

Sustainable Facades: Multimodal System

...,the building envelope remains a crucial element of architecture (in fact, perhaps one the most crucial elements), but its performance occurs through the literal and material embodiments of economic, technological, and environmental contingencies rather than through the dialectics of superficial, ornamental representation.

By Zaera-Polo & Anderson



Kyoung Hee Kim PhD AIA NCARB
Professor of Architecture
Director of Integrated Design Research Lab
Ravin School of Architecture
UNC Charlotte

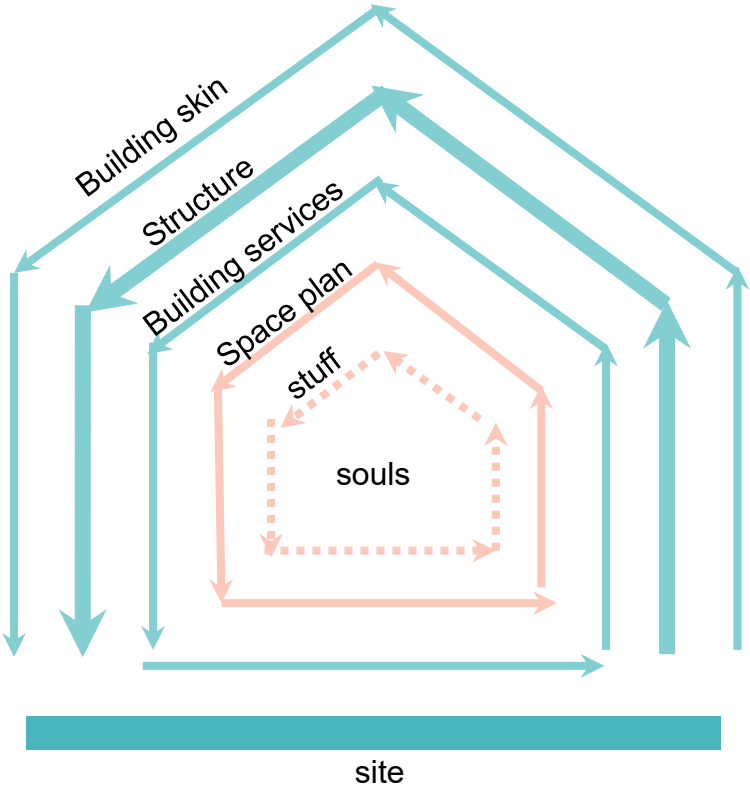
Functions of Sustainable Building Envelopes

Protect-Promote-Re/Generate



Functions of Sustainable Building Envelopes

Protect-Promote-Re/Generate



Shearing layers	Description	Typical lifespan/activity
Site	Location and context	Permanent
Structure	Framework	30-300 years
Skin	Enclosures	20+ years
Services	Lifeblood	7-20 years
Space plan	Interior layout	3 years
Stuff	Furniture/equipment	Under 3 years
Souls		Daily

Shearing layers of change | Brand, 1994

Functions of Sustainable Building Envelopes

Protect-Promote-Re/Generate

Protect

Structural performance
a. Strength
b. Serviceability
Energy requirement
- Heat Transmission
- Solar Heat Gain
- Daylighting illumination
- Air Infiltration
Water proofing
Durability
Life safety
Impact resistance
OSHA requirements
Condensation resistance
Acoustic protection (OITC)
Bird anti-collision
Sea turtle protection
Blast resistance

Promote, Re/Generate

Indoor Environment Quality
- Glare control
- View-out/daylight illumination
- good air quality
Biophilic quality
Renewable energy generation
Carbon Sequestration
User experience
Aesthetics

PROTECT

Functions of Sustainable Building Envelopes

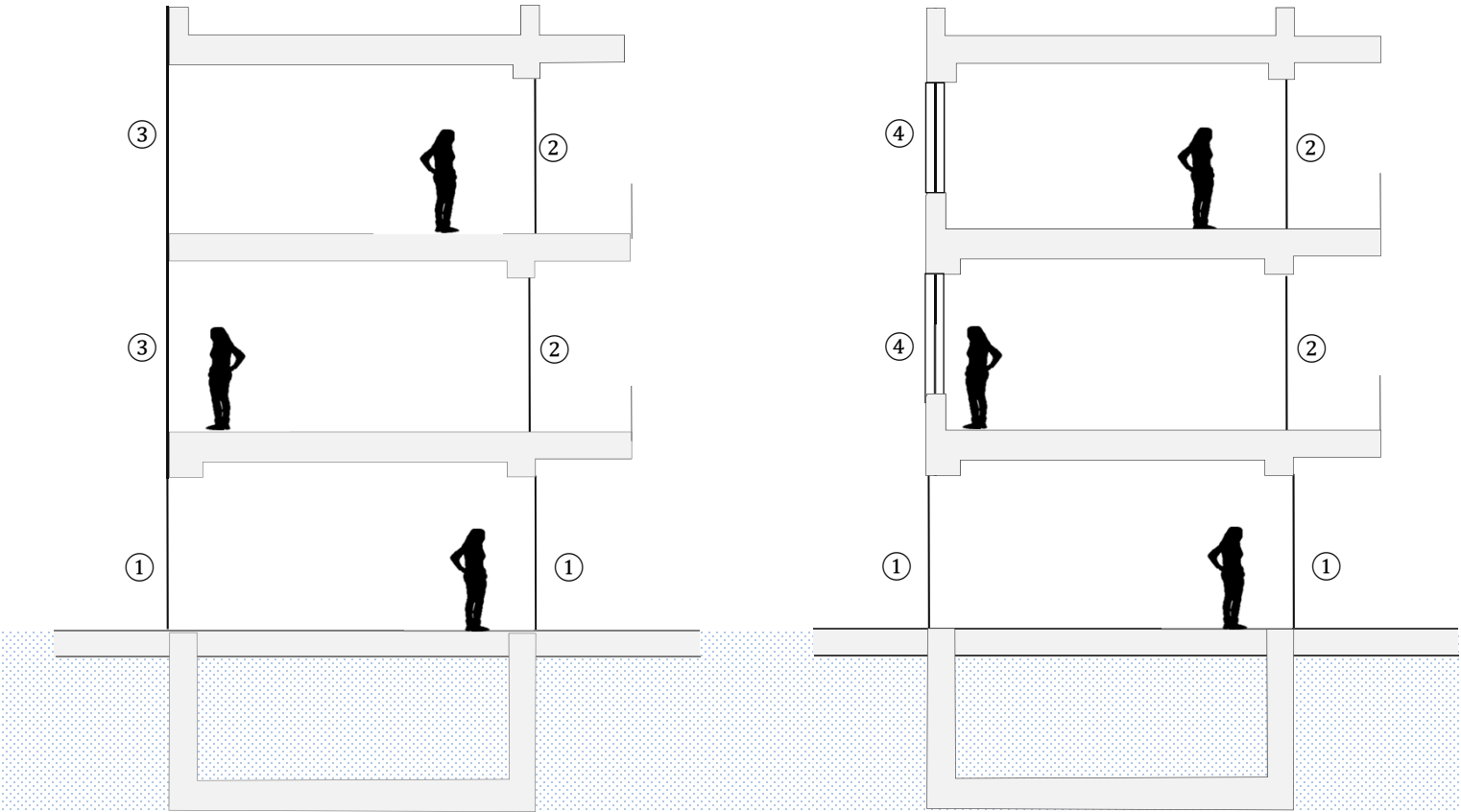
Protect-Promote-Re/Generate

Glazed Envelopes

- ① Storefront
- ② Window wall
- ③ Curtainwall
- ④ Window

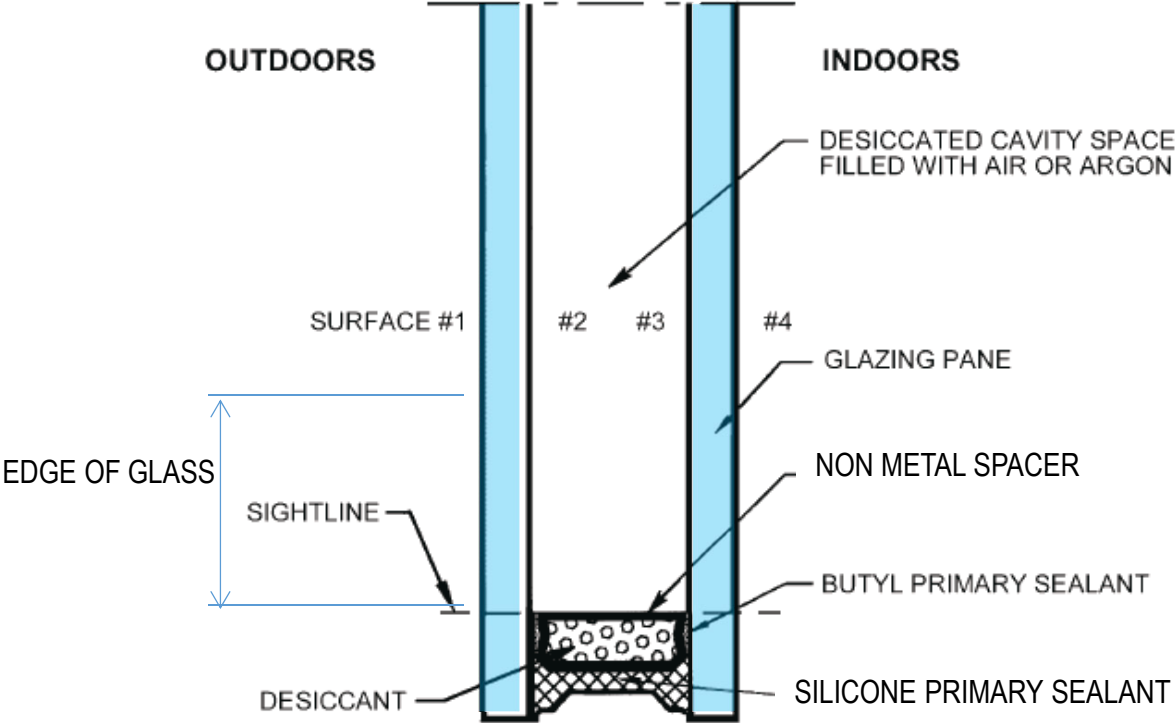
Opaque Envelopes

- a. Mass
- b. Metal
- c. Steel framed wall
- d. Wood framed wall

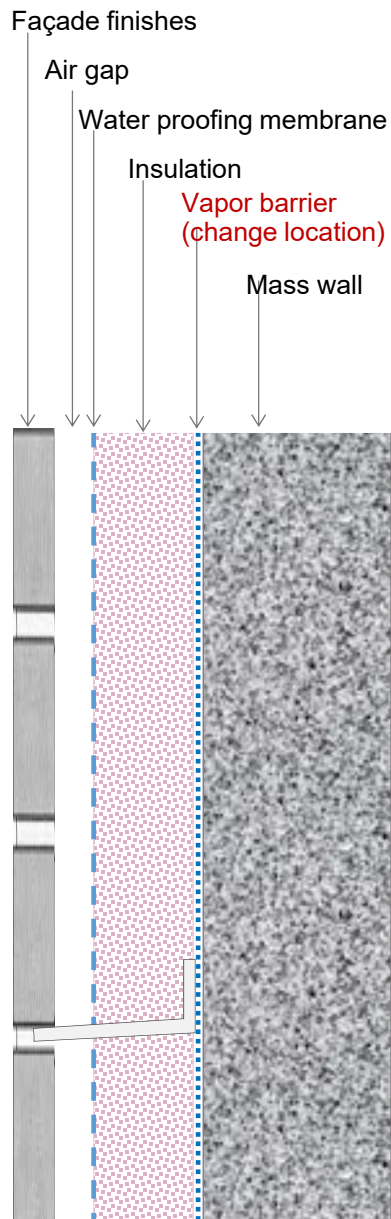


Functions of Sustainable Building Envelopes

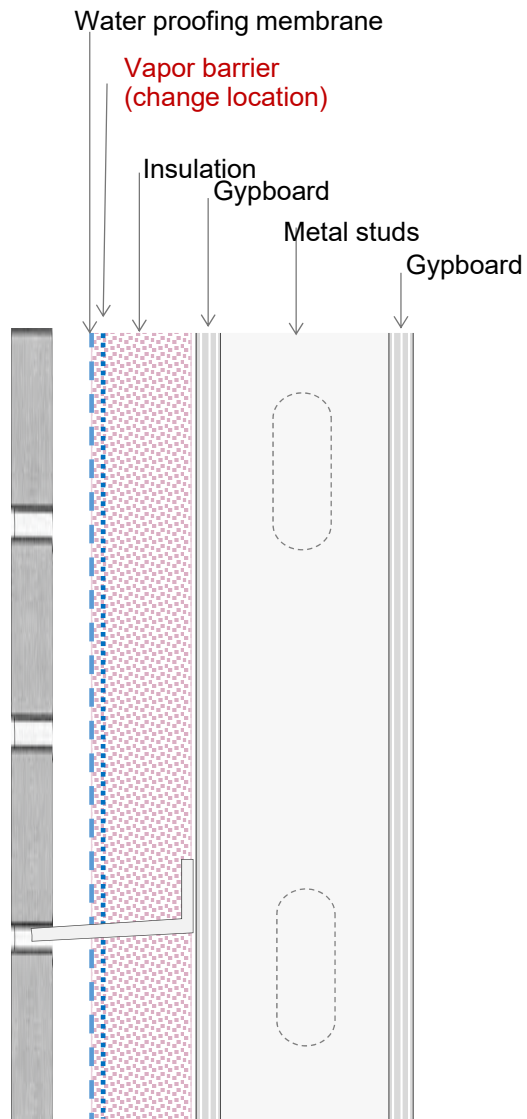
Protect-Promote-Re/Generate



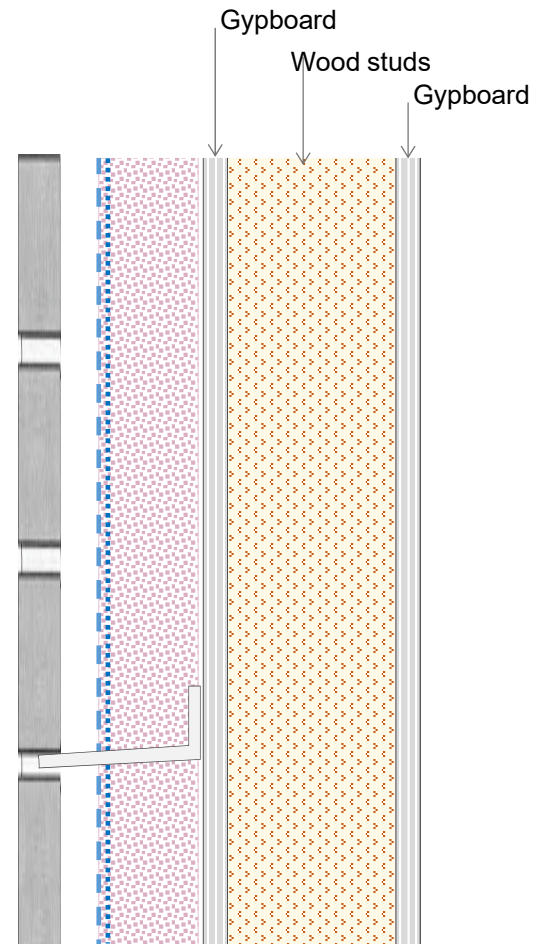
Insulated Glazing Unit (IGU) Construction



Mass wall



Steel framed wall



Wood framed wall

Opaque Envelopes

- a. Mass
- b. Metal
- c. Steel framed wall
- d. Wood framed wall

Functions of Sustainable Building Envelopes

Protect-Promote-Re/Generate

$$\text{Assembly } R = R_i + R_1 + R_2 + R_3 + \dots + R_n + R_o$$

Where

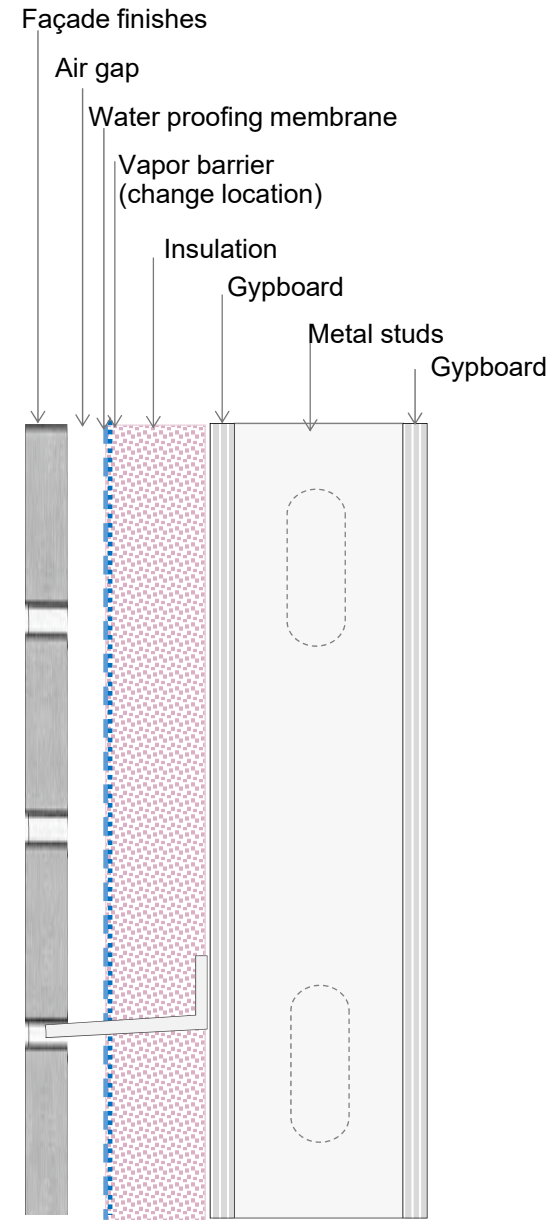
R = Total thermal resistance of bldg envelope

R1, R2, ..., Rn = individual resistances of the parts

$R_i = 0.68 \text{ } ^\circ\text{F}\cdot\text{ft}^2\cdot\text{h}/\text{Btu}$ based on stagnant air

$R_o = 0.25 \text{ } ^\circ\text{F}\cdot\text{ft}^2\cdot\text{h}/\text{Btu}$ based on 15mph wind speed

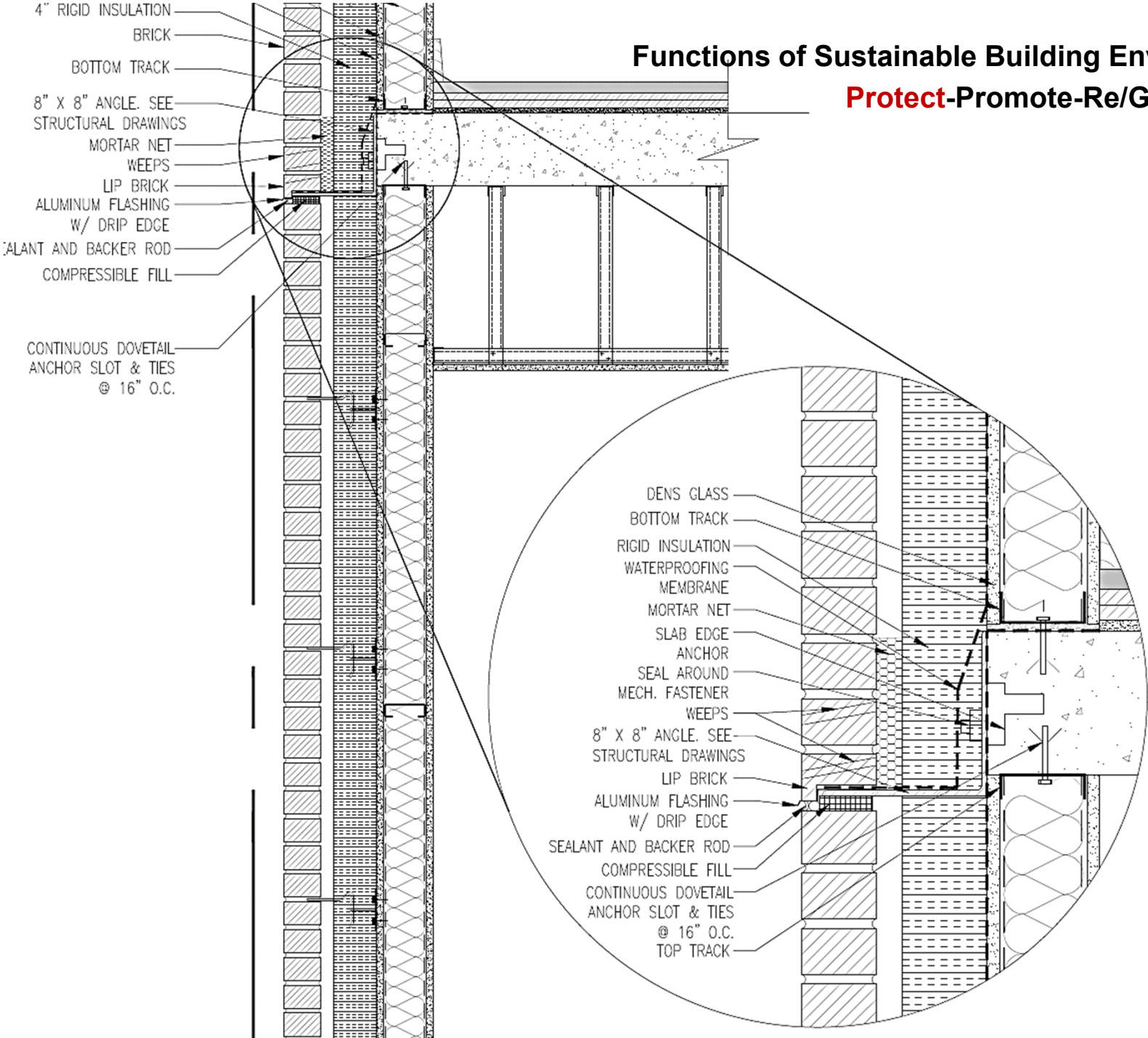
Material	R value
Air film coefficient @ interior R_i	0.68
Air film coefficient @ exterior R_o	0.25
air cavity	1
Semi-rigid insulation	10
Brick	1
Gypsum board	0.5
Steel stud w/ air gap	1



Steel framed wall

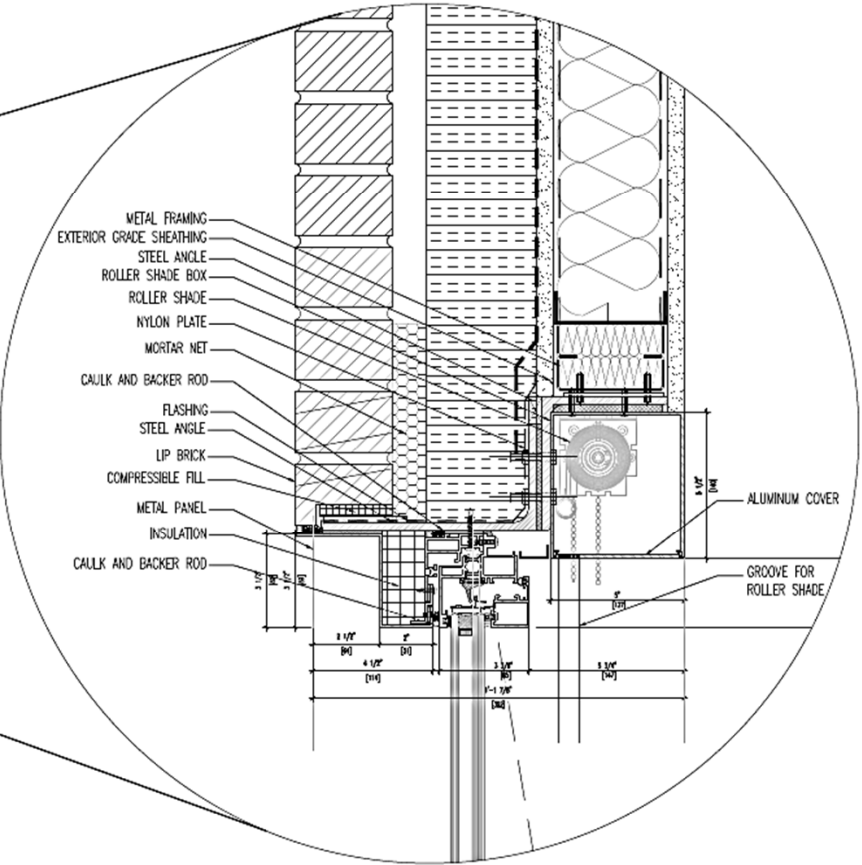
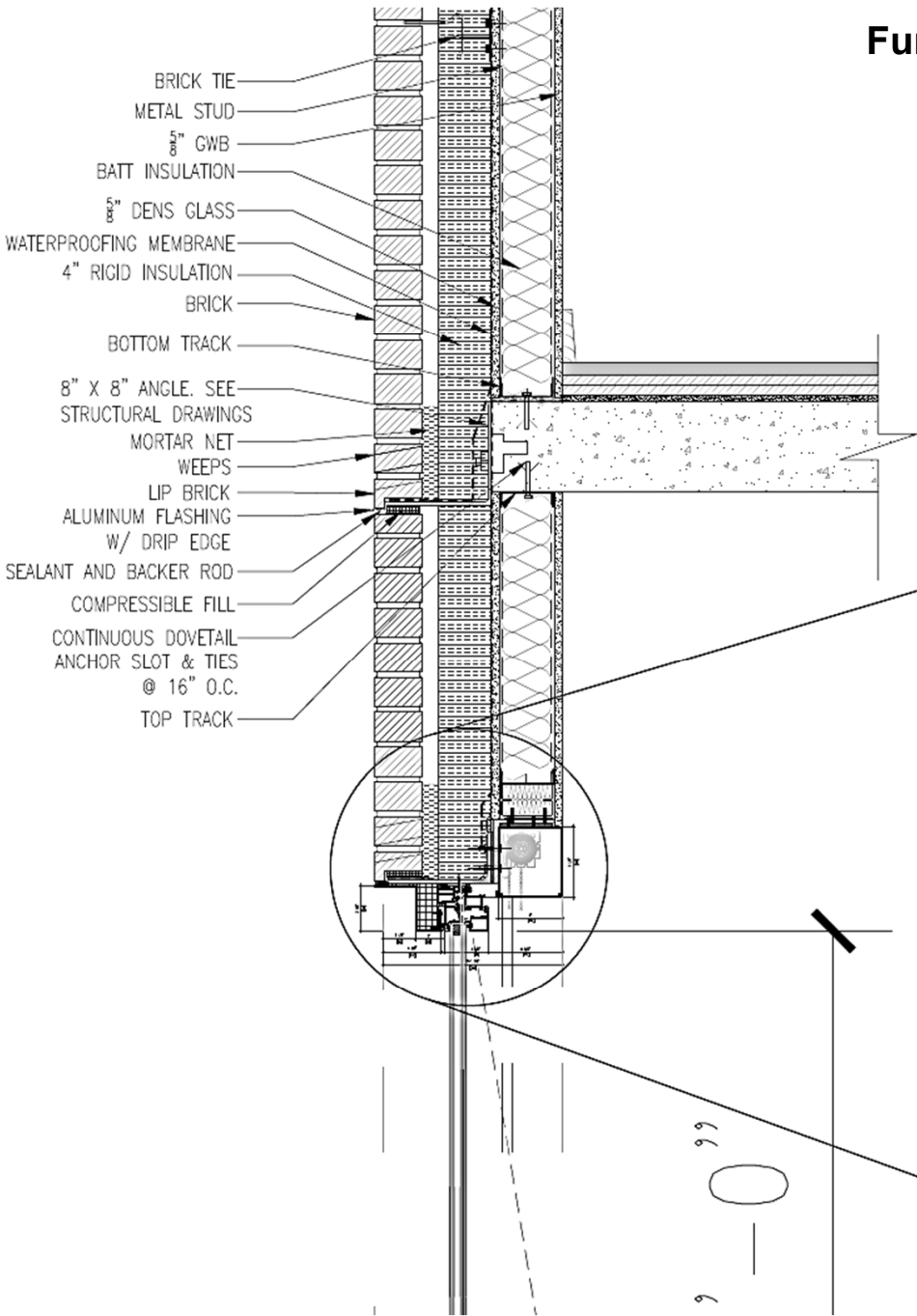
Functions of Sustainable Building Envelopes

Protect-Promote-Re/Generate



Functions of Sustainable Building Envelopes

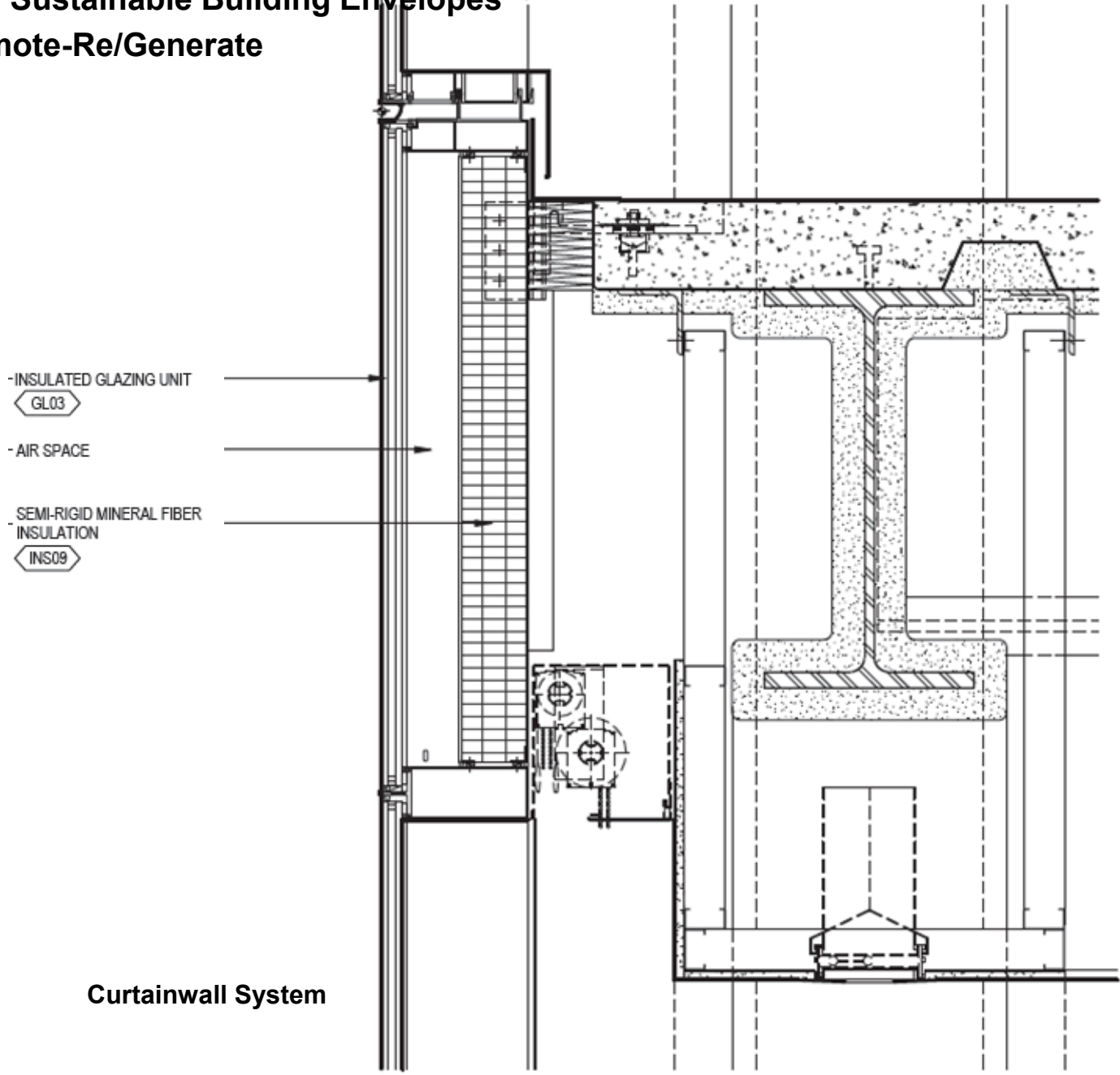
Protect-Promote-Re/Generate



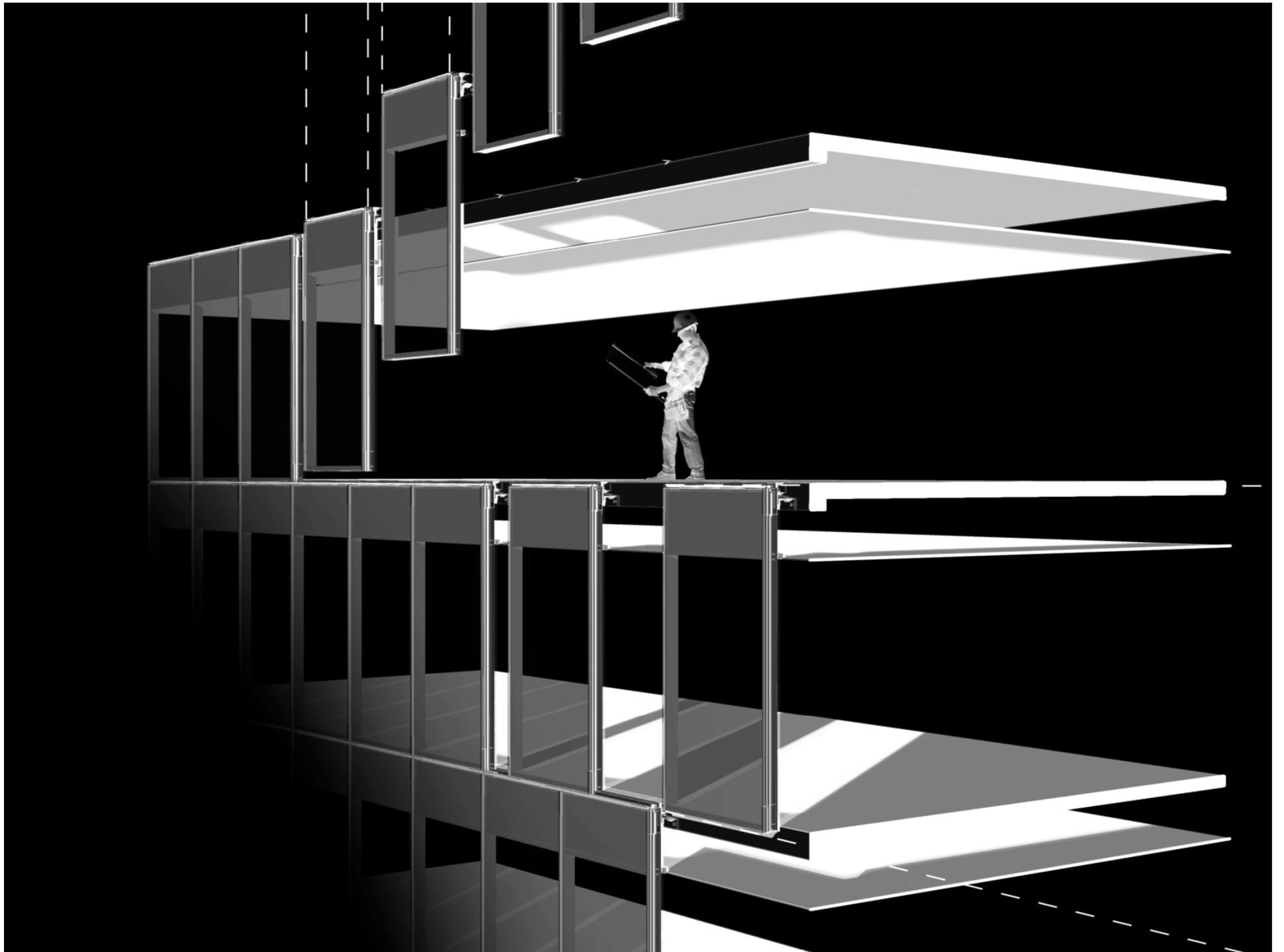
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Functions of Sustainable Building Envelopes

Protect-Promote-Re/Generate



Curtainwall System



Functions of Sustainable Building Envelopes

Protect-Promote-Re/Generate



Image source: Halfen

Location Queens, NY

Architect beyer blinder belle, Lubrano Ciavarra

Facade consultant Front Inc.

Acoustics Cerami & Associates

Structural engineer ARUP

Client

MCR Development

Type

Hotel

Size

512 hotel rooms

Sustainability

Targeted LEED Gold

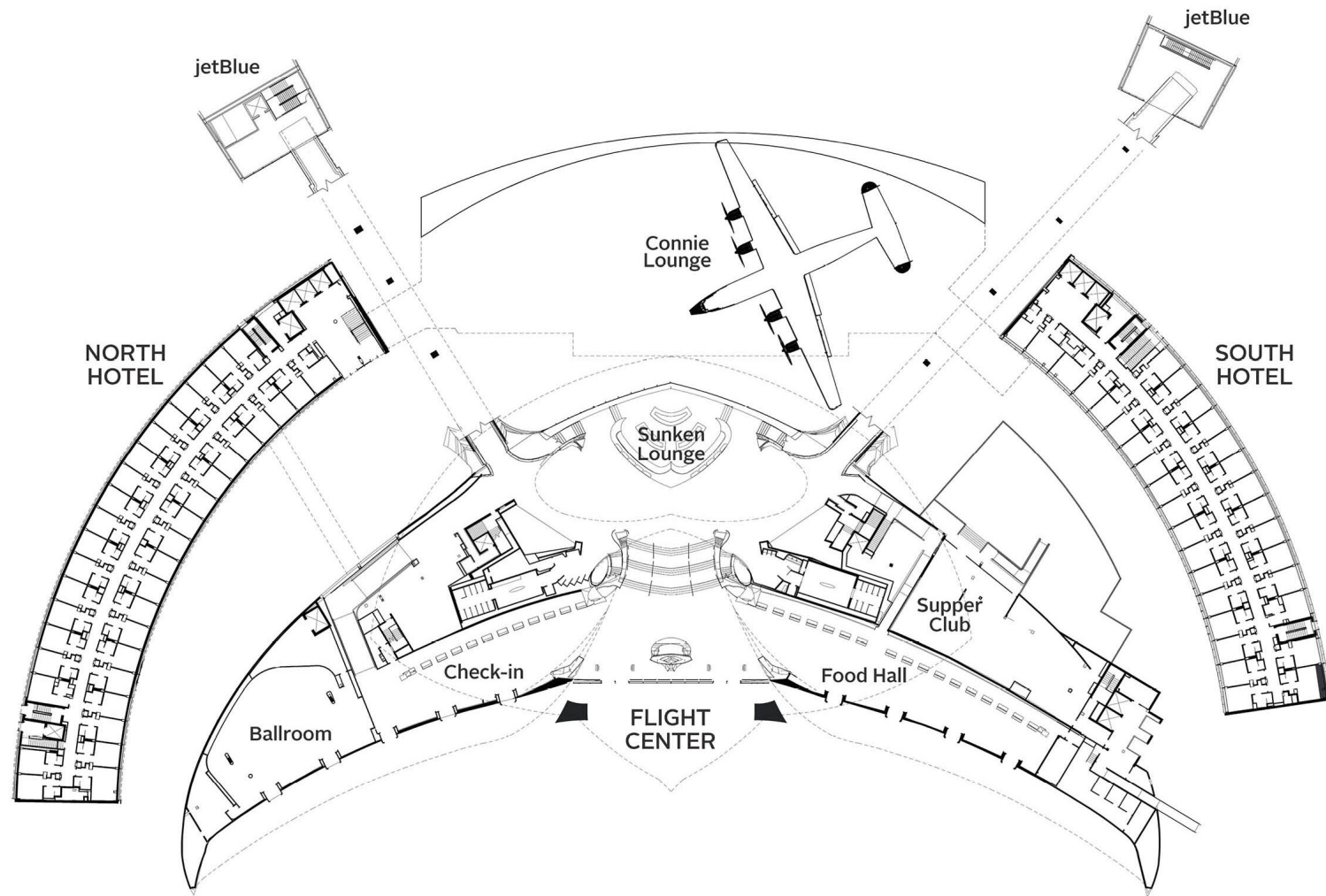




J. Bartlestone Photography, 2011



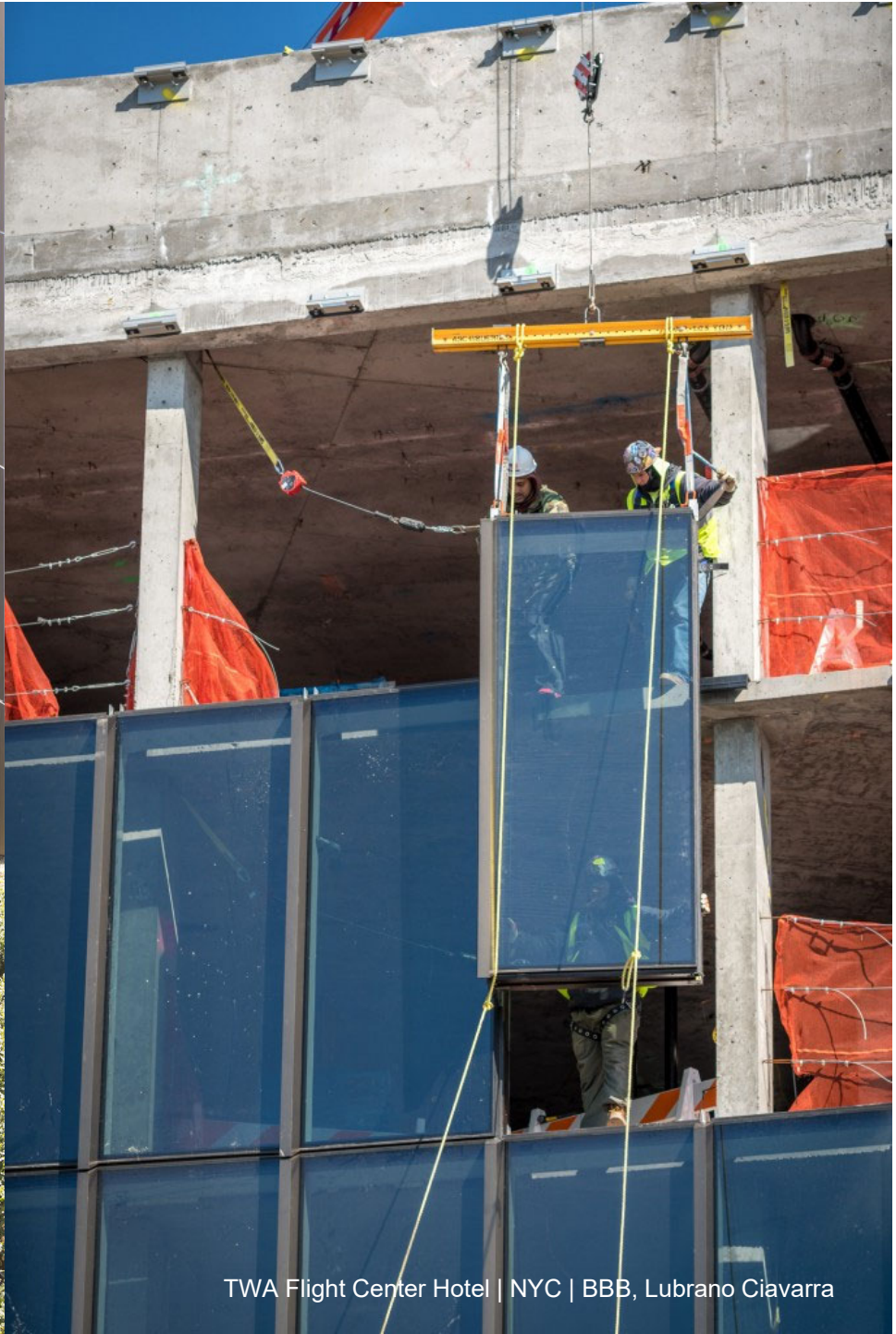
TWA Flight Center Hotel | NYC | BBB, Lubrano Ciavarra



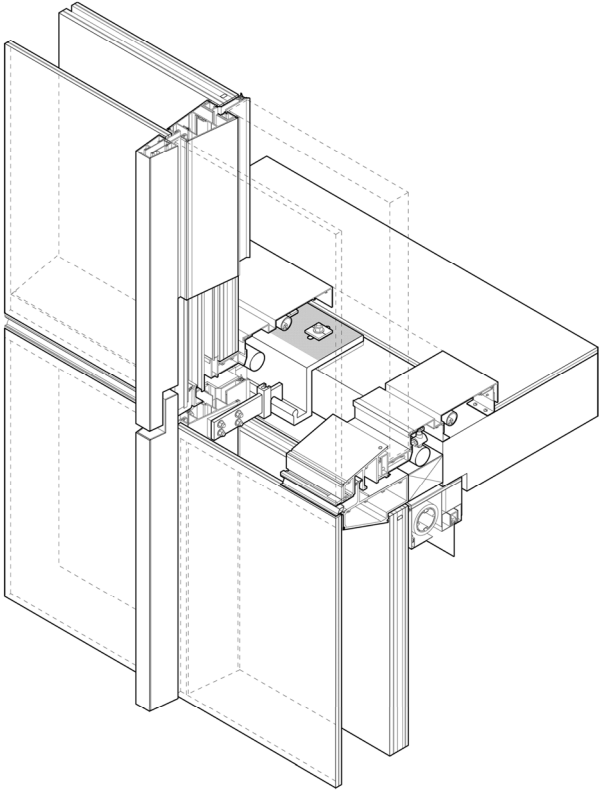
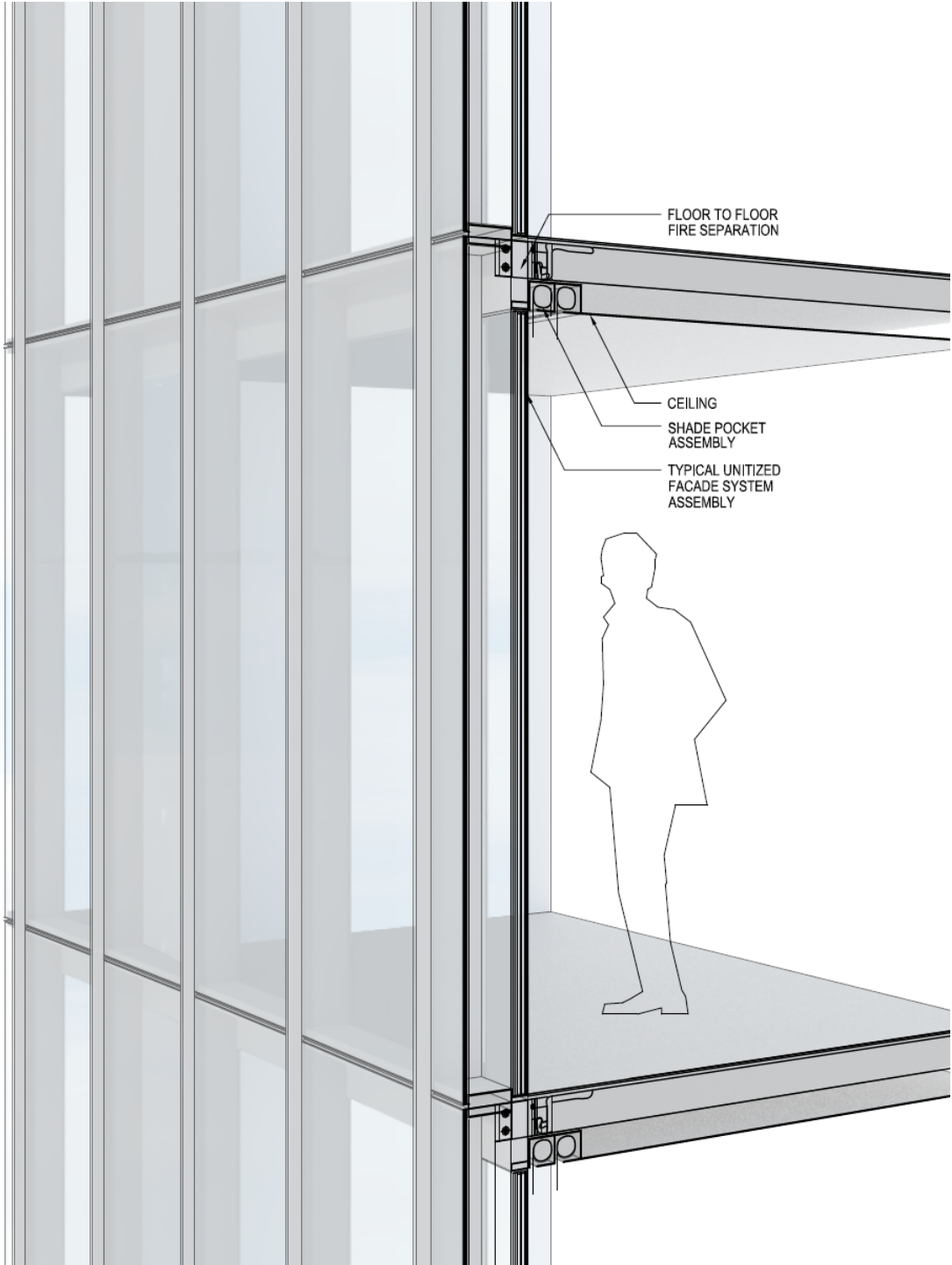
LOBBY LEVEL



TWA Flight Center Hotel | NYC | BBB, Lubrano Ciavarra



TWA Flight Center Hotel | NYC | BBB, Lubrano Ciavarra



TWA Flight Center Hotel | NYC | Front Inc

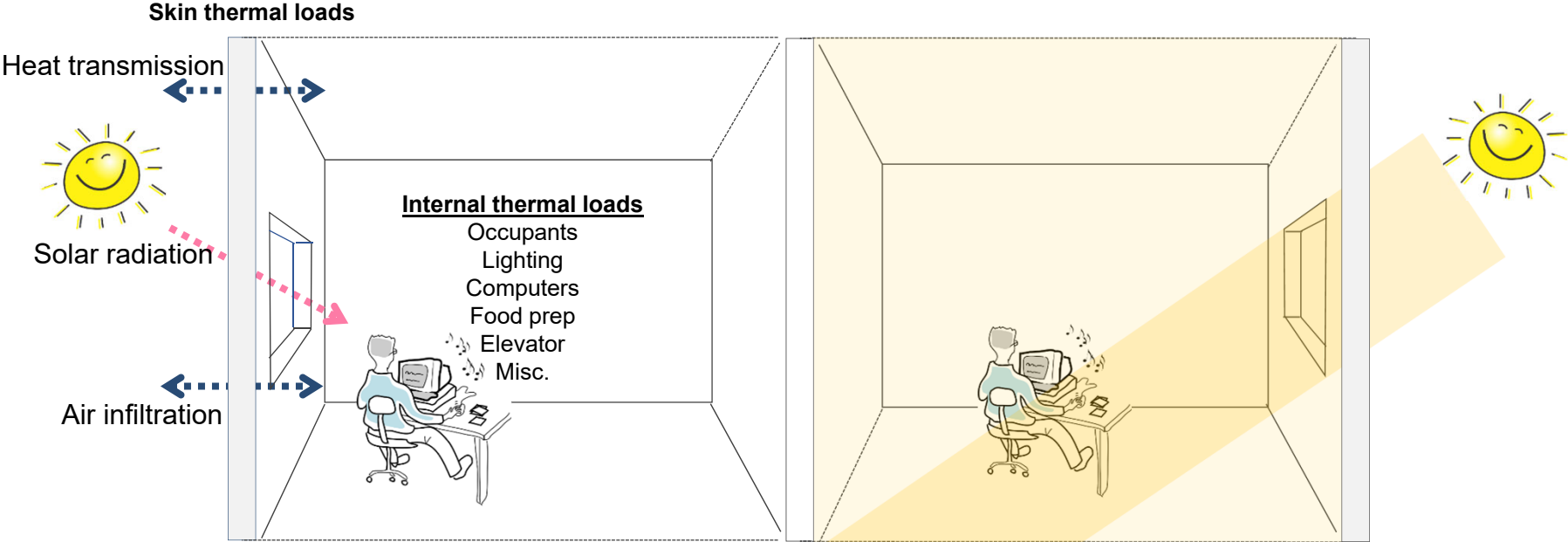


TWA Flight Center Hotel | NYC | BBB, Lubrano Ciavarra

PROMOTE

Functions of Sustainable Building Envelopes

Protect-Promote-Re/Generate



Thermal design science:

- Heating
- Cooling
- Ventilation

Luminous design science:

- Daylighting
- Glare

Location

Denver, CO

Architect

Studio Gang

Client

Urban Villages

Type

Hotel

Size

135,000 sf / 159 ft / 13 stories

265 hotel rooms

Sustainability

Targeting LEED Gold

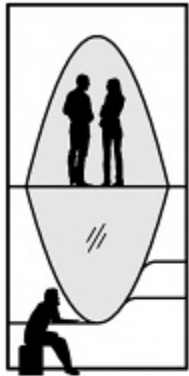


Populous Hotel | Denver, CO | Studio gang



Populous Hotel | Denver, CO | Studio gang





Micro-Unit
Grand Window



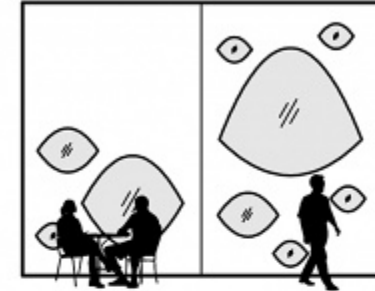
Micro-Unit
Seat Window



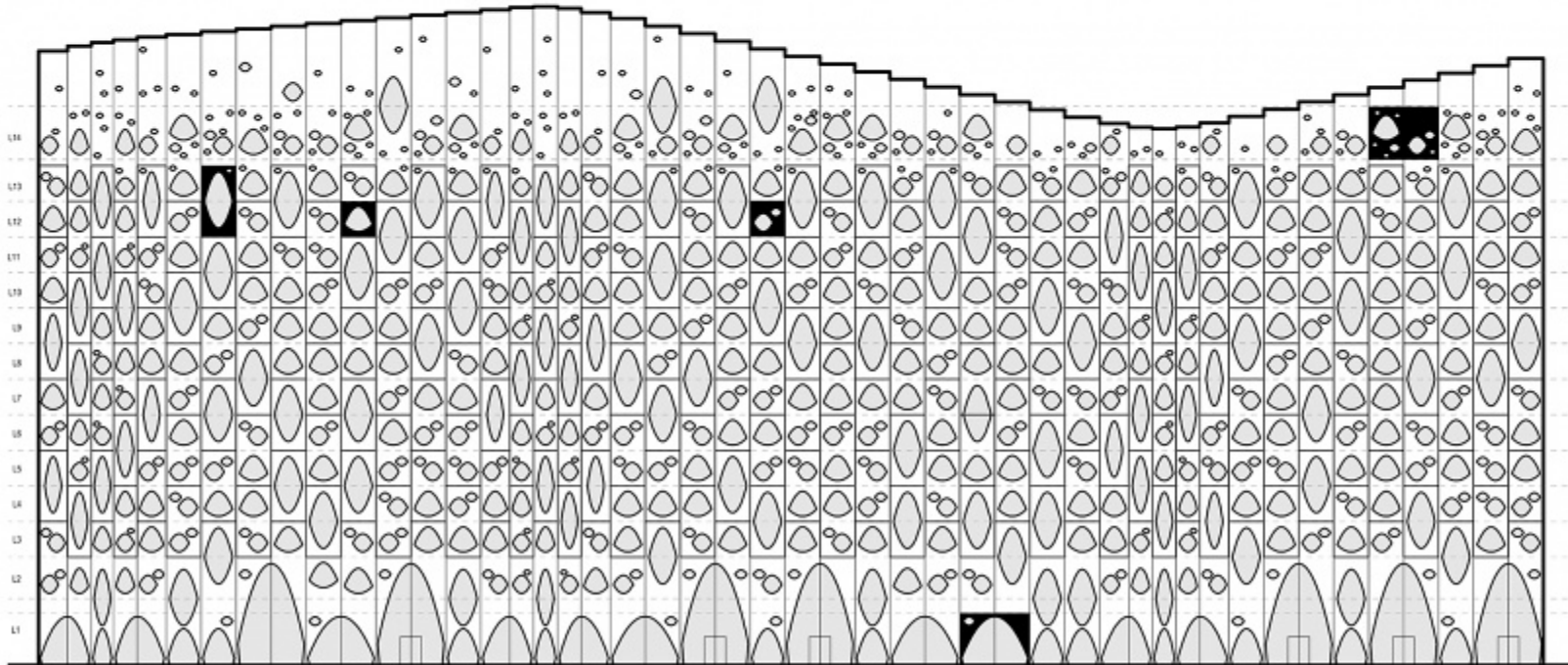
Micro-Unit
Lounge Window

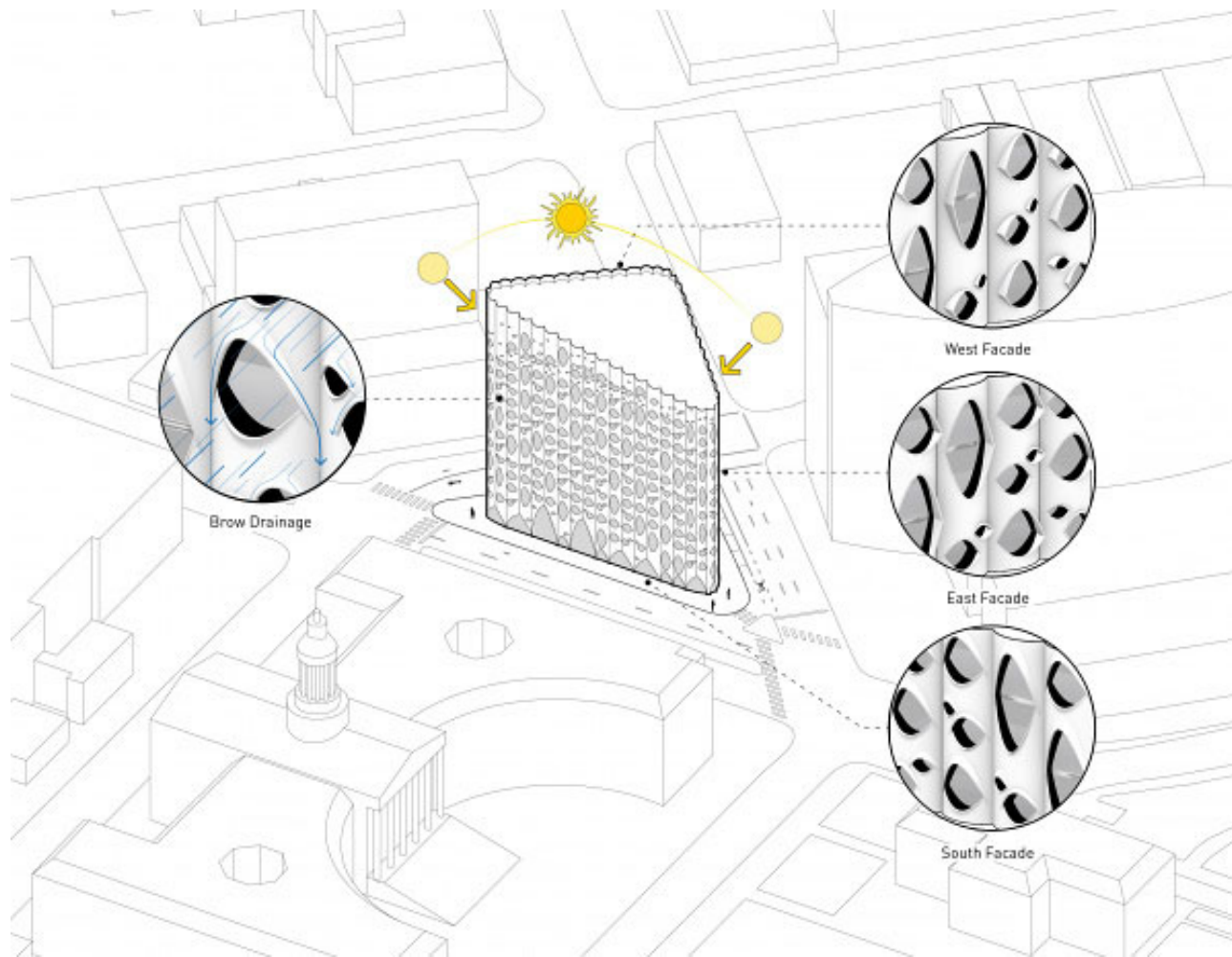


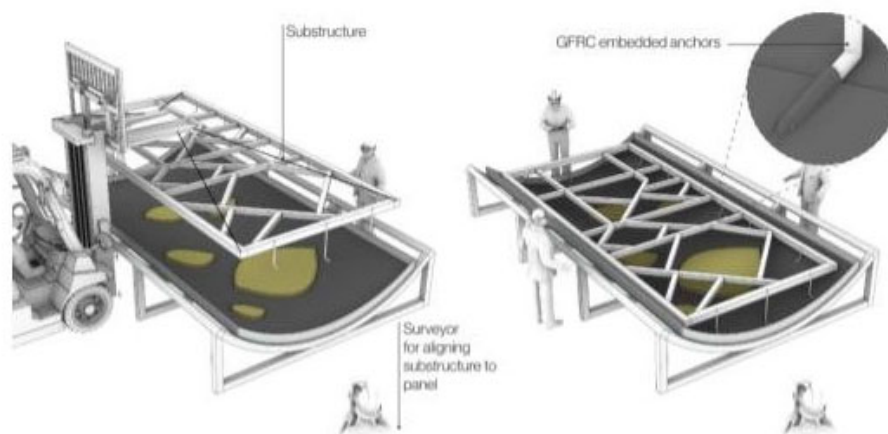
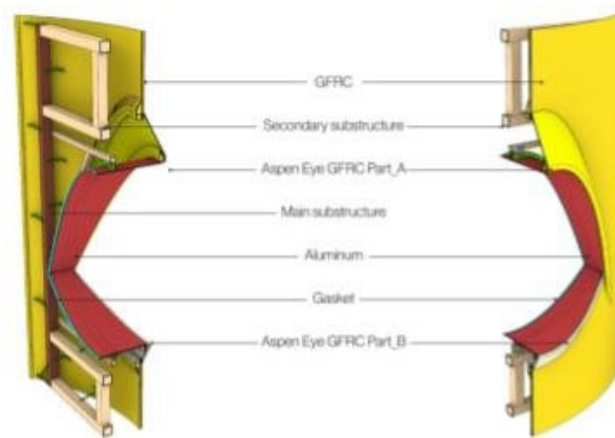
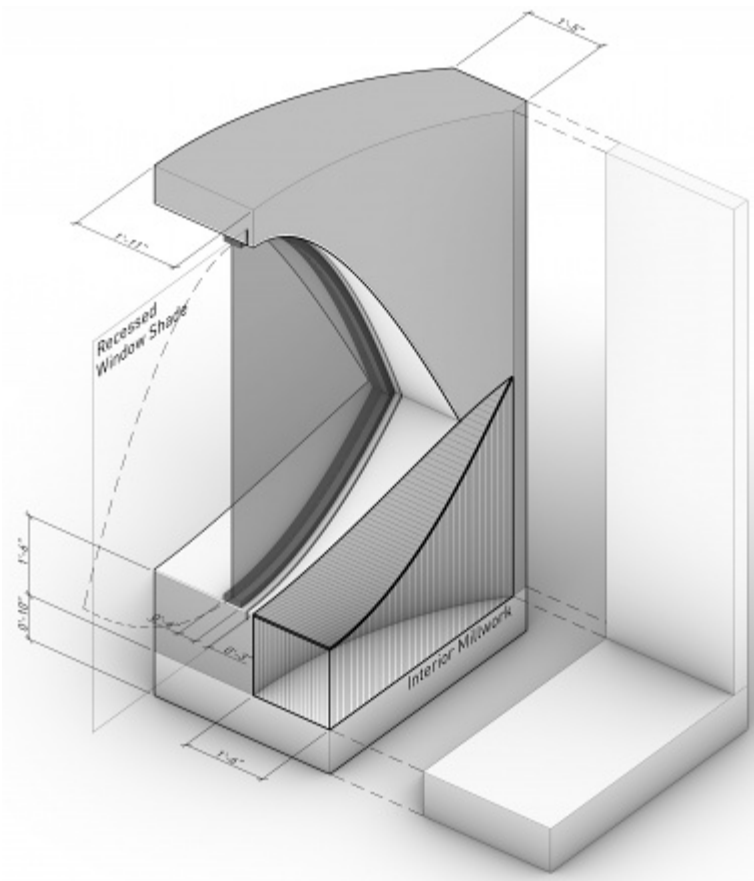
Ground Floor Storefront



Rooftop Lounge









Populous Hotel | Denver, CO | Studio gang



Populous Hotel | Denver, CO | Studio gang



Location

Jiaozuo, Henan Province, China

Architect

Domain Architects

Client

Urban Villages

Type

Hotel

Size

50.000 sf / 4 stories

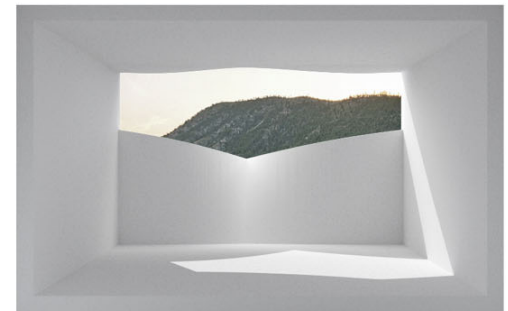
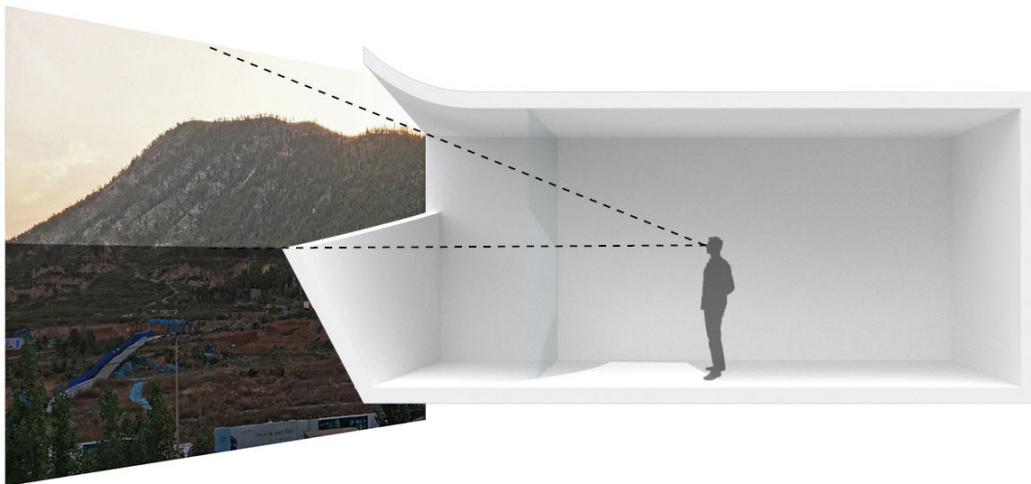
48 hotel rooms



Sky Yards Hotel | Henan Prov., China | Domain Architects



Hotel Norm: Outward Box



Sky + MicroYard = Sky Yard



Conventional Hotel Room



Blocking



Lifting



Sky Yard



Sky Yards Hotel | Henan Prov., China | Domain Architects



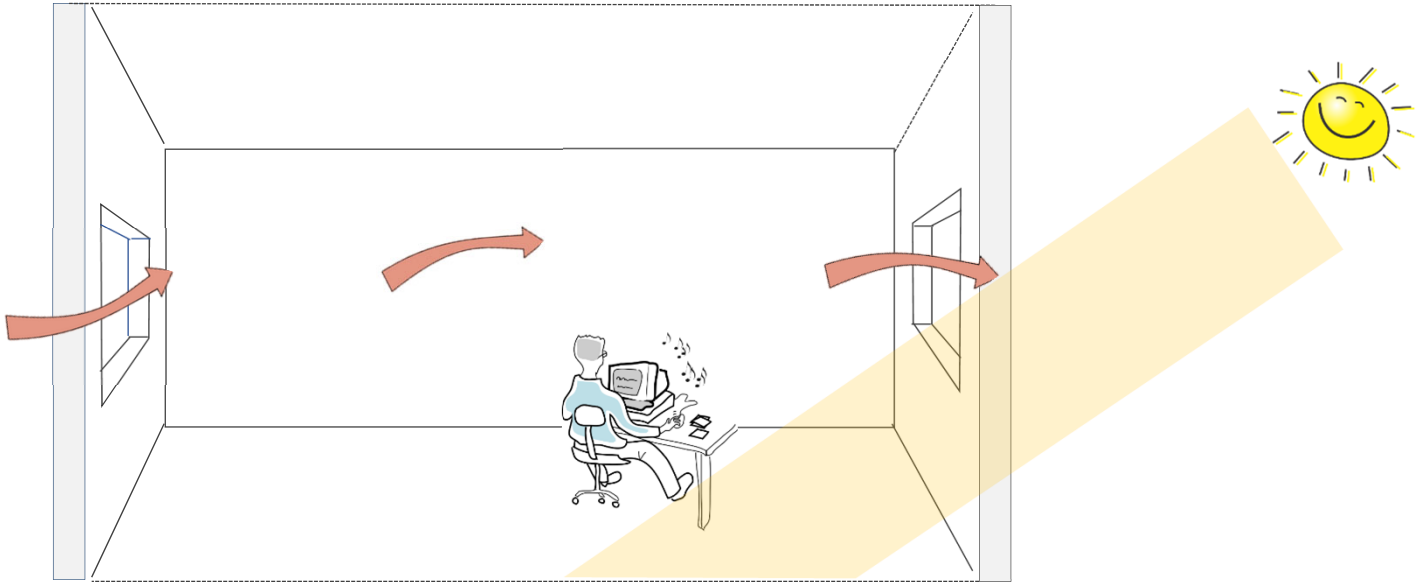
Sky Yards Hotel | Henan Prov., China | Domain Architects



Sky Yards Hotel | Henan Prov., China | Domain Architects

Functions of Sustainable Building Envelopes

Protect-**Promote**-Re/Generate



Good Indoor Environmental Quality

Daylighting

Natural Ventilation



Location

rio de janeiro, brazil

Architect

Studio Arthur Casas

Client

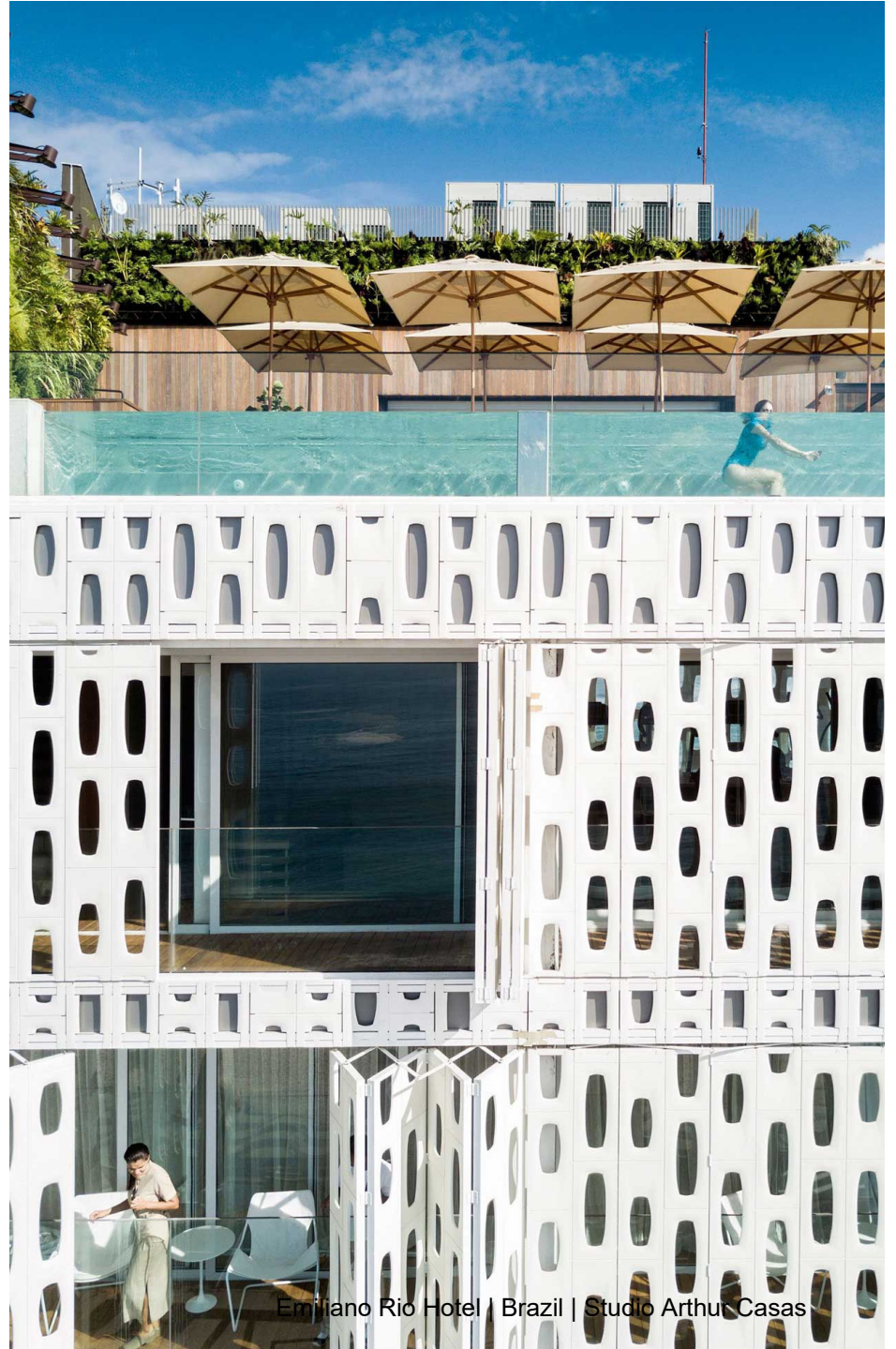
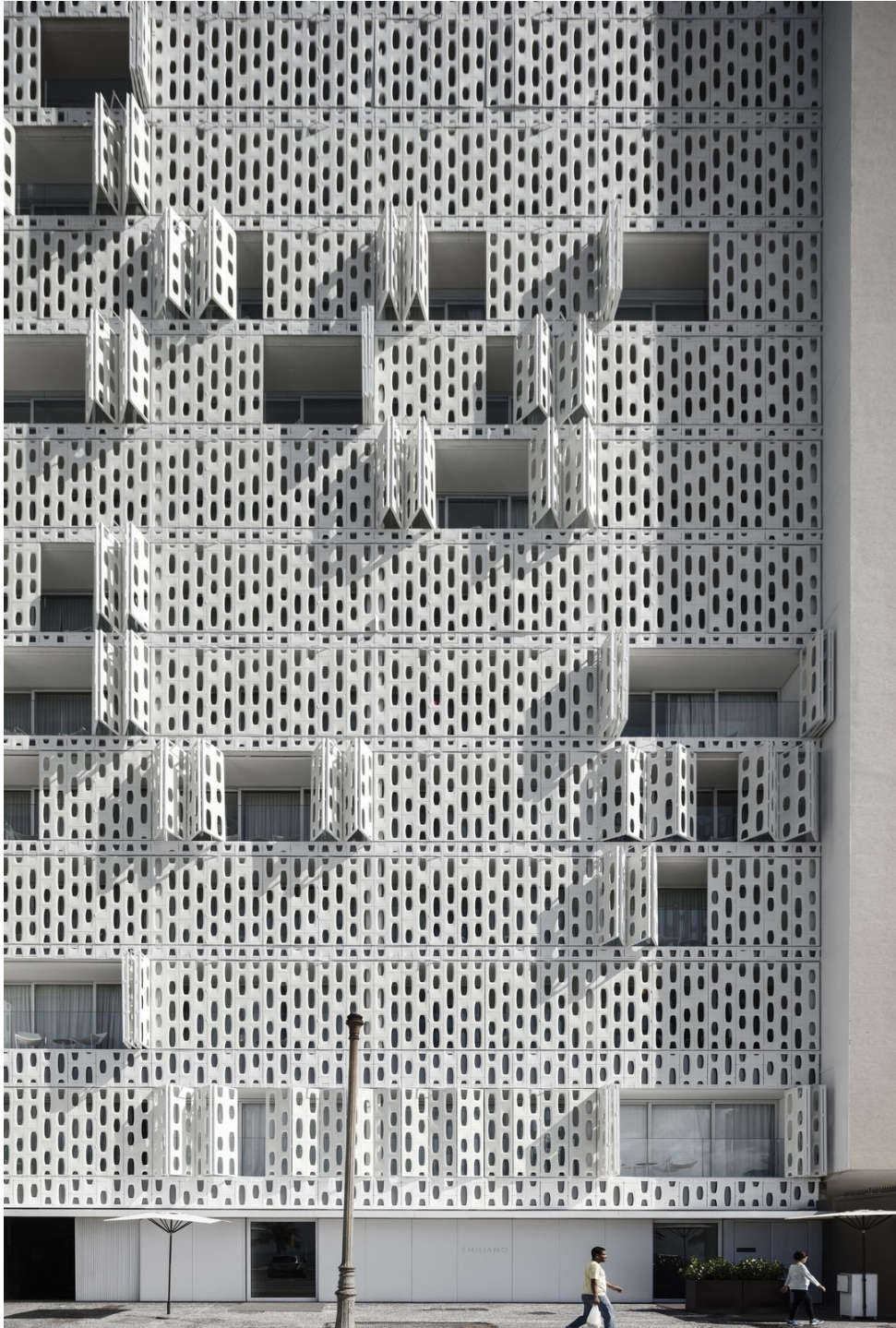
Emilliano Rio Hotel

Type

Hotel

Size

100,000 sf / 90 rooms



Emiliano Rio Hotel | Brazil | Studio Arthur Casas

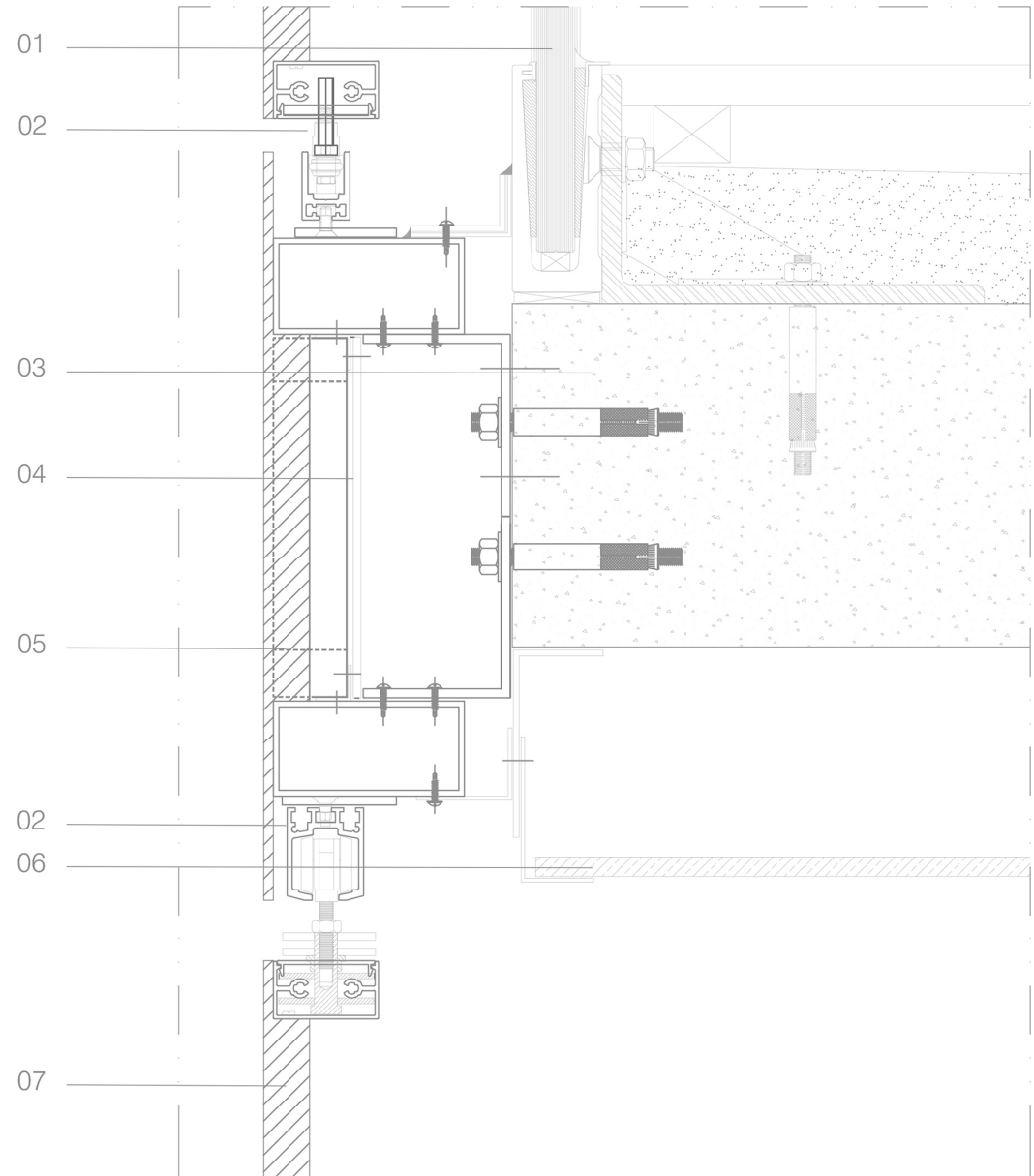


Emiliano Rio Hotel | Brazil | Studio Arthur Casas



Emiliano Rio Hotel | Brazil | Studio Arthur Casas

- 01. GUARDA-CORPO DE VIDRO
- 02. TRILHO PARA PORTA CAMARÃO
- 03. LAJE DE CONCRETO
- 04. CHAPA DE ACM
- 05. REQUADRO EM TUBO DE ALUMÍNIO
- 06. FORRO DE GESSO
- 07. COBOGÓ



CORTE TÍPICO

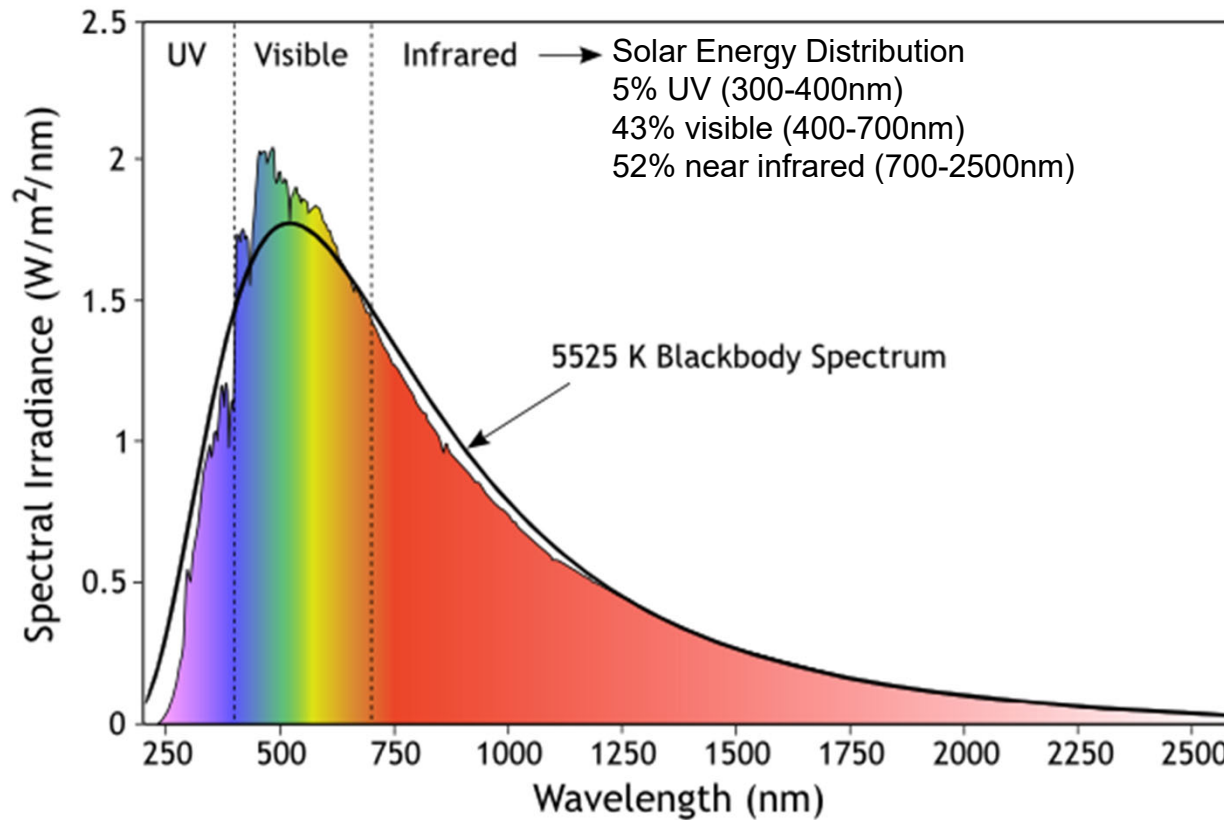
Emiliano Rio Hotel | Brazil | Studio Arthur Casas

RE/GENERATE

Functions of Sustainable Building Envelopes

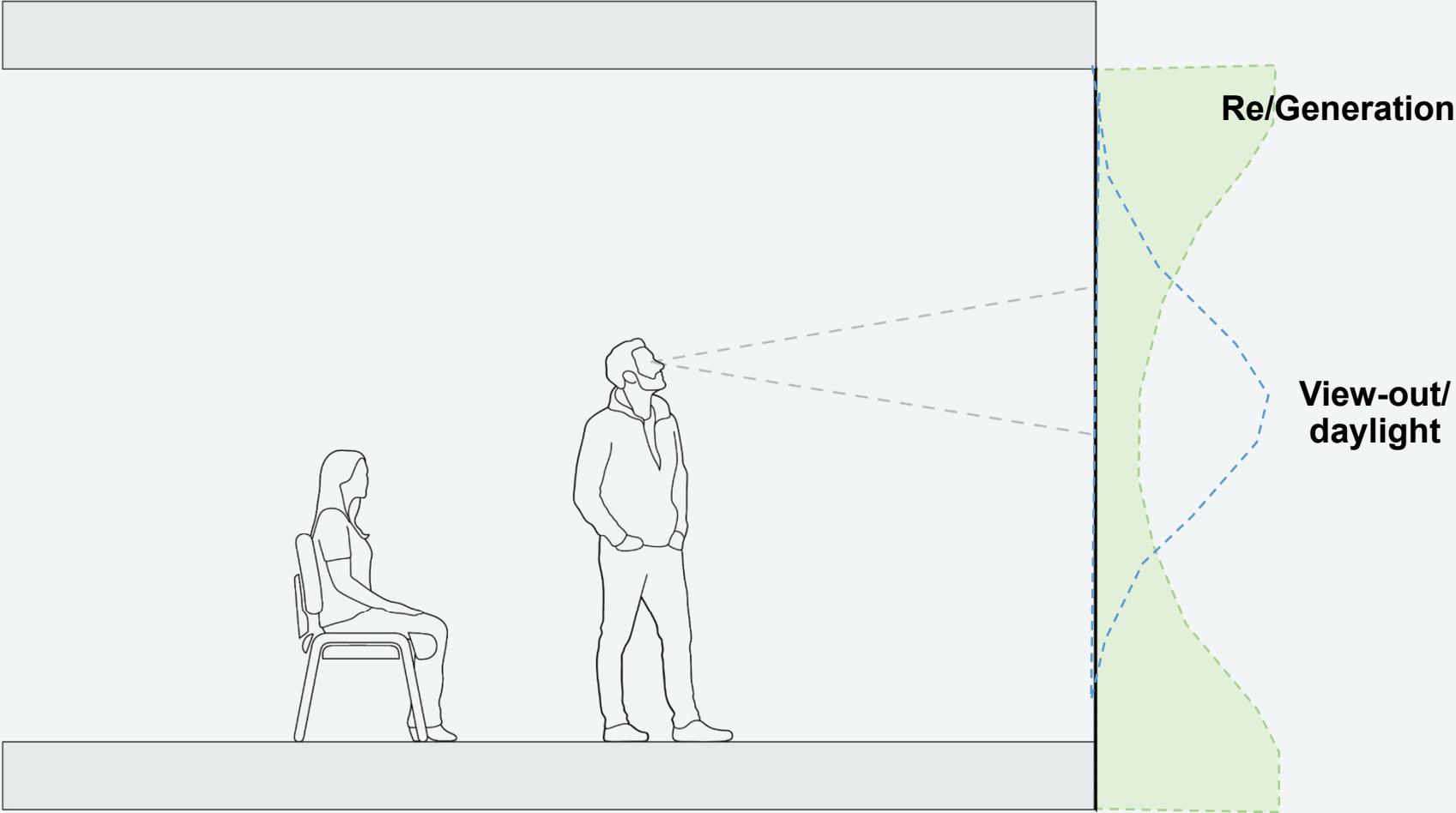
Protect-Promote-**Re/Generate**

One hour of solar energy has the potential to power the energy consumption of the entire Earth for one year.



Functions of Sustainable Building Envelopes

Protect-Promote-**Re/Generate**



Functions of Sustainable Building Envelopes

Protect-Promote-Re/Generate: Solar Facades

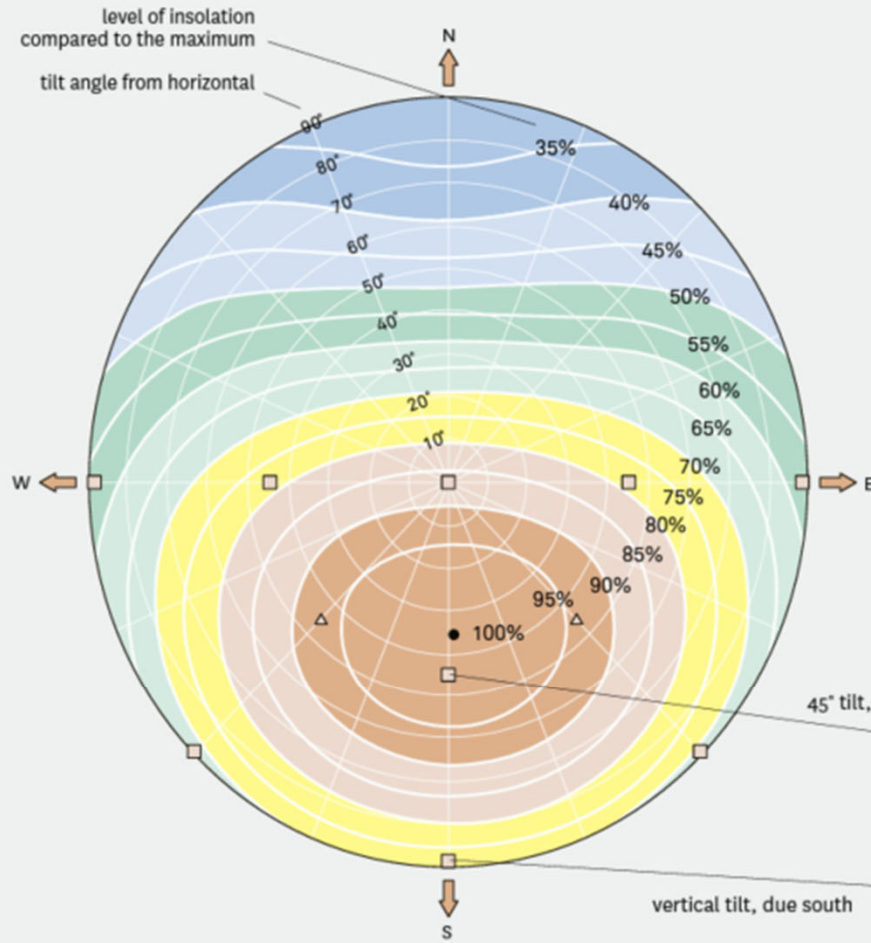
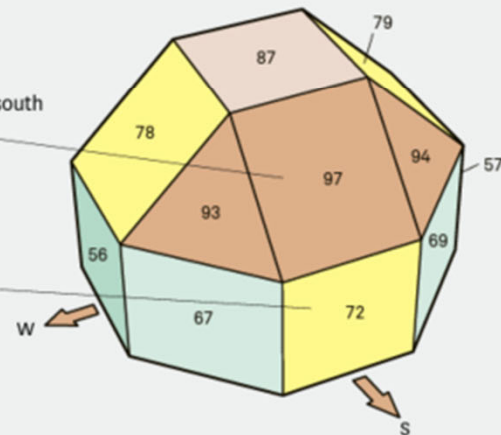


Fig. 3.5 Chart of comparative total insolation over one year for all angles of tilt from horizontal and orientation, at Freiburg, Germany (latitude +50.9°, longitude +13.3°). The actual value of maximum insolation is 1,278 kWh/m² at the 100% point that is positioned with a tilt of 35° and oriented 2° east of due south. (The position slightly to east follows from mornings being a little less cloudy than afternoons.)

Fig. 3.6 Selected values from Fig. 3.5 for 45° facets of a building. Colour shading of the facets relates to the bands of insolation in Fig. 3.5.

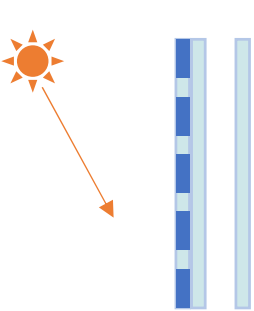


Functions of Sustainable Building Envelopes

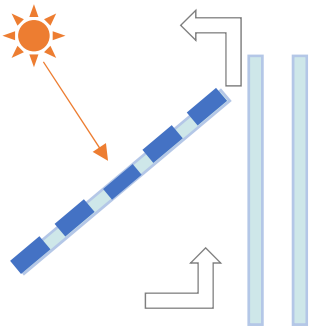
Protect-Promote-Re/Generate: Solar Facades

BIPV Typologies

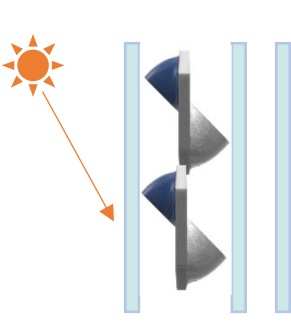
Glazing application



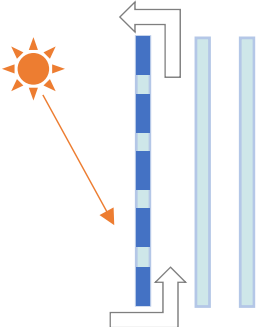
Laminated



Shading device

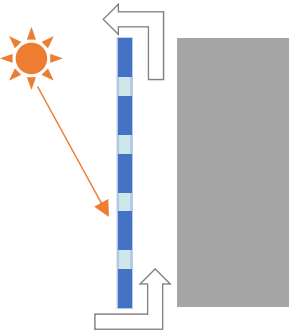
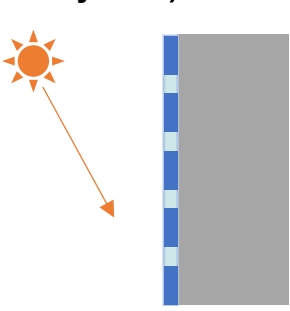


Closed cavity façade (CCF)



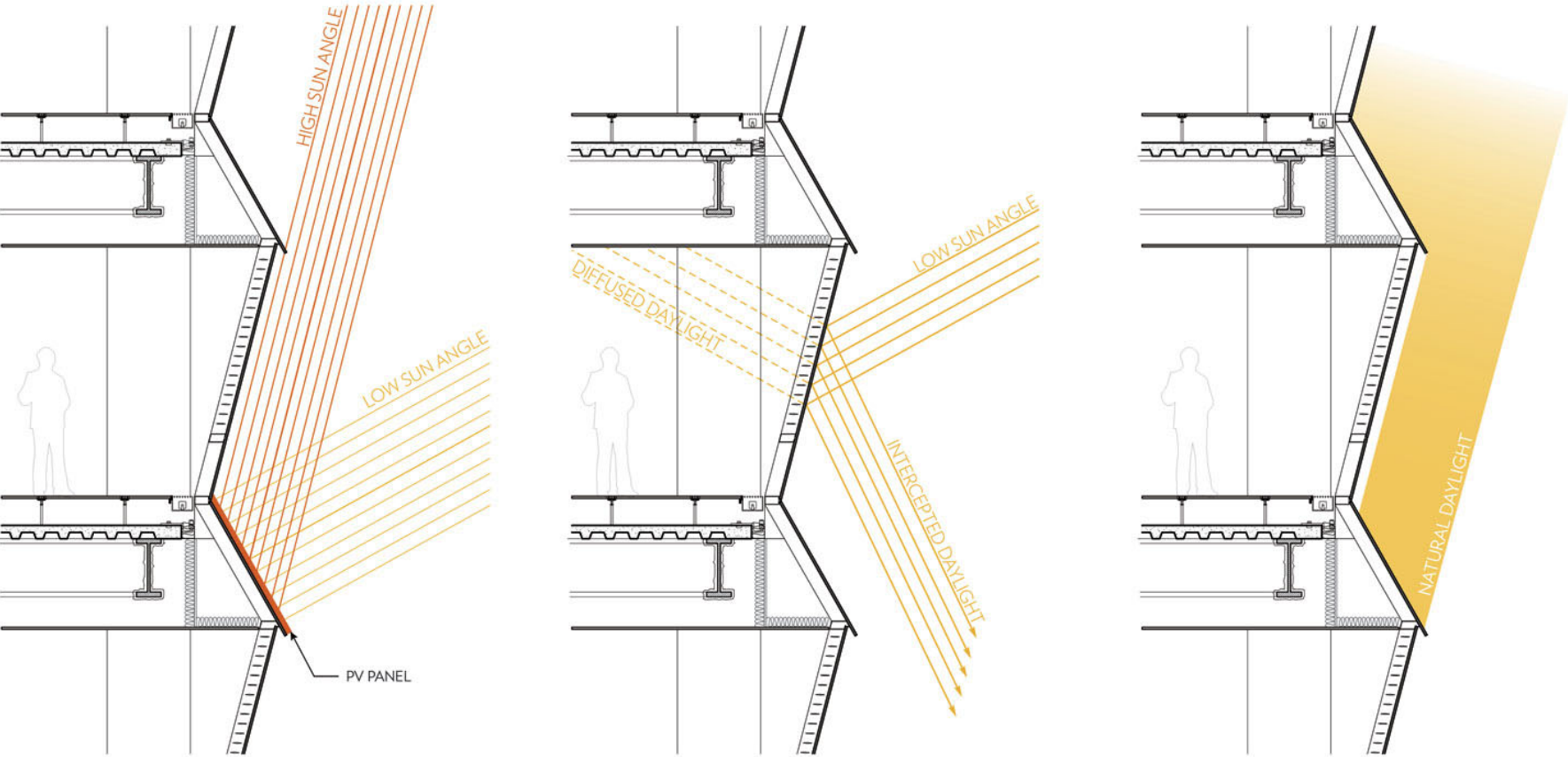
Double facade

Opaque wall application (rain screen system)



Functions of Sustainable Building Envelopes

Protect-Promote-Re/Generate: Solar Facades





FKI, Korea



Dubai Electricity and Water Authority, Abu Dabi



Green Dot Animo Leadership High School, USA



550 Spencer Tower, Australia



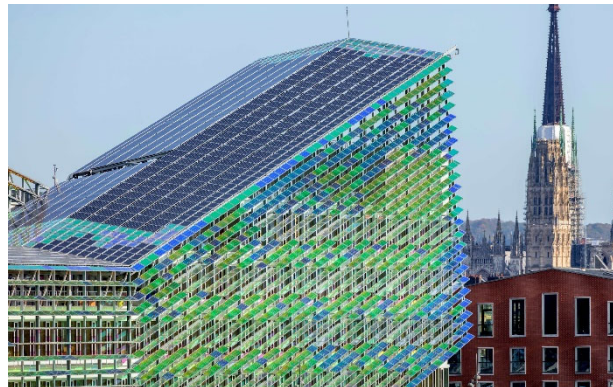
Copenhagen International School, Denmark



Solar Parking, Sweden



Blauhau, Germany



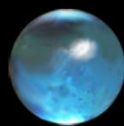
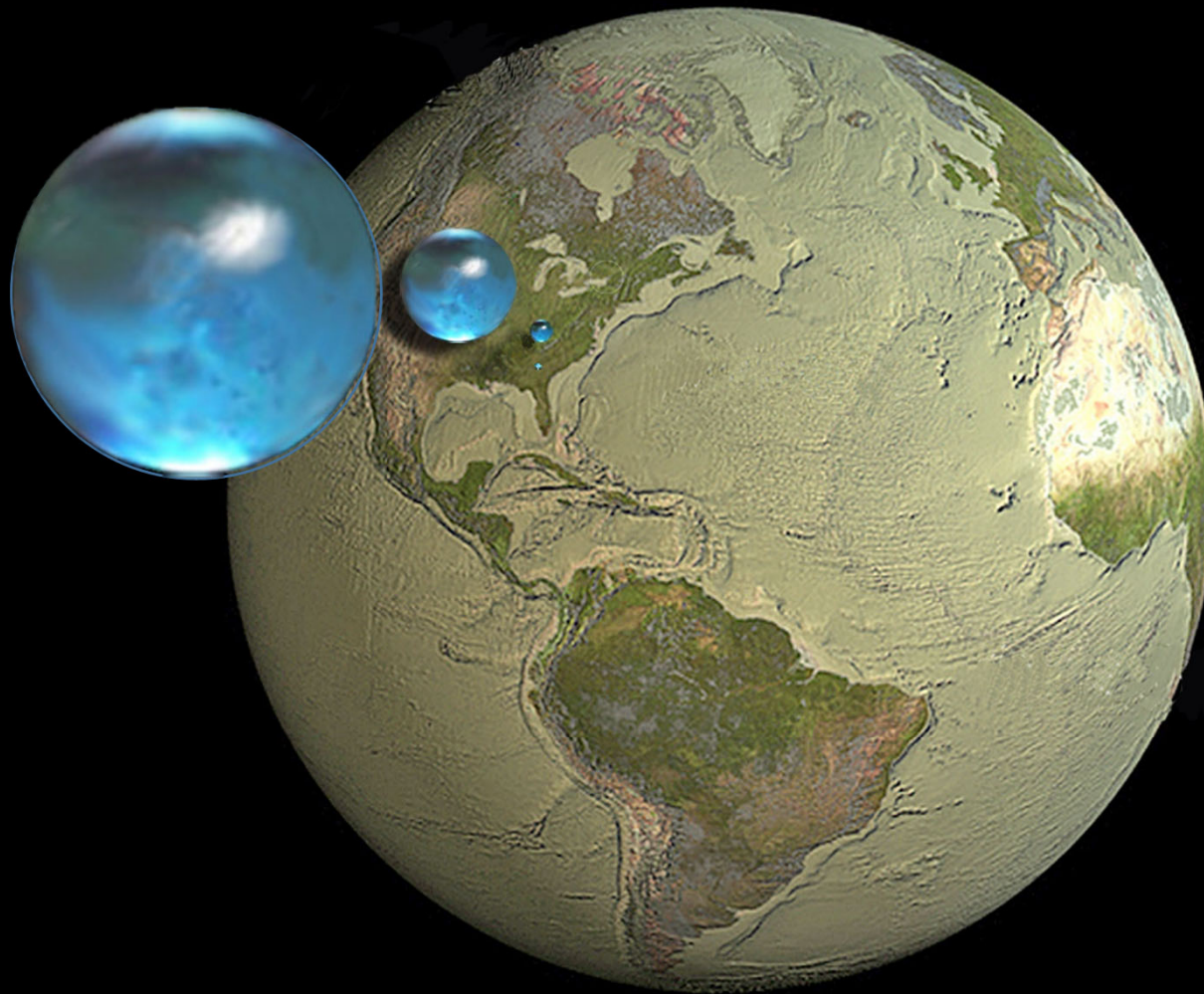
Métropole Rouen Normandie HQ, France



Sun Rock Building, Taiwan

REGENERATE

The World's Water



All water on, in, and above the Earth



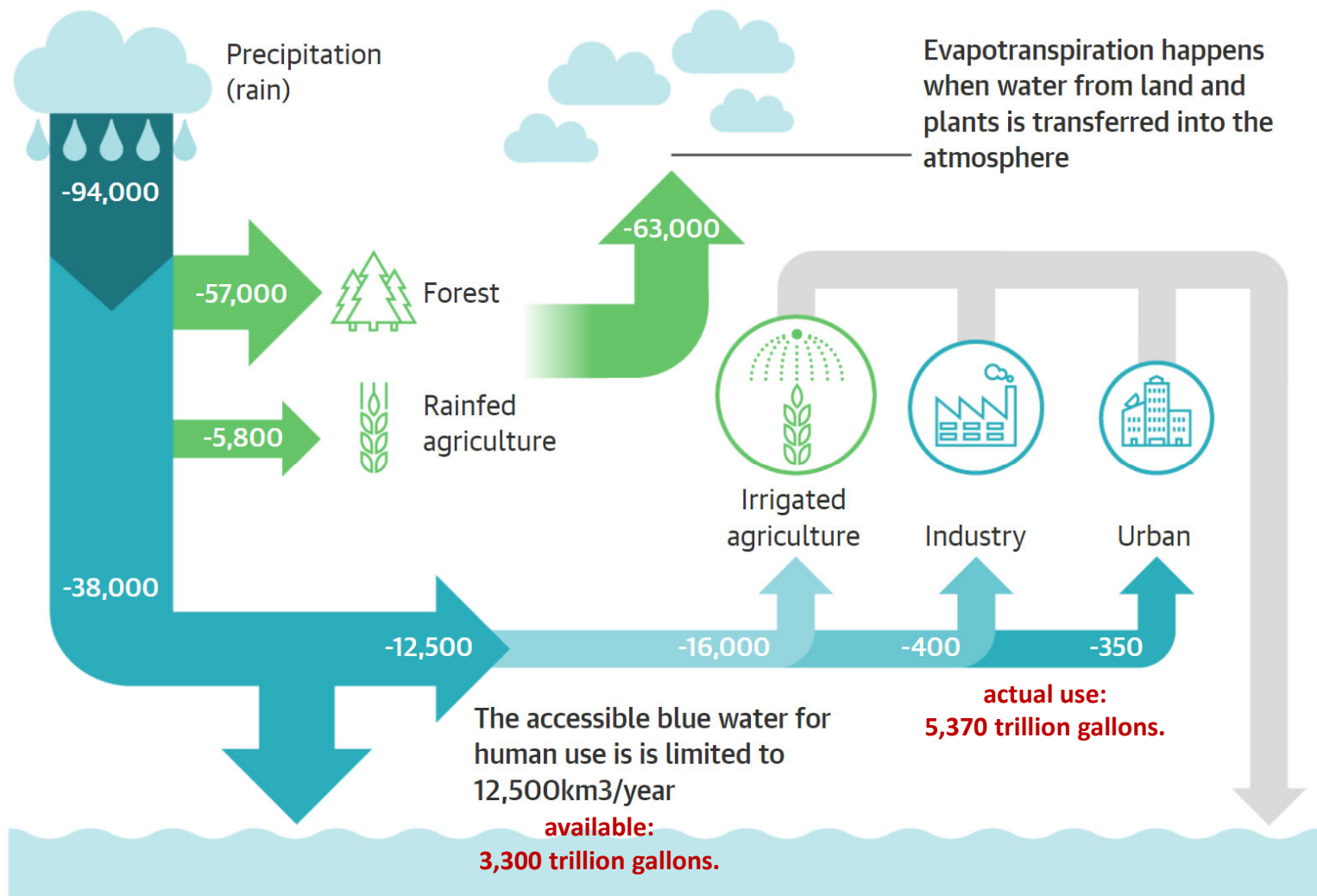
Liquid fresh water



Fresh-water lakes and rivers

Howard Perlman, USGS,
Jack Cook, Woods Hole Oceanographic Institution,
Adam Nieman
Data source: Igor Shiklomanov
<http://ga.water.usgs.gov/edu/earthhowmuch.html>

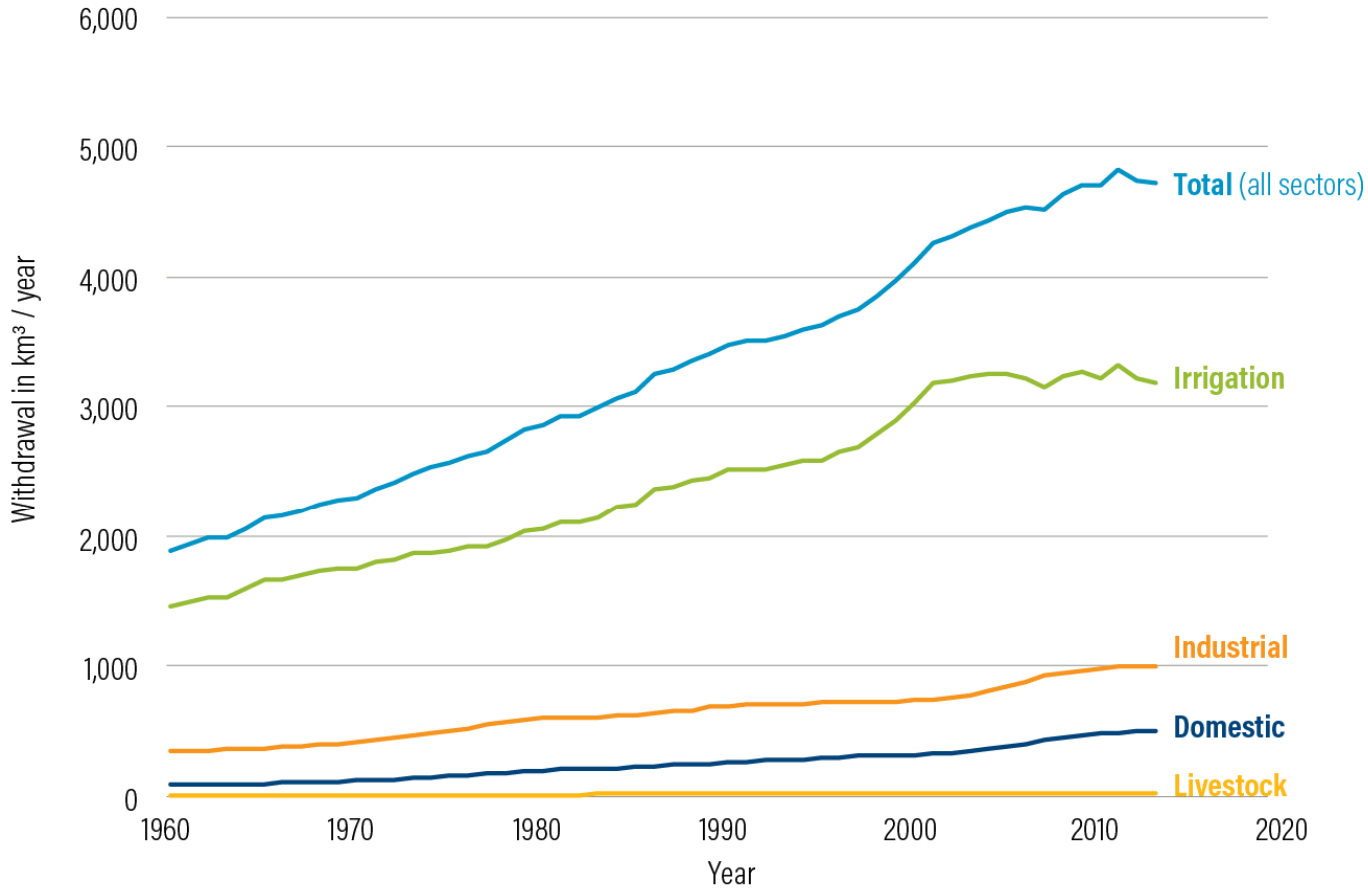
US Geological Survey



Guardian graphic. Source: Global Commission on the Economics of Water

North Carolina: 503 miles (810 km) long by 150 miles (241 km) wide.

Water withdrawals by sector, 1960-2014



Source: Authors.
20.2.10

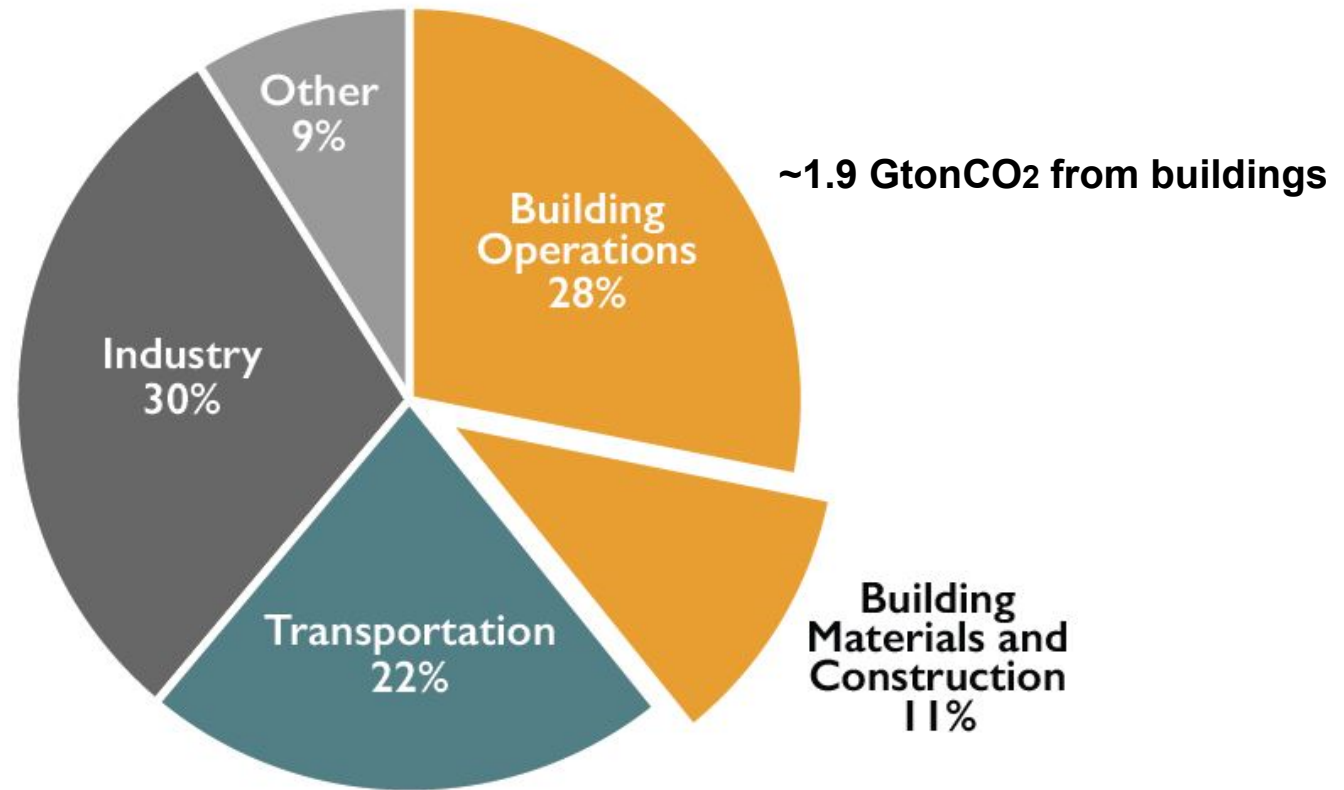


Betsy Otto and Leah Schleifer, World Resources Institute (WRI)





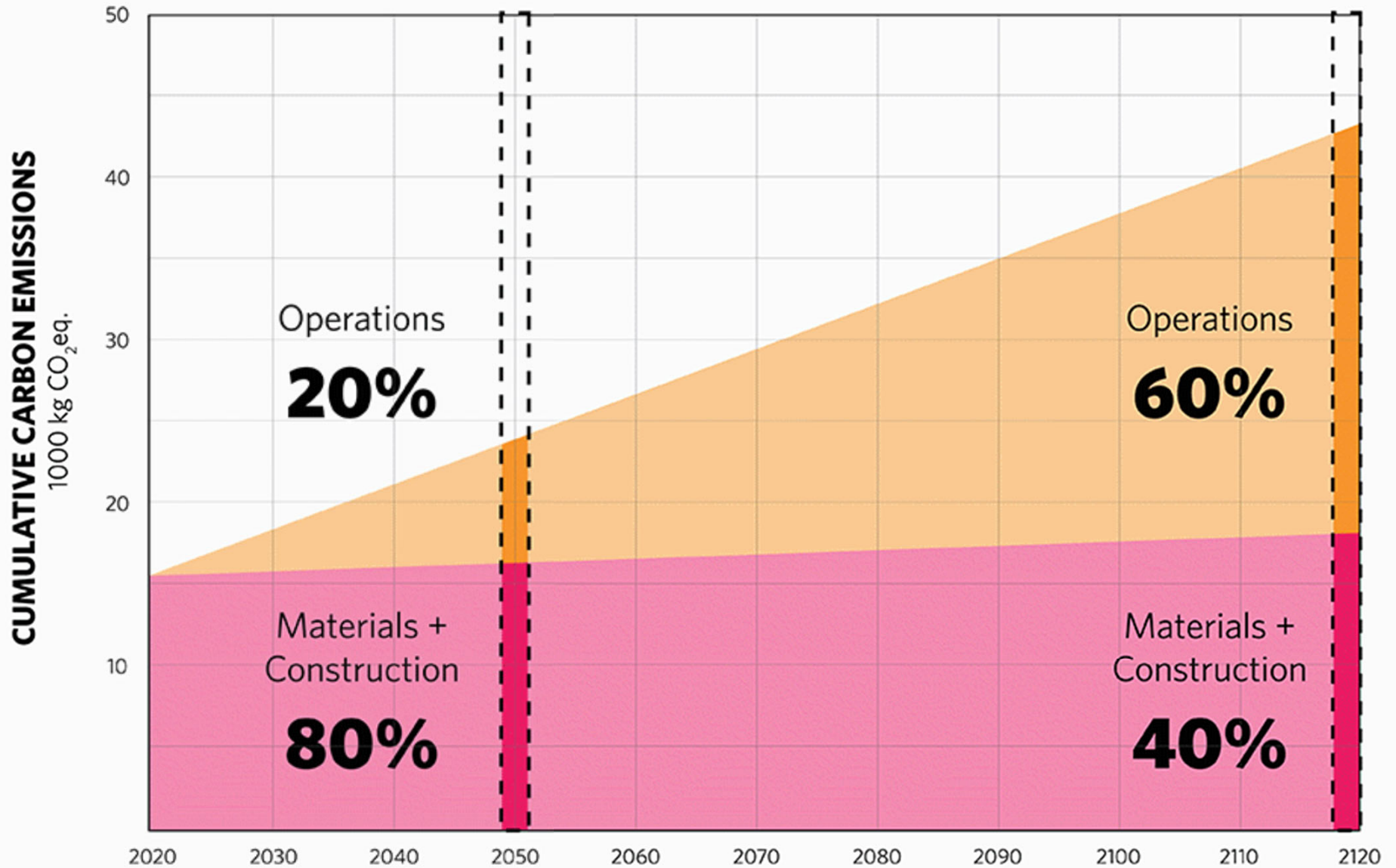
Global CO₂ Emissions by Sector



Source: © 2018 2030, Inc. / Architecture 2030. All Rights Reserved. Data Sources: UN Environment Global Status Report 2017; EIA International Energy Outlook 2017

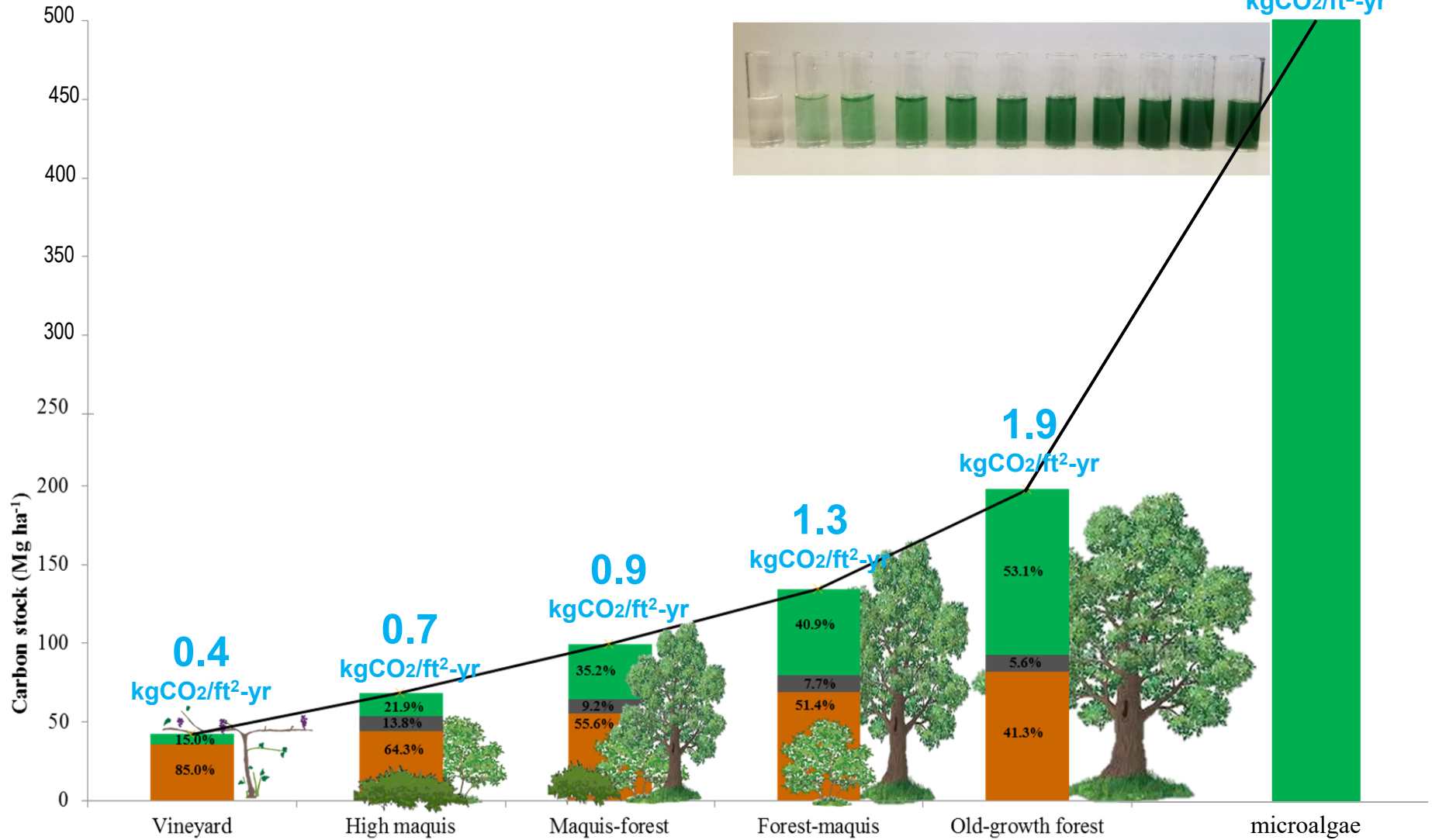
CARBON EMISSIONS

Typical High Performance Commercial Building



Functions of Sustainable Building Envelopes

Protect-Promote-**Re/Generate**: Bio-Facades



doi: <https://doi.org/10.1371/journal.pone.0220194.g002>



The Richness Of 'Poor' Places, From National Geographic's Photo Contest : Goats and Soda : NPR

Location

Singapore

Architect

WOHA

Client

UOL Group Limited

Type

Hotel

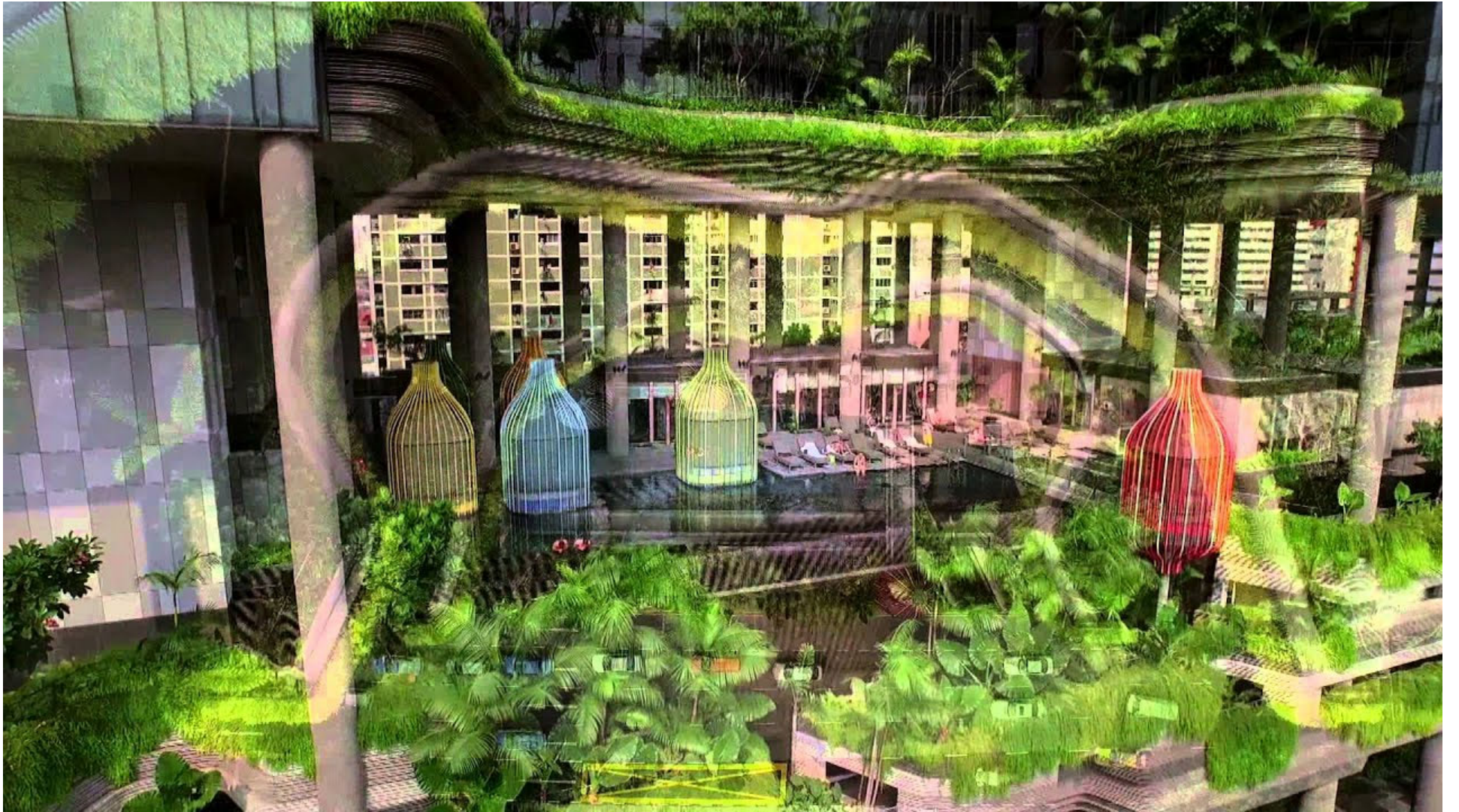
Size

29,811m²/367 hotel rooms





Park Royal Hotel | Singapore | WOHA



Park Royal Hotel | Singapore | WOHA



Park Royal Hotel | Singapore | WOHA

Functions of Sustainable Building Envelopes

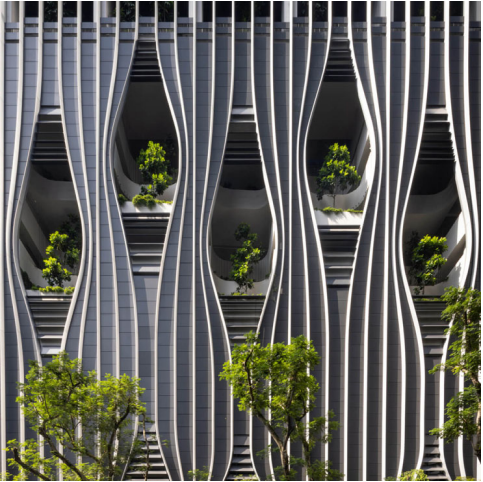
Protect-Promote-**Re/Generate**: Bio-Facades



Acros Fukuoka Prefectural Hall,
Japan



Le Nouvel, Malaysia



CapitaSpring, Singapore



Baltimore Inner Harbor, USA



House E, Zurich



Stacking green, Vietnam



City garden layers, UK



Vertical forest, Milan



Google image

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Director of Integrated Design Research Lab
UNC Charlotte
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CITIES PARTNERSHIP**