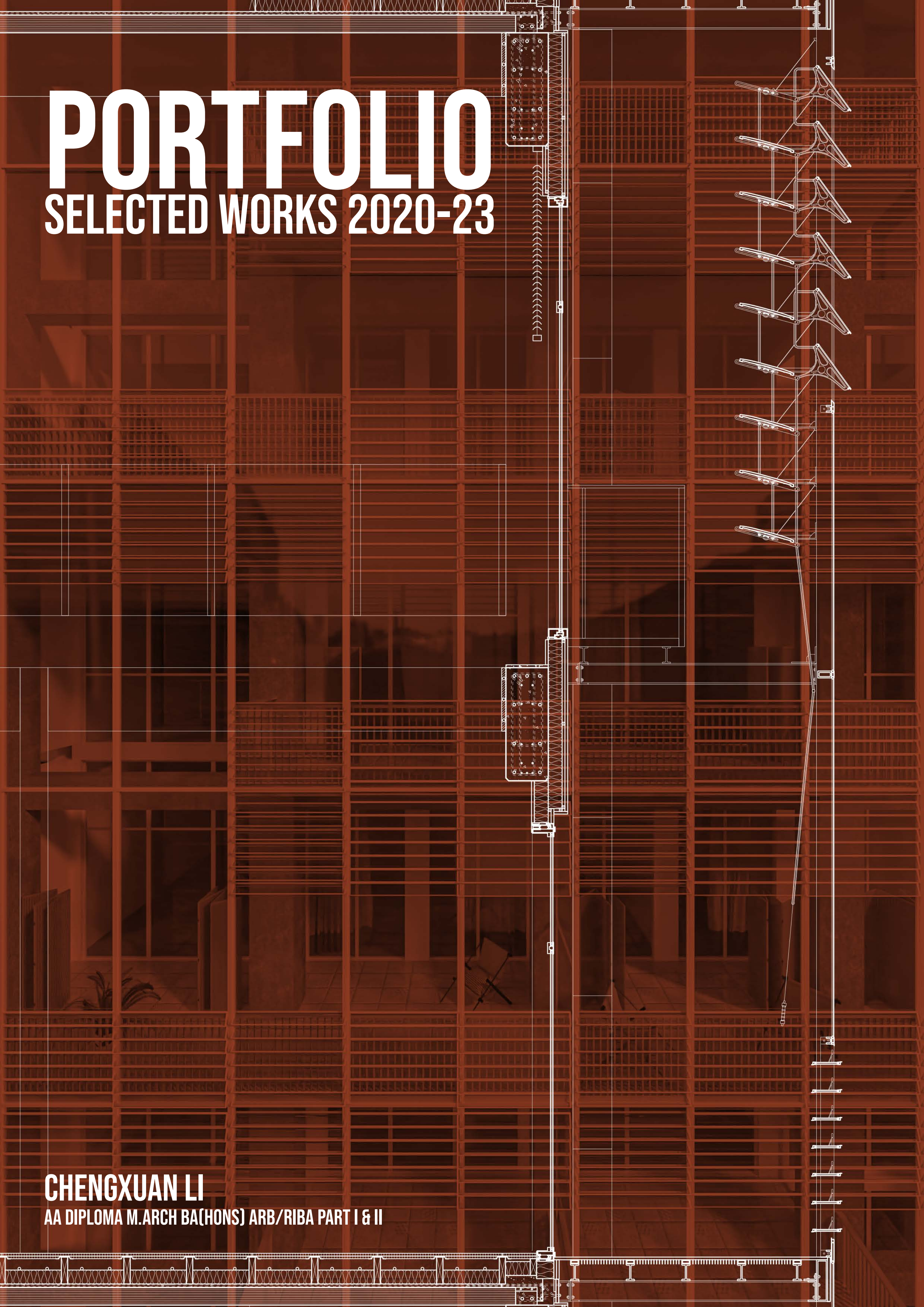


PORTFOLIO
SELECTED WORKS 2020-23

CHENGXUAN LI
AA DIPLOMA M.ARCH BA(HONS) ARB/RIBA PART I & II

Chengxuan Li

London, United Kingdom

T +44 (0) 7375840005
E Chengxuan.Li@aaschool.ac.uk
W https://www.lcx.works/

As an architectural designer, environmental specialist, computational designer, and software developer, I merge diverse expertise to craft innovative design solutions. Paying great attention to detail, I believe in the transformative potential of architectural design for a brighter tomorrow. My interest and experience drives me to shape sustainable and high-performance buildings with evidence-based design-decisions and cutting-edge computational workflows.

Skills

3D modelling and drafting
Rendering and Visualisation
Computational and Parametric Design
Sustainable Design & Evaluations
Energy Modelling (EnergyPlus & Ladybug)
GeoSpatial Analysis (QGIS & GeoPandas)

Software

Rhinoceros & Grasshopper
VRay, Enscape
PhotoShop, Illustrator, InDesign
C#/.NET with RhinoCommon
Python with Numpy, Pandas, Matplotlib
Microsoft Office Suites

Language

TOEFL: 119/120
GRE: Q170/170(*94%*) V160/170(*84%*) AW5.5/6 (*98%*)
English: Proficient
Chinese (Mandarin): Native
Japanese: Intermediate
Spanish: Elementary

Education

Architectural Association School of Architecture — *Sep 2022-Jun 2024 (expected)*
MArch Diploma Programme RIBA/ARB Part II; current GPA 3.89/4.00
(*Ongoing*) **Thesis**: Methods and guidelines for the design and planning of urban public spaces in the historical urban environment: A case study in Poplar, London

Architectural Association School of Architecture — *Sep 2020-Jun 2022*
BA(Hons) Intermediate Programme RIBA/ARB Part I; GPA 3.86/4.00
Design Thesis: Infrastructure for Housing Affordability, Community Well-being and Sustainable Growth
Technical Thesis: The Energy-Efficient Refurbishment of an Industrial Building in Royal Docks, London
2021/22 Undergraduate Technical Thesis Commendation Award
2020/21 & 2021/22 Undergraduate History&Theory Thesis Award Finalist

Xi'an Jiaotong-Liverpool University — *Sep 2018-Jun 2020*
BEng Architecture; GPA 3.88/4.00 (1/196)
2020/21 & 2019/20 University Academic Excellence Award (5%)
2020/21 University of Liverpool Scholarship (1%)

Experience

Teaching Assistant — *Sep 2023*
AA Visiting School (DLAB) https://dlab.aaschool.ac.uk/ — Architectural Association, London
Through teaching computational design, form-finding and structural optimization principles at the AA Visiting School in 2023, I helped students explore new frontiers in active bending and lightweight structures. The AA DLAB 2023 focused on robotically bundling and twisting rattan canes to create unique and structurally-efficient forms. The project was featured in the UK Construction week in Birmingham.

Environmental Consultant — *Jul-Sep 2023*
Urban Systems Design https://www.urbansystems.design/ — London
In my role supporting Google's sustainability initiatives, I coordinated evaluation efforts of its North American and Latin American workplaces to assess compliance with environmental guidelines. This included data collection, processing and analysis of the workplaces' performance. I assisted with reports and presentations, contributing insights that informed strategic planning and decision-making around de-carbonising Google's real estate portfolio.

Architectural Assistant (Part I) — *Jul-Sep 2022*
Hopkins Architects https://www.hopkins.co.uk/ — London
For a prestigious UK client, I contributed to the feasibility assessment of a site in Cambridge. Combining manual and generative approaches, my role involved optimisation of early-design/massing schemes within the parameters of the client brief, planning regulations, sustainability, site covenants and easements by collaborating closely with decision-makers, lighting, environmental, and planning consultants to synthesise inputs from various stakeholders.

Architectural Assistant — *Jul-Sep 2021*
AntiStatics Architectural Design https://www.antistatics.net/ — Beijing, China
I was responsible for various architectural design and masterplan projects, including the conversion of an office building in Haidian, and the masterplan for a new high-speed railway station in Beijing. Alongside working in the design team, I also participated in interior design and parametric furniture design.

Publications

Optimising Urban Morphological Tessellation: Methodological Advancements Using Adaptive Tessellation and Guided Triangulation — *Expected Aug 2024*
Peer-Reviewed Abstract
The 2nd International Conference on Architecture Across Boundaries (AAB2024)

Morphological Insights on Building Energy Demand: A Machine Learning Approach Using Gradient-Boosted Decision Tree — *Expected Jul 2024*
Peer-Reviewed Abstract
The 6th International Conference on Computational Design and Robotic Fabrication (CDRF2024)

Design Works

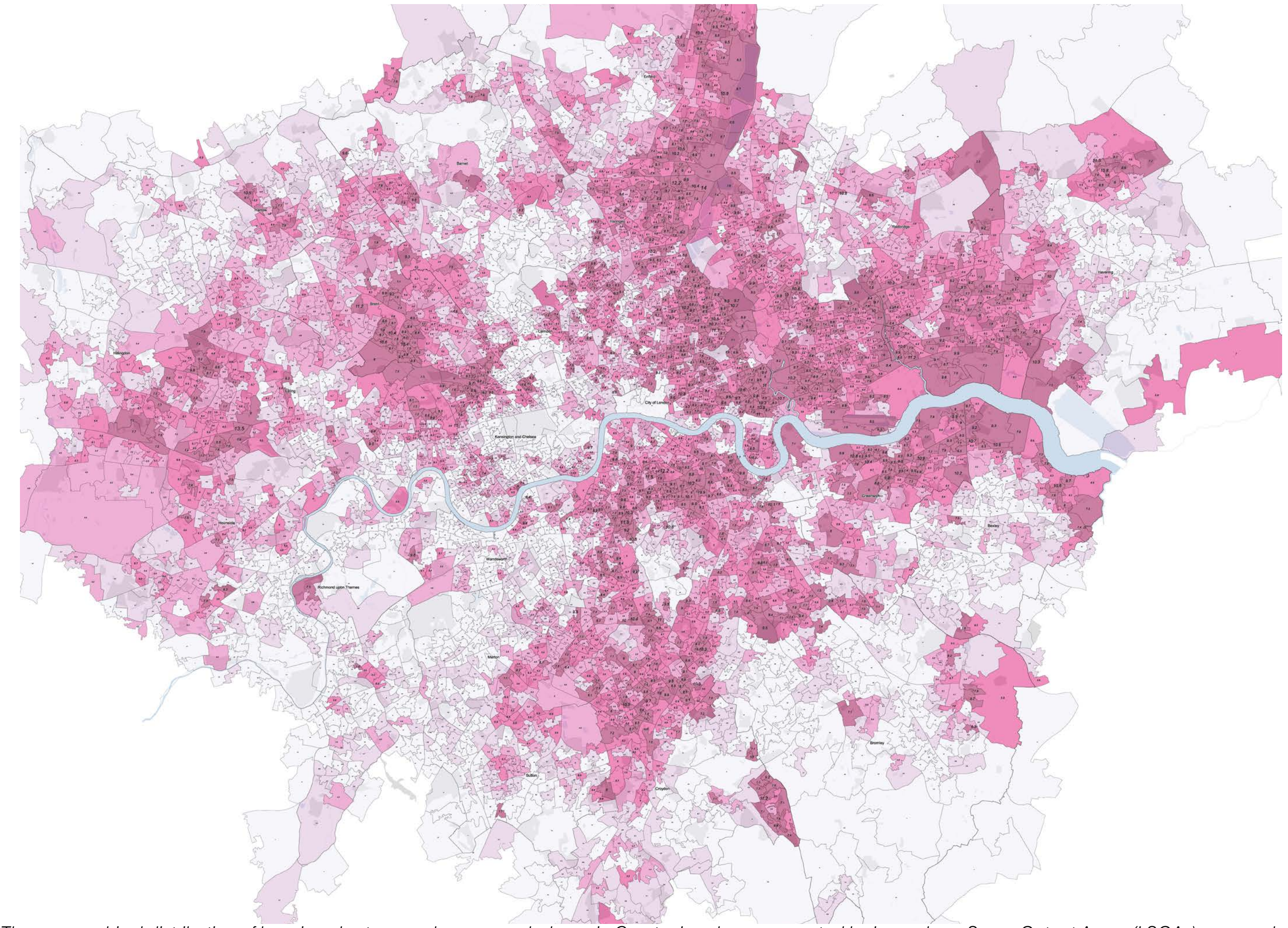
Research and Software Development

Sun, Air and Housing for All

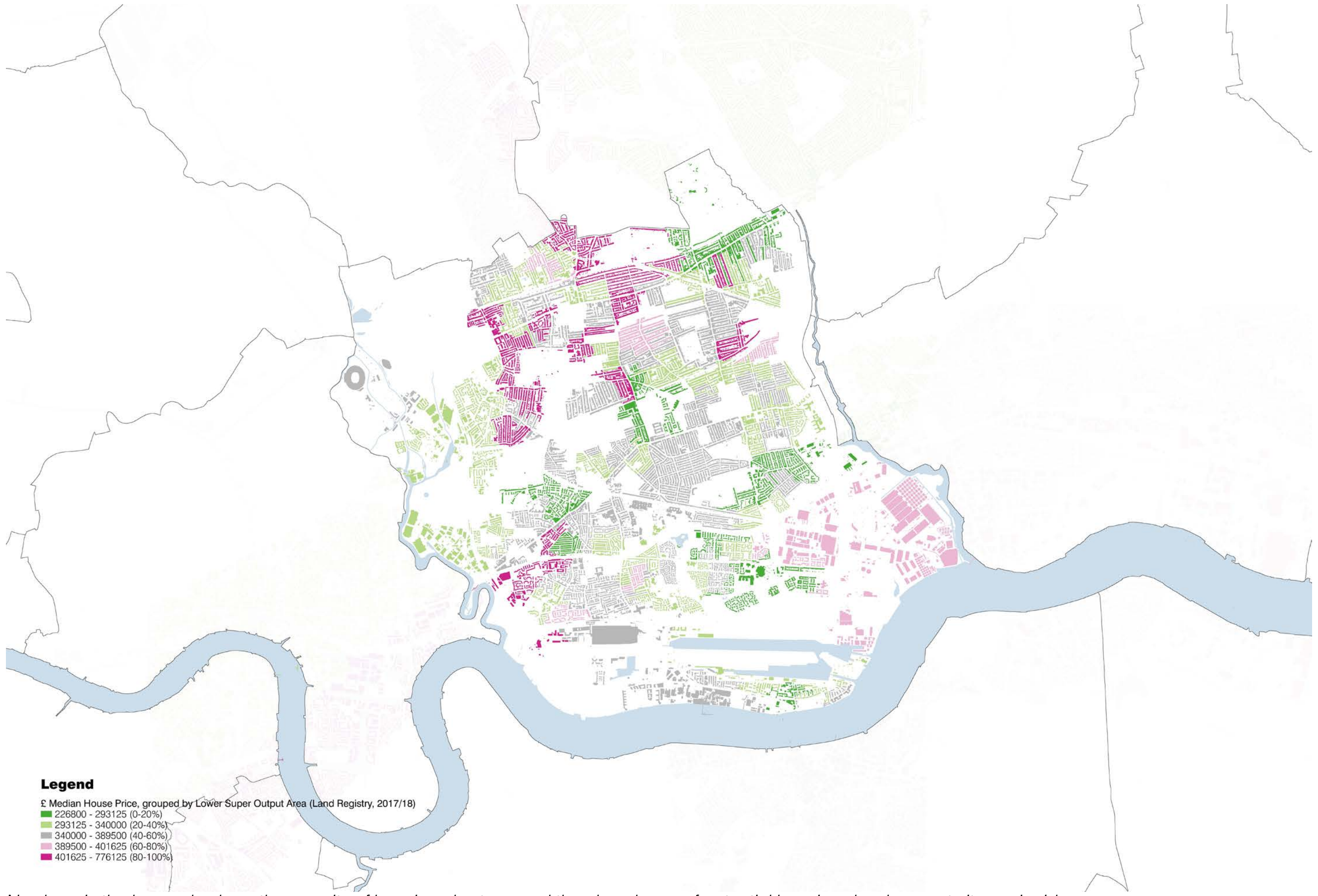
Validated Energy-efficient Retrofit for Quality Living

Environmental Design, Energy Modelling, Energy Efficient Retrofit

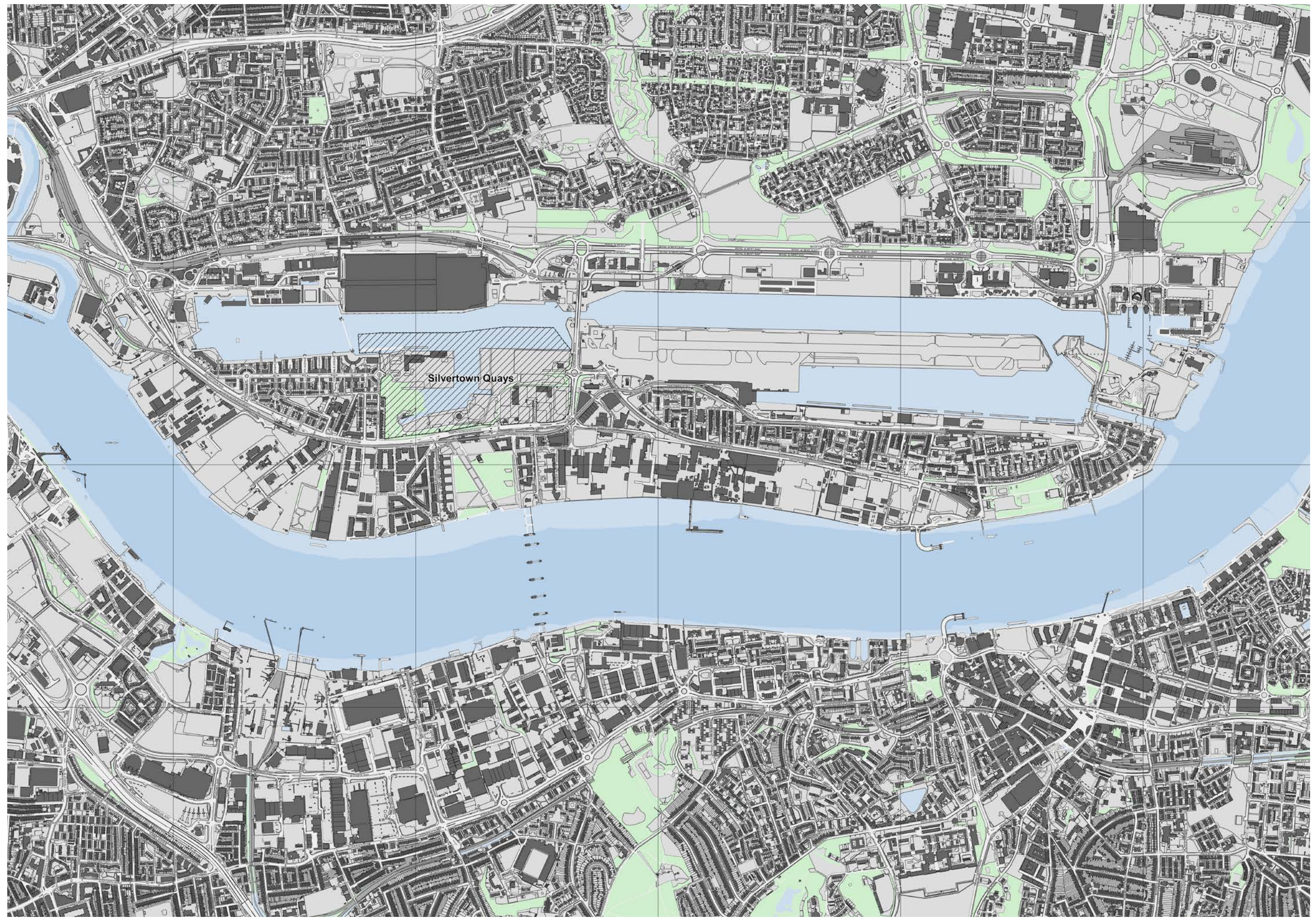
Architectural Association, 2021-22



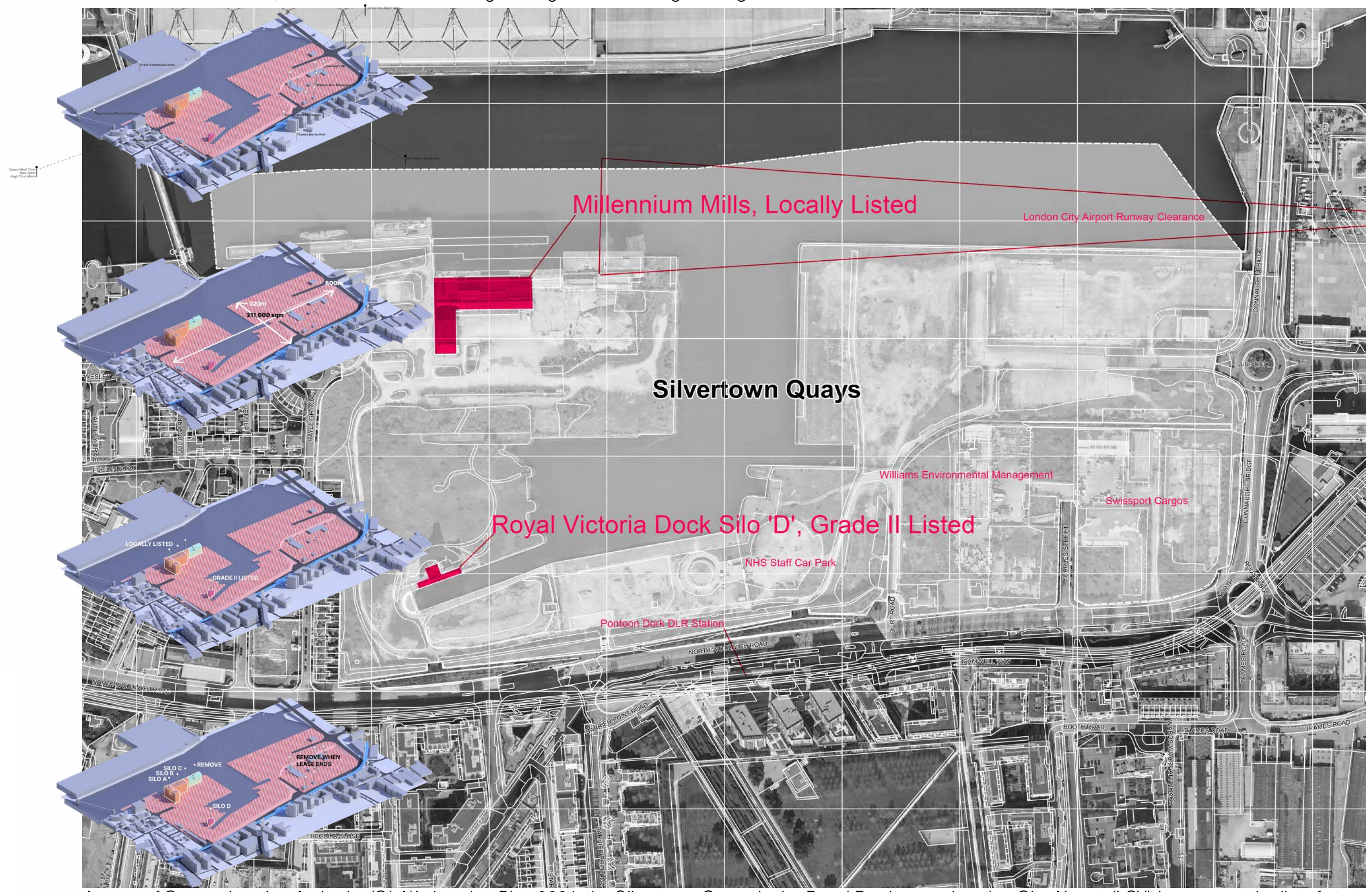
The geographical distribution of housing shortage and over-crowdedness in Greater London, aggregated by Lower layer Super Output Areas (LSOAs), mapped with British Census 2011; darker colours indicate higher degrees of housing shortage.



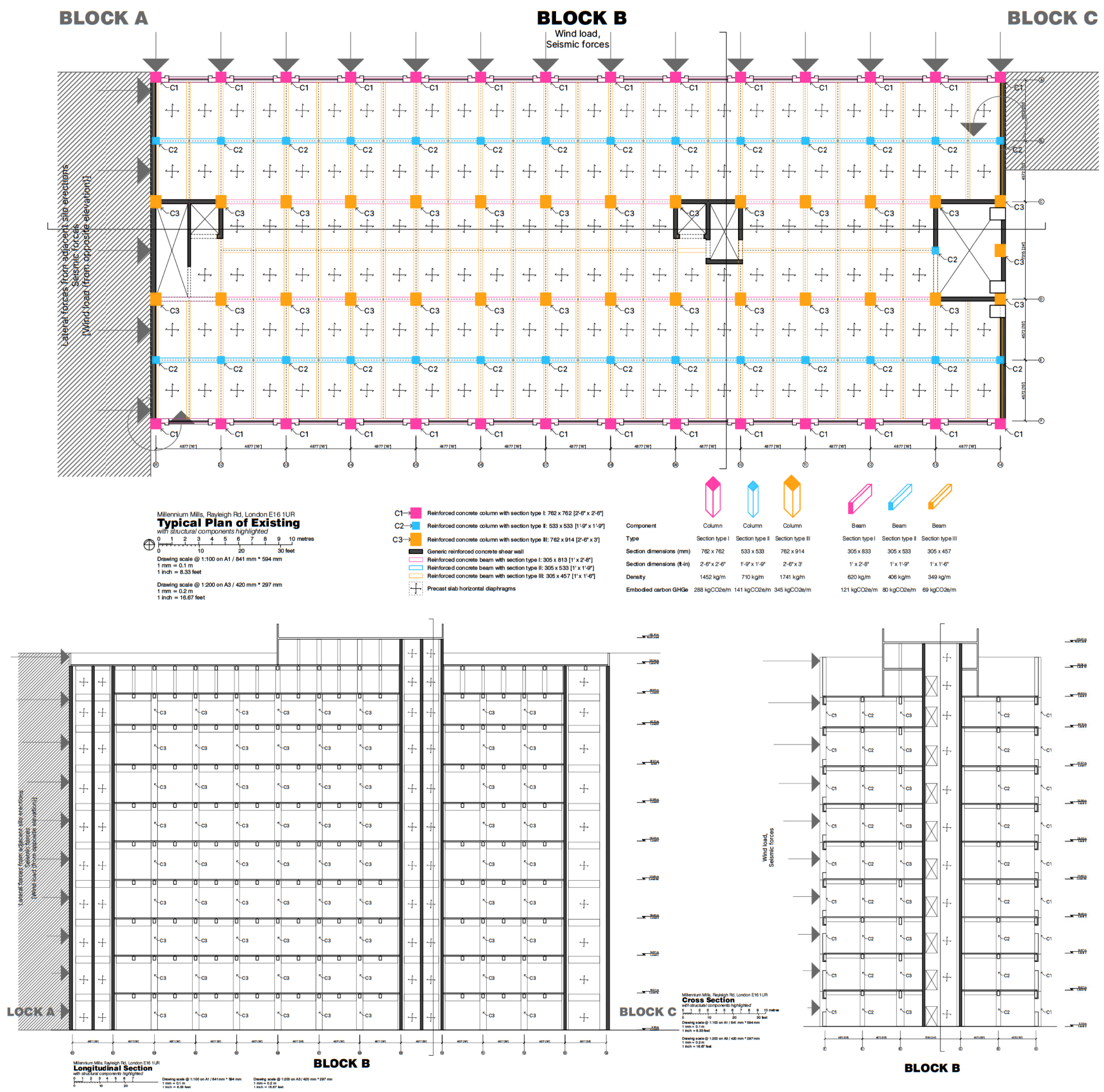
Newham is the borough where the severity of housing shortage and the abundance of potential housing development sites coincide. Above is a geographical distribution of housing prices across the borough based on Land Registry Real Estate Transactions dataset



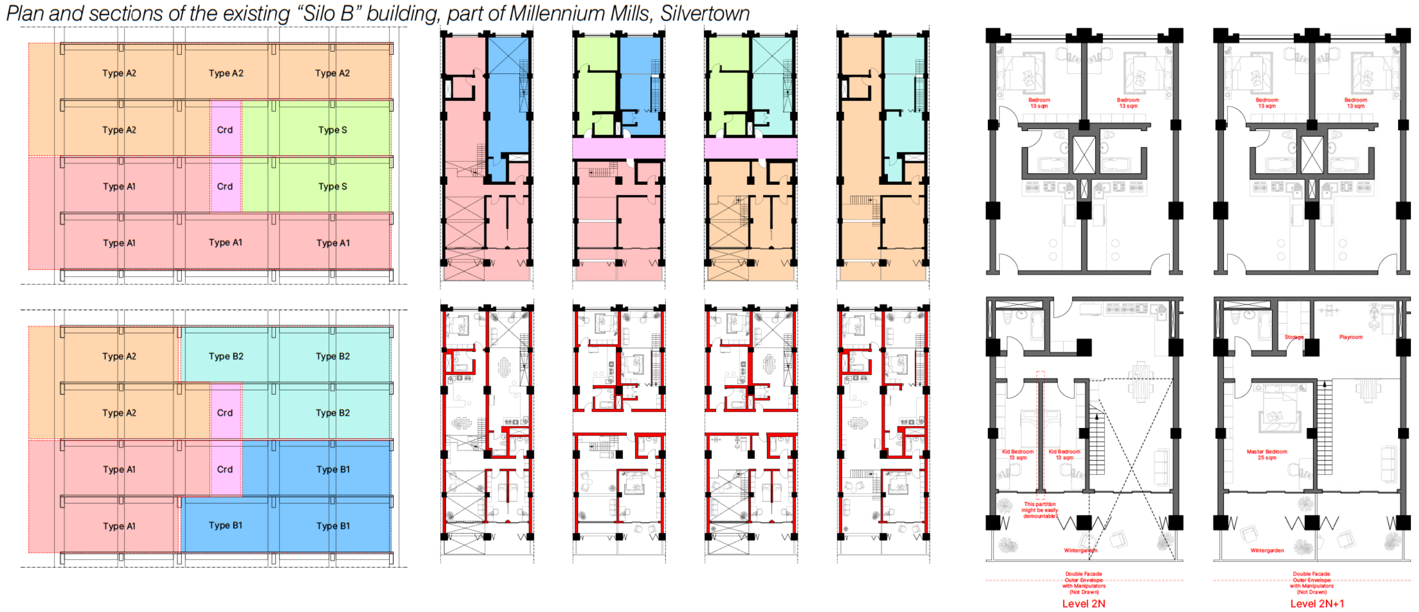
The geographical distribution of housing shortage and over-crowdedness in Greater London, aggregated by Lower layer Super Output Areas (LSOAs), mapped with British Census 2011; darker colours indicate higher degrees of housing shortage.



As part of Greater London Authority (GLA)'s London Plan 2021, the Silvertown Quays in the Royal Docks near London City Airport (LCY) is amongst the list of strategic sites. This design focuses on an alleged brief in this planning document where "Silo B" is retrofitted and re-purposed as housing of mixed tenures.



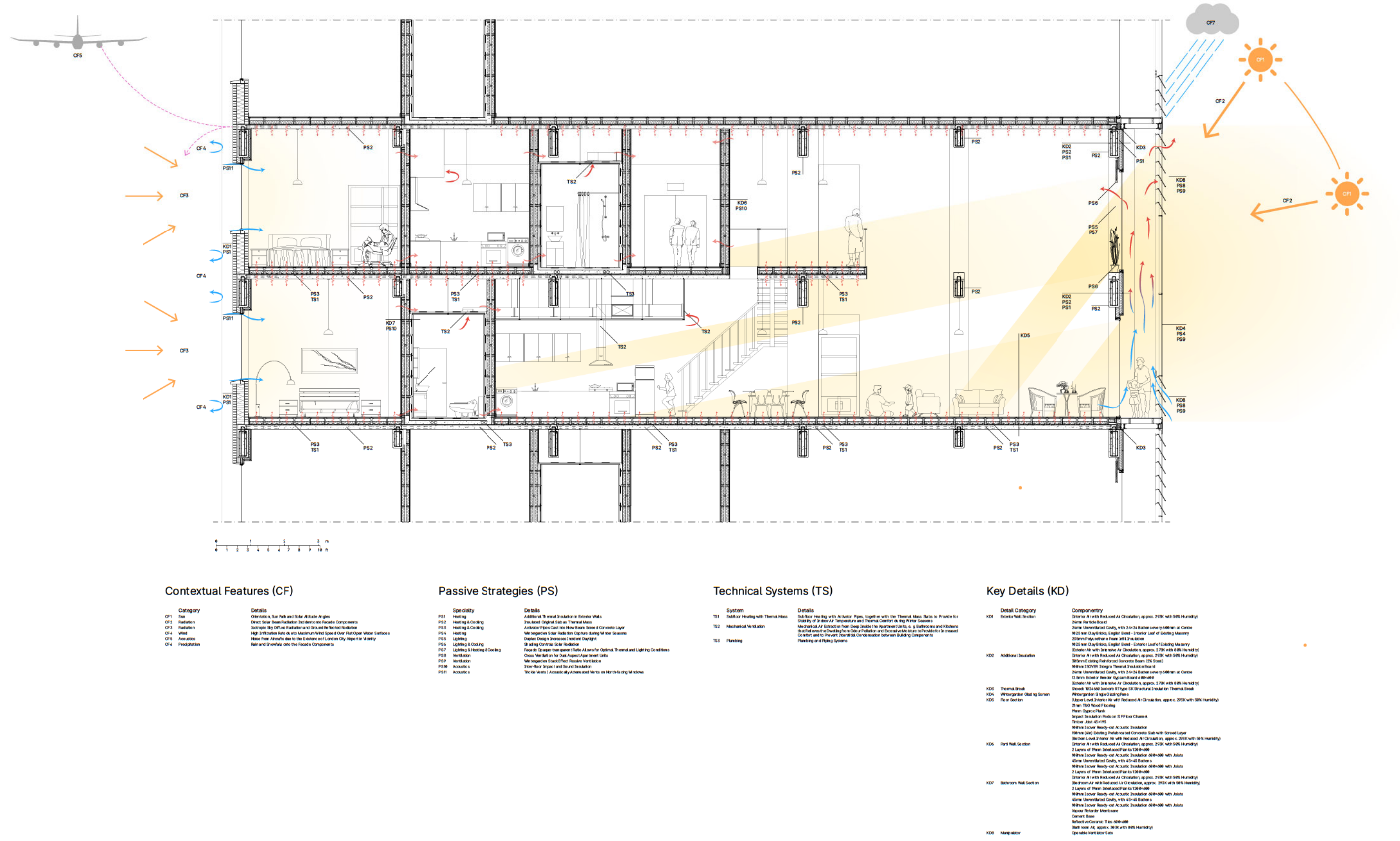
Plan and sections of the existing "Silo B" building, part of Millennium Mills, Silvertown



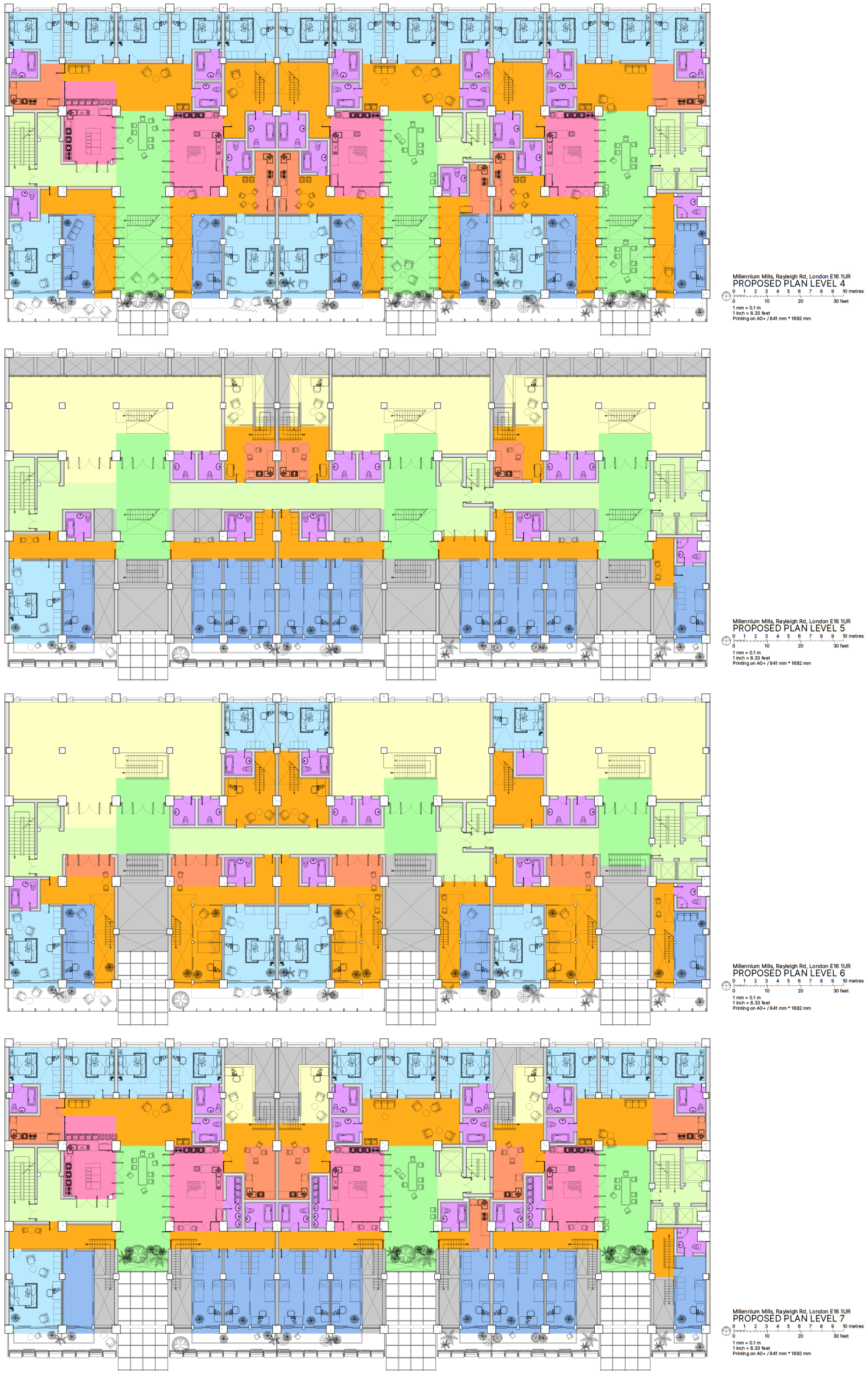
This retrofit proposal bases its initial design principle upon the interlocking section layout, minimising spaces for circulation while encouraging dual-aspect housing units, similar to the Unite d'Habitation Typ Marseilles.

Render, showing facade extension with wintergarden climatic barriers and vents/ shades

Render, showing the desired duplex living room, facing a semi-private courtyard



Principle ideas for energy efficiency and building sustainability performance, with a reference to building components, systems, contextual objects and conditions, etc.

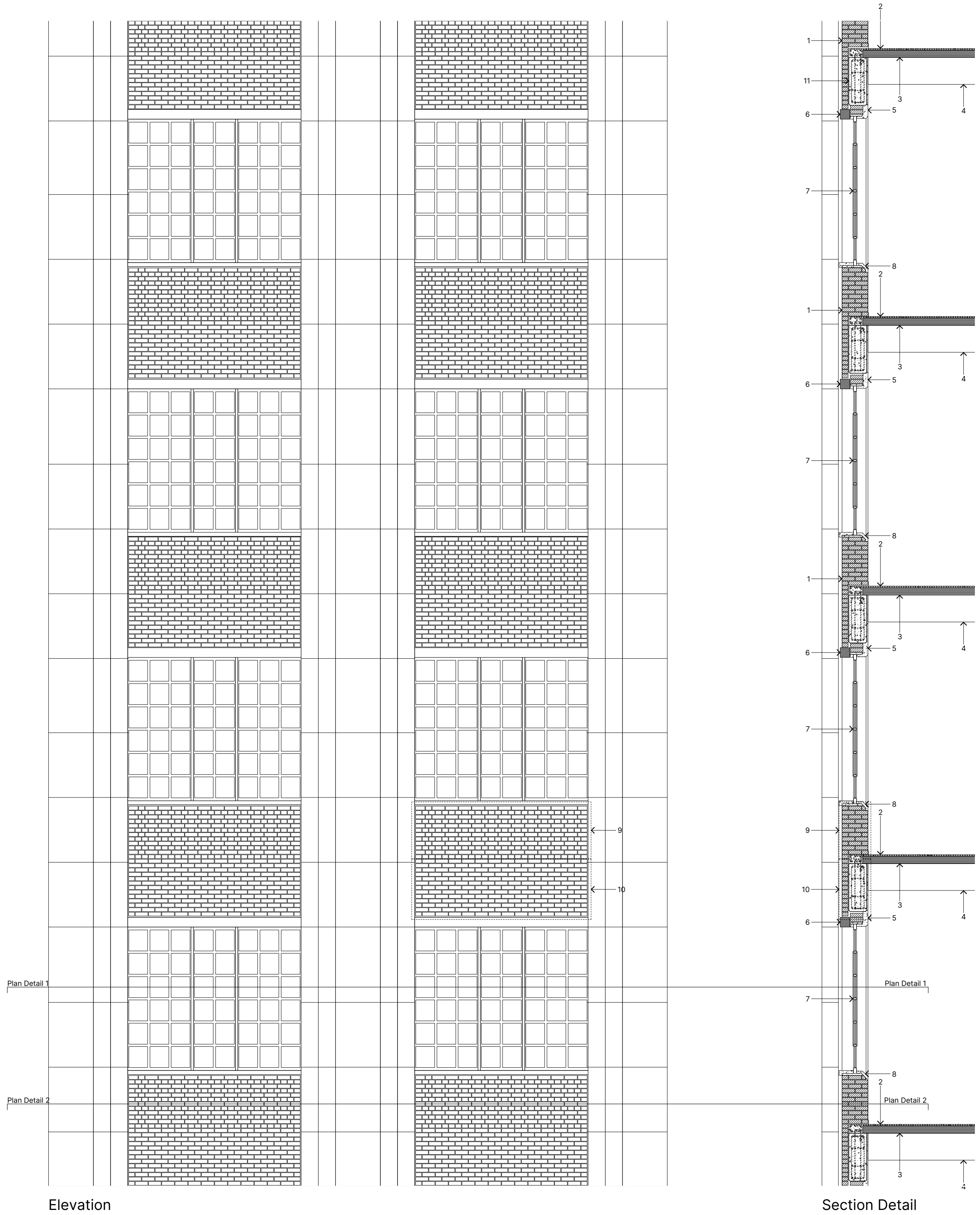


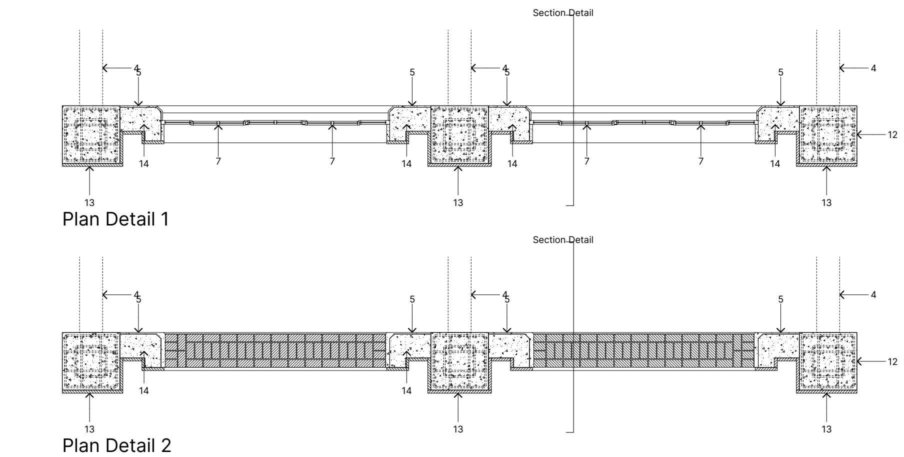
Programmatic floor plans showing spatial arrangement.

Renders showing interior views.

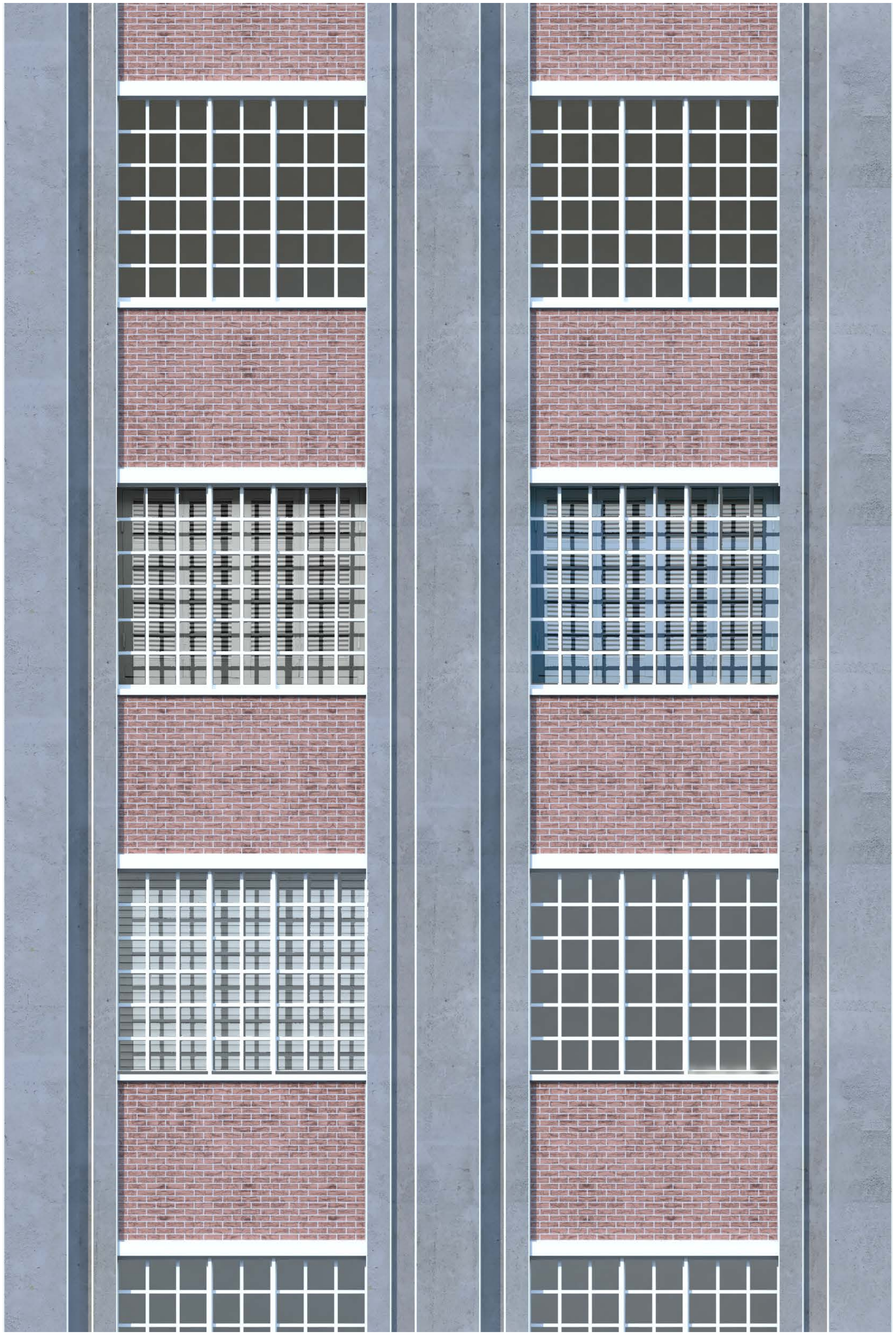
1. Solid exterior wall masonry composition with stucco render on north-facing facade (direct exposure on the south-facing aspect), single leaf (componentry to be specified in 9 and 10), non load-bearing element
2. In-situ concrete screed, cast in place after the installation of component 3 panels
3. 5” [127 mm] precast solid concrete panels of which the structural behaviour varies according to different construction and finishing methods of the screed layer(s) - in the case of a consistent rebar connection, forming a planar grid that strengthens and provides for lateral stability, the panels could qualify as diaphragms that resist shearing forces in the horizontal directions
4. W 1’ x D 1’ 6” [305 mm x 457 mm] in-situ reinforced concrete beams, spanning in the transverse direction
5. Interior in-situ concrete finish
6. Window header / lintel piece which could be concrete prefab or whole masonry block
7. Timber-framed casement windows with wrought iron opening lights, art-deco style, single glazed
8. General window sill plates and sheathing
9. English bond 1’ 6” single leaf masonry (also known as the 18-inch pier), of which the individual brick size: L 215 mm x W 102.5 mm x H 65 mm (with approx. 10 mm mortar gaps), three layers
10. Single layer masonry bricks, stretcher bond, brick size as above - note that not all exterior walls contain stretcher bond sectors, e. g. partial elevation in the image on the left
11. W 1’ x D 2’ 8” [305 mm x 813 mm] in-situ reinforced concrete beams, spanning in the longitudinal direction
12. 2’ 6” x 2’ 6” [762 mm x 762 mm] in-situ reinforced concrete columns
13. 20 mm exterior cladding panels
14. “Entasis” with art-deco style tapered profile

Existing facade, images and drawings (note that the existing facade is assumed to be made up of similar constructions on either aspect, south or north).

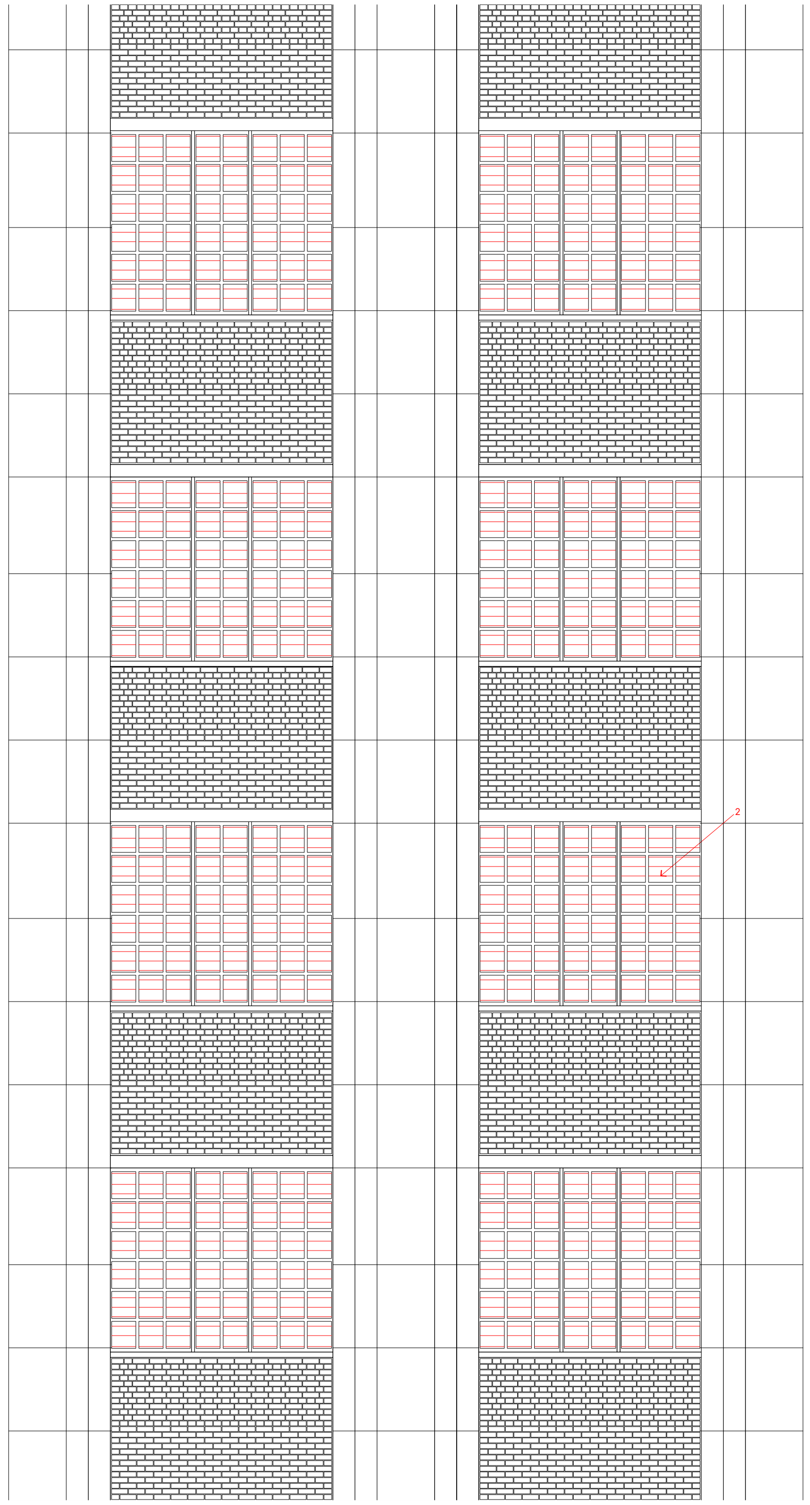




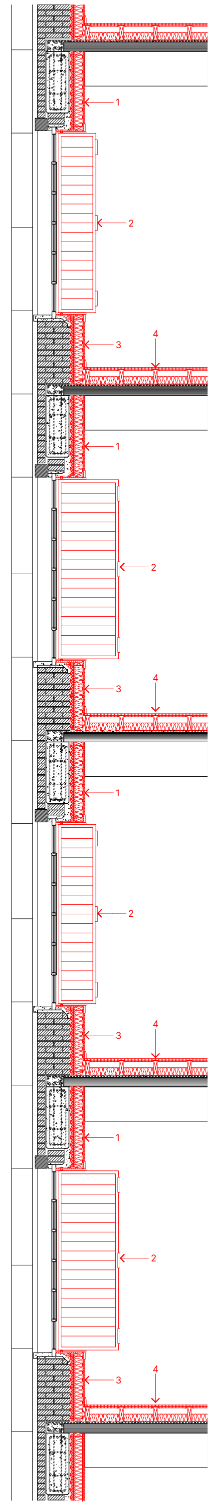
Existing facade, images and drawings (note that the existing facade is assumed to be made up of similar constructions on either aspect, south or north).



North facade alteration with added internal shutters, window upgrades, engendering minimal changes on the exterior - part of a strategic view and the identity of Royal Docks



Elevation

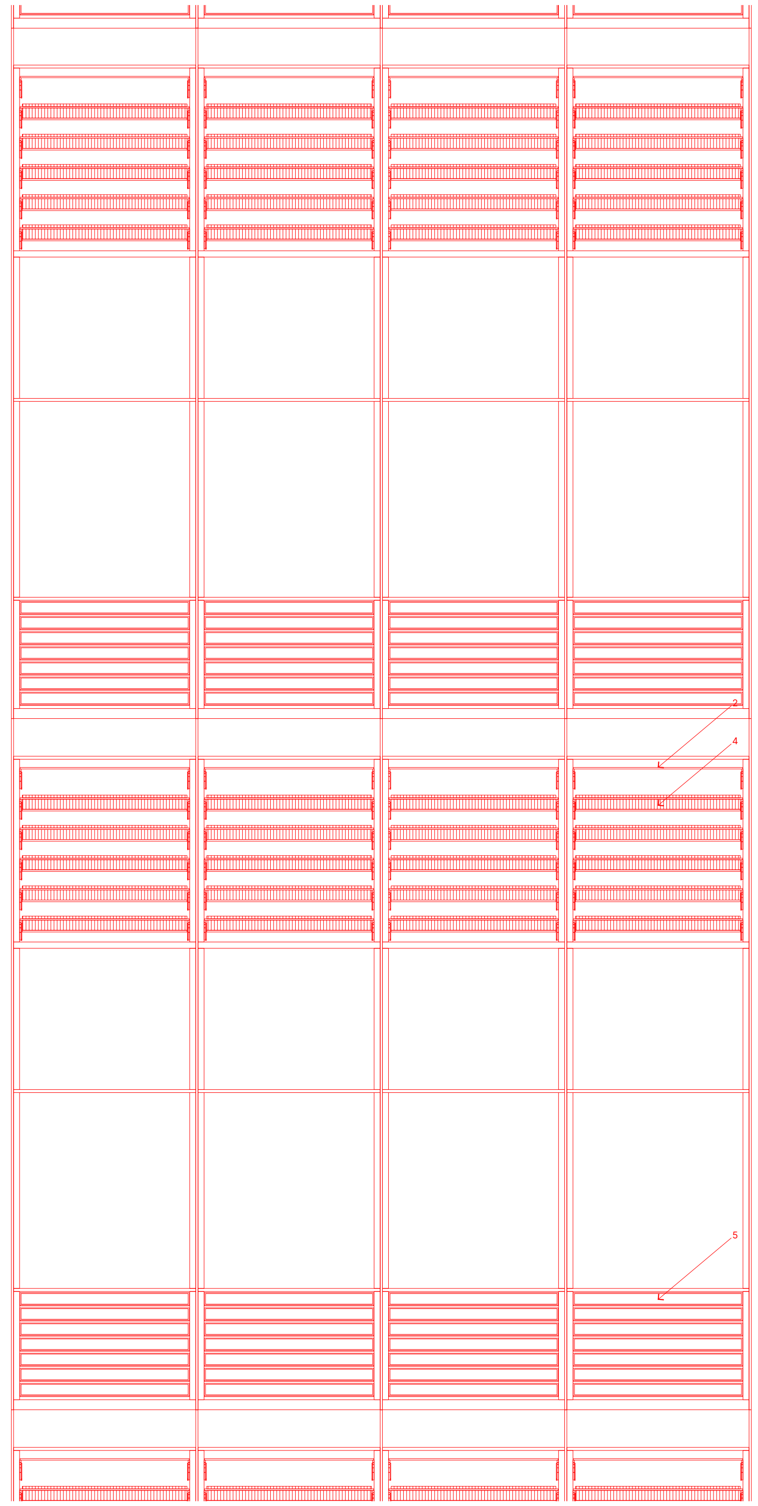


Section Detail

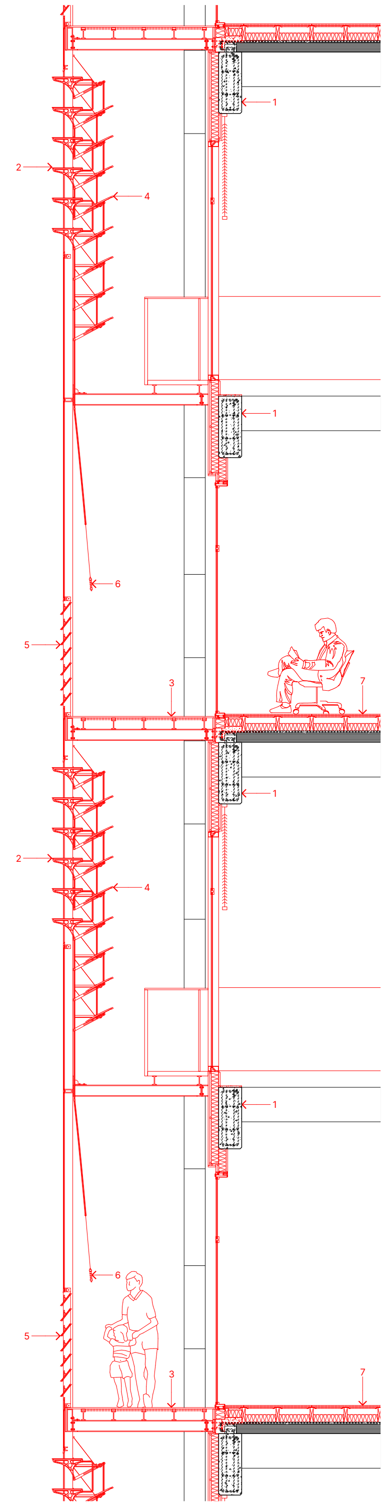
1. **Internal insulation of existing beams**
   12.5 mm plywood board
   18 mm OSB
   Vapour retarder foil, sd = 10 m
   100 mm x 45 mm timber battens (post-and-rail construction) with 100 mm ready-cut wood fibre insulation boards
   18 mm OSB
   40 mm x 40 mm timber battens with cork infill insulation
   Vapour control membrane (breather membrane), sd < 0.5 m
   [Existing] concrete screed, washed down
   [Existing] W 1' x D 2' 8" [305 mm x 813 mm] in-situ reinforced concrete beams, spanning in the longitudinal direction
   [Existing] brick masonry, with a combination of stretcher bond and English bond
   [Existing] exterior stucco render
2. **Reduction in facade glazing ratio & improvement of thermal properties**
   Internal shutter set, sliding & folding
3. **Internal insulation of existing masonry construction**
   12.5 mm plywood board
   18 mm OSB
   Vapour retarder foil, sd = 10 m
   100 mm x 45 mm timber battens (post-and-rail construction) with 100 mm ready-cut wood fibre insulation boards

North facade alteration with added internal shutters, window upgrades, engendering minimal changes on the exterior - part of a strategic view and the identity of Royal Docks

South facade renovation with wintergarden extension, creating a climatic buffer zone



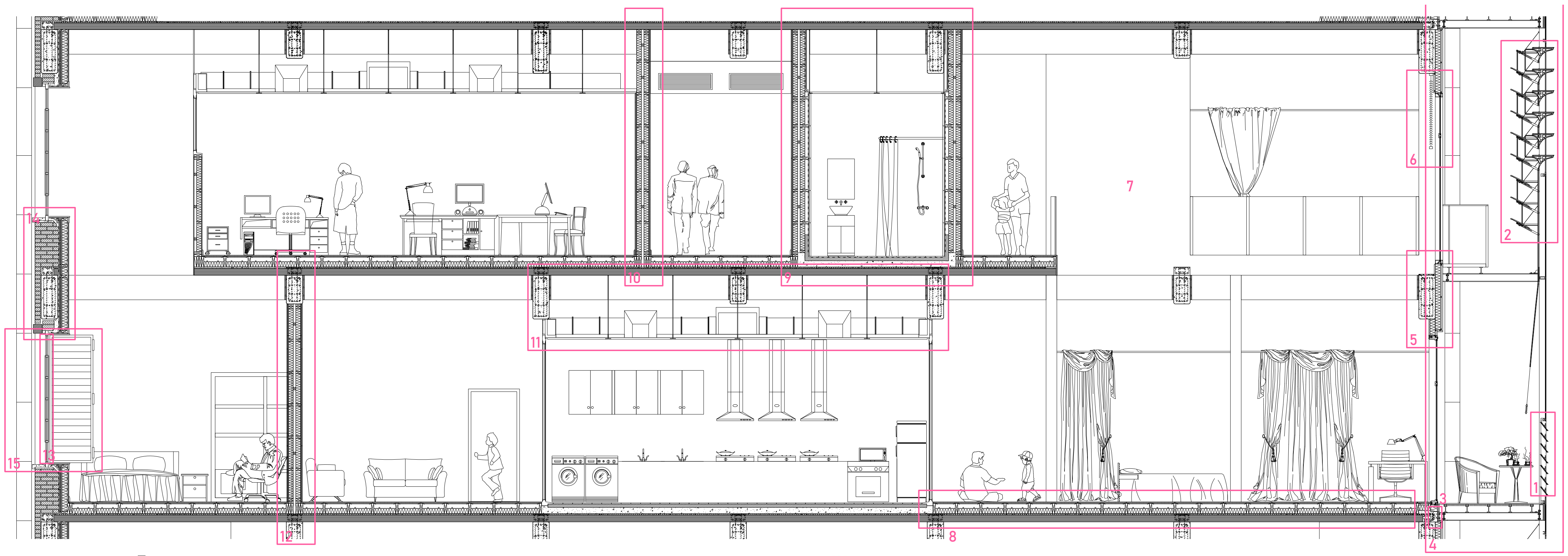
Elevation

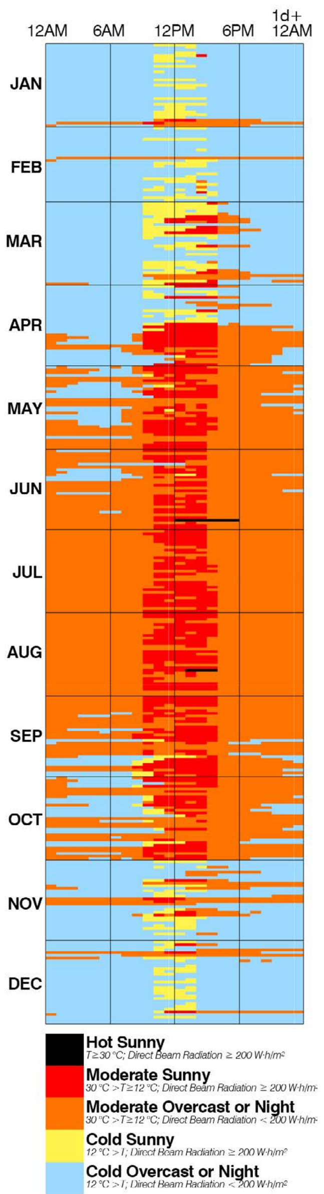


Section Detail

1. **External insulation of existing beams**
   [Existing] concrete screed, washed down
   [Existing] W 1' x D 2' 8" [305 mm x 813 mm] in-situ reinforced concrete beams, spanning in the longitudinal direction
   100 mm ISOVER Integra thermal insulation Board
   24 mm unventilated cavity, with 24 mm × 24 mm battens every 600mm centre
   12.5 mm fire-resistant gypsum board 600 mm × 600 mm
2. **Upper vents - air extraction**
3. **Wintergarden fire-proof decking**
   19 mm Gyproc plank
   I-section metal joist, with supporting rails attached and gratings
   I-section metal joist, attached with bolts to the load-bearing thermal break joints (Shock Isokerb) which connect with the existing fabric through rebars cast into new concrete layers onto existing beams
4. **Louvres, lamination with moisture-resistant coatings**
5. **Bottom vents - air supply**
6. **Manipulator handle**
7. **Modernisation of the floor construction with underfloor heating applied**
   21 mm T&G wood flooring
   19 mm Gyproc plank
   Impact insulation pads on SIF floor channel
   195 mm x 45 mm timber joist with 100 mm Isover ready-cut acoustic insulation (with underfloor heating system)

South facade renovation with wintergarden extension, creating a climatic buffer zone





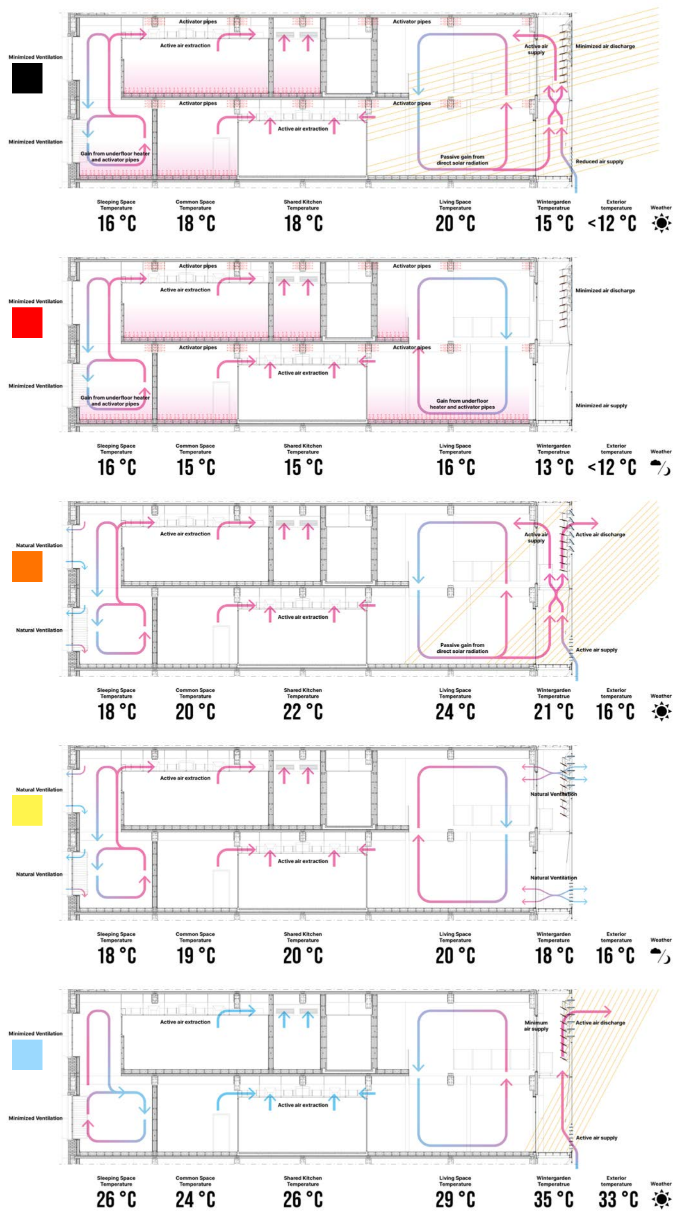
Hot Sunny
A hot daytime scenario is defined as a daytime hour with an exterior dry bulb temperature over 30 degrees Celsius. Blinds and closed ducts in the internal layer should prevent the hot air from entering the interior living space facing the south which could overheat easily otherwise. There should be a need for a night purge to relinquish thermal masses in the internal fabric which has passively gained and stored a considerable amount of heat during the summer daytime hours.

Moderate Sunny daytime
A moderate daytime scenario is defined as a daytime hour with an exterior dry bulb temperature over 12 degrees Celsius but below 30. Direct beam radiation should also exceed 200 Wh/m2 per hour. In this scenario, the wintergarden function more as a tiny solar chimney allowing for passive ventilation and air exchange, than a barrier since there are no needs to thermally insulate the interior from the exterior due to the fact that both environments are exceptionally habitable and comfortable thermally. The ducts should be full open to maximize the natural ventilation and in some cases, there could be a possibility of slight overheating issues in the south facing living spaces and internal blinds and manual shadings situated in the barrier layer could help.

Moderate overcast or night
A moderate overcast or night scenario is defined as a hour with an exterior dry bulb temperature between 12 and 30 degrees Celsius and the direct beam radiation less than 200 kWh/m2 per hour. This scenario is typically found in spring cloudy days and summer nights. For the former, the strategy is similar to moderate sunny days with ventilators open wide. For the latter, the strategy could be called a night purge where the heat passively gained during the sunny daytime and stored in the internal fabric and thermal masses could be brought away by a considerably high natural ventilation air exchange rate.
There should be no concerns for overheating.

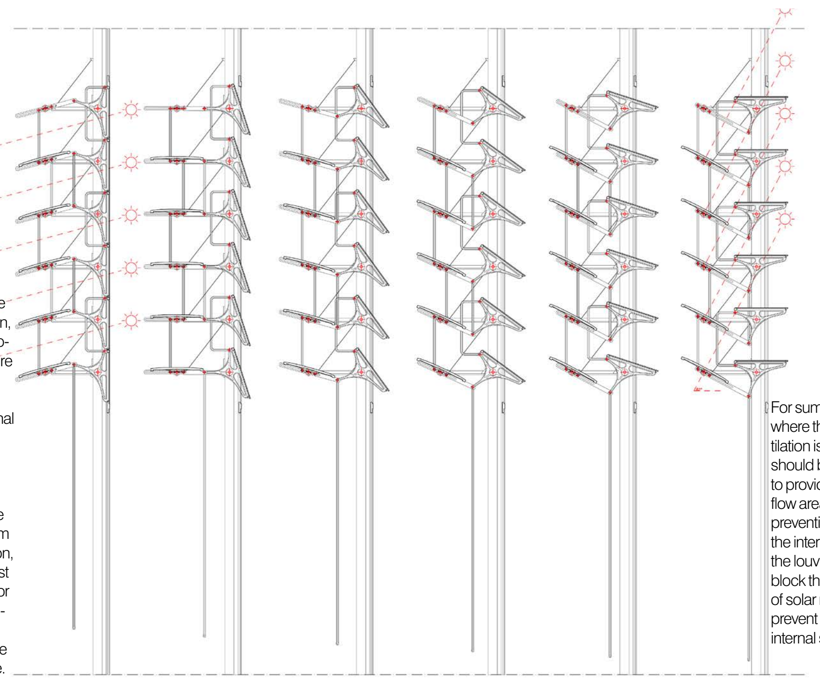
Cold sunny
A cold sunny daytime scenario is defined as a daytime hour with an exterior dry bulb temperature below 12 degrees Celsius and the hourly direct solar beam radiation over 200 Wh/m2. In this scenario, the wintergarden could serve as BOTH a climatic barrier AND a tiny solar chimney that pre-heats the cold fresh air supply from the exterior environment and mixes it with the air extracted from the interior. This process heats up the fresh air supply passively and reduces heating load during cold sunny winter days.

Cold overcast or night
A cold overcast or night scenario is defined as an hour with exterior dry bulb temperature below 20 degrees Celsius and direct radiation below 200 Wh/m2 per hour. In this scenario, due to the lack of the direct solar gain that raises the floor temperature resulting in the inadequacy of vertical temperature difference in the wintergarden, the air inside does not rise passively due to the buoyancy forces and the wintergarden could ONLY function as a climatic barrier. Thus the correct strategy is to close all the ventilator ducts to reduce heat convection losses.

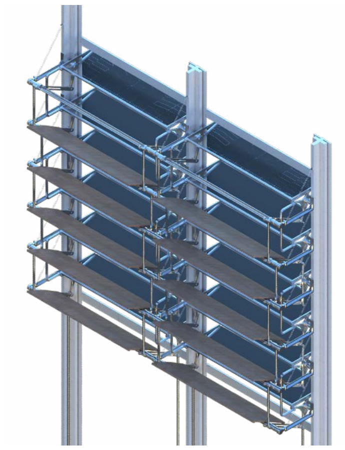


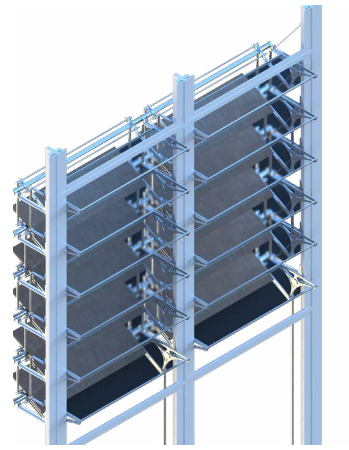
5 different weather scenarios requires different measures to be taken to correctly and responsively react to changes in the external environment. For each scenario there is a clear definition with a strategic definition of the resolution tactic.

Specifically, for winter seasons when there are abundant solar radiation, the ventilator should provide for complete closure to direct the passively heated air driven up by buoyancy into the internal environment to provide for heat gains through convection. Also, the louvres should be adjusted to a certain angle that blocks the minimum amount of solar radiation, thus bringing in the most solar gain into the interior to provide thermal comfort and reduce energy usage for heating up the domestic interior space.



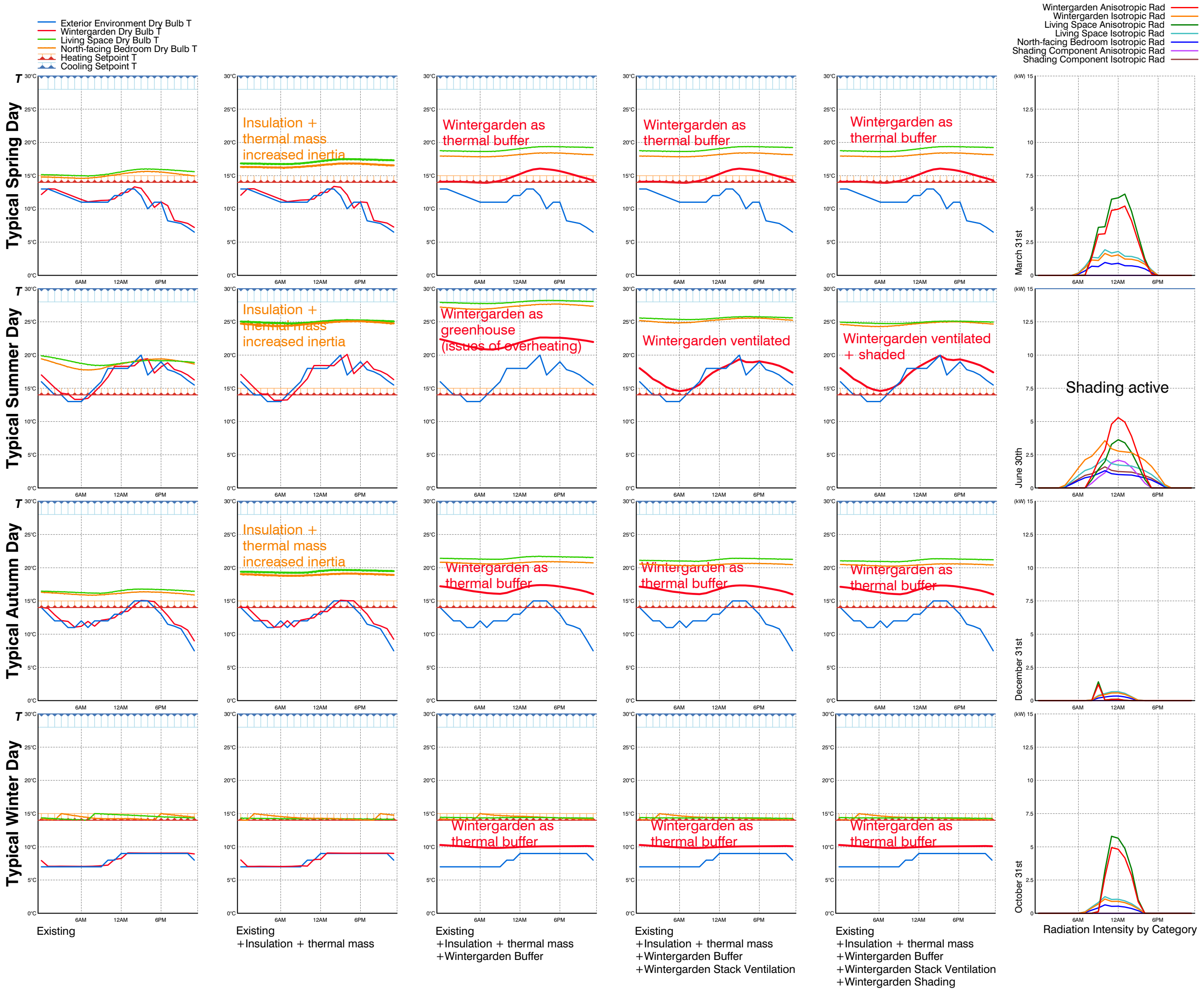
For summer seasons where the need for ventilation is high, the ducts should be fully opened to provide for maximum flow area. And, for the prevention of overheating the interior living spaces, the louvre pieces should block the most amount of solar radiation and prevent it from reaching internal surfaces.





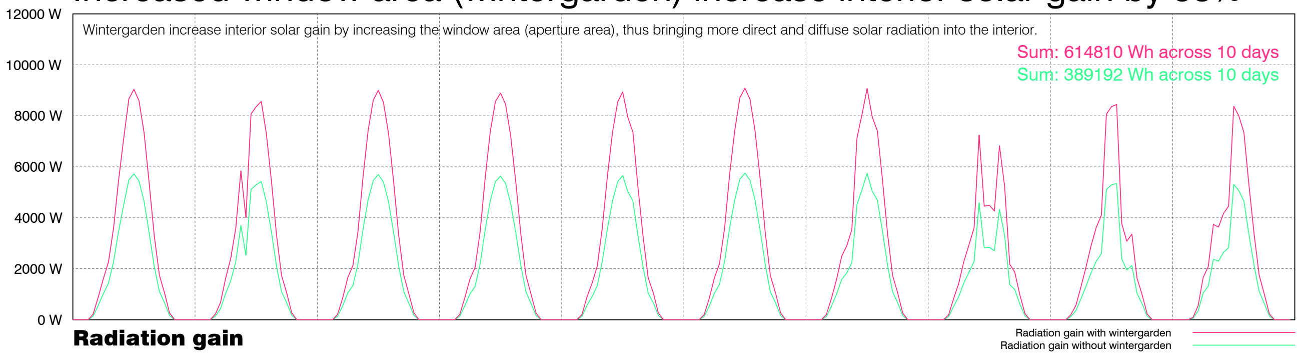
This facade has a movable physical model and an animated digital model available. Please refer to the links below for a video demonstration of the principles of this facade detail design.
The animated facade detail: https://vimeo.com/693291089?share=copy
The physical facade model in motion: https://vimeo.com/703548067?share=copy

1. Ventilator duct with manual control, flow area variable, from 0 (complete closure) to approx. 3.2 m2 per duct set; 2 sets of ducts per span.
2. Combined upper ventilator duct with adjustable louvre components. See detailed sections and mechanism explanations in following chapters. Flow area variable from 0 (complete closure) to approx. 5.2 m2 per duct set; 2 sets of ducts per span. Louvres also have adjustable angles, while the sun-angle projected area of coverage varies from approx. 0.5 m2 to approx. 4.1 m2.
3. Shoeck 1024660 Isokorb RT type SK Structural Insulation Thermal Break
4. Intermediate zone between the first skin and the additional skin. This area is generally described as a climatic barrier or buffer, however its role is flexible and fluid and is highly dependent on the climatic condition and the activities taking place in the spaces inside and adjacent to this zone. By definition, the main and also the default role of this area is a climatic buffer that mitigates extremities in temperature, moisture and lighting. However, given the appropriate circumstances (which will have detail analysis and evaluations in the following chapters), this zone could also serve as a micro solar chimney that has the effective height of around 6-7 metres that powers the passive ventilation of the adjacent living space. Additionally, this area could also serve as a supply-air double facade (opposed to the solar chimney as a extract-air double facade). All the conditions and the usages of this zone will be included in the following chapters, with a detailed depictions of the status of all the sub-components of this zone, i. e. the ventilation ducts, louvres, shading, etc.
5. Conversion of the existing beam exposed to the exterior (originally):
(Direct contact with conditioned interior room air)
[Existing] concrete screed, washed down
[Existing] W 1' x D 2' 8" [305 mm x 813 mm] in-situ reinforced concrete beams, spanning in the longitudinal direction
100 mm Isover Integra thermal insulation Board
24 mm unventilated cavity, with 24 mm × 24 mm battens every 600mm centre
12.5 mm fire-resistant gypsum board 600 mm × 600 mm
(Direct contact with unconditioned exterior air)
6. Internal blind, adjustable
7. Duplex design incorporates increased solar gains and natural lighting and ventilation, at the sacrifice of usable internal floor area.
8. Floor build-up with embedded under floor heating system:
(Upper level)
21 mm T&G wood flooring
19 mm Gyproc plank
Impact insulation pads on SIF floor channel
195 mm x 45 mm timber joist with 100 mm Isover ready-cut acoustic insulation (with underfloor heating system)
[Existing] precast concrete floor slab, with screed (level below)
9. Party wall, with wet conditions in the interior (WC+Bath):
(Interior air with reduced air circulation, approx. 20 degC with 50% humidity)
2 layers of 19 mm planks 1200 mm × 600 mm
100 mm Isover ready-cut acoustic insulation 600 mm × 600 mm with joists
45 mm unventilated cavity, with 45 mm × 45 mm battens
100 mm Isover ready-cut acoustic Insulation 600 mm × 600 mm with joists
Vapour retarder membrane
Cement mortar base
Ceramic tiles with fire resistant treatments
(Wet bathroom air, approx. 30 degC with 80% humidity)
10. Party wall, with normal indoor conditions on both sides:
(Interior air with reduced air circulation, approx. 20 degC with 50% humidity)
2 layers of 19 mm planks 1200 mm × 600 mm
100 mm Isover ready-cut acoustic insulation 600 mm × 600 mm with joists
45 mm unventilated cavity, with 45 mm × 45 mm battens
100 mm Isover ready-cut acoustic Insulation 600 mm × 600 mm with joists
2 layers of 19 mm planks 1200 mm × 600 mm
(Interior air with reduced air circulation, approx. 20 degC with 50% humidity)
11. Suspended ceiling conduction for air extraction pipes, kitchen equipment and artificial lighting
12. Sleeping space party wall, for details see 10.
13. Refurbished window construction with double glazing and new metal casements
14. Existing north wall with internal insulation applied:
(Direct contact with conditioned interior room air)
12.5 mm plywood board
18 mm OSB
Vapour retarder foil, sd = 10 m
100 mm x 45 mm timber battens (post-and-rail construction) with 100 mm ready-cut wood fibre insulation boards
18 mm OSB
40 mm x 40 mm timber battens with cork infill insulation
Vapour control membrane (breather membrane), sd < 0.5 m
[Existing] concrete screed, washed down
[Existing] single leaf brick masonry, with a combination of stretcher bond and English bond
[Existing] exterior stucco render
(Direct contact with unconditioned exterior air)
15. Internal shutters, sliding & folding

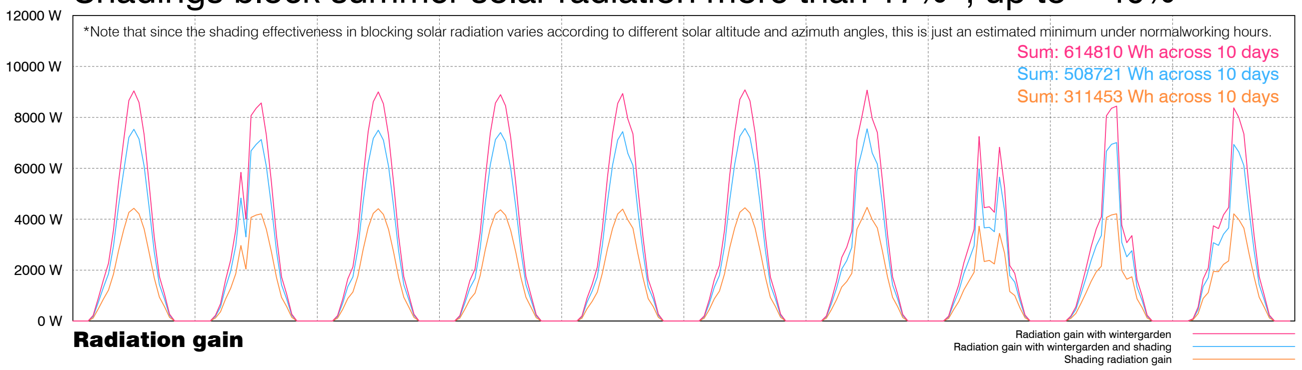


Typical day plots showing the behaviour of different retrofit scenarios and their impact on the overall energy performance of the building environment

Conversion stage II:
Increased window area (wintergarden) increase interior solar gain by 58%

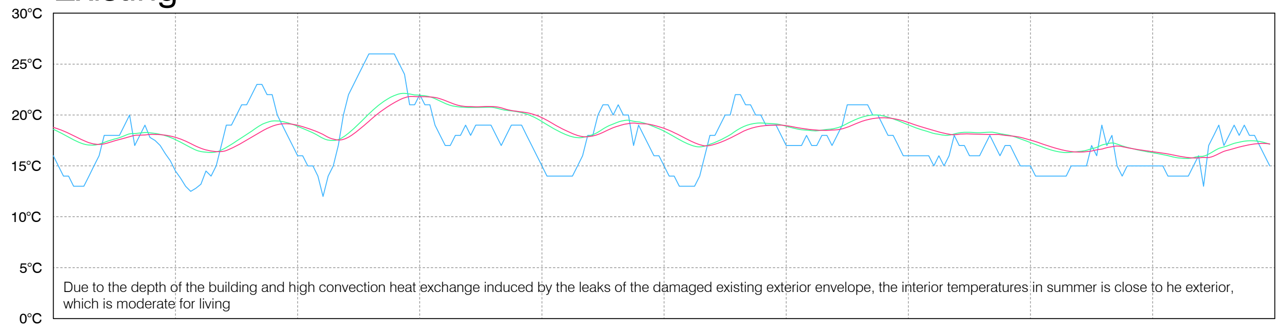


Conversion stage III:
Shadings block summer solar radiation more than 17%*, up to ~40%

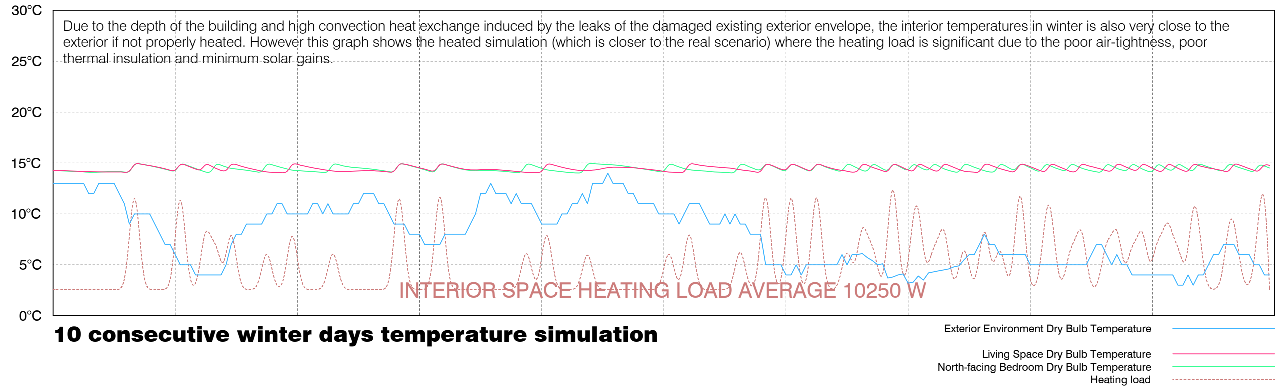


10-day plots showing the effect of window area increase and shading on the amount of solar radiation absorbed

Phase:
Existing



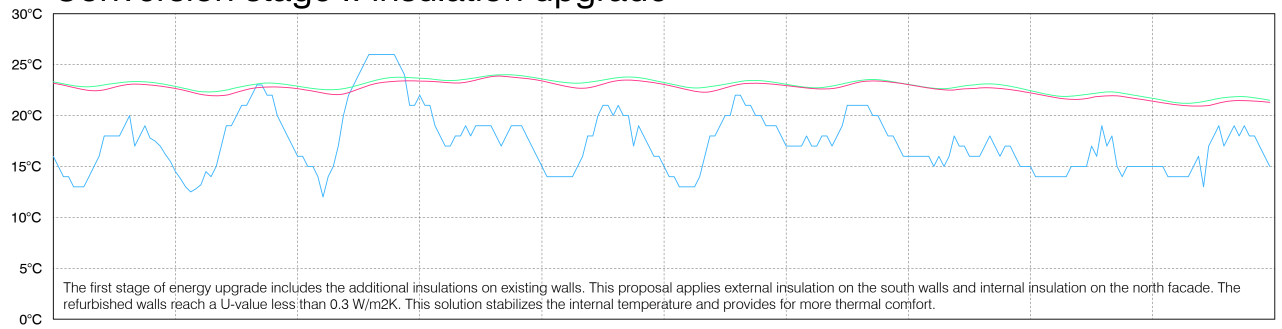
10 consecutive summer days temperature simulation



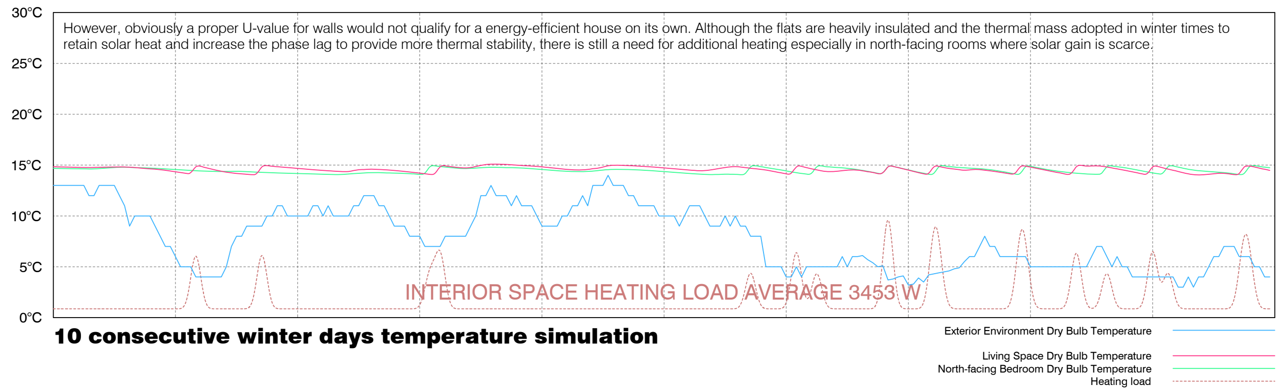
10 consecutive winter days temperature simulation

Exterior Environment Dry Bulb Temperature
Living Space Dry Bulb Temperature
North-facing Bedroom Dry Bulb Temperature
Heating load

Phase:
Conversion stage I: insulation upgrade



10 consecutive summer days temperature simulation



10 consecutive winter days temperature simulation

Exterior Environment Dry Bulb Temperature
Living Space Dry Bulb Temperature
North-facing Bedroom Dry Bulb Temperature
Heating load

Energy modeling *with Python*

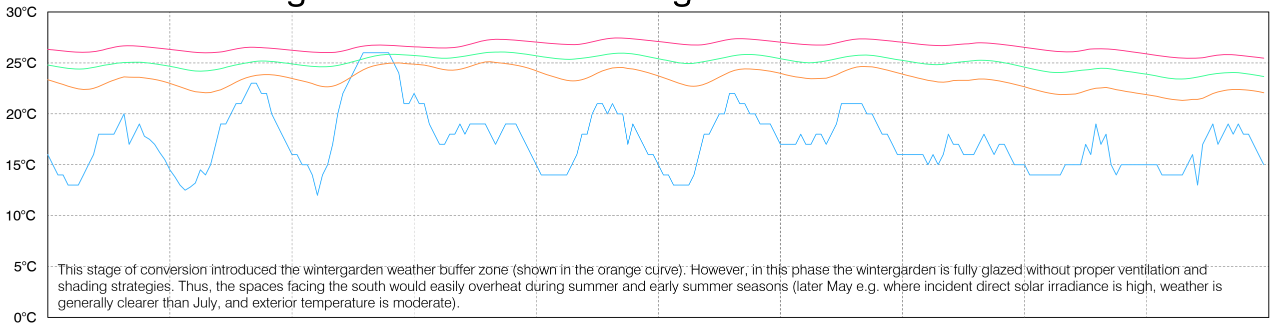
Results, evaluations and discussions

Energy model demo
Louvre + vent animation
Louvre + vent physical model

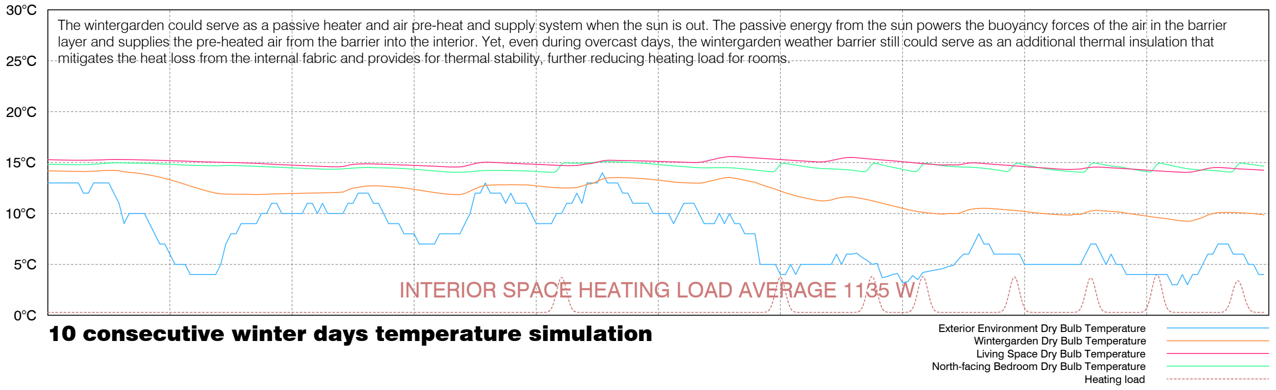
Validation of important design decisions are mostly based on a self-made shoebox energy model in python.
A demo could be found here: https://vimeo.com/693290964?share=copy
GitHub repository: https://github.com/Chengxuan-Li/WinterGardenEnergy

10-day plots showing the impact of each stage of retrofit and each measure taken on the overall heating and cooling load

Phase:
Conversion stage II: insulation + wintergarden climatic buffer

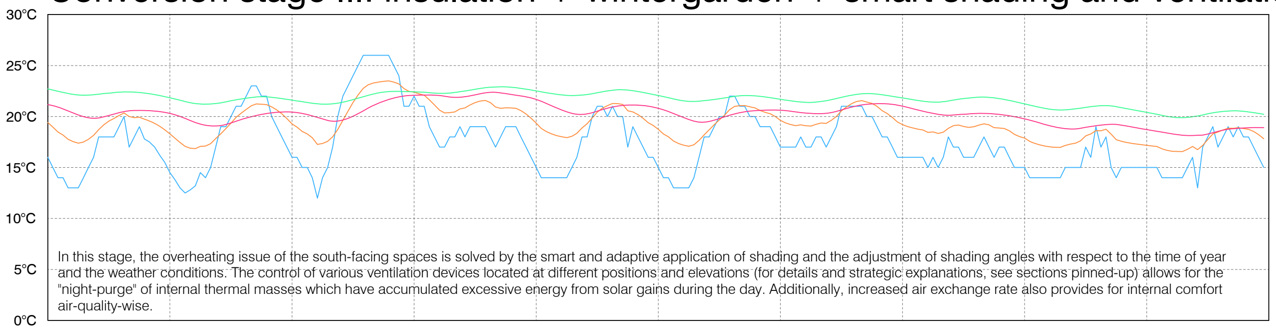


10 consecutive summer days temperature simulation

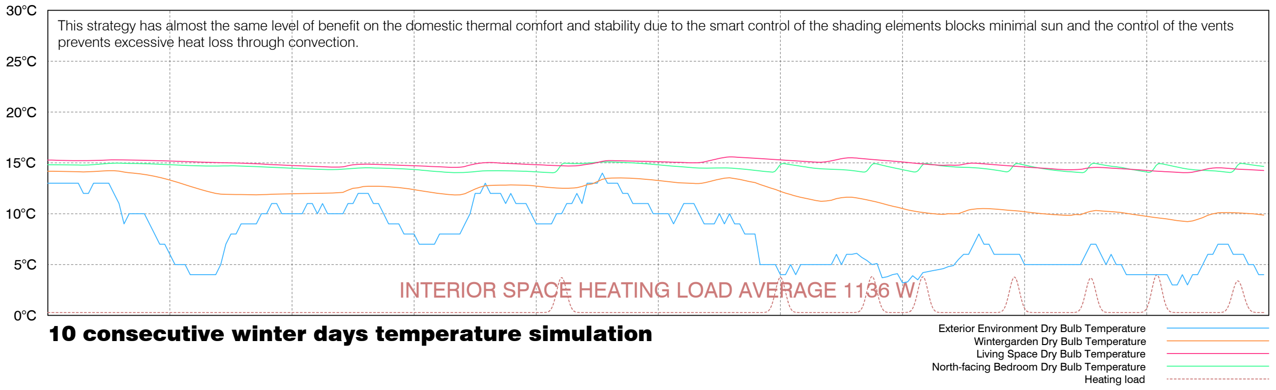


10 consecutive winter days temperature simulation

Phase:
Conversion stage III: insulation + wintergarden + smart shading and ventilation



10 consecutive summer days temperature simulation



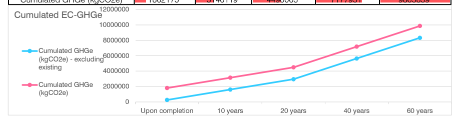
10 consecutive winter days temperature simulation

10-day plots showing the impact of each stage of retrofit and each measure taken on the overall heating and cooling load

Embodied carbon green house gases equivalent EC-GHGe for existing and refurbishment of 4 selected levels of Millennium Mills block B

Phase	Category	Sub-category	Specification	Material / construction method	Material and component qualities: Density	Density unit	Volume / length / area / quantity	Wastage / usage modifier (%)	Mass (kg)	Manufacture [A1 - A3]: EC-GHG coefficient (kgCO2e/kg)	EC-GHGe (kgCO2e)	Transportation and delivery [A4]: Distance (km)	Means of transportation	EC-GHG coefficient (kgCO2e/tkm)	EC-GHGe (kgCO2e)	Summary: Original structure EC-GHGe (kgCO2e)	Reused structure EC-GHGe (kgCO2e)	Reused
Existing	Structure and loadbearing components	Columns	Type I	Generic reinforced concrete*	1452.0	kg/m	515.20	0	748070.40	0.198	148117.94	100	50-60s road transport	0.219	3243.78	151361.72	151361.72	100%
			Type II	Generic reinforced concrete*	710.0	kg/m	533.60	0	378856.00	0.198	75013.49	100	50-60s road transport	0.219	1642.80	76656.28	76656.28	100%
			Type III	Generic reinforced concrete*	1741.0	kg/m	533.60	0	928997.60	0.198	183941.52	100	50-60s road transport	0.219	4028.32	187969.84	187969.84	100%
			Others	Generic reinforced concrete*	2500.0	kg/m3	58.30	0	145750.00	0.198	28858.50	100	50-60s road transport	0.219	632.00	29490.50	29490.50	100%
		Beams	Type I	Generic reinforced concrete*	619.9	kg/m	839.20	-3	504613.48	0.198	99913.47	100	50-60s road transport	0.219	2188.10	105259.35	102101.57	97%
			Type II	Generic reinforced concrete*	406.4	kg/m	455.60	-5	175898.05	0.198	34827.81	100	50-60s road transport	0.219	762.73	37463.73	35590.54	95%
			Type III	Generic reinforced concrete*	348.5	kg/m	2555.20	-8	819248.22	0.198	162211.15	100	50-60s road transport	0.219	3552.42	180177.80	165763.57	92%
			Others	Generic reinforced concrete*	2500.0	kg/m3	0.00	0	0.00	0.198	0.00	100	50-60s road transport	0.219	0.00	0.00	0.00	100%
		Shear walls	Generic 1 ft	Generic reinforced concrete*	762.5	kg/m2	1527.20	-10	1048041.00	0.198	207512.12	100	50-60s road transport	0.219	4544.52	235618.48	212056.63	90%
		Precast slabs	Solid 5 inch	Generic precast concrete	297.6	kg/m2	6188.16	-15	1565356.95	0.242	378816.38	500	Barge***	0.063	11932.72	459704.82	390749.10	85%
		Screed	Generic	Generic concrete	20.0	kg/m2	6000.00	-15	102000.00	0.12	12240.00	100	50-60s road transport	0.219	268.06	14715.36	12508.06	85%
		Parapet	NOT INCLUDED IN THIS PHASE	NOT INCLUDED IN THIS PHASE	--	--	0.00	--	0.00	--	0.00	--	--	--	0.00	0.00	0.00	--
		Foundation and basement	NOT INCLUDED IN THIS PHASE	NOT INCLUDED IN THIS PHASE	--	--	0.00	--	0.00	--	0.00	--	--	--	0.00	0.00	0.00	--
		(Summary for structure and loadbearing components)									1331452.38				32795.44	1478417.89	1364247.83	
	Freestanding components	Exterior wall masonry blockwork	English bond double 440 mm	Clay generic baked products** with mortar	811.8	kg/m2	630.60	-50	255960.54	0.24	61430.53	50	50-60s road transport	0.219	672.66	124206.39	62103.19	50%
		Lintel	Generic	Generic precast concrete	80.0	kg/count	104.00	-50	4160.00	0.242	1006.72	100	50-60s road transport	0.219	22.05	2057.53	1028.77	50%
		Column profile decor exposed	Generic	Generic reinforced concrete*	2500.0	kg/m3	234.42	-20	468832.00	0.198	92828.74	100	50-60s road transport	0.219	2032.95	118577.11	94861.69	80%
		Window	Generic single pane window	Single glazing	82.1	kg/count	104.00	-70	2561.52	0.91	2330.98	100	50-60s road transport	0.219	51.05	7940.11	2382.03	30%
			Generic single pane casement	Cast iron casement,with lead coating	106.7	kg/count	104.00	-45	6103.24	2.8	17089.07	100	50-60s road transport	0.219	374.25	31751.50	17463.32	55%
		(Summary for freestanding components)									174686.04				3152.96	284532.63	177839.00	
		(Summary for existing)									1506138.42				35948.40	1762950.52	1542086.83	
																Newbuild structure EC-GHGe (kgCO2e)		
New	Structural reparation	Structural reparation and reinforcem	Estimated 10%	Exterior carbon reinforcement	35.0	kg/m2	400.00	10	15400.00	0.5	7700.00	200	Contemporary road transport	0.15	231.00	7931.00		
		(Summary for structural reparation)									7700.00				231.00	7931.00		
	Thermal upgrade refurbishmen	Insulation	Internal insulation - north	Weighted average, for details see wall 1-Ds	50.9	kg/m2	315.30	5	16851.21	0.78	13143.94	50	Contemporary road transport	0.15	98.58	13242.52		
			External insulation - south	Weighted average, for details see wall 1-Ds	10.0	kg/m2	234.00	5	2457.00	0.72	1769.04	50	Contemporary road transport	0.15	13.27	1782.31		
		Window	Pane casement upgrade	Weighted average	120.0	kg/count	104.00	1	12604.80	1.2	15125.76	50	Contemporary road transport	0.15	113.44	15239.20		
			Internal timber shutters - north	Weighted average softwood	30.0	kg/count	104.00	1	3151.20	0.45	1418.04	30	Contemporary road transport	0.15	6.38	1424.42		
			Blinds - south	Weighted average reflective coated steel	5.0	kg/count	104.00	1	525.20	2.4	1260.48	30	Contemporary road transport	0.15	5.67	1266.15		
		(Summary for thermal upgrade refurbishment)									32717.26				237.34	32954.61		
	Thermal upgrade newbuild	Wintergarden / climatic barrier	Mullions, gratings and decking	Weighted average over wintergarden floor area	120.0	kg/m2	115.20	3	14238.72	2.1	29901.31	100	Contemporary road transport	0.15	448.52	30349.83		
			Floor finish planks	Generic two layers fireproof gyproc planks	30.0	kg/m2	115.20	5	3628.80	0.8	2903.04	50	Contemporary road transport	0.15	21.77	2924.81		
			Exterior screen single glazing	Single pane glazing screen layer	15.0	kg/m2	72.00	3	1112.40	0.91	1012.28	50	Contemporary road transport	0.15	7.59	1019.88		
			Interior screen double glazing	Double glazing with argon infill	30.0	kg/m2	48.00	3	1483.20	1.05	1557.36	50	Contemporary road transport	0.15	11.68	1569.04		
			Louvre and vent metal	Weighted average per span	50.0	kg/span	13.00	3	669.50	2.1	1405.95	50	Contemporary road transport	0.15	10.54	1416.49		
			Louvre and vent timber	Weighted average per span	80.0	kg/span	13.00	1	1050.40	0.45	472.68	20	Contemporary road transport	0.15	1.42	474.10		
		Floor	Floor	Weighted average over floor area	29.0	kg/m2	5000.00	5	152250.00	0.6	91350.00	50	Contemporary road transport	0.15	685.13	92035.13		
		(Summary for thermal upgrade newbuild)									128602.63				1186.65	129789.28		
	Compartmentalization	Party wall	12 inch dry party wall	Weighted average, for details see section	20.0	kg/m2	5451.80	5	114487.80	0.4	45795.12	50	Contemporary road transport	0.15	343.46	46138.58		
			12 inch wet party wall	Weighted average, for details see section	30.0	kg/m2	200.00	5	6300.00	0.38	2394.00	50	Contemporary road transport	0.15	17.96	2411.96		
		(Summary for compartmentalization)									48189.12				361.42	48550.54		
	Special construction	Stair	Stair	Weighted average per set	600.0	kg/set	36.00	10	23760.00	0.73	17344.80	50	Contemporary road transport	0.15	130.09	17474.89		
		Door	Type I corridor access fire door	Weighted average per element	150.0	kg/count	14.00	0	2100.00	0.8	1680.00	50	Contemporary road transport	0.15	12.60	1692.60		
			Type II generic door	Weighted average per element	80.0	kg/count	162.00	0	12960.00	1.2	15552.00	50	Contemporary road transport	0.15	116.64	15668.64		
		Manipulator	Movable partitions and shutters	Weighted average per set	200.0	kg/set	40.00	0	8000.00	0.75	6000.00	30	Contemporary road transport	0.15	27.00	6027.00		
		(Summary for special construction)									40576.80				286.33	40863.13		
		(Summary for newbuild)									257785.81				2302.74	260088.55		
Use	Services	Building services and equipment	Low density	Artificial lighting, water-heating, mechanical ventilation with heat recovery, refrigeration, cooking, etc.	80.0	kWh/m2a	5768	0	461440.00	0.233	107515.52							
		Heating and cooling	Calculated from energy model	Heating and cooling load energy intensity per area per year	20.0	kWh/m2a	5768	0	115360.00	0.233	26878.88							
		(Summary for annual running energy intensity)									134394.40							

Overall summary	Upon completion	10 years	20 years	40 years	60 years
Cumulated GHGe (kgCO2e) - excluding existing	260089	1604033	2947977	5635865	8323753
Cumulated GHGe (kgCO2e)	1802175	3146119	4490063	7177951	9865839



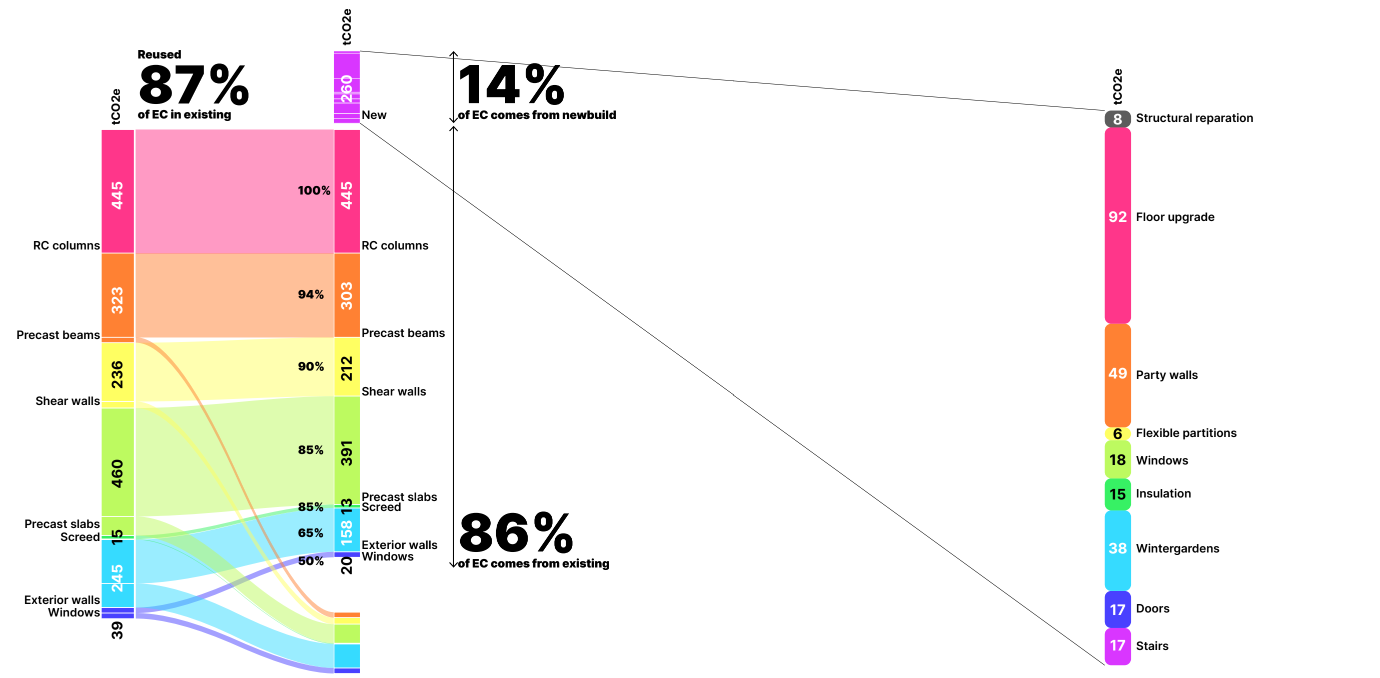
NOTES:

* Generic reinforced concrete refers to a UK average RC construction 25/30 Mpa with 110 kg steel per m3 concrete. See Geoffrey Hammond and Craig Jones, *Embodied Carbon, the Inventory of Carbon and Energy (ICE): a BSRIA Guide*, eds. Fiona Lowrie & Peter Tse

** Engineering ToolBox (2011) *Brick Densities*. [online] Available at: https://www.engineeringtoolbox.com/bricks-density-d_1777.html [Accessed 23 Apr 2022].

*** Note that as the energy intensity of freight shipment through barge has witnessed minor changes compared to that of the road freight shipment, which has undergone significant changes comparably, it is important to take into consideration this difference. See, European Environment Agency, TERM 2000: "Are we moving in the right direction? Indicators on transport and environment integration in the EU," in Environmental issues series, no. 12 (Feb 2000): 45-53. See also, European Environment Agency, TERM 2015: "Evaluating 15 years of transport and environmental policy integration: transport indicators tracking progress towards environmental targets in Europe," in EEA Report, no. 7 (2015). doi:10.2800/214

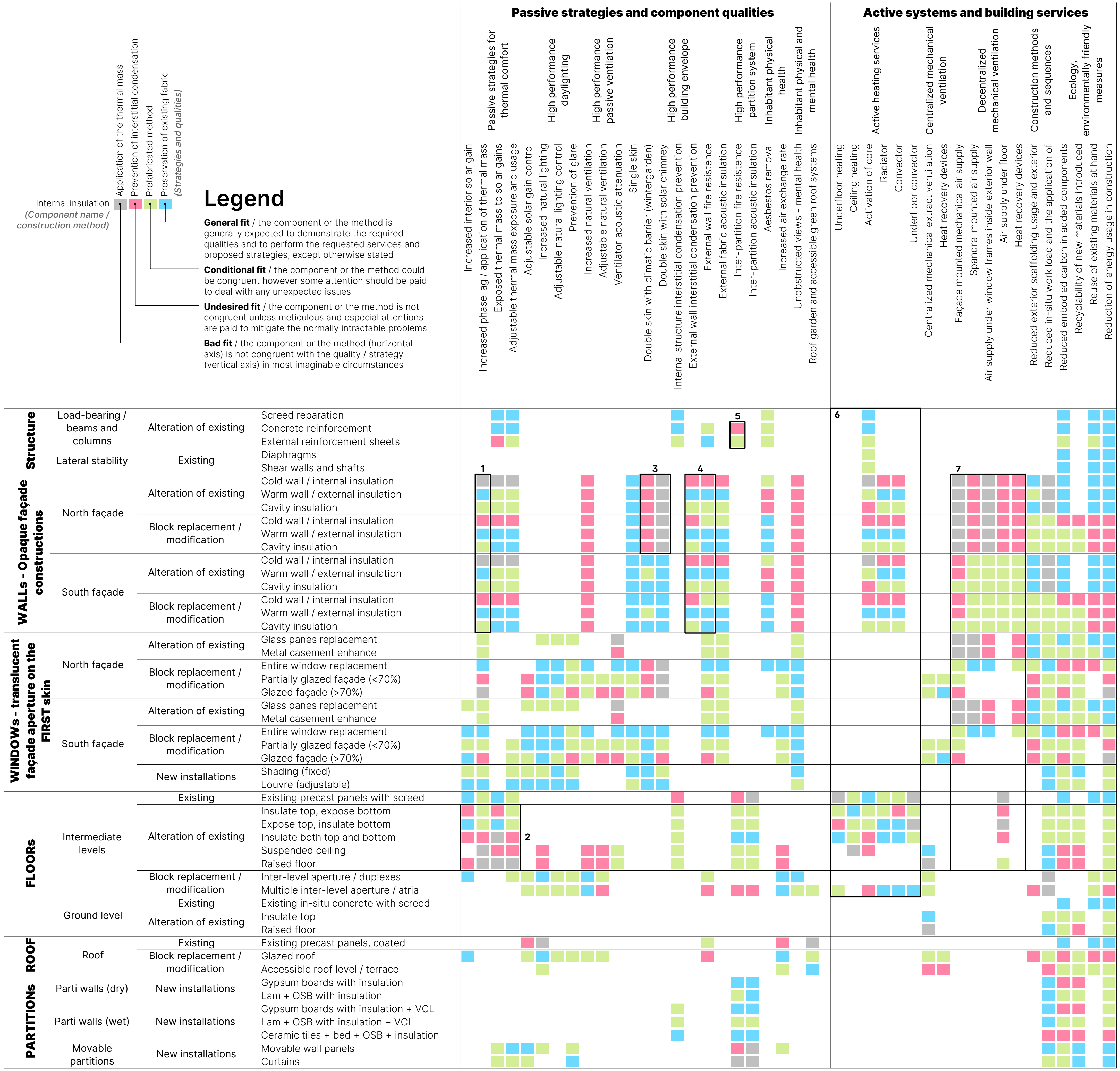
Stage A1-A5 + B1 carbon footprint assessment



As this project is about to retain most of the existing structure while carrying out thermal upgrades on the basis of the existing fabric, most of the embodied carbon comes from the existing fabric and is somewhat considered "free."

The materials and construction methods of refurbishing the existing fabric have also taken into consideration the carbon footprint of the products used and has deliberately avoided the usages of gypsum and other high energy intensity (and thus, carbon embodied in this process) materials. For details, see sections and details.

Flow of carbon in building materials, showing the proportional amount of embodied carbon remains in the primary structures if the building and new retrofit only contributes to a limited portion of the overall building carbon footprint



A general guideline to refurbishment of industrial buildings. This chart shows the relation between individual building components with their methods of construction and modification, and the general, schematic strategies and desired building service systems.

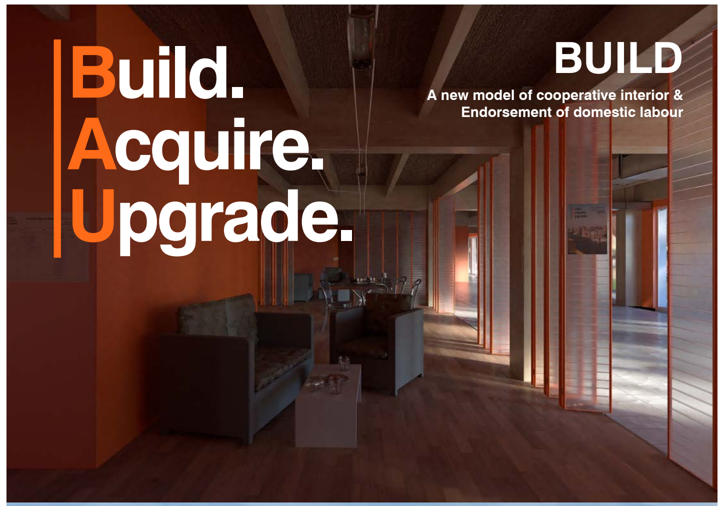
1. These conclusive notes are based on the analysis of the distribution of temperature across a 1-D cross section of the wall build-up. The time delay of the internal surface temperature wave from the external temperature wave is described by the Phase Shift / Phase Lag: this is the time in hours between the maximum temperature on the outer and inner surface. A typical value of 12 hours means that the maximum internal temperature reaches the highest 12 hours after the maximum external surface temperature. A phase shift of 10-12 hours is therefore ideal, so that the maximum temperature of the inner surface is reached in the second half of the night. At this time, the heat input can normally be compensated for by ventilation.
2. See 1-D sections of floor build-up options.
3. Climatic barriers refer to a double skin facade system that mainly functions as a climatic barrier that stabilises the indoor thermal environment, while providing for some additional solar gains and passive ventilation. This scheme differs significantly from double facade solar chimneys which mainly serve as passive ventilation devices, powered by the buoyancy forces of the hot air heated by the sun. Thus, by definition, climatic barriers might still work somehow on the north facade, however, due to the lack of solar gains, solar chimneys work very poorly on the north facade.
4. For specific explanations of the wall build-up of different insulation schemes, with regard to the resulted interstitial vapour pressure distribution, relative humidity and dew point temperature throughout the wall section, please refer to relevant chapters that show such diagrams for detailed analysis and discussions.
5. Although the fire resistance of different reparation methods varies significantly according to loading conditions, reparation processes, finish types, test conditions, etc. See this paper DOI:10.1016/j.proeng.2017.02.137 for an example.
6. The applicability of different heating schemes and device tends to vary significantly according to the specificity of each project, and the possibilities this sheet outlines takes into account a limitedly generalized solution based on the knowledge of the ongoing project, i. e. the floor build-up and the construction method influences the choices and the possibilities.
7. The applicability of different heating schemes and device tends to vary significantly according to the specificity of each project, and the possibilities this sheet outlines takes into account a limitedly generalized solution based on the knowledge of the ongoing project, i. e. the wall and floor build-up and the construction method influences the choices and the possibilities.

Build.
Acquire.
Upgrade.

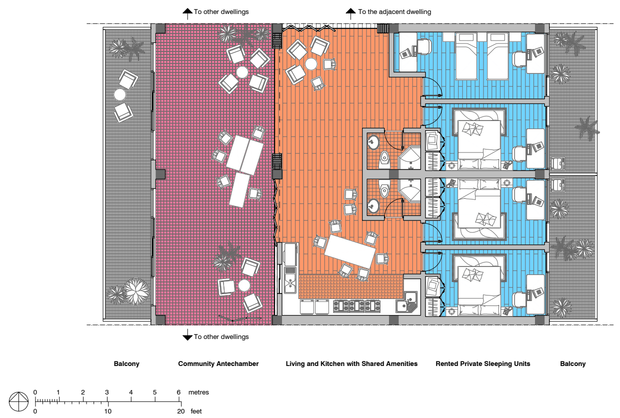
Build.
Acquire.
Upgrade.

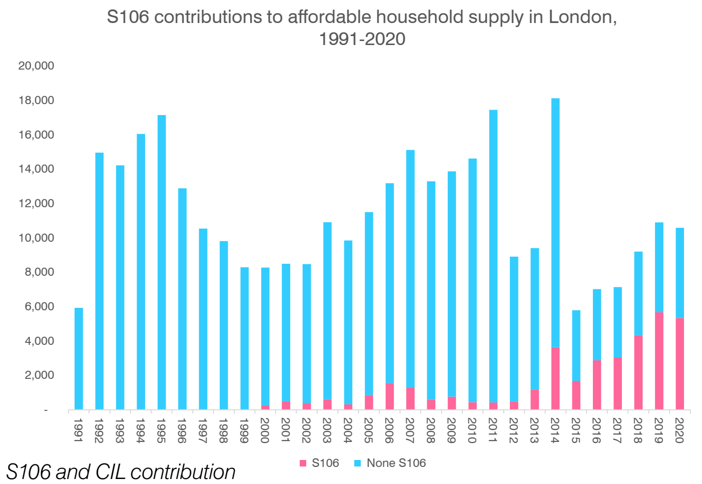
The BAU Framework is a (proposed) registered Public Corporation (PC) that starts to operate on the Greater London scale to deal with social housing shortage in local authorities in London. Initially it is joint-funded by the Greater London Authority and Homes England, and has the power to establish branch agencies that works with the local government to operate at a constituency / ward level. Such agencies are run cooperatively by commissioners from the parent corporations, local government officials, housing association stuff, and the local residents who live in the houses managed by such agencies. They make collective decisions and investments on developing new, affordable homes for rent (social tenure) with decent amenities and community infrastructure; acquiring homes from private developers through S106 grant; upgrading existing homes and converting existing buildings.

1. Build more homes that could be considered "Social"
2. Acquire homes from private developers and landlords through the legislative framework of S106+CIL, and the Right to Buy-back empowered by the mayor of London
3. Upgrade existing council and social homes; convert existing buildings to new, decent social homes when suitable

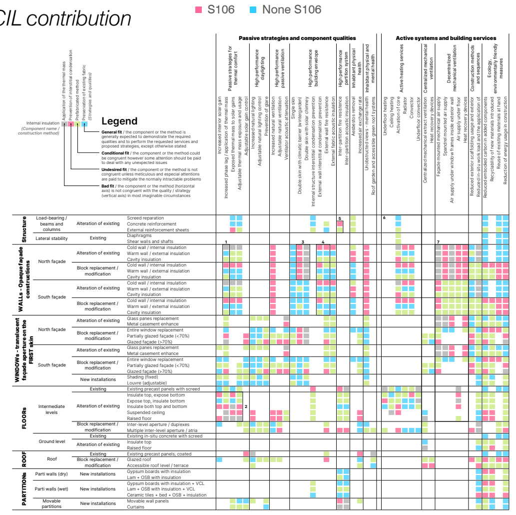


Guides on Best Practices

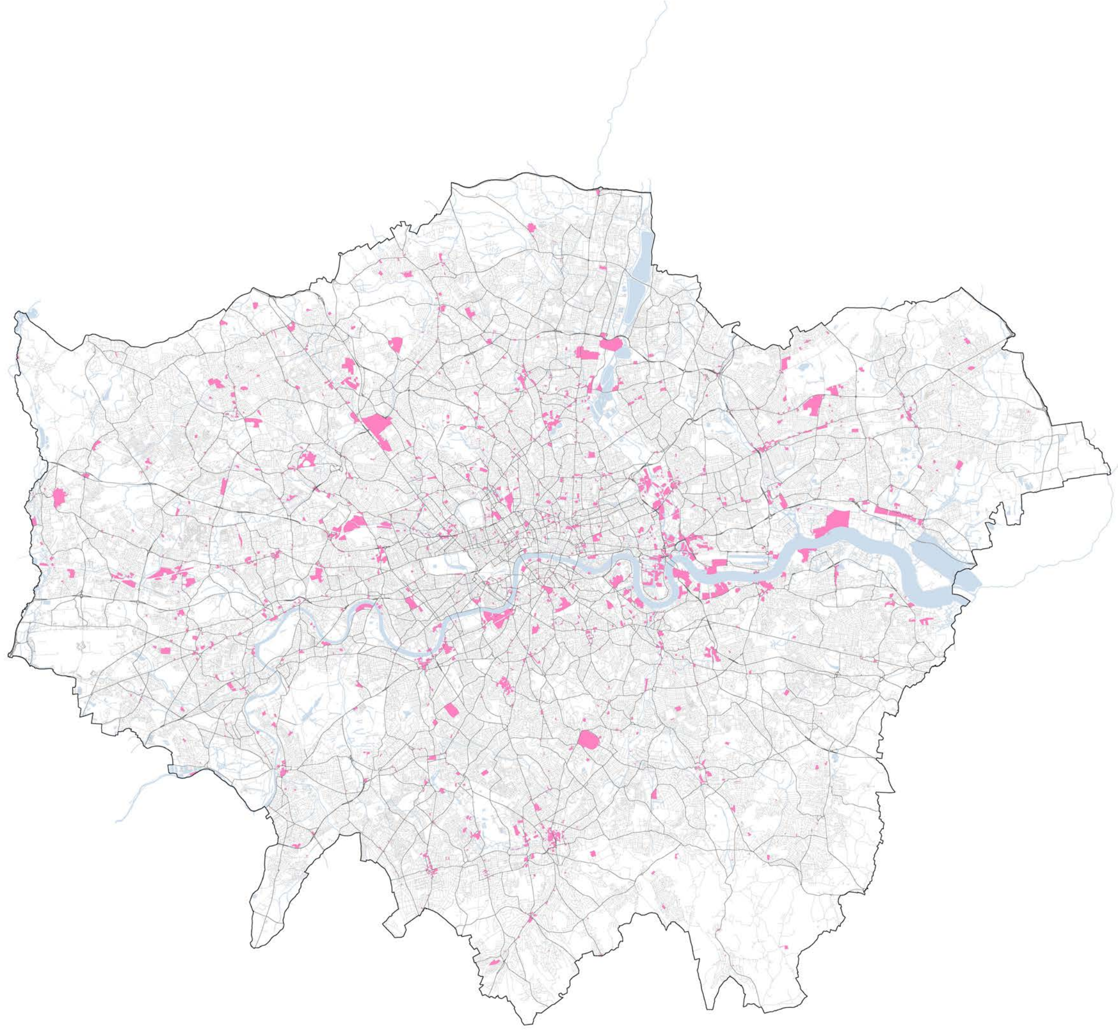




S106 and CIL contribution



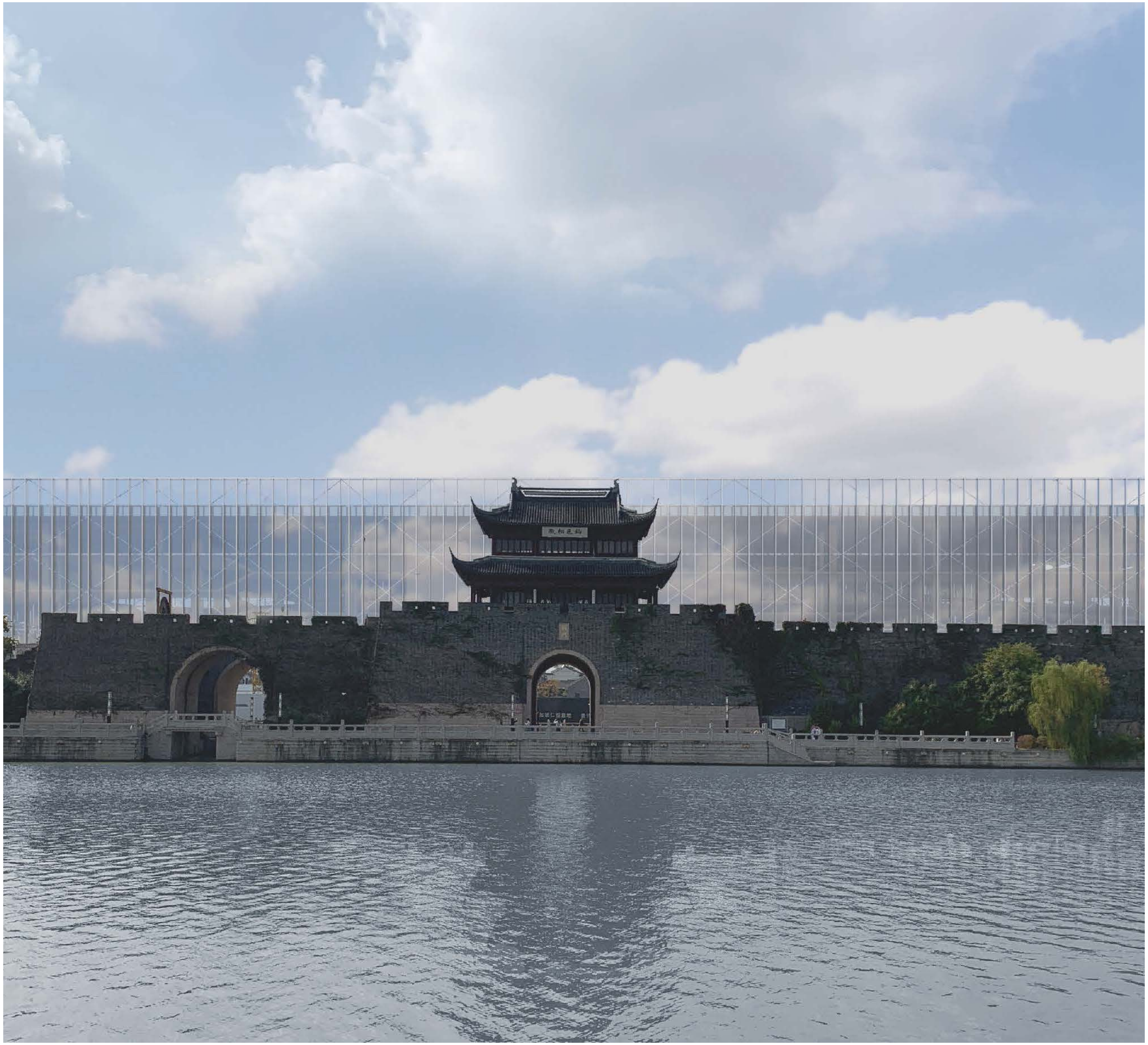
Knowledge repository on sustainable upgrade and retrofit



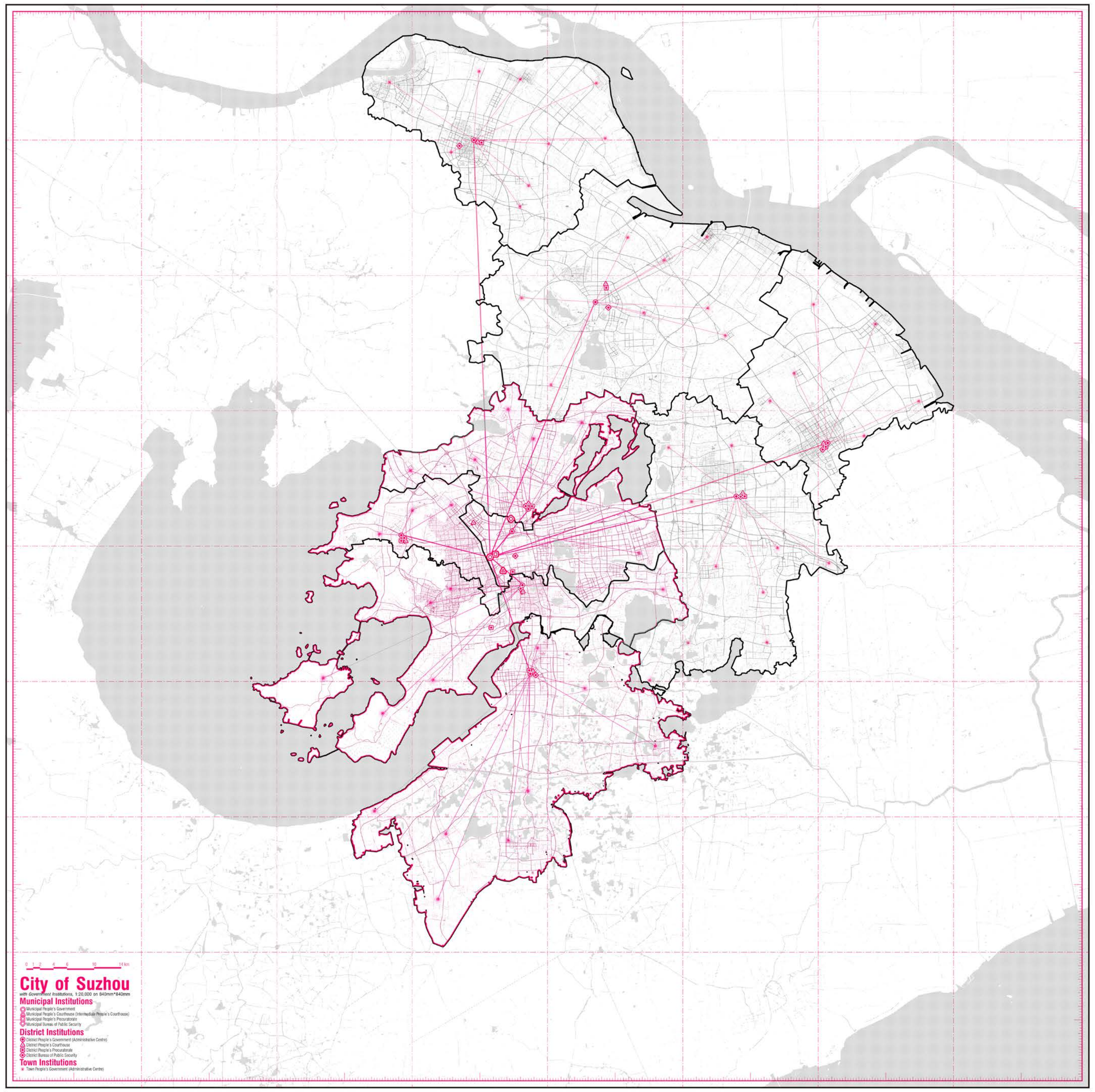
Legend

London Strategic Housing Land Availability Assessment (SHLAA) approvals and allocations (2017)

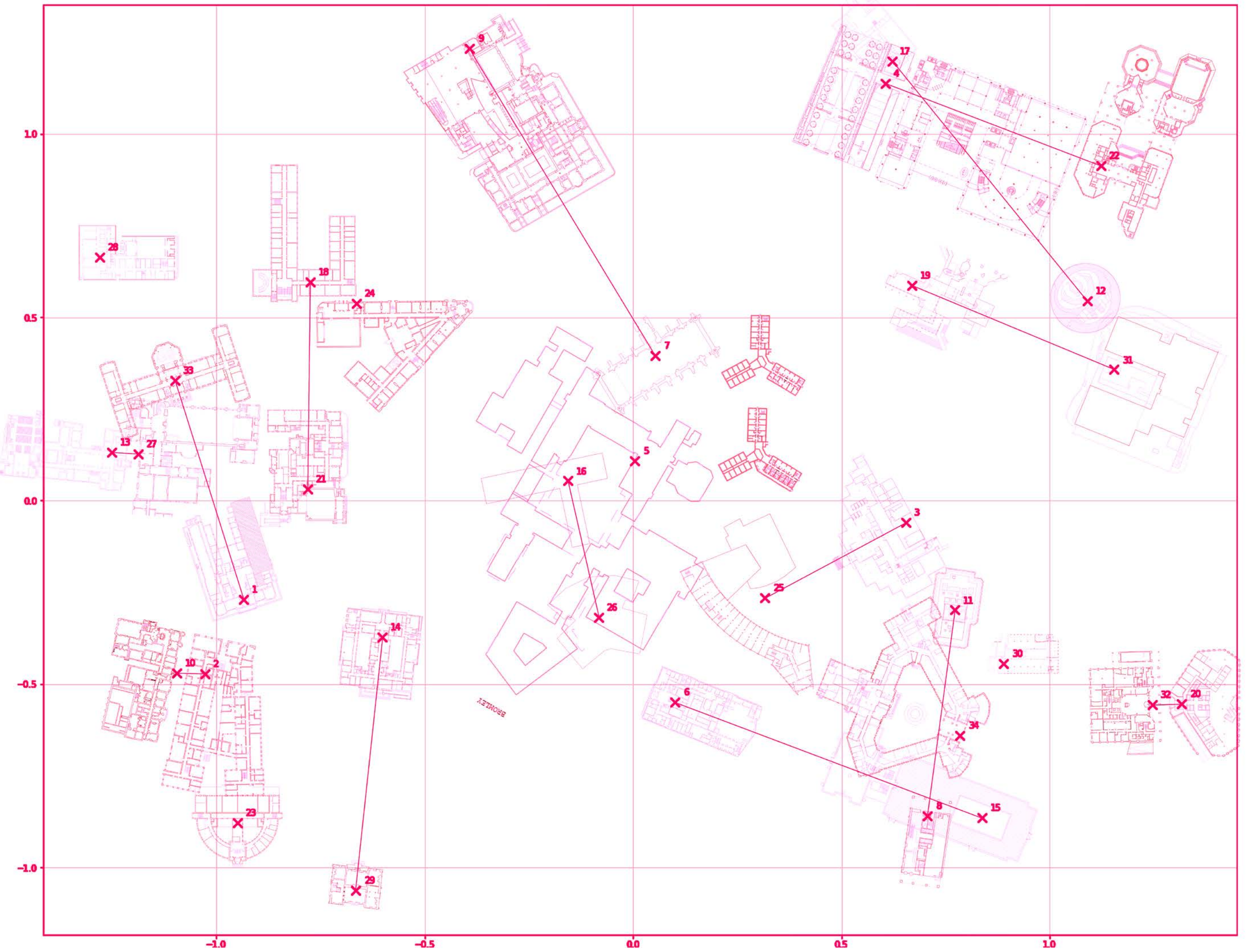
Potential BAU development locations in London, highlighting the Silvertown (proposed) project as flagship

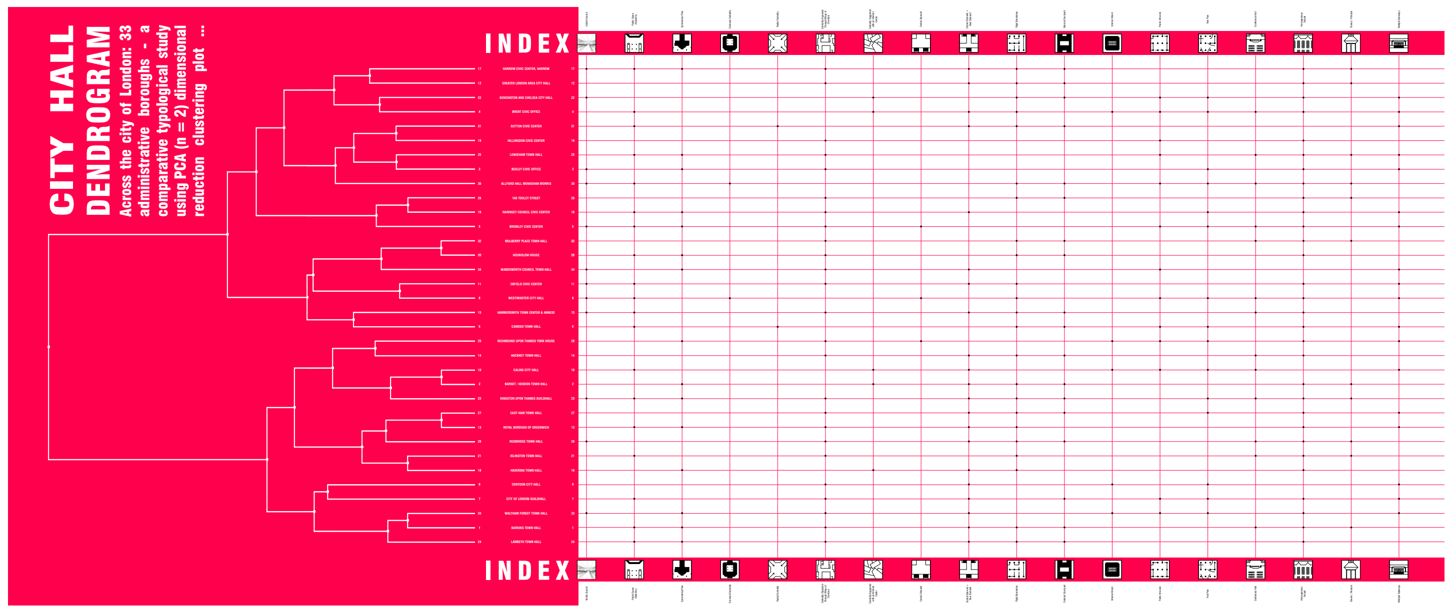


City Hall for Suzhou
Power Relations and City Hall as Archive, as Panopticon, as Inter-Panopticon
Architectural Provocation, Diagram
Architectural Association, 2020-21

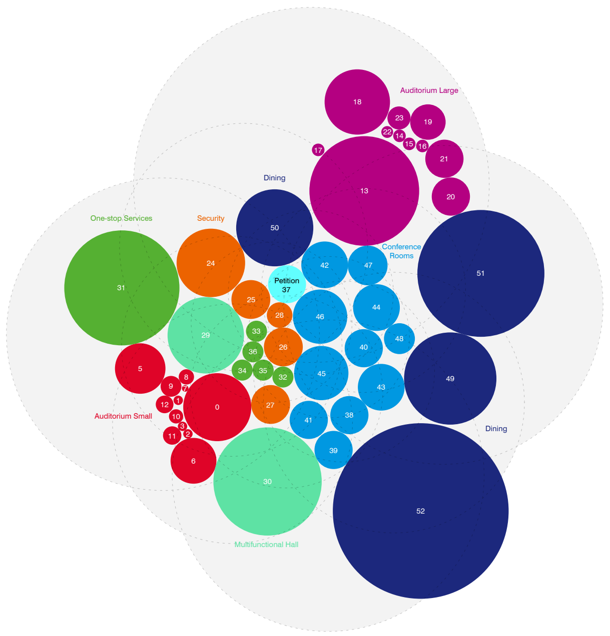


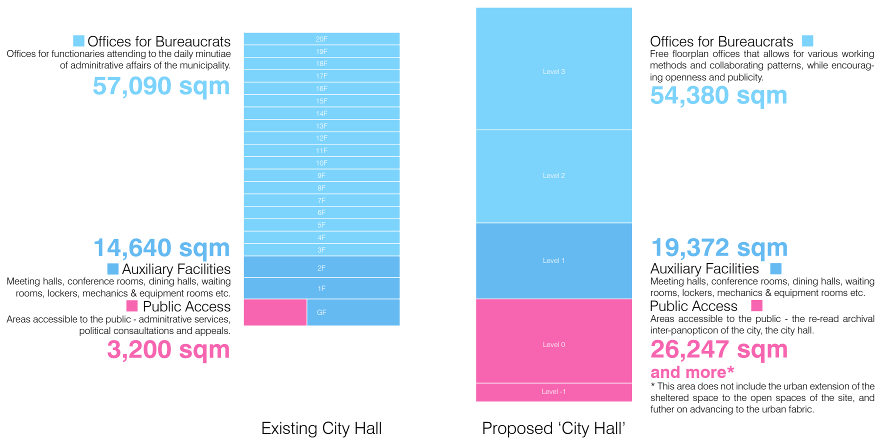
Map of Suzhou Greater Metropolitan Region, showing the network of governmental institutions



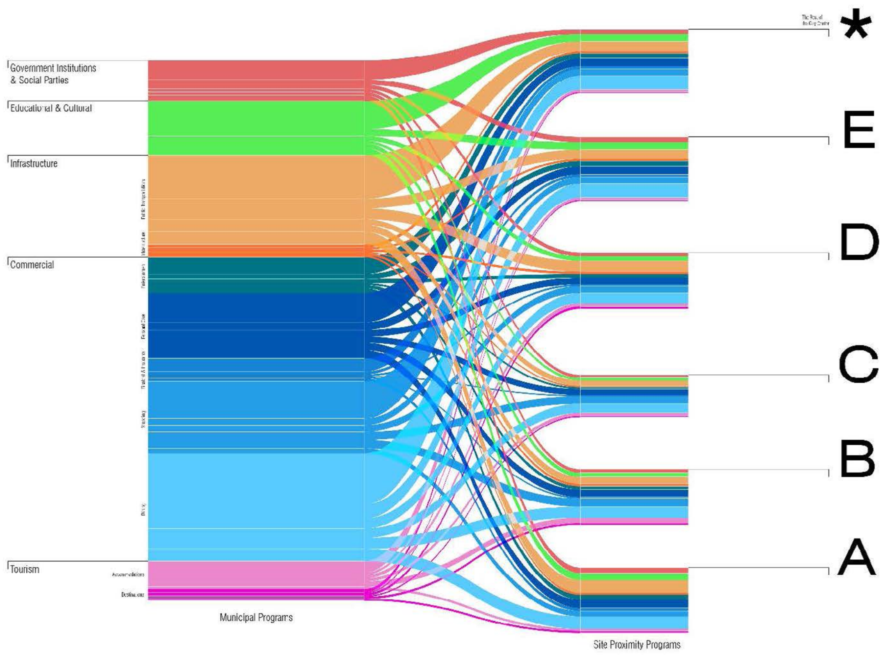


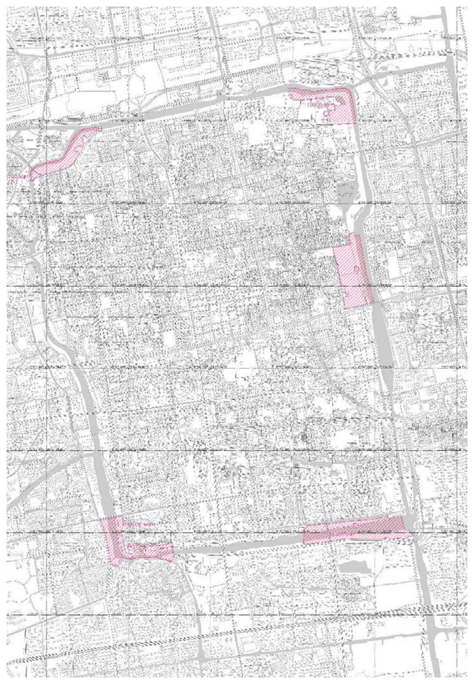
This project analysed more than 30 city halls around the world in terms of their spatial quality and contextual quality (closeness to a bus stop, for example). Using a PCA analysis, a retrospective genealogy of the formal basis of city halls is constructed.

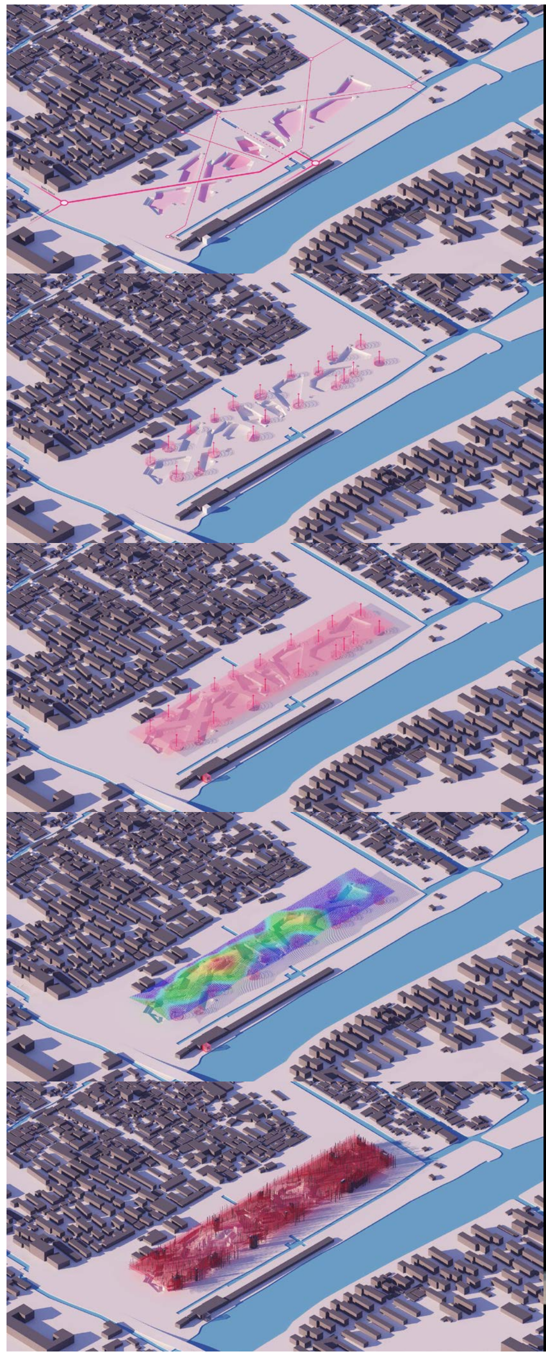

Auditorium Large
Dining
Security
One-stop Services
Conference Rooms
Petition
Auditorium Small
Multifunctional Hall

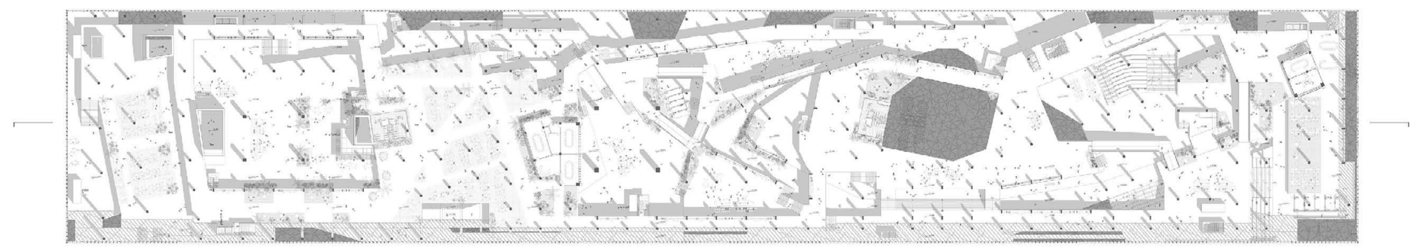

Offices for Bureaucrats
Offices for functionaries attending to the daily minutiae of admintrative affairs of the municipality.
57,090 sqm
14,640 sqm
Auxiliary Facilities
Meeting halls, conference rooms, dining halls, waiting rooms, lockers, mechanics & equipment rooms etc.
Public Access
Areas accessible to the public - admintrative services, political consaultations and appeals.
3,200 sqm
20F
19F
18F
17F
16F
15F
14F
13F
12F
11F
10F
9F
8F
7F
6F
5F
4F
3F
2F
1F
GF
Level 3
Level 2
Level 1
Level 0
Level -1
Offices for Bureaucrats
Free floorplan offices that allows for various working methods and collaborating patterns, while encouraging openness and publicity.
54,380 sqm
19,372 sqm
Auxiliary Facilities
Meeting halls, conference rooms, dining halls, waiting rooms, lockers, mechanics & equipment rooms etc.
Public Access
Areas accessible to the public - the re-read archival inter-panopticon of the city, the city hall.
26,247 sqm
and more*
* This area does not include the urban extension of the sheltered space to the open spaces of the site, and futher on advancing to the urban fabric.
Existing City Hall
Proposed 'City Hall'

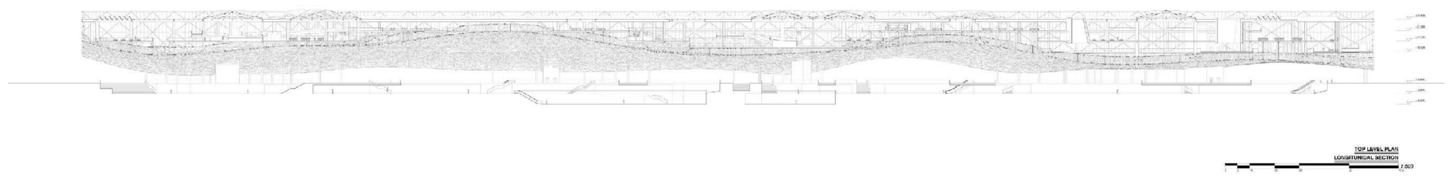

ADMIN ADMIN ADMIN ADMIN ADMIN ADMIN ADMIN ADMIN ADMIN ADMIN ADMIN ADMIN ADMIN ADMIN ADMIN ADMIN ADMIN
PUBLIC PUBLIC PUBLIC PUBLIC PUBLIC PUBLIC PUBLIC PUBLIC

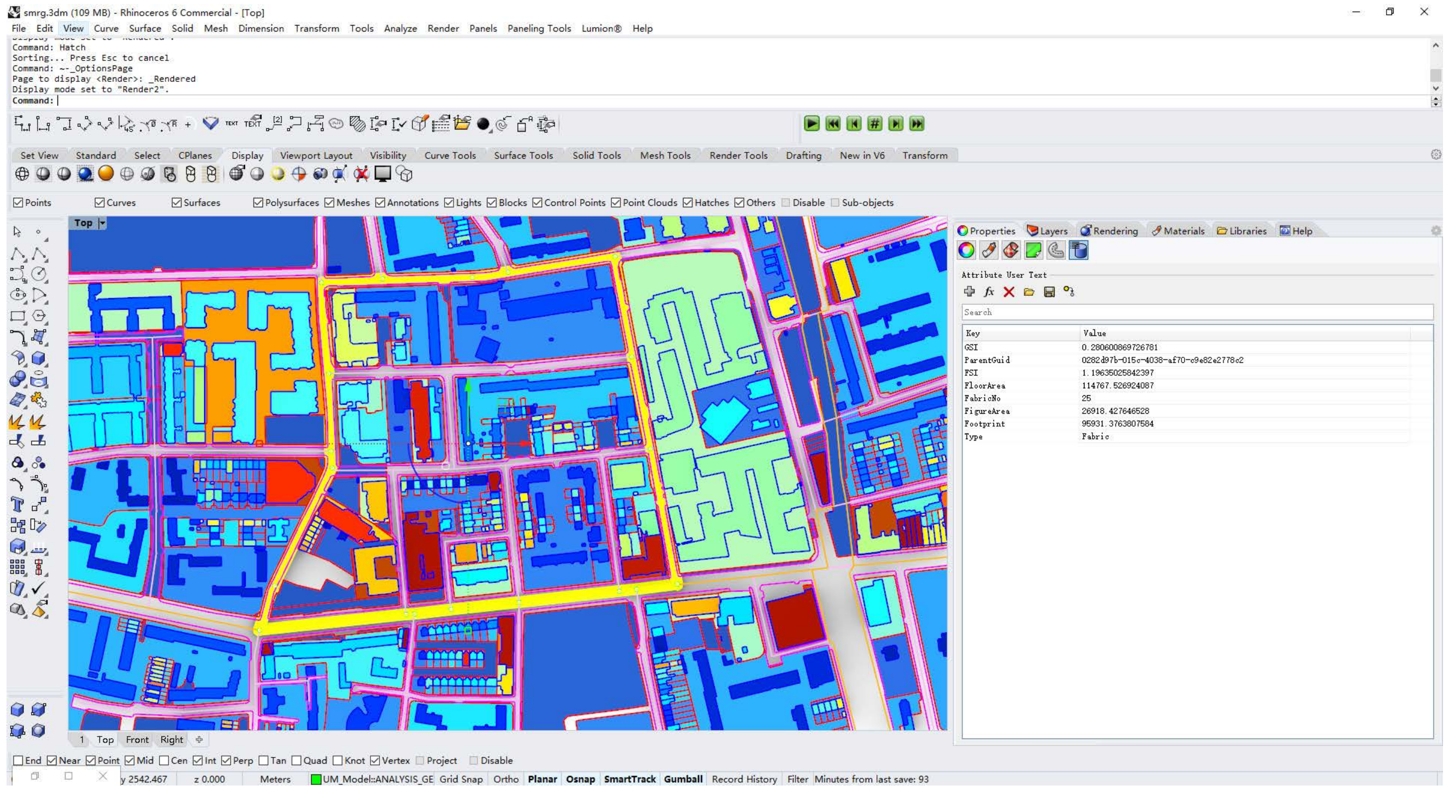

Government Institutions & Social Parties
Educational & Cultural
Infrastructure
Commercial
Tourism
Municipal Programs
Site Proximity Programs
*
E
D
C
B
A

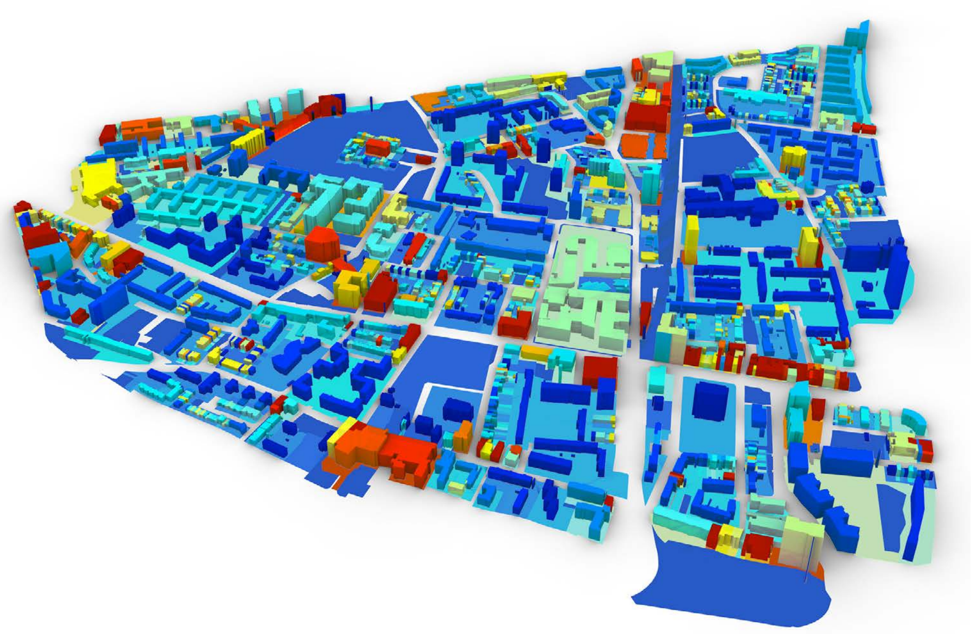


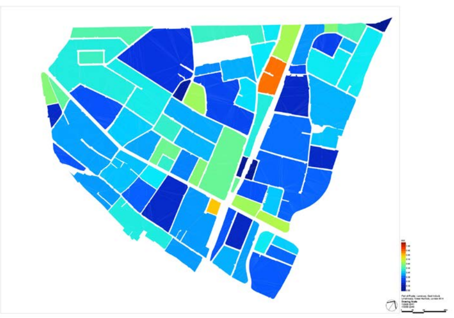












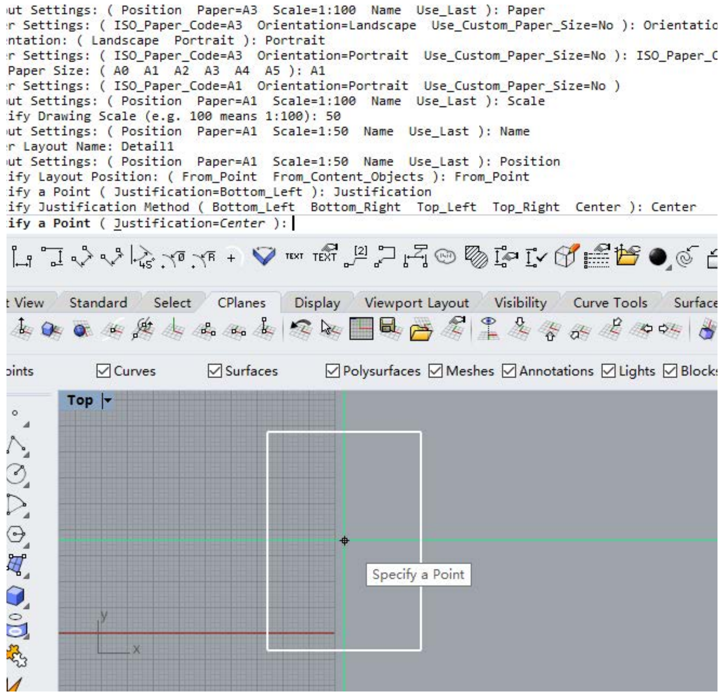
SpaceMatrix and Urban Density Indicators

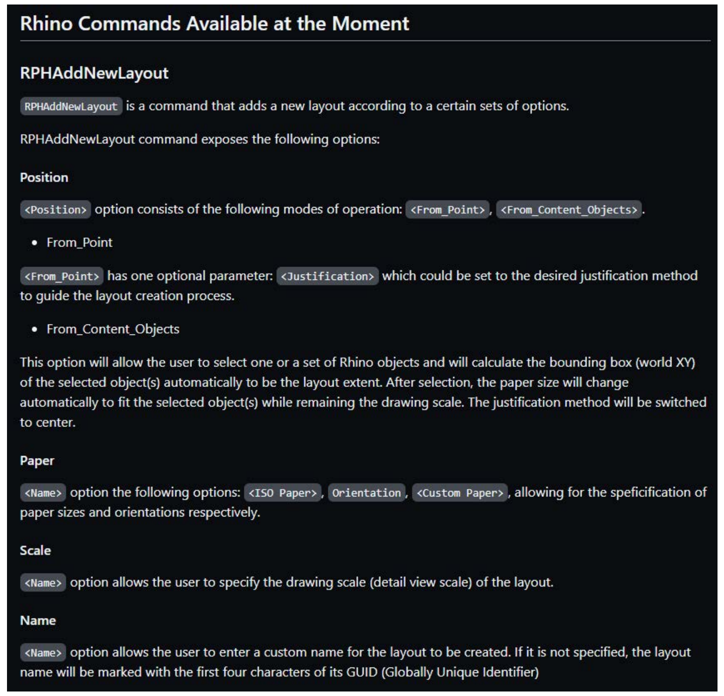
C#/.NET Based on RhinoCommon

C#/.NET, RhinoCommon SDK, Second-Development

Architectural Association, 2022-Ongoing

This grasshopper definition with custom C# scripts allows for the automatic assignment of parent-child relations according to geo-spatial relations. In such way, the building is assigned as a child to the corresponding plot, the island, the fabric and so on down the line. In such way, it makes it possible to lively calculate and update various density indicators at different scales and assists visualisation, urban analytics, morphometrics etc.





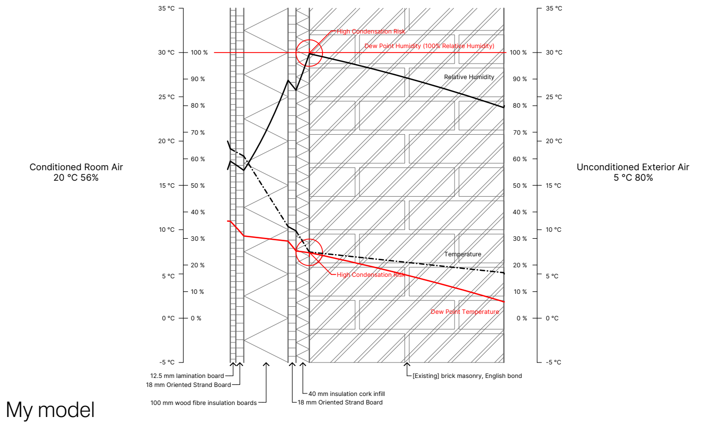
RhinoSmartLayout (RPH Plugin)

Rhinoceros Utility Plugin Based on RhinoCommon SDK

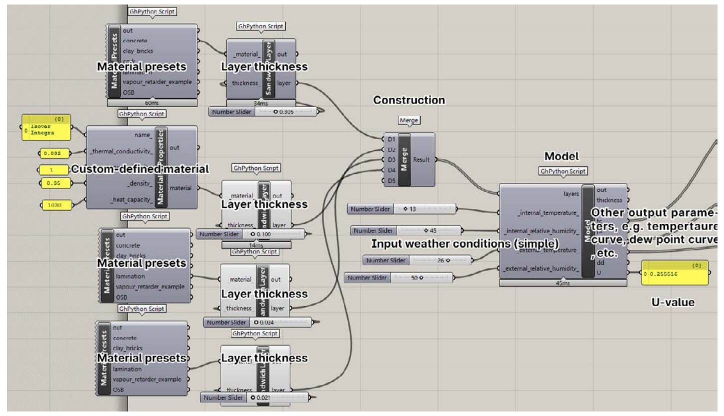
C#/.NET, RhinoCommon SDK, Second-Development

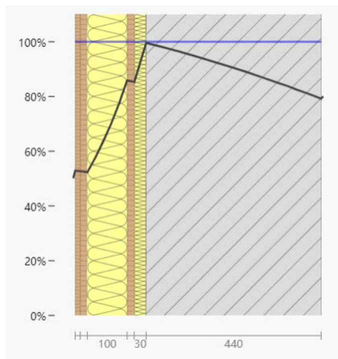
Architectural Association, 2022

RhinoLayoutHelper is a plugin for Rhinoceros 6 (SR18+) written in C#/.NET that assists the user to easily and effortlessly create Rhino LayoutViews with a dynamic preview of the layout extent. This plugin exposes one command that can take in different settings such as paper size, drawing scale, layout name, layout location (following mouse movement, with a user-specified alignment method), etc.
This plugin is available for download on GitHub: https://github.com/Chengxuan-Li/RPH

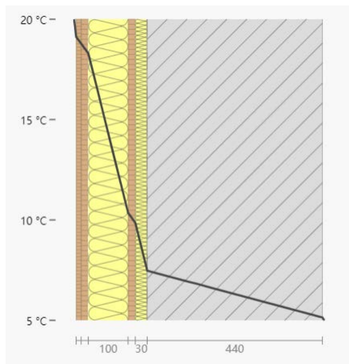


My model





Ubakus.de result (relative humidity)



Ubakus.de result (temperature)

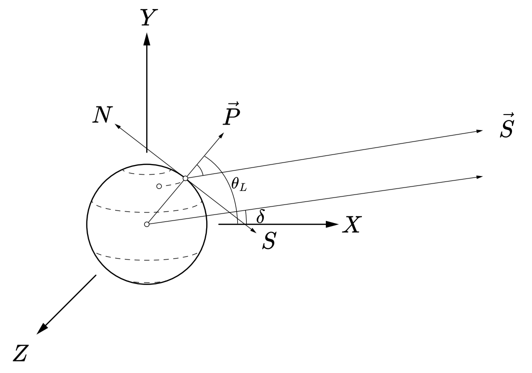
U-Value Calculator and Wall 1-D Section Thermal Profile

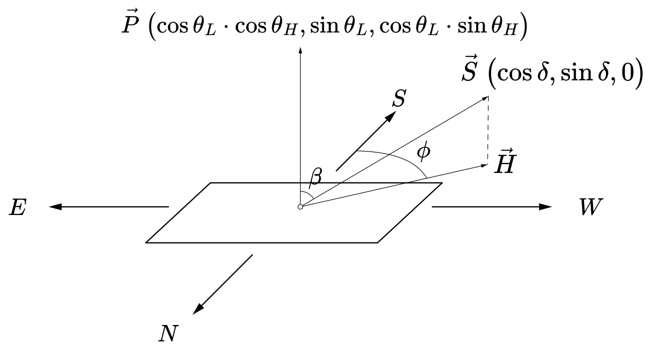
Grasshopper Definition Based on RhinoCommon and GhPython

GhPython, RhinoCommon SDK, Second-Development

Architectural Association, 2022

This is part of the energy model used for validating certain design decisions in a previous design project. This code not only calculates the U-Value and other important properties of a given wall construction but also assists the translation of sectional distribution of temperature and humidity profiles into Rhino geometries.
Code is partially available on GitHub: https://github.com/Chengxuan-Li/U-Value-and-Condensation-Calculator





For an arbitrary location $\vec{P}$ on the surface of the earth, due to the distance between the earth and the sun is significantly larger than any other parameters involved in this calculation, the unitized vector showing the direction from the geometric center of the earth, (coordinate origin) to the sun, and the one showing the direction from the observer location $\vec{P}$ to the sun, are considered the same vector, $\vec{S}$. Using spherical coordinates, it is not difficult to obtain them with relation to: latitude of $\vec{P}$, denoted as θ_L; solar declination angle δ; local-time-related hour angle θ_H.

The first step is obtaining solar deviation angle β, which could be obtained somehow effortlessly

$$\cos\beta = \cos\langle\vec{P},\vec{S}\rangle = \frac{\vec{P}\cdot\vec{S}}{||\vec{P}||\cdot||\vec{S}||} = \frac{\cos\theta_L \cdot \cos\theta_H \cdot \cos\delta + \sin\theta_L \cdot \sin\delta}{\sqrt{\cos^2\theta_L \cdot \cos^2\theta_H + \sin^2\theta_L + \cos^2\theta_L \cdot \sin^2\theta_H} \cdot \sqrt{\cos^2\delta + \sin^2\delta}}$$
$$= \cos\theta_L \cdot \cos\theta_H \cdot \cos\delta + \sin\theta_L \cdot \sin\delta$$

There has been a variety of ways to obtain the solar azimuth angle ϕ , and the method adopted here to solve the azimuth is by first obtaining the projection vector of the solar direction vector, onto a local ground plane. If we denote the projected sun direction vector (no longer unitized, naturally), as $\vec{H}$, then the following relations are easily obtained

$$\vec{H}\cdot\vec{P} = (\vec{S} + \lambda\vec{P})\cdot\vec{P} = 0$$
$$\vec{S}\cdot\vec{P} + \lambda||\vec{P}||^2 = \vec{S}\cdot\vec{P} + \lambda = \cos\beta + \lambda = 0 \qquad \lambda = -\cos\beta, \quad \vec{H} = \vec{S} - \cos\beta\vec{P}$$

Meanwhile, the locally defined south direction (unitized, naturally, derived from spherical coordinates) is represented as

$$S = (\sin\theta_L \cdot \cos\theta_H, -\cos\theta_L, \sin\theta_L \cdot \sin\theta_H) \quad s.t. \ \ S\cdot\vec{P} = 0$$

which should be naturally perpendicular to the location vector which is normal to the locally defined ground plane.

Finally, the cosine value of ϕ is expressed as

$$\cos\langle S,\vec{H}\rangle = \frac{S\cdot(\vec{S} - \sin\phi\vec{P})}{||S||\cdot||\vec{H}||} = \frac{\cos\delta \cdot \sin\theta_L \cdot \cos\theta_H - \sin\delta \cdot \cos\theta_L}{1\cdot\sqrt{||S||^2 + \cos^2\beta\,||\vec{P}||^2 - 2\cos^2\beta\,||\vec{P}||}} = \frac{\cos\delta \cdot \sin\theta_L \cdot \cos\theta_H - \sin\delta \cdot \cos\theta_L}{\sin\beta}$$

using basic vector operations and trigonometry.

Notably, to adjust such set of formulae to the tradition of calendar days and local time zones, essential parameters might well be organized in such manner that (although in obtaining rough climatic calculations, many of the parameters included might be superfluous and unnecessary)

$$\delta = \sin\left(\frac{360(284+N_d)}{365.25}\right)\cdot 23.45^\circ$$
$$\theta_H = (T_{std} + 4(L_{std} - L_{loc}) + E_t - DT - 12)\cdot 15^\circ$$

where N_d represents the calendar day numbered from the first day of the year (Jan 1st); T_{std} represents the standard local time in the time zone; L_{std} represents the center-most longitudinal position of the time zone; L_{loc} represents the local longitude; E_t represents a equation-of-time correction factor that takes into account the perturbations in earth's rotation, and finally DT is the possible correction for daylight saving hour(s).

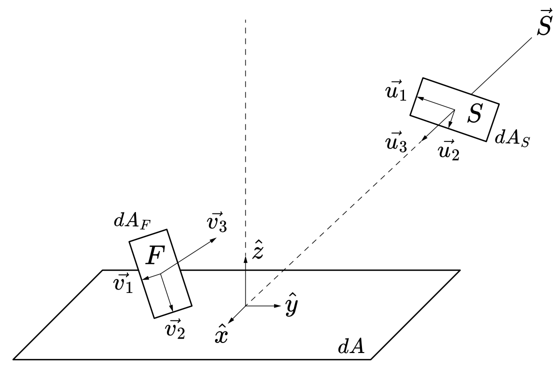
Incident Radiation Module (Simple Shoebox, No Raytracing)

Grasshopper Definition Based on RhinoCommon and GhPython

GhPython, RhinoCommon SDK, Second-Development

Architectural Association, 2022

This is part of the energy model used for validating certain design decisions in a previous design project. This module has been incorporated into the energy model.
Code is partially available on GitHub: https://github.com/Chengxuan-Li/WinterGardenEnergy



To recapitulate, from the previous step, the direction of the sun is obtained as

$$\vec{S} = [\sin\phi\cdot\sin\beta \quad \cos\phi\cdot\sin\beta \quad \cos\phi]^T$$

while the cumulated radiance Q_{rad} over a given period of time T on a given surface A , under the overall daylight condition of direct radiance G_{dir}, diffuse radiance G_{diff} (both measures are easily obtained through climatic records at weather stations of the local area of investigation. As a reminder, the actual incident radiance, diffuse g_{diff}, reflected g_{ref} , or direct, should be corrected between different coordinate systems and thus different area differential elements dA_S , dA , dA_F , of which the following relations thus apply

$$Q_{rad} = \iiint_{A,T}(G_{dir}\cdot dT\cdot dA_S + g_{diff}\cdot dT\cdot dA_F + g_{ref}\cdot dT\cdot dA_F) \qquad dA_S = du_1\cdot du_2 \quad dA = dx\cdot dy \quad dA_F = dv_1\cdot dv_2$$

It is without question that, as seen in this formula, incident radiations differ naturally from the observed value of rations, regardless of type, and they takes into account the equivalent incident area, obtained through the coordinate translation shown as

$$[\vec{u}_1 \quad \vec{u}_2 \quad \vec{u}_3]^T = T_S[\hat{x} \quad \hat{y} \quad \hat{z}]^T = T_S\ T_F^{-1}[\vec{v}_1 \quad \vec{v}_2 \quad \vec{v}_3]^T$$

where the vector set represents one set of normalized unitized base vectors that spans the equivalent incident surface with the first two column vectors; and represents the normal of the incident surface with the third column vector. Thus, the following relations apply

$$\mathbf{S_3} = \{\vec{u}_1,\vec{u}_2,\vec{u}_3\} \quad s.t. \quad \vec{u}_1\perp\vec{u}_2\perp\vec{u}_3, \quad ||\vec{u}_1|| = ||\vec{u}_2|| = ||\vec{u}_3|| = 1$$
$$\mathbf{F_3} = \{\vec{v}_1,\vec{v}_2,\vec{v}_3\} \quad s.t. \quad \vec{v}_1\perp\vec{v}_2\perp\vec{v}_3, \quad ||\vec{v}_1|| = ||\vec{v}_2|| = ||\vec{v}_3|| = 1$$

To be specific, for the three-dimensional vector space defined by $\mathbf{S_3} = \{\vec{u}_1,\vec{u}_2,\vec{u}_3\}$, as we are already fully aware, we have

$$\vec{u}_1 = \vec{S} = [\sin\phi\cdot\sin\beta \quad \cos\phi\cdot\sin\beta \quad \cos\phi]^T$$

Effortlessly, we could easily figure out a valid combination of the other two base vectors, or we can simply utilize two perpendicular tangent vectors that lie in the tangent surface at the chosen location. Regardlessly, immediately when one of them is determined, the other could be easily obtained through the cross product of the previous two. Here, a possible solution is shown as follows

$$\vec{u}_2 = [\sin\phi\cdot\cos\beta \quad \cos\phi\cdot\cos\beta \quad \sin\beta]^T$$
$$\vec{u}_3 = [\cos\beta \quad -\sin\phi \quad 0]^T$$

As a result, the translation matrix $\mathbf{T_S}$ from $[\hat{x} \quad \hat{y} \quad \hat{z}]^T$ to $[\vec{u}_1 \quad \vec{u}_2 \quad \vec{u}_3]^T$, i. e. $[\vec{u}_1 \quad \vec{u}_2 \quad \vec{u}_3]^T = T_S[\hat{x} \quad \hat{y} \quad \hat{z}]^T$, is written as

$$\mathbf{T_S} = \begin{bmatrix} \cos\phi & \sin\phi\cdot\cos\beta & \sin\phi\cdot\sin\beta \\ -\sin\phi & \cos\phi\cdot\cos\beta & \cos\phi\cdot\sin\beta \\ 0 & \sin\beta & \cos\beta \end{bmatrix}$$

Similarly, the translation $\mathbf{T_F^{-1}}$ from $[\vec{v}_1 \quad \vec{v}_2 \quad \vec{v}_3]^T$ to $[\hat{x} \quad \hat{y} \quad \hat{z}]^T$, i. e. $[\hat{x} \quad \hat{y} \quad \hat{z}]^T = T_F^{-1}[\vec{v}_1 \quad \vec{v}_2 \quad \vec{v}_3]^T$, is written as

$$\mathbf{T_F} = \begin{bmatrix} \cos\psi & \sin\psi\cdot\cos\gamma & \sin\psi\cdot\sin\gamma \\ -\sin\psi & \cos\psi\cdot\cos\gamma & \cos\psi\cdot\sin\gamma \\ 0 & \sin\gamma & \cos\gamma \end{bmatrix} \qquad \mathbf{T_F^{-1}} = \frac{1}{-\sin^2\gamma + \cos^2\gamma}\cdot\begin{bmatrix} (-\sin^2\gamma + \cos^2\gamma)\cdot\cos\psi & \cos\gamma\cdot\sin\psi & -\sin\gamma\cdot\sin\psi \\ (\sin^2\gamma - \cos^2\gamma)\cdot\sin\psi & \cos\gamma\cdot\cos\psi & -\sin\gamma\cdot\cos\psi \\ 0 & -\sin\gamma & \cos\gamma \end{bmatrix}^T$$

where β and ϕ are the deviation and azimuth of the sun, while γ and ψ are the altitude and the azimuth of the incident surface normal.

The ratio of the equivalent incident radiance over the observed f_{dir} s. t. $g_{dir} = f_{dir}\cdot G_{dir}$ is expressed as

$$f_{dir} = \cos\alpha = \cos\langle\vec{u}_3,\vec{v}_3\rangle = \frac{\vec{u}_3\cdot\vec{v}_3}{||\vec{u}_3||\cdot||\vec{v}_3||} = \sin\phi\cdot\sin\beta\cdot\sin\psi\cdot\sin\gamma + \cos\phi\cdot\sin\beta\cdot\cos\psi\cdot\cos\gamma + \cos\beta\cdot\cos\gamma$$

There are generally three types of radiation in the simulation of solar gains.

Direct beam radiation

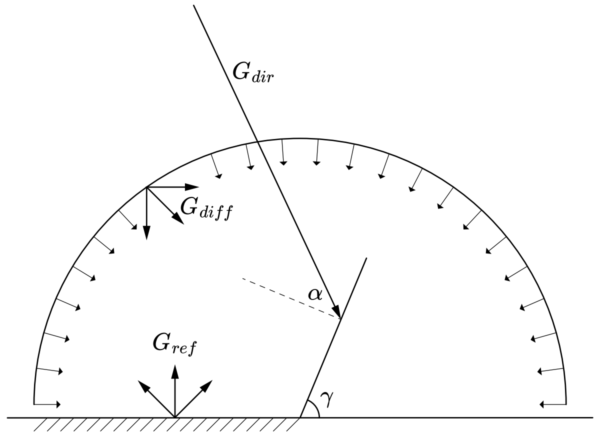
Direct beam radiation is an anisotropic radiation that results from the solar ray hitting a surface of the building fabric. Contrary to isotropic radiation, anisotropic radiation depends on the angle of incidence i. e. the effective area of incidence projected from the original surface (planar infinitesimally small surface da = du * dv) to the normal plane (dA = dx * dy) of the incident radiation ray or beam.

Sky diffuse radiation

Sky diffuse radiation is the diffused solar beam radiation by the sky dome. It is an isotropic radiation. In a simulation or a solar model, the isotropic radiation is described ideally as a type of radiation that is not dependent on the direction of incidence. For example, a plain surface of fixed area and amount of incident isotropic radiation, will have the same amount of irradiance from isotropic radiation regardless of its directions (represented by the direction vector of the face normal). However, one should always bear in mind that this is merely an approximation and estimation in the theoretical model which might differ from the actual conditions and measured values.

Ground reflected radiation

Ground reflected radiation is the reflected radiation (of the solar beam direct and the sky diffuse) by the sky dome. It is an isotropic radiation. In a simulation or a solar model, the isotropic radiation is described ideally as a type of radiation that is not dependent on the direction of incidence. For example, a plain surface of fixed area and amount of incident isotropic radiation, will have the same amount of irradiance from isotropic radiation regardless of its directions (represented by the direction vector of the face normal). However, one should always bear in mind that this is merely an approximation and estimation in the theoretical model which might differ from the actual conditions and measured values.



As introduced previously, the total solar radiation incident on a given surface consists of three different types of radiations: the direct beam radiation from the sun; the diffuse radiation from the sky; the reflected radiation from the ground. The latter two types are considered isotropic. From weather reports or records, the sky diffuse and direct beam radiations are easily obtained. Yet one should always be aware that such observed radiation levels does not reflect and actual incident values of radiations on a given surface, due to the inclination of the surface, the view factor of the sky, etc. Meanwhile, the ground reflected radiation is dependent both on the amount of sky diffuse radiation available on site, and the general reflectivity of the nearby ground surface. Without any loss of generosity, for a given moment at this given location, if we inherit the previous nomenclature to represent the observed direct radiation as G_{dir}, the actual incident direct radiation on surface as g_{dir}, the observed diffuse radiation as G_{diff}, the actual incident diffuse radiation on surface as g_{diff}, the ground reflected radiation as G_{ref}, the actual incident ground reflected radiation as g_{ref}, and the total incident radiation as g, we have the following relations

$$g = g_{dir} + g_{diff} + g_{ref} = f_{dir} \cdot G_{dir} + f_{diff} \cdot G_{diff} + f_{ref} \cdot G_{ref}$$

where the factors that translate the observed levels of radiation to the incident levels have the following relations

$$f_{dir} = \cos\alpha$$

$$f_{diff} = \frac{1+\cos\gamma}{2}$$

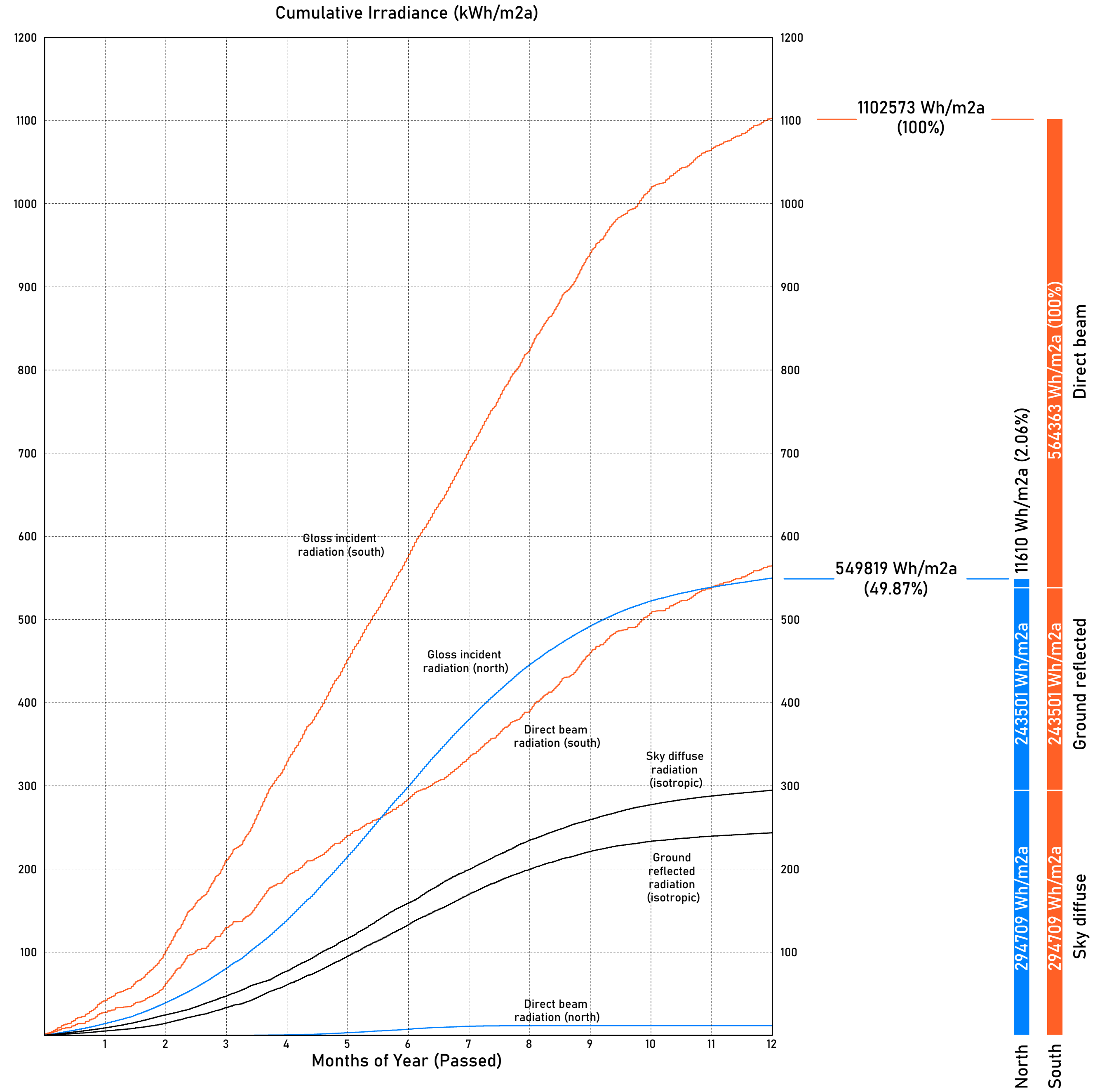
$$f_{ref} = \frac{1-\cos\gamma}{2}$$

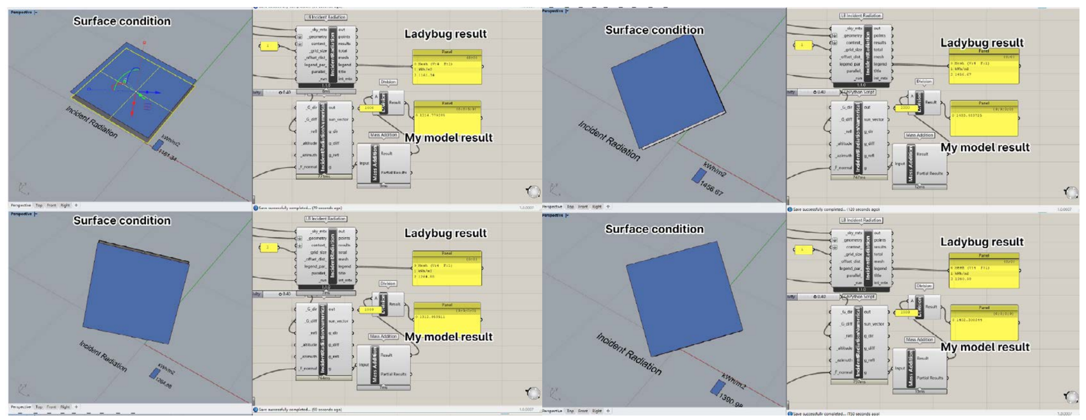
Since the ground reflected radiation from a contextual endless surface with reflectivity ρ is the reflection of a combination of sky diffuse radiation (isotropic) and direct radiation (incident on the contextual surface with altitude angle β), we could rewrite the ground reflected radiation (isotropic) as

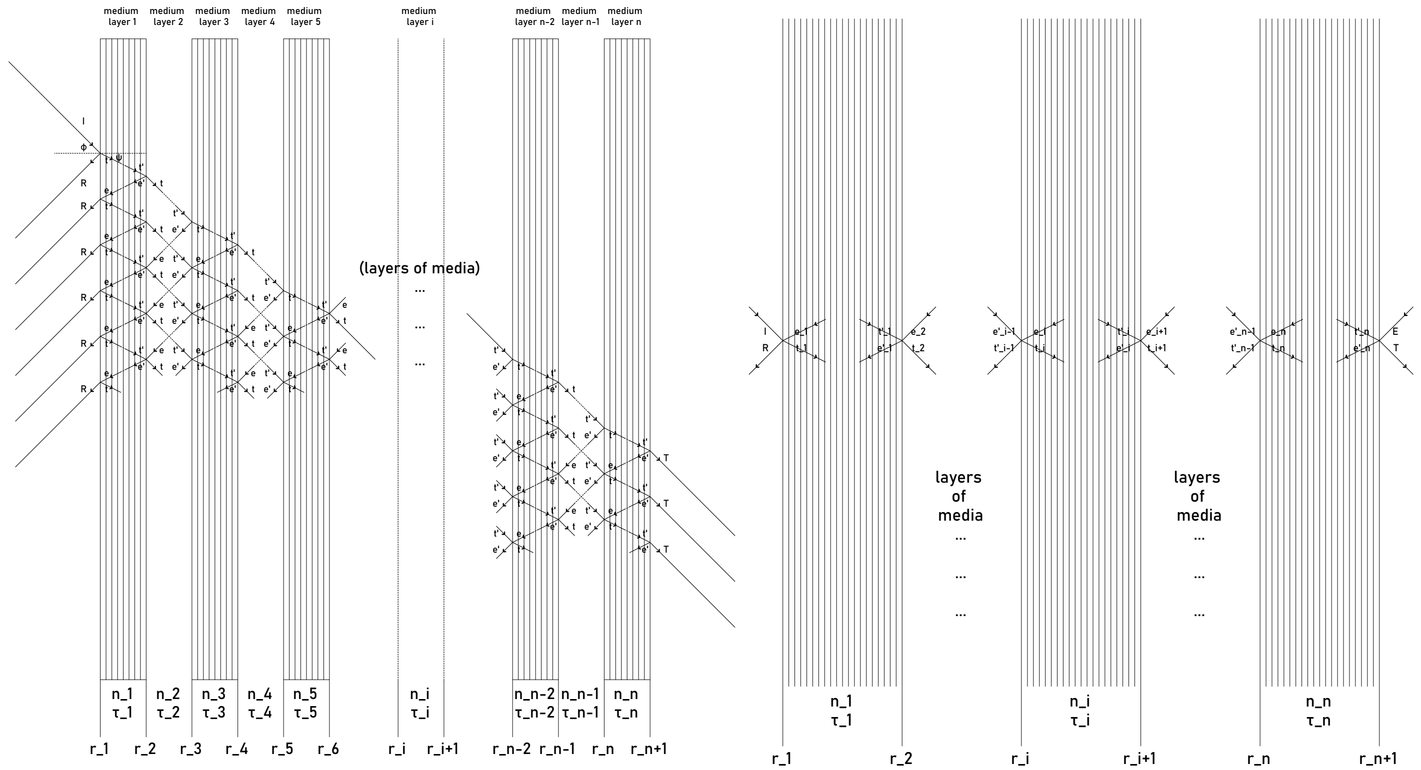
$$G_{ref} = \rho \cdot (G_{diff} + G_{dir} \cdot \cos\beta)$$

Thus, the total incident radiation is represented in the following formula as

$$g = \left[\cos\alpha + \frac{1-\cos\gamma}{2} \cdot \rho \cdot \cos\beta\right] \cdot G_{dir} + \left[\frac{1+\quad\gamma}{2} + \frac{1-\cos\gamma}{2} \cdot \rho\right] \cdot G_{diff}$$







Angle-Specific Fresnel Module for Multi-Layered Fenestration with Infill Gases

Grasshopper Definition Based on RhinoCommon and GhPython

GhPython, RhinoCommon SDK, Second-Development

Architectural Association, 2022

This is part of the energy model used for calculating detailed absorbance, transmittance and reflectance for multi-layered fenestration with infill gases. This model deducts the angle-specific results, and assumes that, similar to the solar rays, all incident rays are unpolarised. This module has been incorporated into the energy model.

Code is partially available on GitHub: https://github.com/Chengxuan-Li/WinterGardenEnergy

From the Fresnel equations, we know that for a given natural light that could normally be described as unpolarized, having equal power in both polar directions, the Reflectivity r_i at the interface between a given medium of IOR n_i and another given medium of IOR n_{i-1} , is

$$r_i = \frac{1}{2}\left(\left[\frac{n_{i-1}\cdot\cos\phi_i - n_i\cdot\sqrt{1-\left(\frac{n_{i-1}}{n_i}\cdot\sin\phi_i\right)^2}}{n_{i-1}\cdot\cos\phi_i + n_i\cdot\sqrt{1-\left(\frac{n_{i-1}}{n_i}\cdot\sin\phi_i\right)^2}}\right]^2 + \left[\frac{-n_i\cdot\cos\phi_i + n_{i-1}\cdot\sqrt{1-\left(\frac{n_{i-1}}{n_i}\cdot\sin\phi_i\right)^2}}{n_i\cdot\cos\phi_i + n_{i-1}\cdot\sqrt{1-\left(\frac{n_{i-1}}{n_i}\cdot\sin\phi_i\right)^2}}\right]^2\right)$$

where ϕ_i is the angle of incident on to the interface.

From the rule of the conservation of energy, it is easy to deduct that the transmitted power (more precisely, the transmitted irradiance, i. e. power per unit area) is the portion of the incident irradiance that does not get reflected, i. e. $1 - r_i$

Thus, for the i-th interface in a typical fenestration construction, i. e. the one between the layer (i - 1) of all materials (including cavity materials), and the layer i, if we have the effective incident iirradiance transmitted from the layer (i - 1) as t'_{i-1} , the effective reflected irradiance reflected back into the layer (i - 1) as e'_{i-1} , the effective backward incident irradiance transmitted from the layer i as e_i, and the effective reflected irradiance reflected back into the layer i as t_i , the energy allocation between these irradiance beams could be described as

$$t_i = r_i \cdot e_i + (1 - r_i)\cdot t'_{i-1}$$

$$e'_{i-1} = (1 - r_i)\cdot e_i + r_i \cdot t'_{i-1}$$

For a chained representation, it could be better to formuate these relations into matrix-based forms, i. e.

$$\begin{bmatrix} e_i \\ t_i \end{bmatrix} = \begin{bmatrix} -\frac{r_i}{1-r_i} & \frac{1}{1-r_i} \\ \frac{-2\cdot r_i+1}{1-r_i} & \frac{r_i}{1-r_i} \end{bmatrix} \begin{bmatrix} t'_{i-1} \\ e'_{i-1} \end{bmatrix}$$

If we assume that the portion of energy absorbed through the process of transmission into the medium layers is a constant with consideration of the thickness, componentry and material properties of each layer, written for the i-th layer as τ_i , we could have the following relation that describes the energy loss through the transmission inbetween interfaces:

$$\begin{bmatrix} t'_i \\ e'_i \end{bmatrix} = \begin{bmatrix} 0 & \tau_i \\ \frac{1}{\tau_i} & 0 \end{bmatrix} \begin{bmatrix} e_i \\ t_i \end{bmatrix}$$

Consequentially, these relations could be combined to be written as follows which could best describe the energy change between interfaces

$$\begin{bmatrix} t'_i \\ e'_i \end{bmatrix} = \begin{bmatrix} 0 & \tau_i \\ \frac{1}{\tau_i} & 0 \end{bmatrix} \begin{bmatrix} -\frac{r_i}{1-r_i} & \frac{1}{1-r_i} \\ \frac{-2\cdot r_i+1}{1-r_i} & \frac{r_i}{1-r_i} \end{bmatrix} \begin{bmatrix} t'_{i-1} \\ e'_{i-1} \end{bmatrix}$$

of which the middle part could be represented through a 2x2 matrix that could be calculated easily from the material properties and the angle of incident of the beams inside the layers of media and interfaces. We thus denote it as follows for the simplification of the argument.

$$\begin{bmatrix} t'_i \\ e'_i \end{bmatrix} = \mathbf{T_i} \begin{bmatrix} t'_{i-1} \\ e'_{i-1} \end{bmatrix}$$

And for the boundary conditions:

$$\begin{bmatrix} t'_1 \\ e'_1 \end{bmatrix} = \mathbf{T_1} \begin{bmatrix} I \\ R \end{bmatrix} \qquad \begin{bmatrix} T \\ E \end{bmatrix} = \mathbf{T_{n+1}} \begin{bmatrix} t'_n \\ e'_n \end{bmatrix}$$

Then we have a generalized form that represents the **INITIAL** and the **FINAL** conditions of irradiance distribution, related by a pre-calculated matrix that is regardless of the process in between the initial and the final conditions.

$$\begin{bmatrix} T \\ E \end{bmatrix} = \mathbf{T_{n+1}}\mathbf{T_n}\cdots\mathbf{T_1} \begin{bmatrix} I \\ R \end{bmatrix}$$

Since the middle products of matrices could be obtained independently, we write it as

$$\begin{bmatrix} T \\ E \end{bmatrix} = \begin{bmatrix} a & b \\ c & d \end{bmatrix} \begin{bmatrix} I \\ R \end{bmatrix}$$

where we could easily obtain the relations:

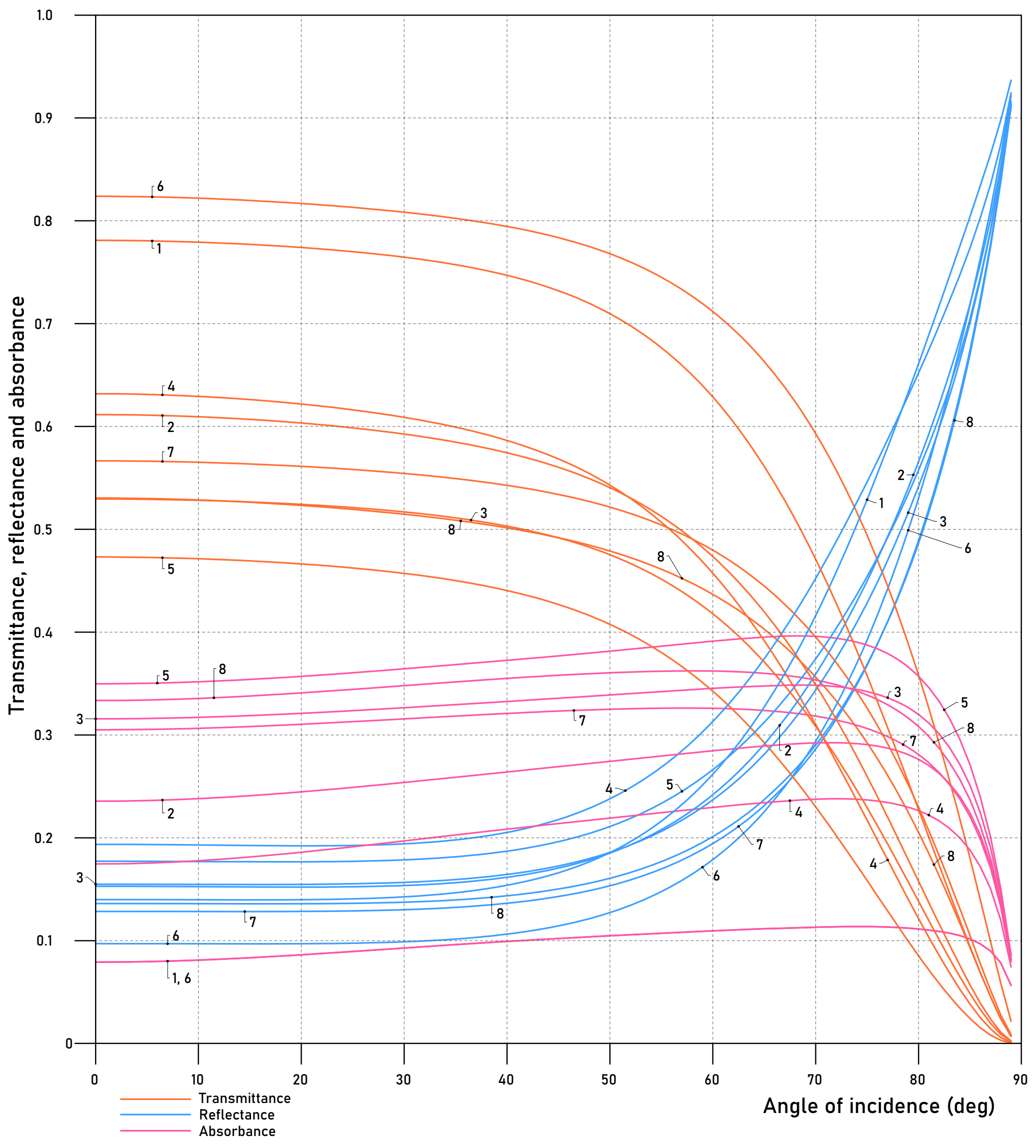
$$R = \frac{1}{b}\cdot E - \frac{a}{b}\cdot I \qquad T = \frac{d}{b}\cdot E + \frac{b\cdot c - a\cdot d}{b}\cdot I$$

where is the total reflected irradiance, is the total incident irradiance, is the total transmitted irradiance. By obtaining a difference between the incident energy and the summation of the reflected and transmitted enerngy, the absorbed energy by the layers of fenestrations could be obtained.

For a simplified solution, we assume that little or no irradiance is incident backwards from the inner surface from interior sources, we could write the result as

$$R = -\frac{a}{b}\cdot I \qquad T = \frac{b\cdot c - a\cdot d}{b}\cdot I$$

which could also show the reflectance of the multi-layered fenestration and the transmittance of it very clearly.



No. 1
Construction
6 mm common glazing
12 mm air gap
6mm common glazing

No. 2
Construction
6 mm common glazing
12 mm air gap
Bronze tint
6mm common glazing

No. 3
Construction
6 mm common glazing
12 mm air gap
Low-E coating
6mm common glazing

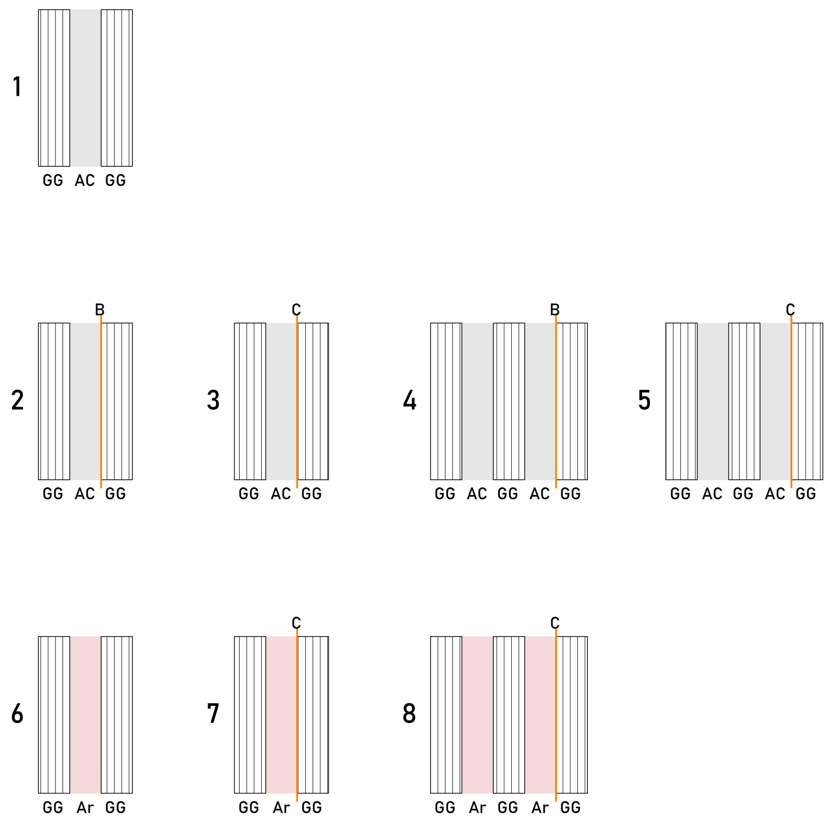
No. 4
Construction
6 mm common glazing
12 mm air gap
6mm common glazing
12 mm air gap
Bronze tint
6mm common glazing

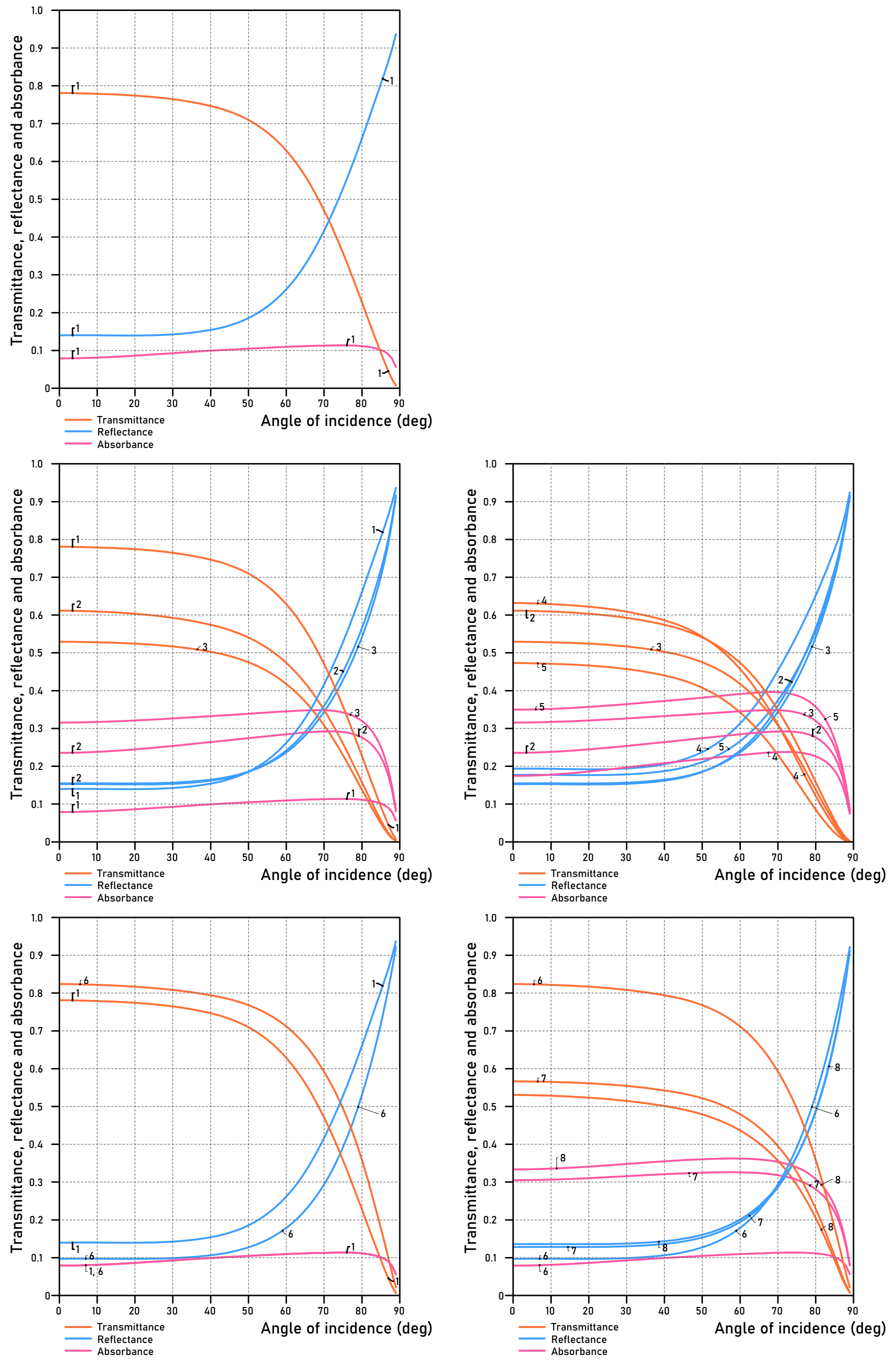
No. 5
Construction
6 mm common glazing
12 mm air gap
6mm common glazing
12 mm air gap
Bronze tint
6mm common glazing

No. 6
Construction
6 mm common glazing
12 mm argon gap
6mm common glazing

No. 7
Construction
6 mm common glazing
12 mm argon gap
Low-E coating
6mm common glazing

No. 8
Construction
6 mm common glazing
12 mm argon gap
6mm common glazing
12 mm argon gap
Low-E coating
6mm common glazing





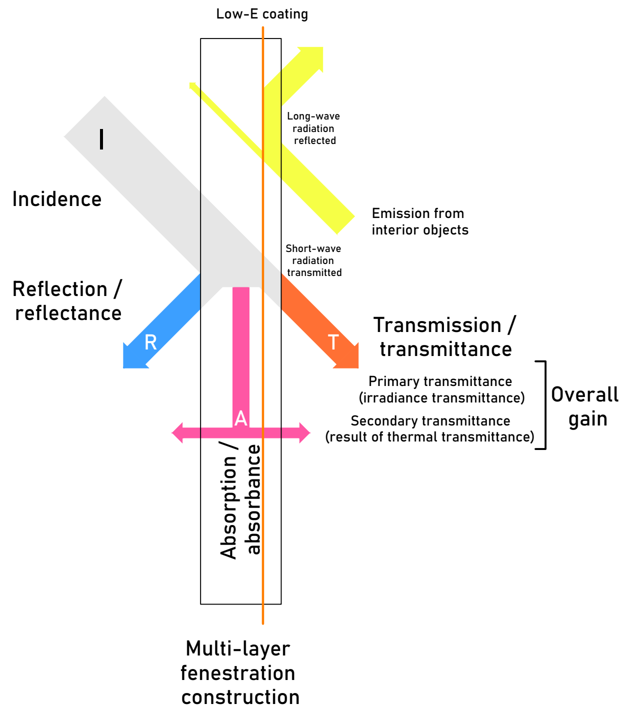
Generic double glazing

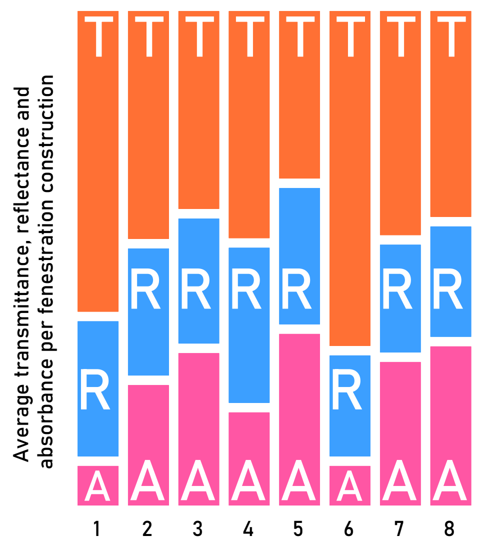
1 - 2 - 3: Comparing the effect of tinting and coating

2 - 3 - 4 - 5: Comparing the effect of an additional layer

1 - 6: Comparing the effectiveness of argon infill

6 - 7 - 8: Comparing between argon infill fenestration constructions





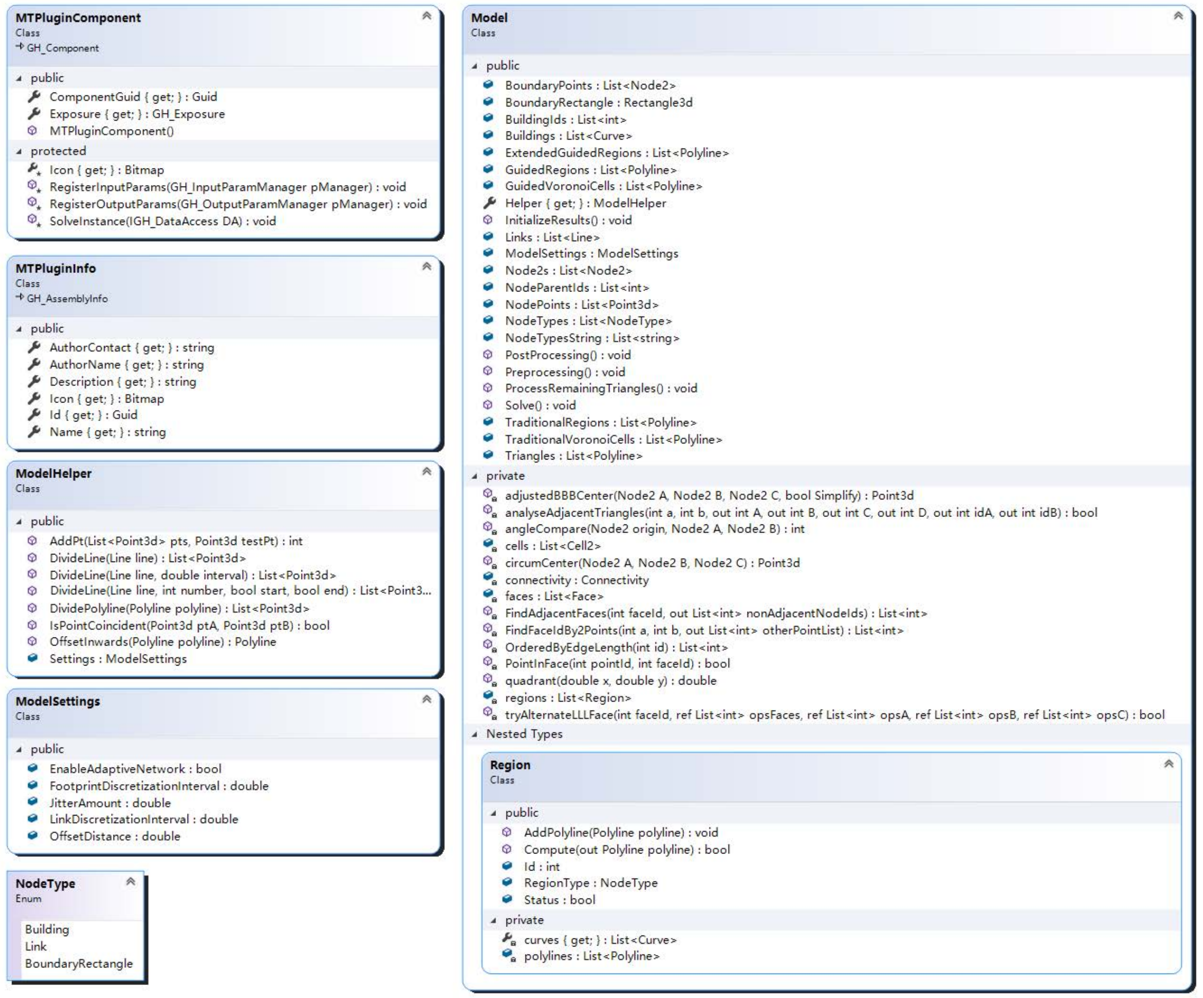
Paper Abstract

The built form of cities is a synthesis of natural climate, human culture, social structures, and economic forces. Urban forms and plot-level features play a crucial role in urban analytics and planning (Kropf 2017). Traditionally, the characterisation of urban forms and plot features relied on visually scrutinizing urban plans. The recently introduced Morphological Tessellation (MT) method (Fleischmann et al. 2020) achieved an automatic partitioning of urban space, using a Voronoi Tessellation (VT) of building footprint geometries for morphological characterisation and classification. However, achieving the desired accuracy often requires highly detailed tessellation and resource-intensive computing; improper presets and oversimplified triangulation easily lead to low quality outcomes.
To address this issue, this paper introduces the Weighted Mean Sinuosity (WMS) measure (Dutton 1999), enhancing existing numeric indicators of undesired tessellation outcomes. This paper then introduces an adaptive tessellation workflow in addition to VT, presenting a locally adapted tessellation method that is uniquely suitable for closely aligned footprint edges in typical urban conditions. This paper then discusses a methodology to incorporate linear guides that controls the triangulation and tessellation process, allowing for increased control over the shape and performance of MT. The fully automatic workflow realised in a Grasshopper Assembly developed for Rhinoceros 3D in .NET/C#. This workflow proves to generate geometrically desirable outcomes with substantially reduced computational workload. Such methodological advancement enables the handling of urban analytical tasks with bigger datasets and at a larger scale.

Full Paper Availability

Please refer to the writing sample for full paper preview.

a) Buildings and Streets Input b) Traditional MT c) MT+Guided Tessellation d) MT+Guided+Adaptive Tessellation



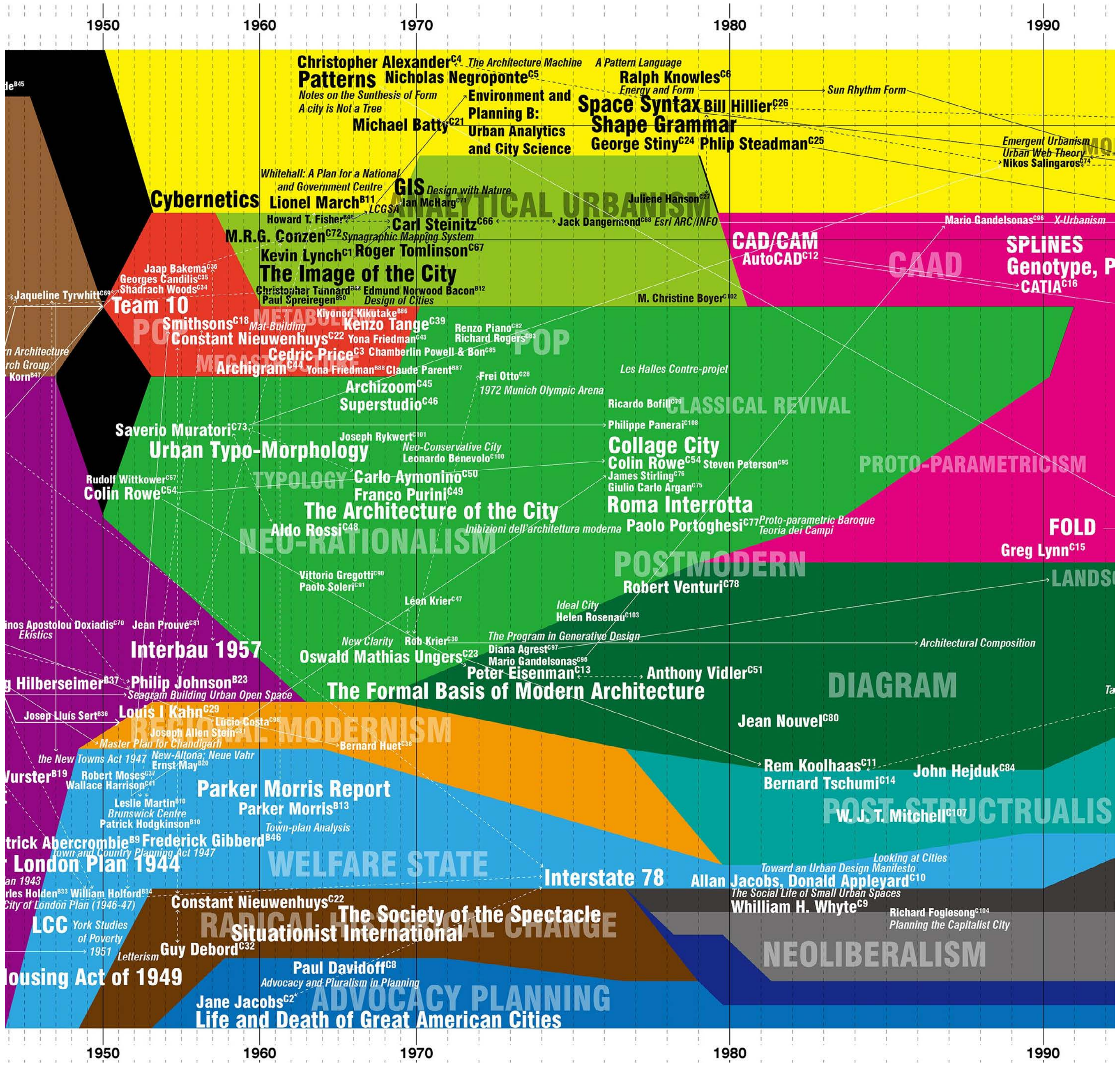
Optimising Urban Morphological Tessellation: Methodological Advancements Using Adaptive Tessellation and Guided Triangulation

Gha Grasshopper Assembly Based on RhinoCommon

C#/.NET, RhinoCommon SDK, Second-Development
Architectural Association, 2023-Ongoing

This is a work-in-progress gha plugin for Grasshopper that works on the morphological tessellation ([Fleischmann et al, 2020]) and advances its functionality to incorporate guide geometries and polylines for more accurate and reasonable tessellation results. The abstract of my research paper titled "Morphological tessellation for urban space partitioning and characterisation at the plot level: An integrated tool for designers" has been accepted by Architecture Beyond Boundaries 2024 conference.

"History has not been shaped solely by deep social groundswells, inexorable economic forces, new sources of power or improved means of communication," notes Reyner Banham, in his artfully crafted obituary for Le Corbusier, "It has also been decisively shaped by unforeseeable individuals whose power to utter the right word, turn the right gesture, has made great trends conscious and comprehensible, defined the forms in which history and their contemporaries could recognised the drift of events."
Within the Chronogram, history assumes the role of an eloquent storyteller, weaving together the threads of grand-figures, their hidden connections and acquaintances, their unspoken coalition and collisions. Within the Chronogram, multiple historical accounts and polyphonic echoes of the past are orchestrated in an interlaced landscape of fresh soils and archaic strata, cutting-edge theories and historically burdened references, revolutionary ideals and reactionary traditions.



Chronogram of Urbanism

A Literature Review on the History and Theory of Urban Planning and Design

Literature Review, Urbanism, Urban Planning, Urban Design, Chronogram
Architectural Association, 2023-Ongoing

Presented here is a part of the Chronogram of Urbanism which reckons with the coming-into-being of the urban environment which we inhabit today. Acknowledging the inherent selectivity of any Chronogram, this project serves not as an exhaustive historical documentation but rather as a nuanced, forward-projecting tool that outlines not only how the as-found urban environment derives from a constellation of differing individual theories and practices but also a potential future that unfolds itself in tandem with this trajectory. For the full version, please visit https://www.lcx.works/Chronogram-of-Urbanism/