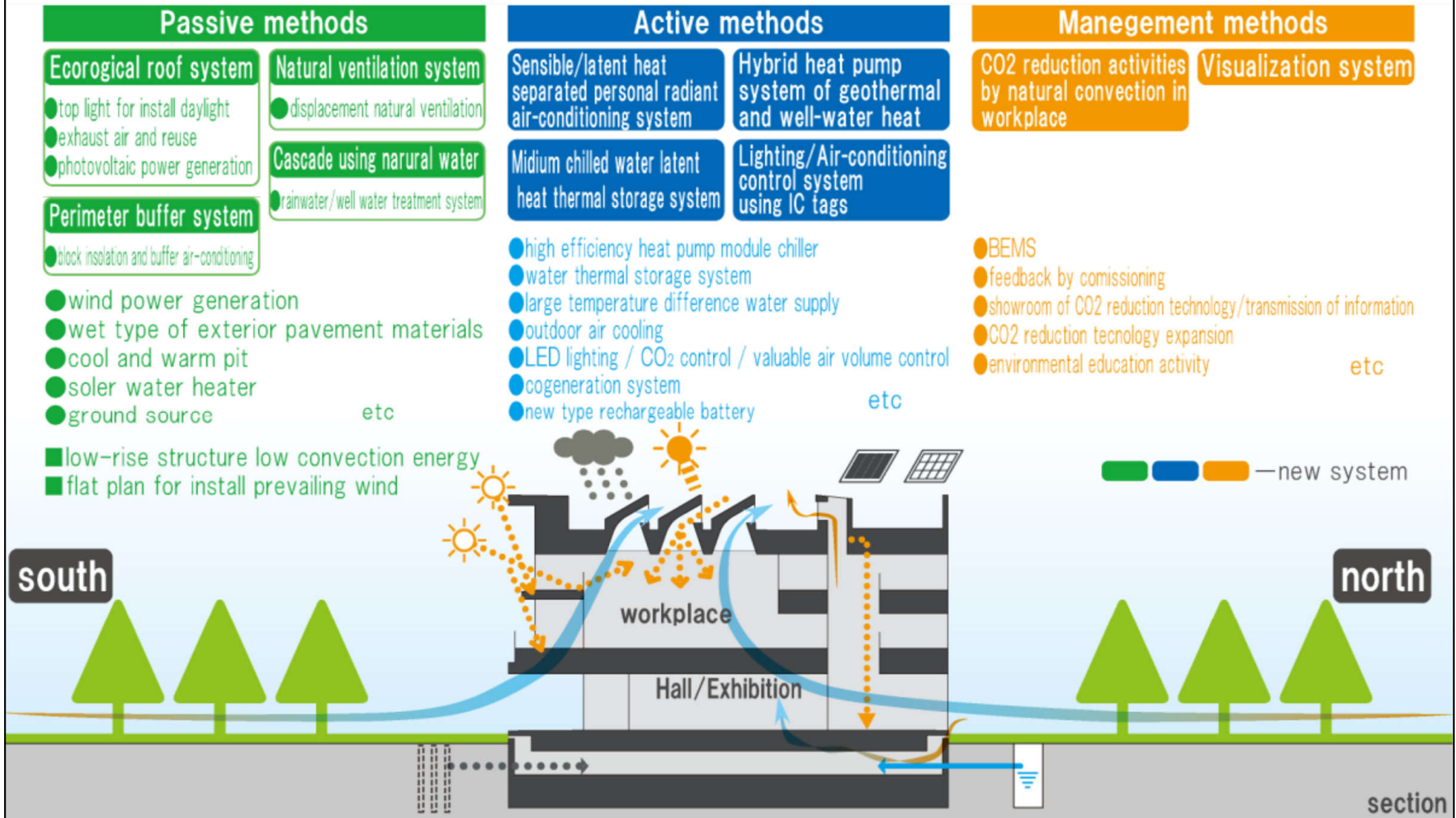
(Source: <https://www.usgbc.org/projects/techno-station-obayashi-corporation>)

ASHRAE Hong Kong Chapter Japan Study Tour 2018



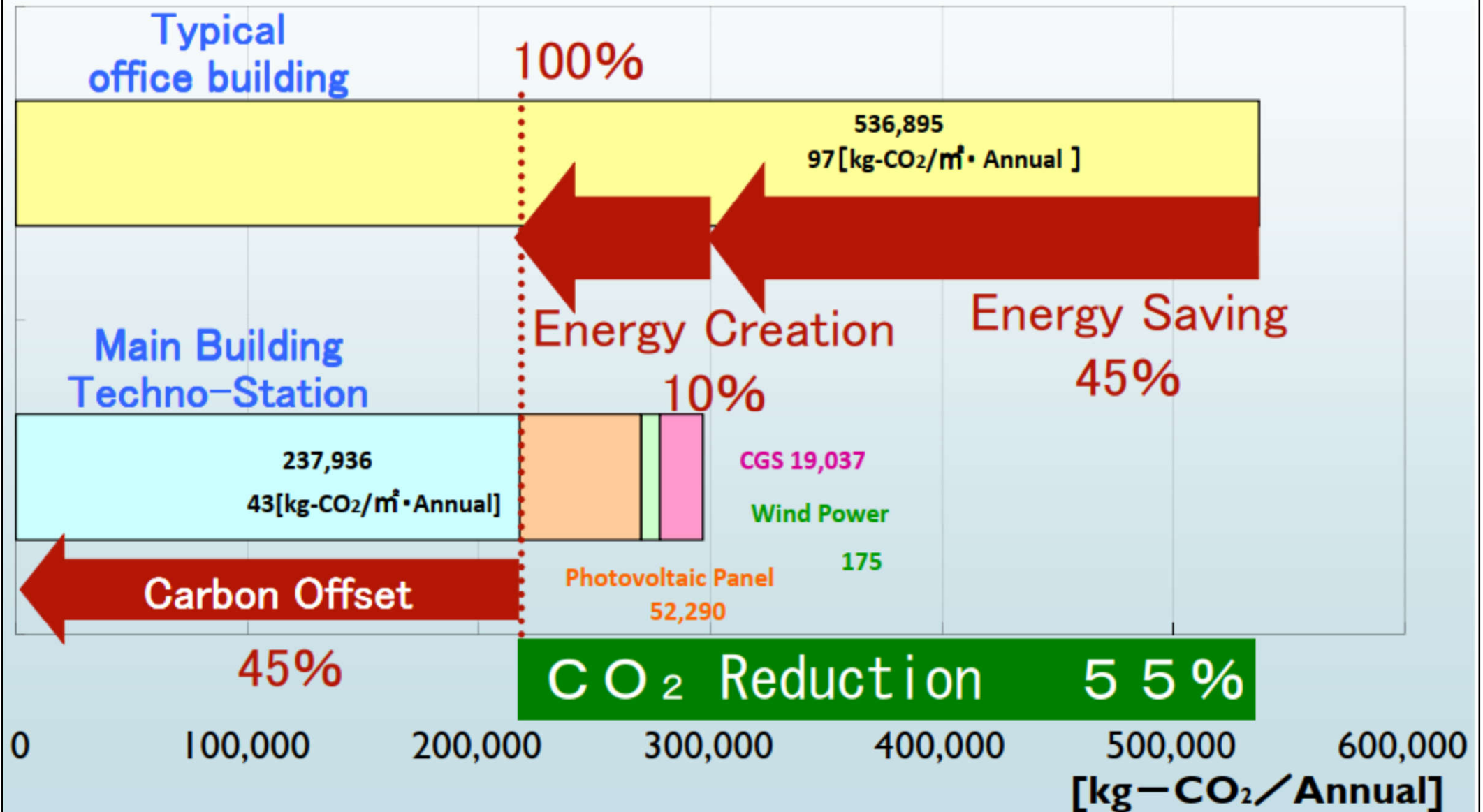
Obayashi Technical Research Institute, Japan

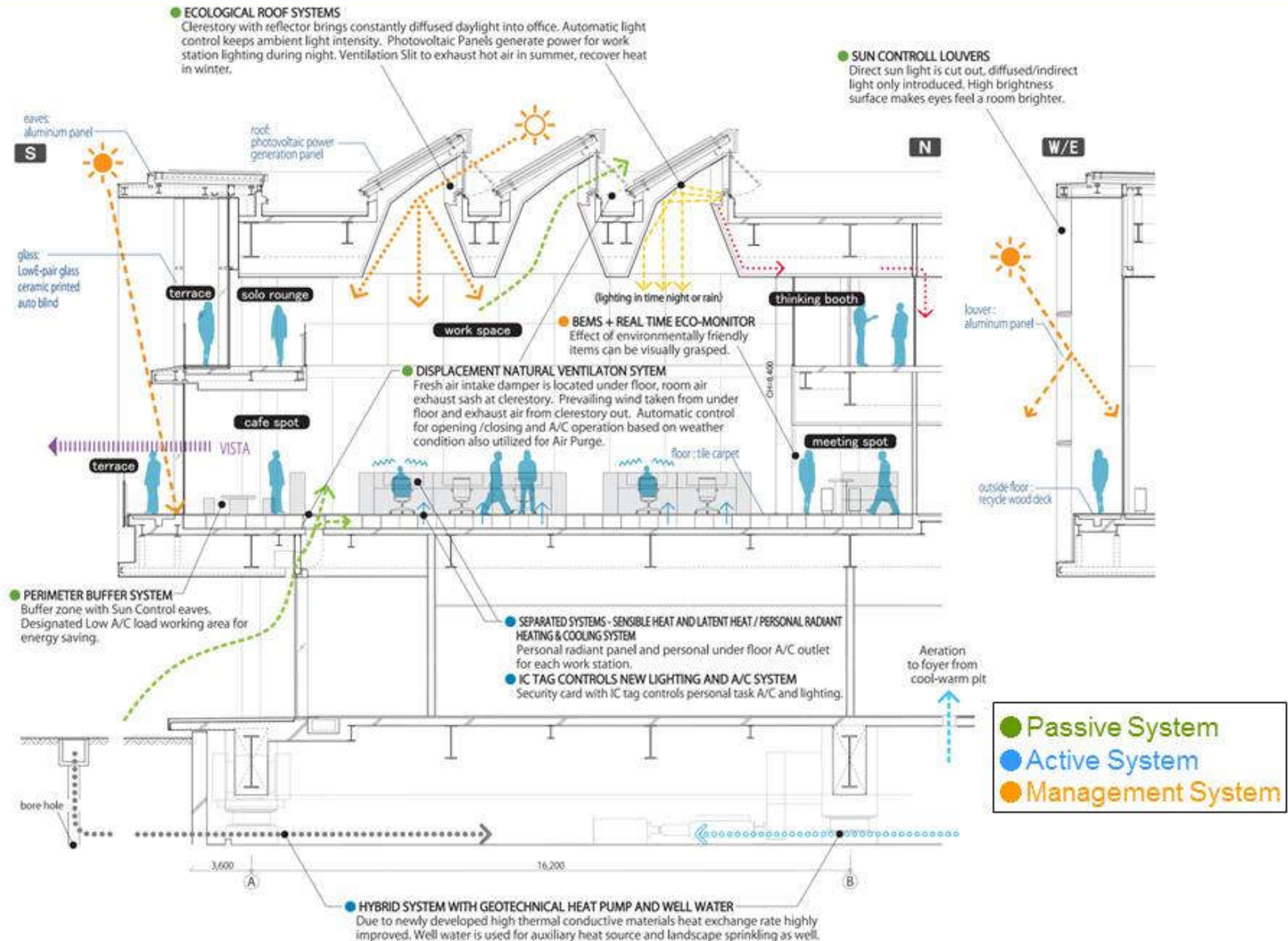
Map of technologies of CO₂ reduction



Obayashi Technical Research Institute, Japan

CO₂ emission reduction (design value)





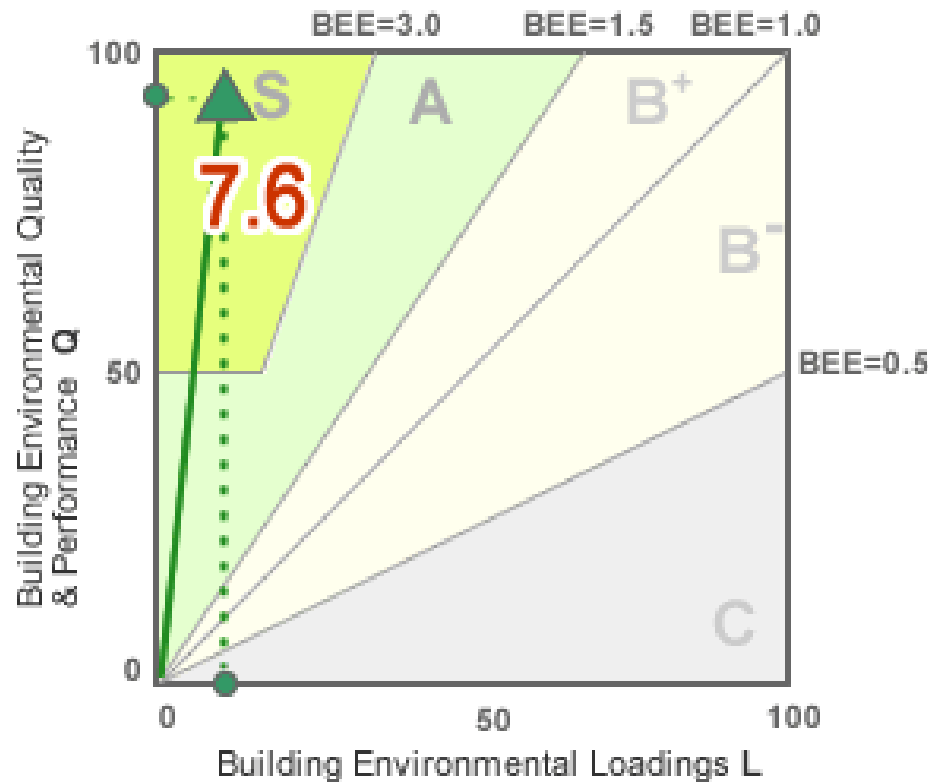
Obayashi Technical Research Institute, Japan – CASBEE score

CASBEE
RANK

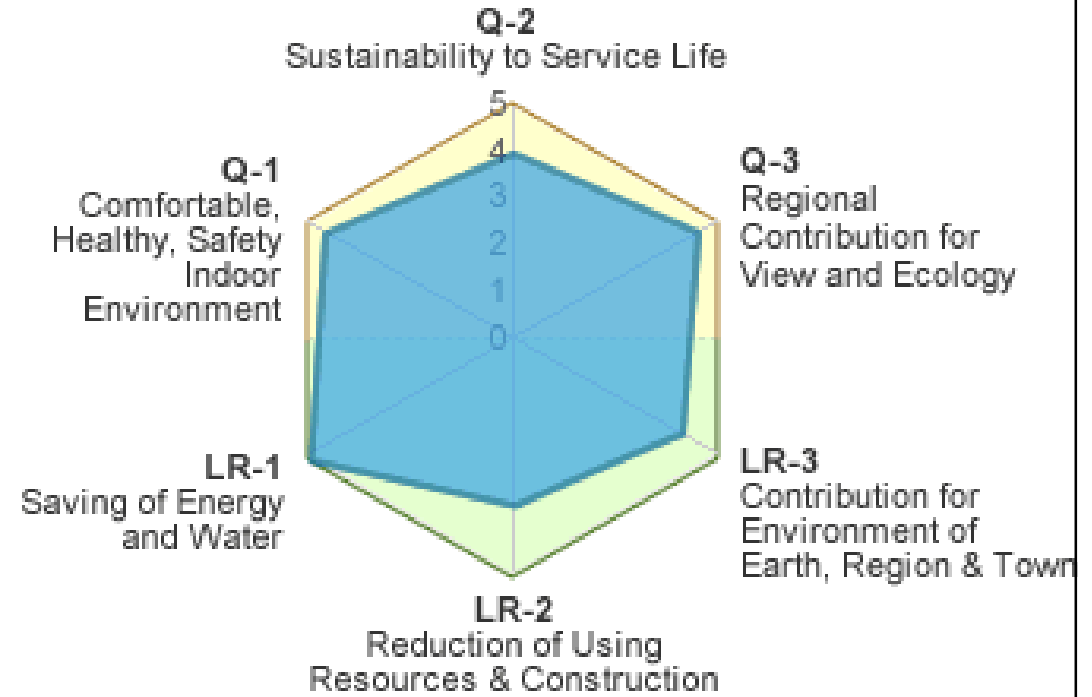
S ★★★★★

TOOL: CASBEE for New Construction (2008 edition)

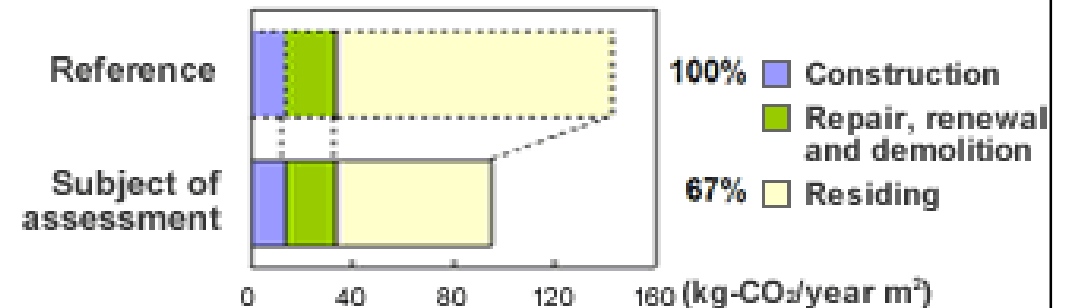
【 BEE: Building Environmental Efficiency 】



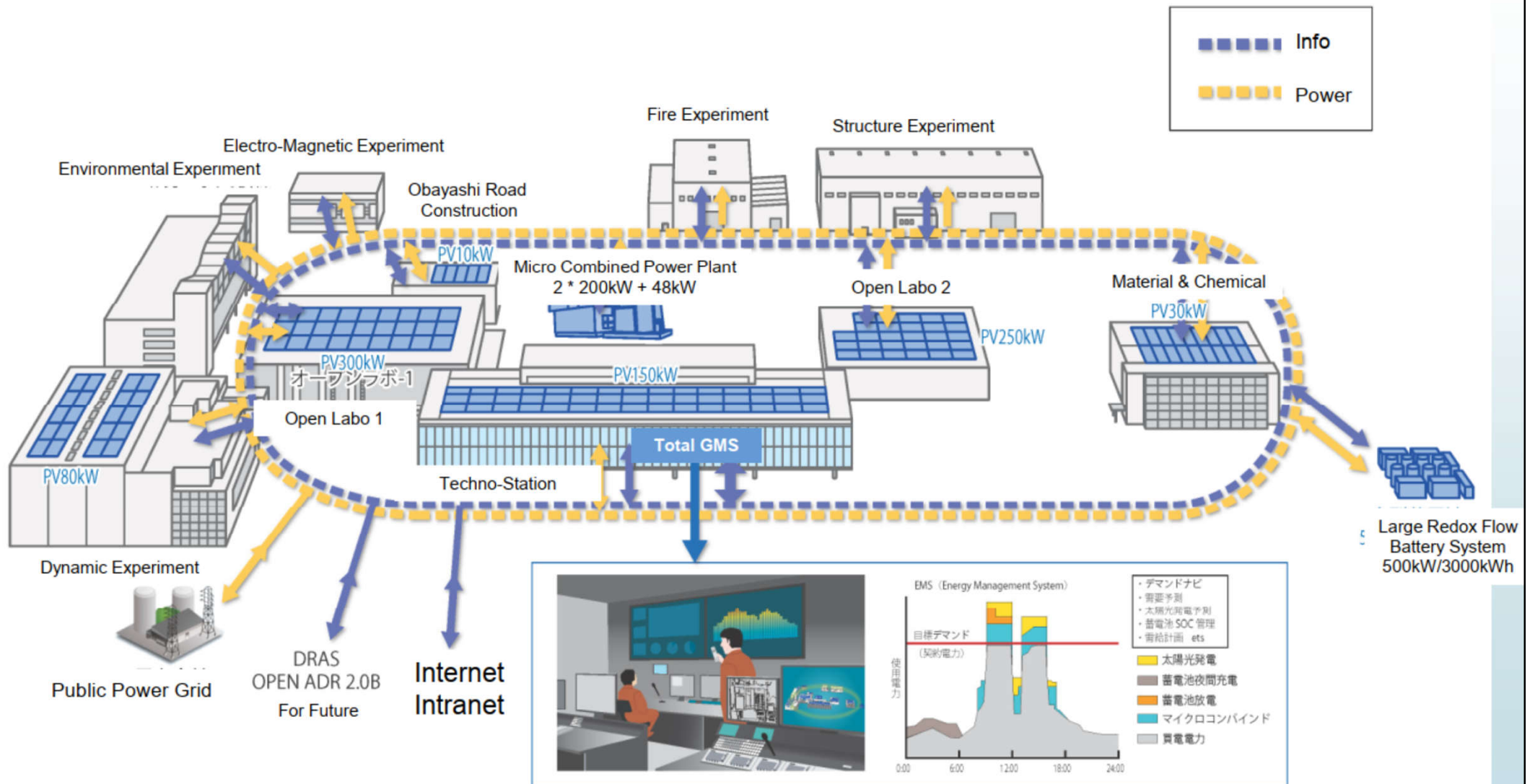
【 Radar Chart 】



【 Life Cycle CO₂ (global warming effect chart) 】



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/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



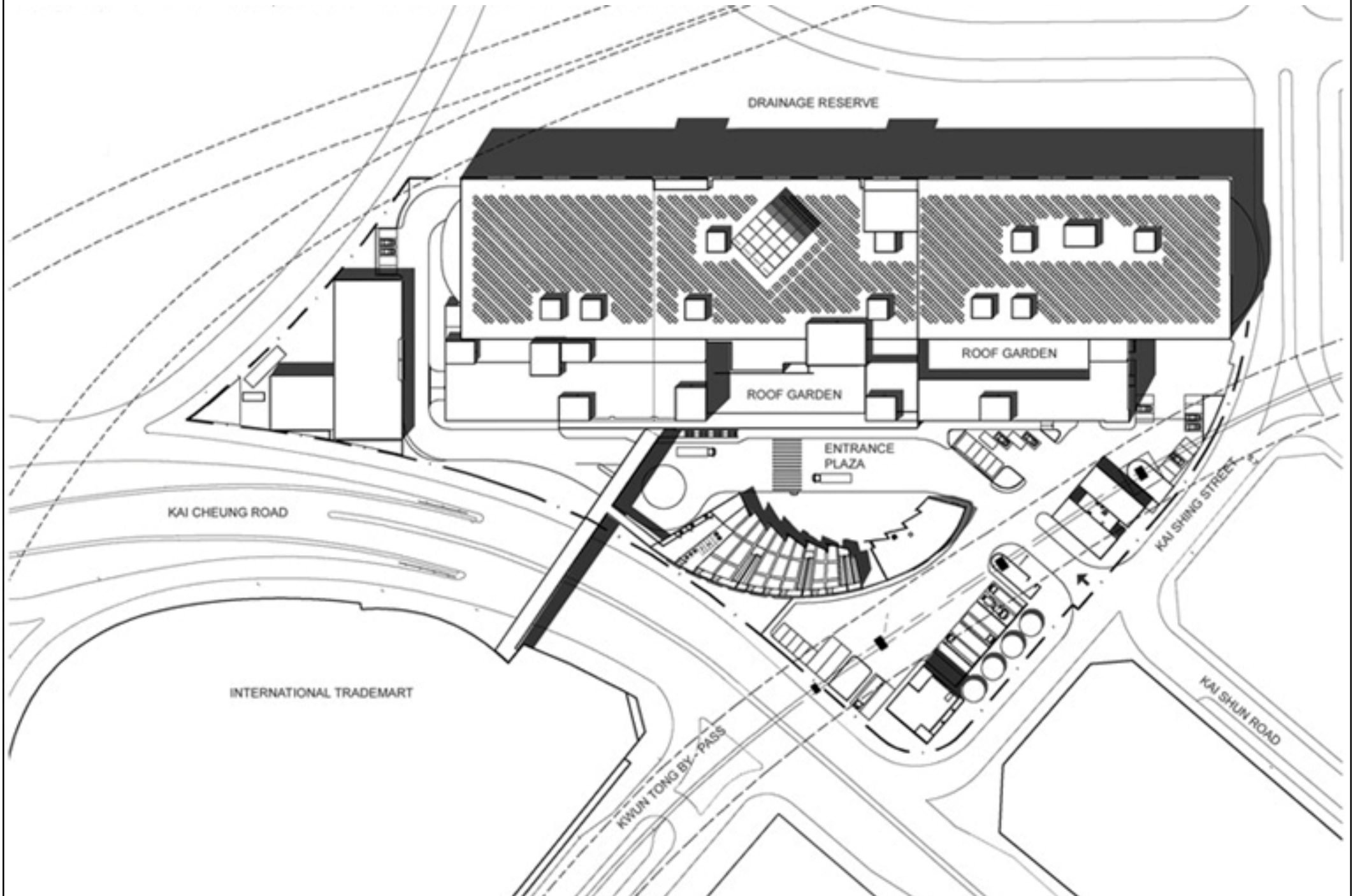
- General information:
 - Location: Kowloon Bay, Hong Kong
 - Reuse of former HACTL cargo terminal building
 - Completion and in operation since 2005
 - Existing building (offices, workshops, car parks)
 - Gross floor area 74,000 sq.m, 8 storeys
 - Sustainable upgrade of existing buildings
 - Use BIM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

EMSD Headquarters 機電工程署總部大樓

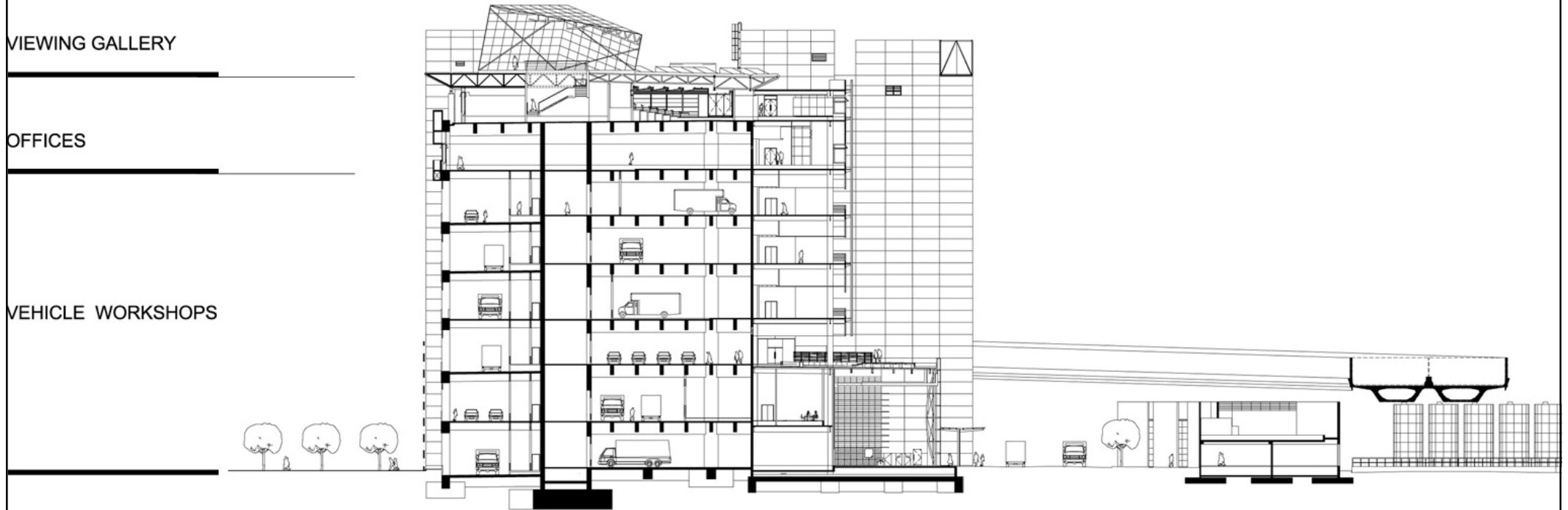


(Source: <http://greenbuilding.hkgbc.org.hk/eng/projects/view/24>)

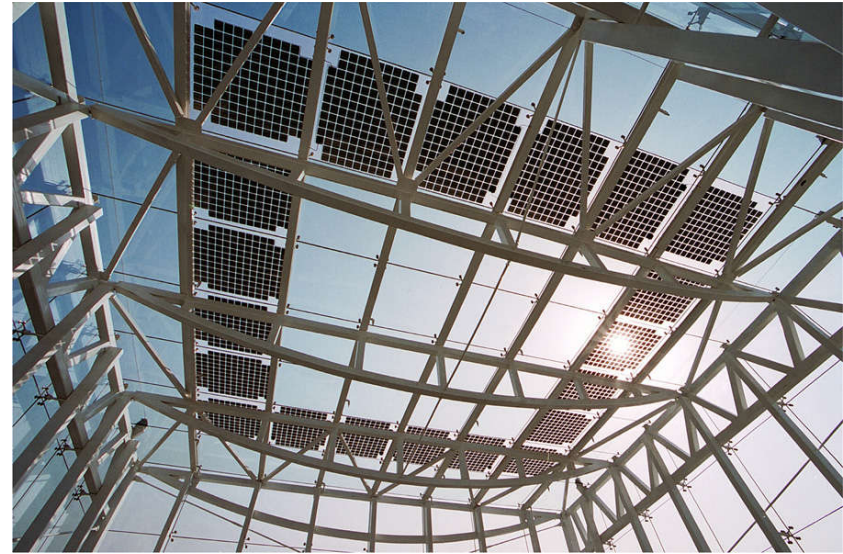
Location and layout of the EMSD Headquarters



Section plan and transformation of the EMSD Headquarters



PV system and interior spaces of the EMSD Headquarters



Green features of EMSD Headquarters

- | | |
|---|--|
| <ol style="list-style-type: none">1. Water-cooled ammonia chiller2. Oil-free magnetic bearing chiller3. Ice thermal storage system4. Displacement ventilation at terminal side5. Daylight & motion sensor for lighting control6. Photovoltaic panels | <ol style="list-style-type: none">7. Solar hot water system8. Sun pipes (as known as light-pipes)9. Double layer curtain wall10. External façade shading11. Grey water recycling12. Vertical greening13. 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 runoff 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/qlcCVY3RnV4>

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

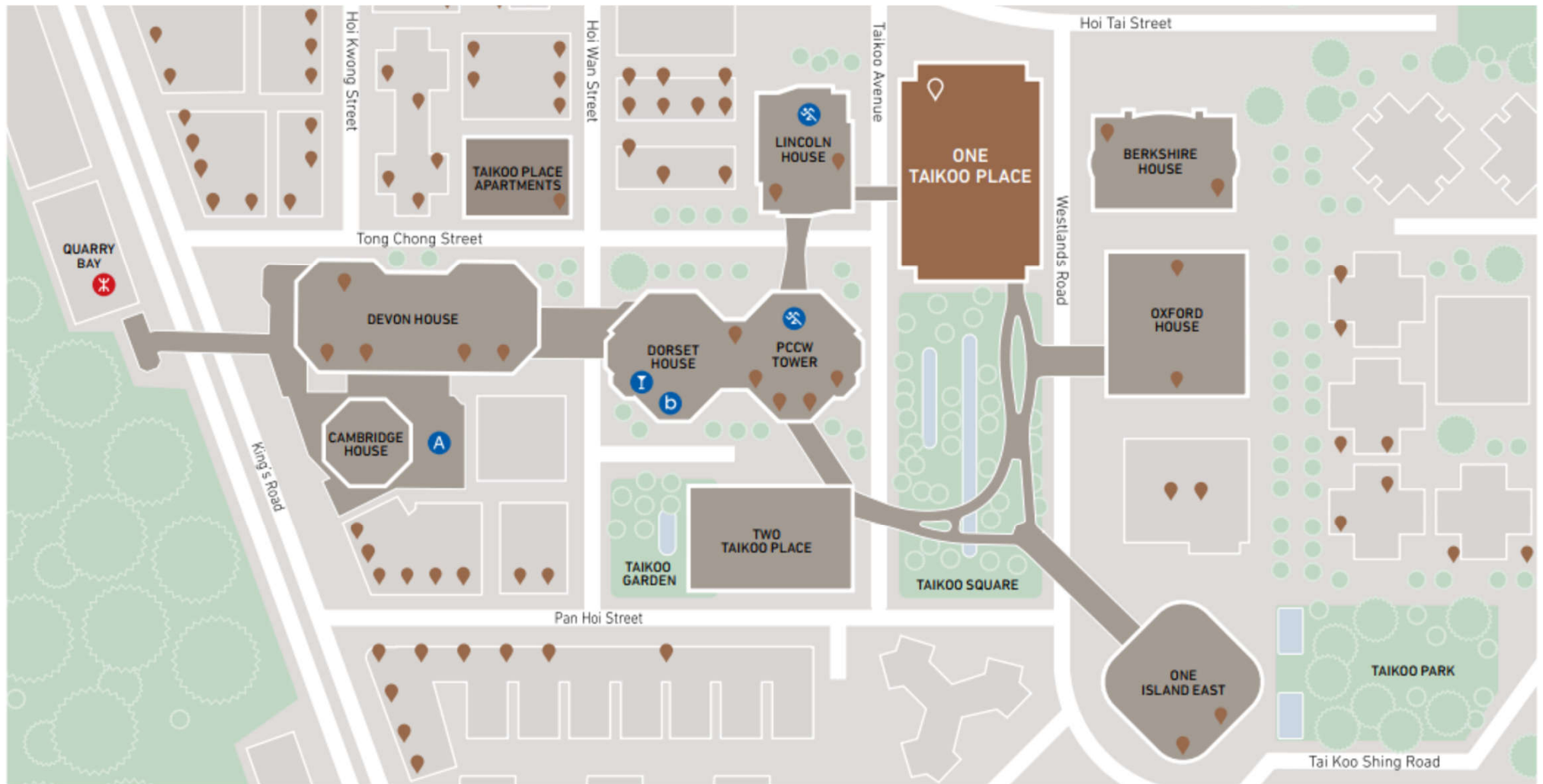
3. Sustainable Water and Wastewater Management

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

Green building assessment results:

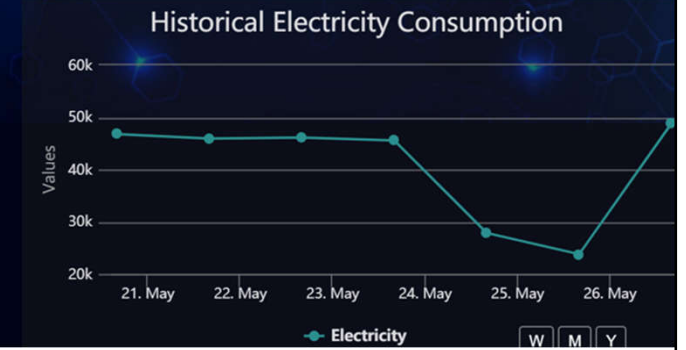
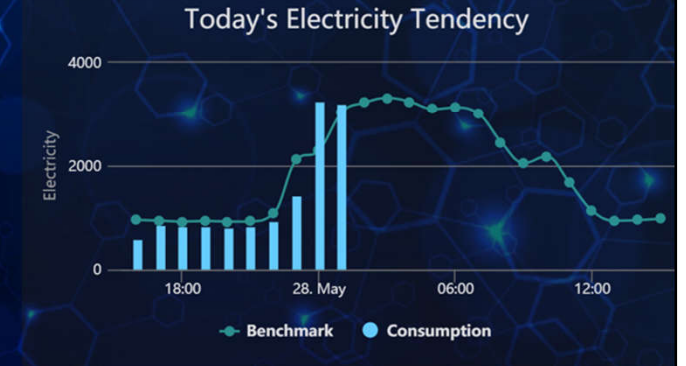
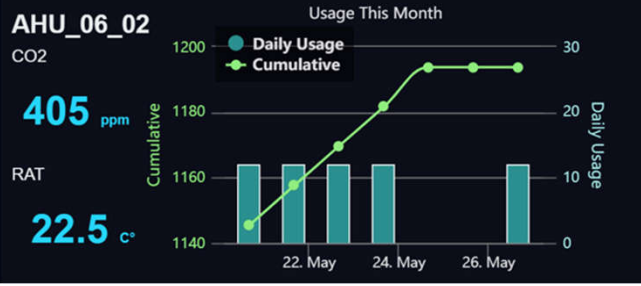
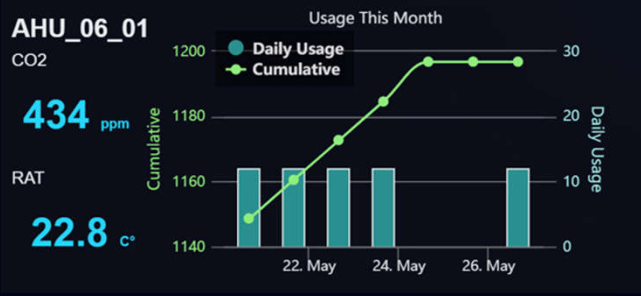
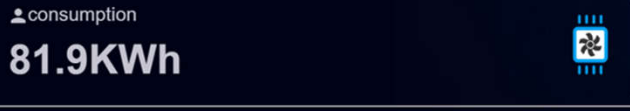
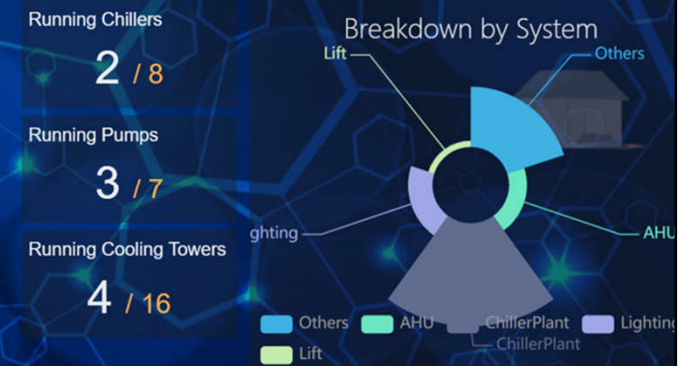
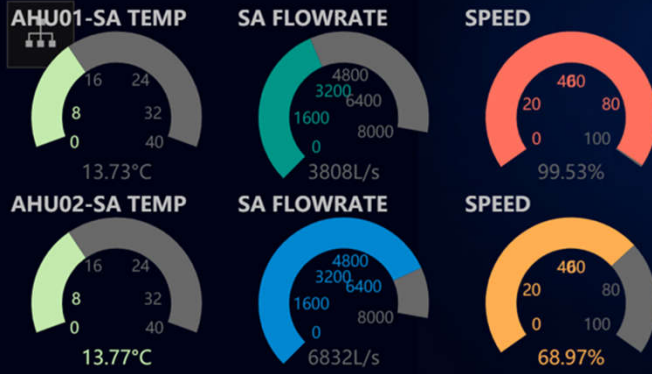
- BEAM Plus New Buildings v1.2 Platinum (score 86)
- LEED Core & Shell 2009 Platinum (score 91)
- WELL v2 Certification Platinum

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.

Neuron AI smart building system at 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>