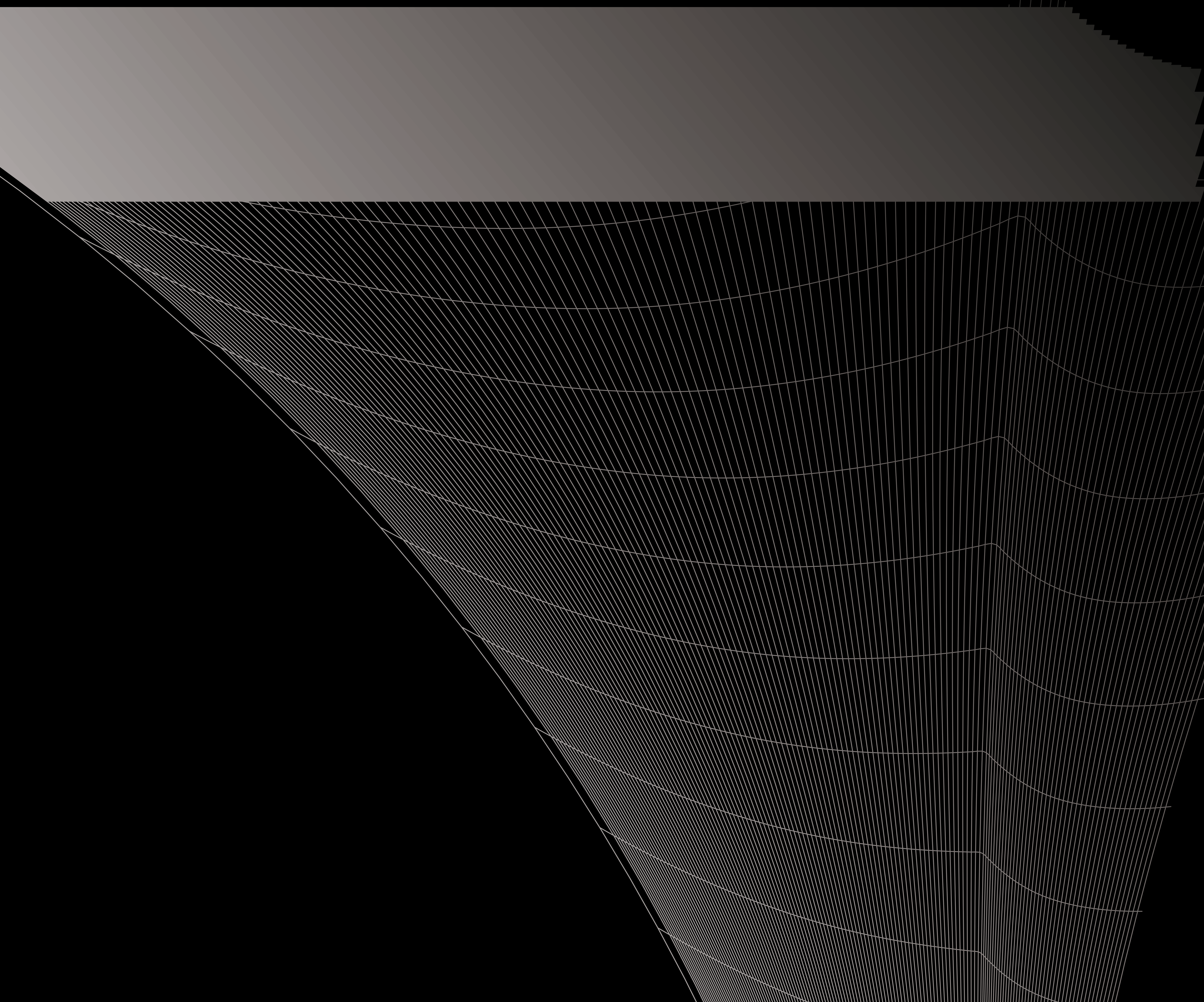
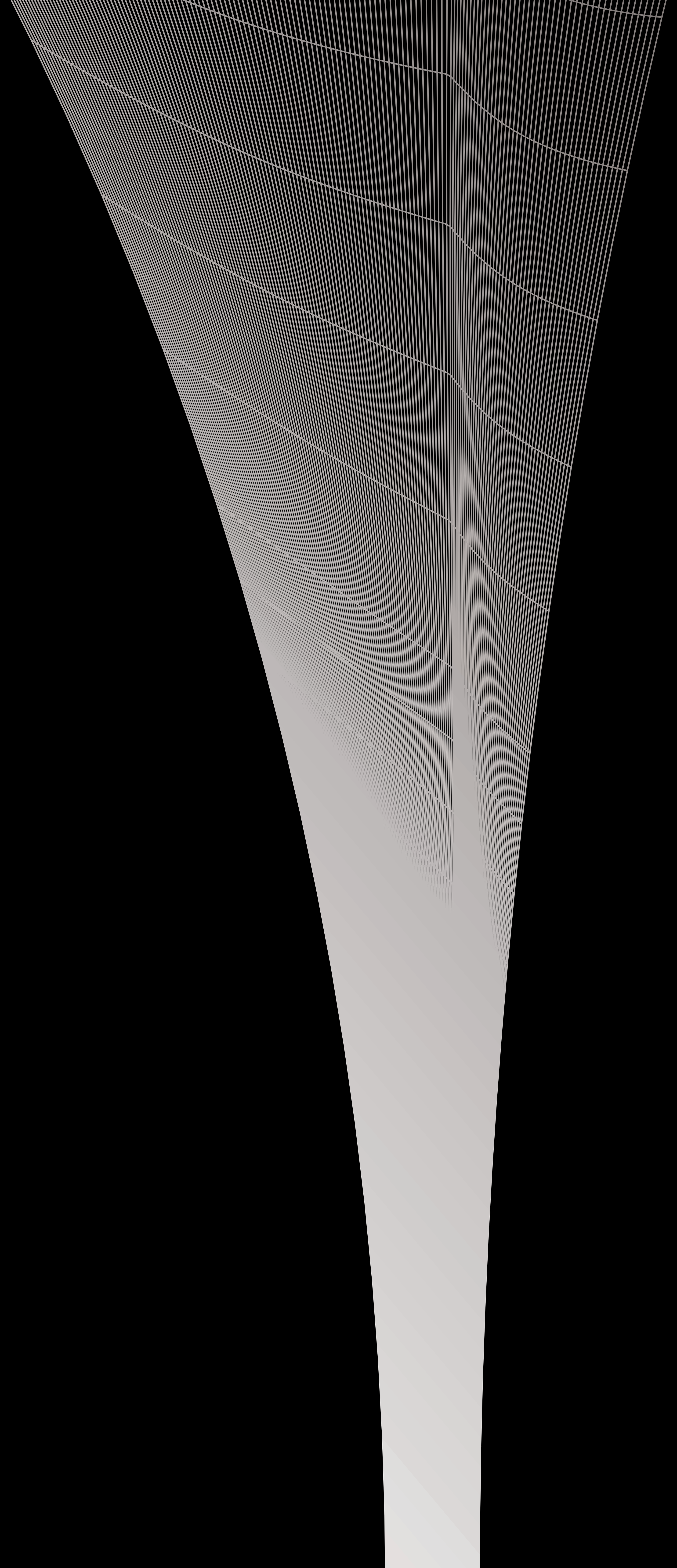
Lundy Terminal

Design Report



The Bartlett School of Architecture
MEng Engineering & Architectural Design
BARC0161 Design Practice 2
Isaac Wang

Content



Abstract

Lundy Island sits west of Devon at the southwest end of England, a strategic location for the vessel routes of the Bristol Channel. Despite its remoteness, it is owned by National Trust and operated as a holiday destination and a place for scientific research. Lundy Island is roughly 5 kilometres long and 1 kilometre wide, with a considerable height difference of 143 metres ascending right from the shore.

It is currently connected with the mainland via helicopters operating on weekdays throughout the whole year and ferry liners operating only in summer. An off-shore transport hub terminal to provide a new transport hub for Bristol Channel and a transfer point between vessels of various sizes is thought to be introduced to Lundy. While building a new centre of connections via waterways for the surrounding towns and ports provides a unique leisure place and new flat solid airfields for transportation via helicopters for Lundy Island. The nuclear battery is to be used to power up the terminal and the ships, ocean liners, and cruise liners travelling through the terminal to reduce carbon emissions and pollution released to the neighbouring ports and cities.

Phase 1 - Registration

10x10 Grid of Images

At the start of the project, a 10x10 grid of images of London with skyscrapers and transportation was taken. These demonstrate the initial ideas on the application of energy and the direction of my project in terms of the purpose and the application of the nuclear battery. These images lead toward the four sets of director drawings which demonstrate the initial ideas of the application of the detector in regards to nuclear battery, nuclear reaction and energy.

Canary Wharf

Southbank

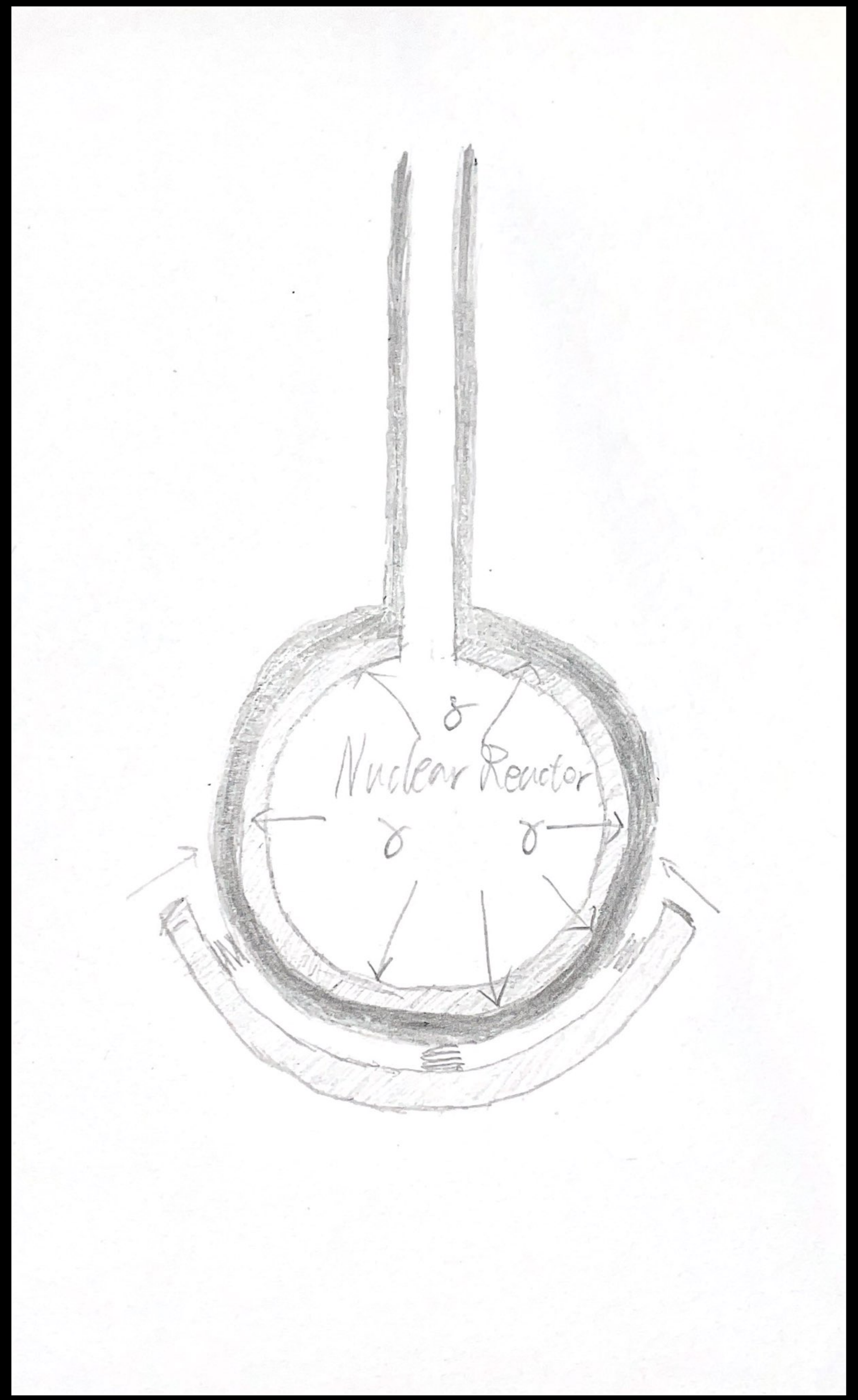
Shoreditch

City

Railway

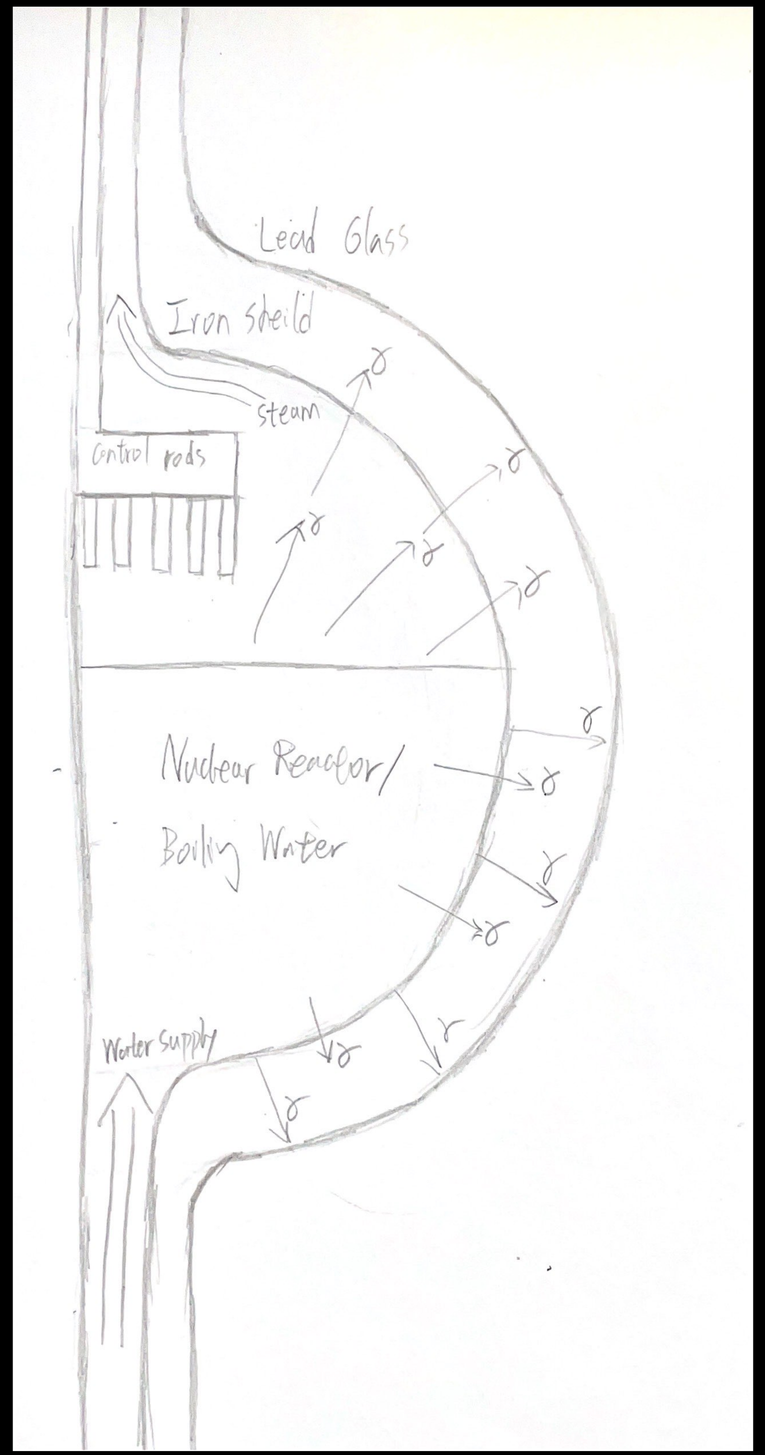
Night View

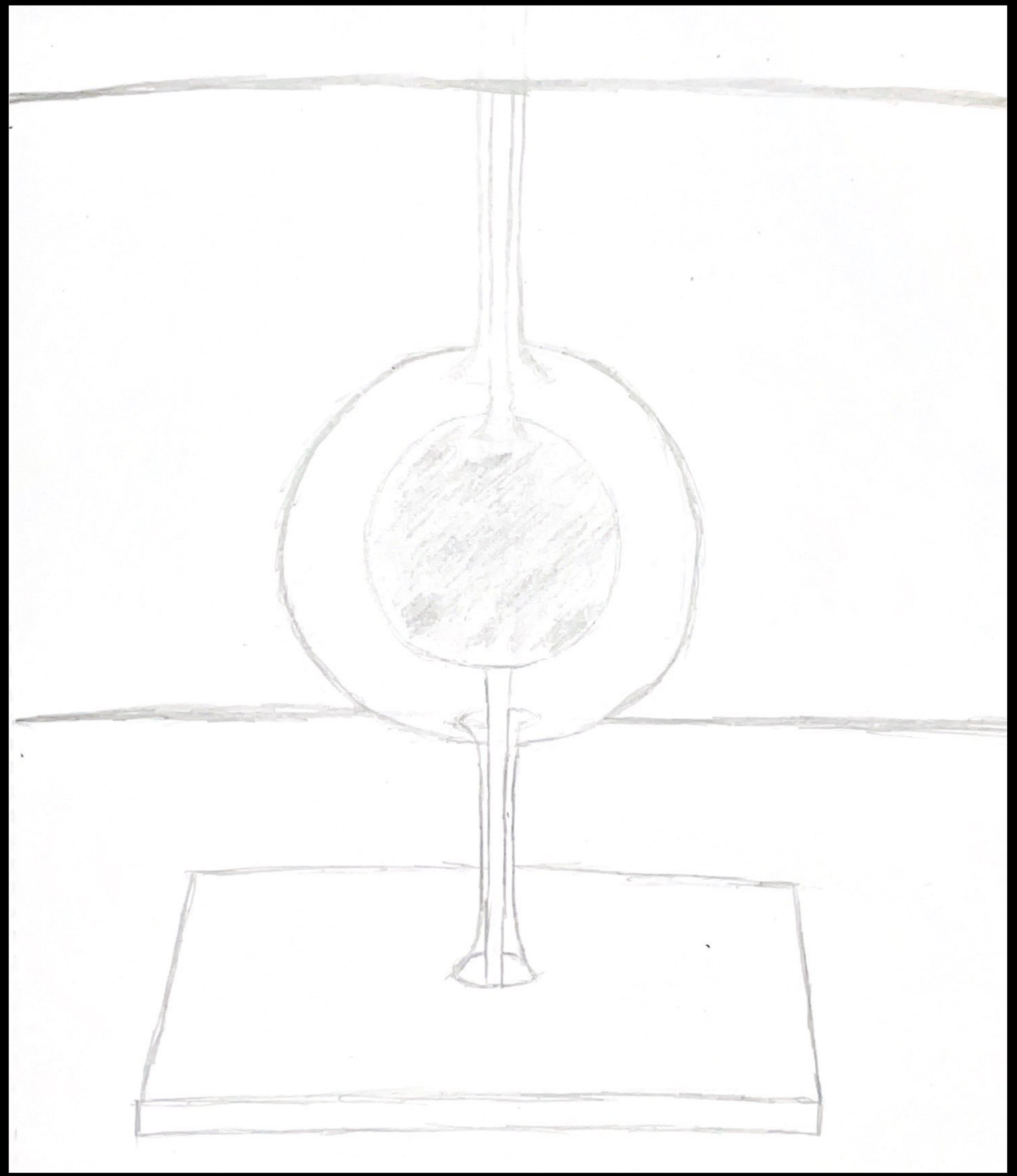
Application of Detector

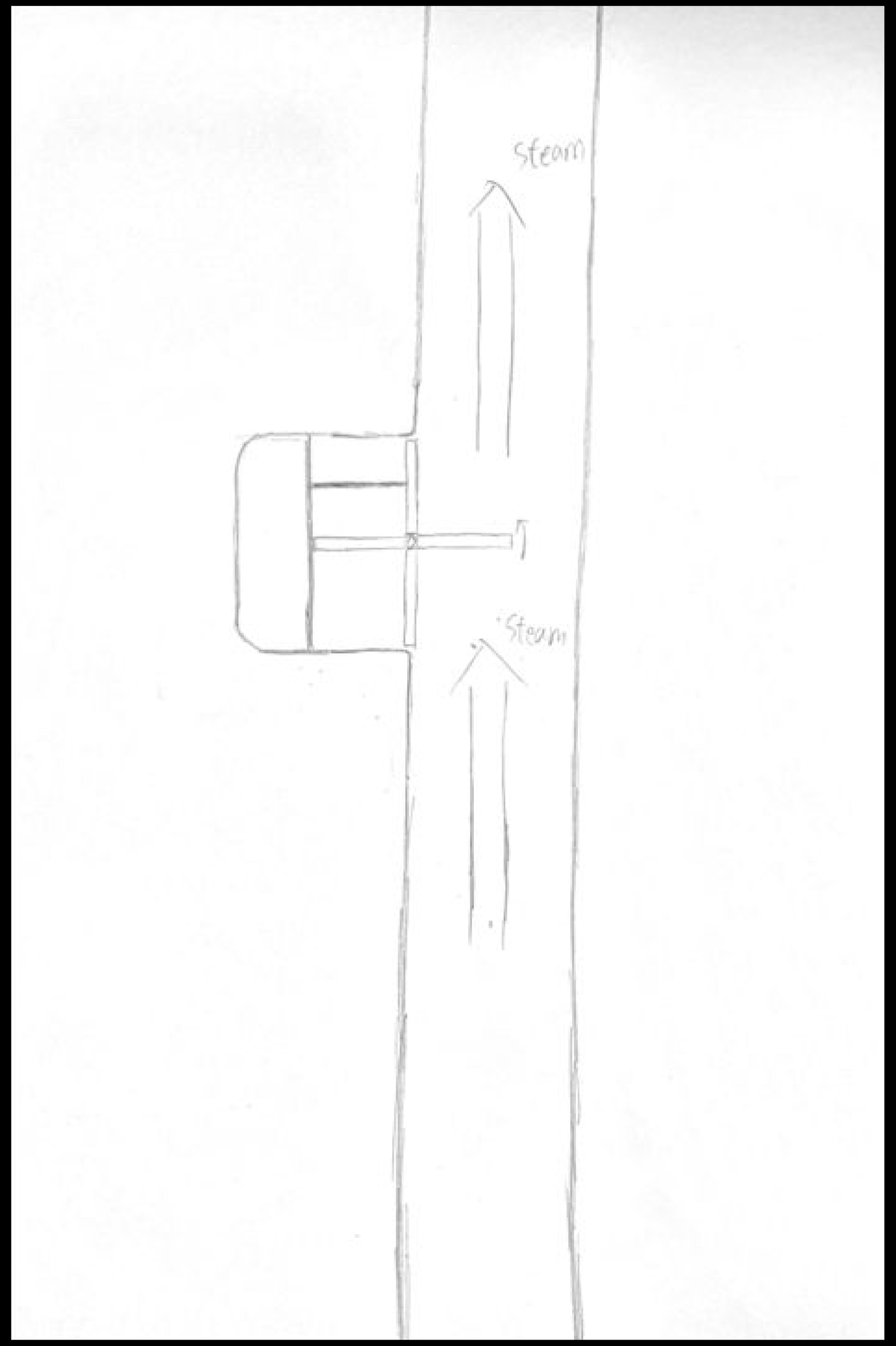


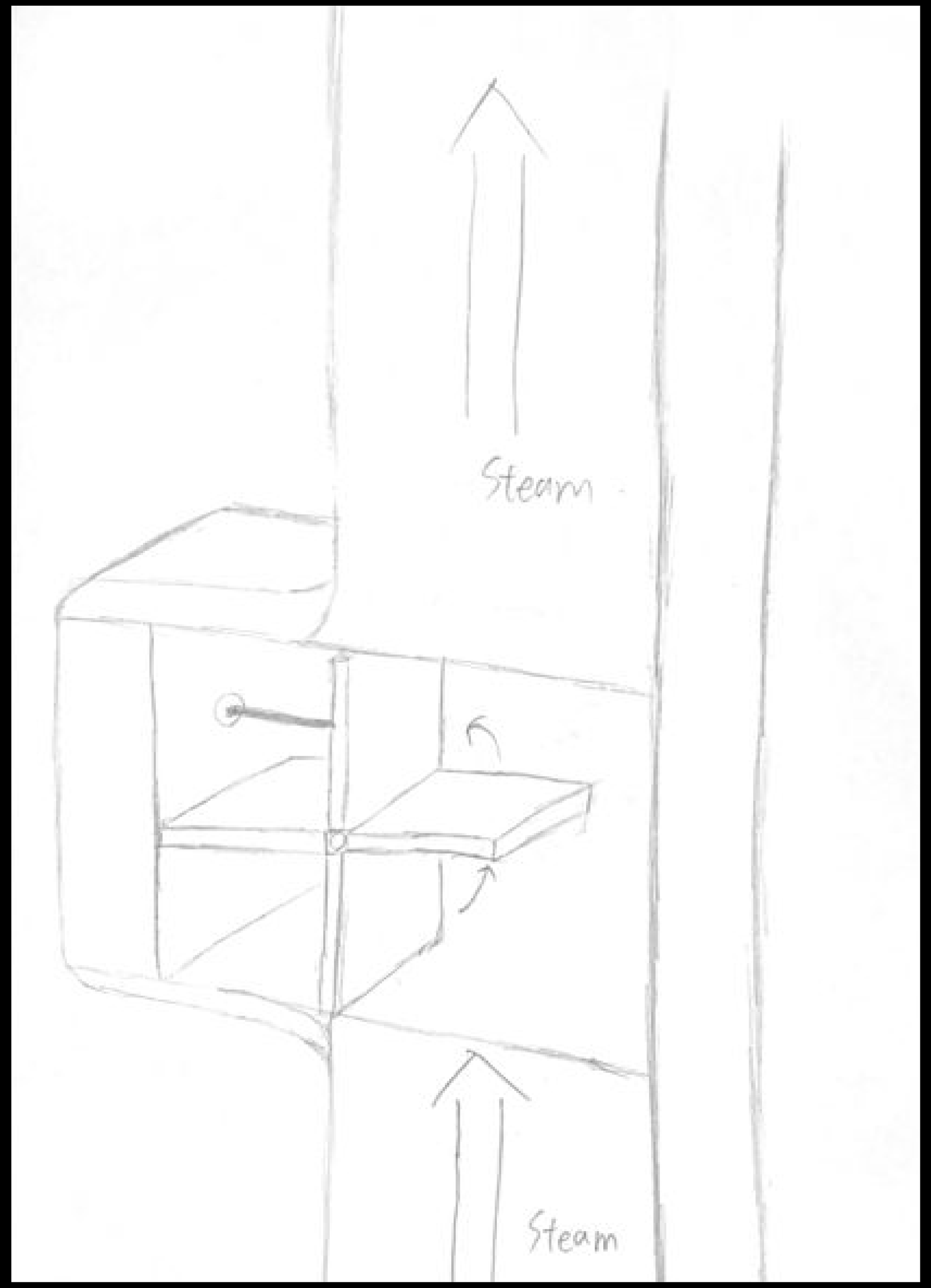
The gamma radiation emitted from the reactor passes through the iron shield which excites the atoms within it, which pushes some electrons away from the nuclei, the electrons would return to their original orbits immediately, and the energy they lose as they return is emitted as photons. Part of the photons are in the visible spectrum range, so the iron shield would emit light that we can see at the points where gamma radiation passes through, which would give a very direct visualisation of energy in form of gamma radiation.

The nuclear reactor is shielded by a metal shield which is further shielded by a layer of pure lead. The reason for using pure lead is that pure lead is not affected by the electromagnetic field while absorbing gamma radiation. And the metal detector is hung with some spring coils. The gamma radiation would cause the metal shield to start emitting electrons, which would then make it positively charged, which would then attract the detector towards it.



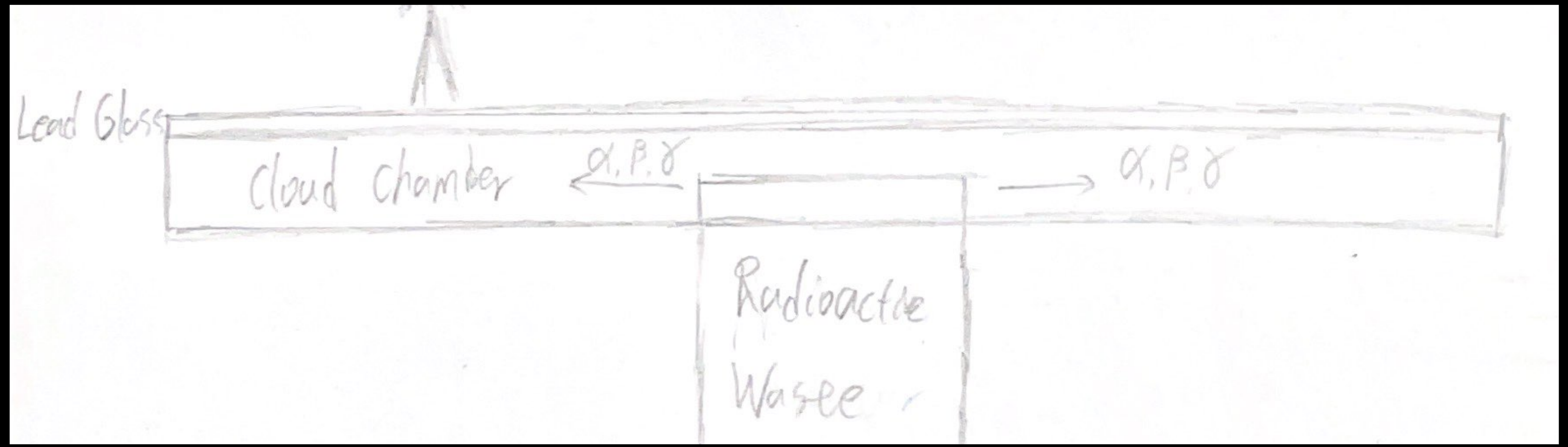


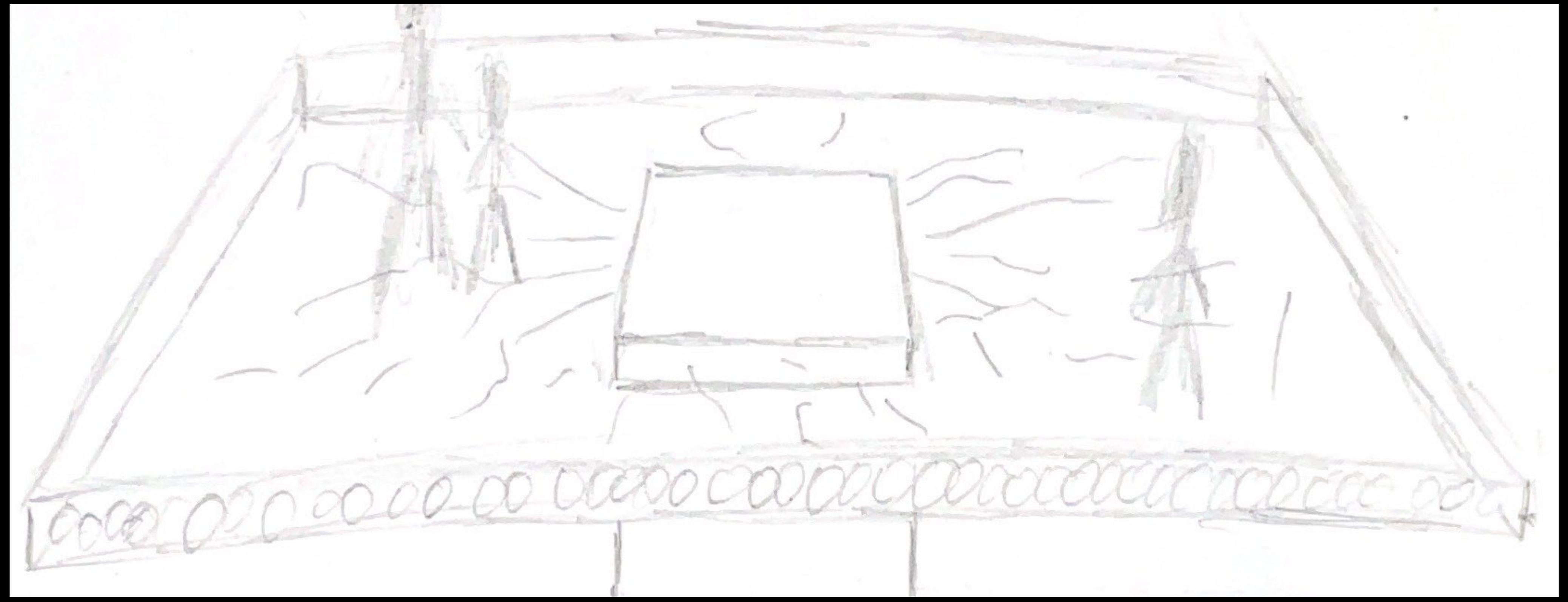




The third one works like a waterwheel installed onto the duct of the nuclear reactor. The nuclear reactor is a boiler that boils water into steam. So this detector is simple, it rotates due to the flow of steam, and a laser counter is installed to detect the number of revolutions, and further the velocity of steam and therefore the volume of steam passing through in a certain amount of time, which could then roughly quantify the thermal energy released within the reactor.

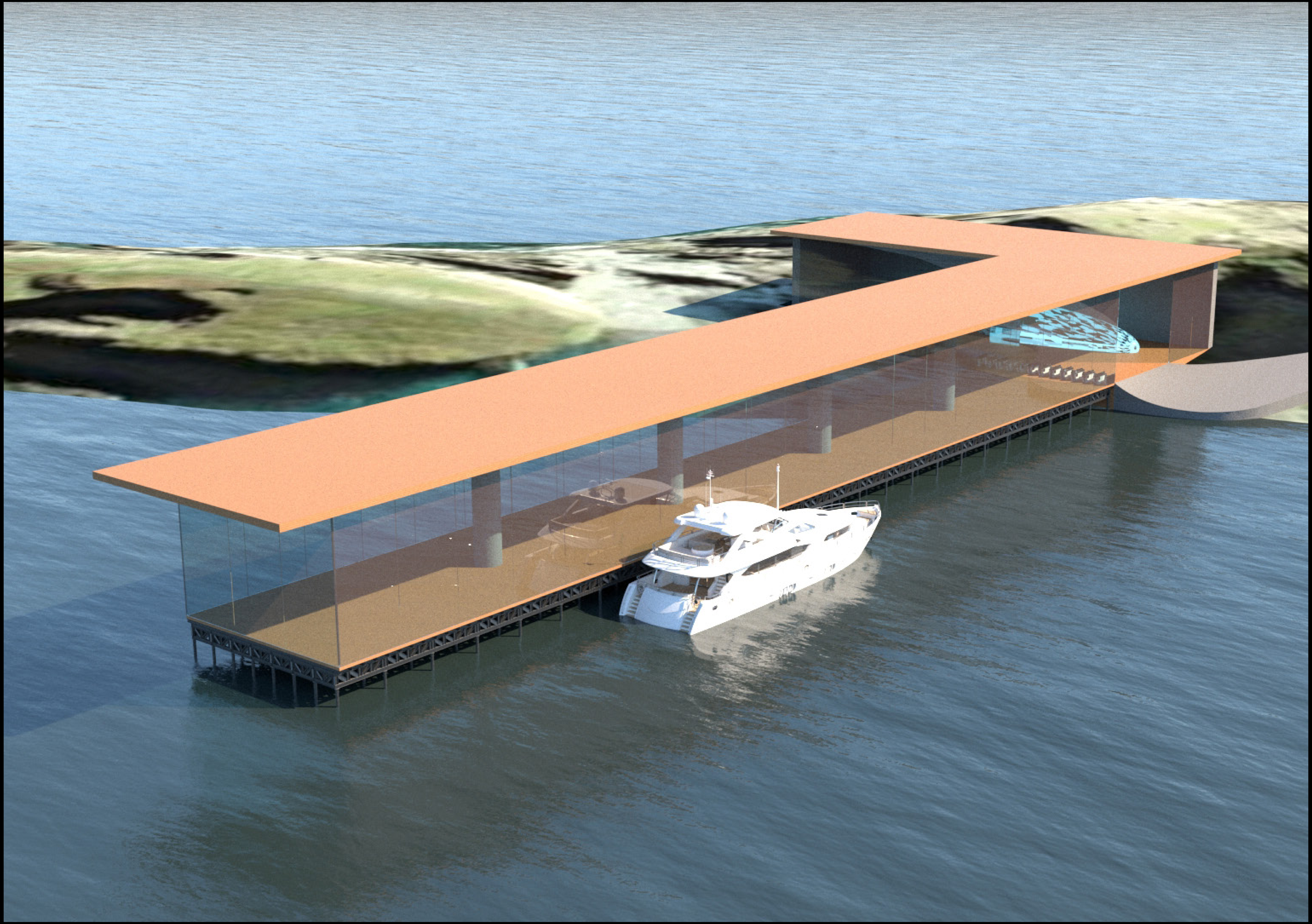
As the nuclei of the radioactive material decay, it emits all radiation, alpha, beta and gamma. The design is a huge cloud chamber that contains vapour of water or alcohol. The energetic particles in the radiation knock off electrons within the gas molecules, which leave tracks of ionised particles, which visualise the track of radiation. The top layer is made of lead glass so people could stand on it while being able to see what's under it. Imagine looking down, you can see the tracks of radiation emitted by the radioactive waste of nuclear fission.





Detector

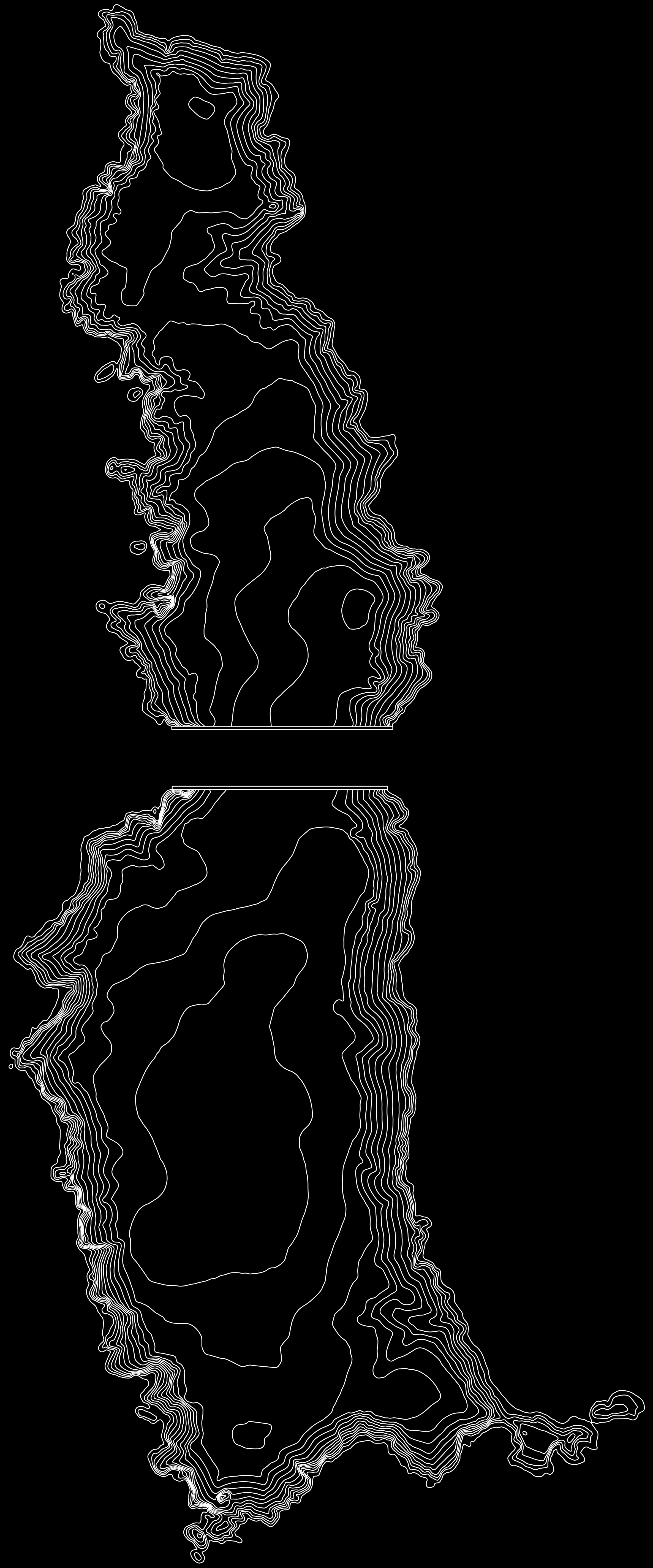
The design of the detector was thought to be placed within a pier, which is visible to all the passengers, forming a solid visualisation of the energy generated from the nuclear battery which powers up the pier and the docking boats, and the radiation it emits. The idea of the first set of director drawings was applied in this detector, which shows the radiation in colours.



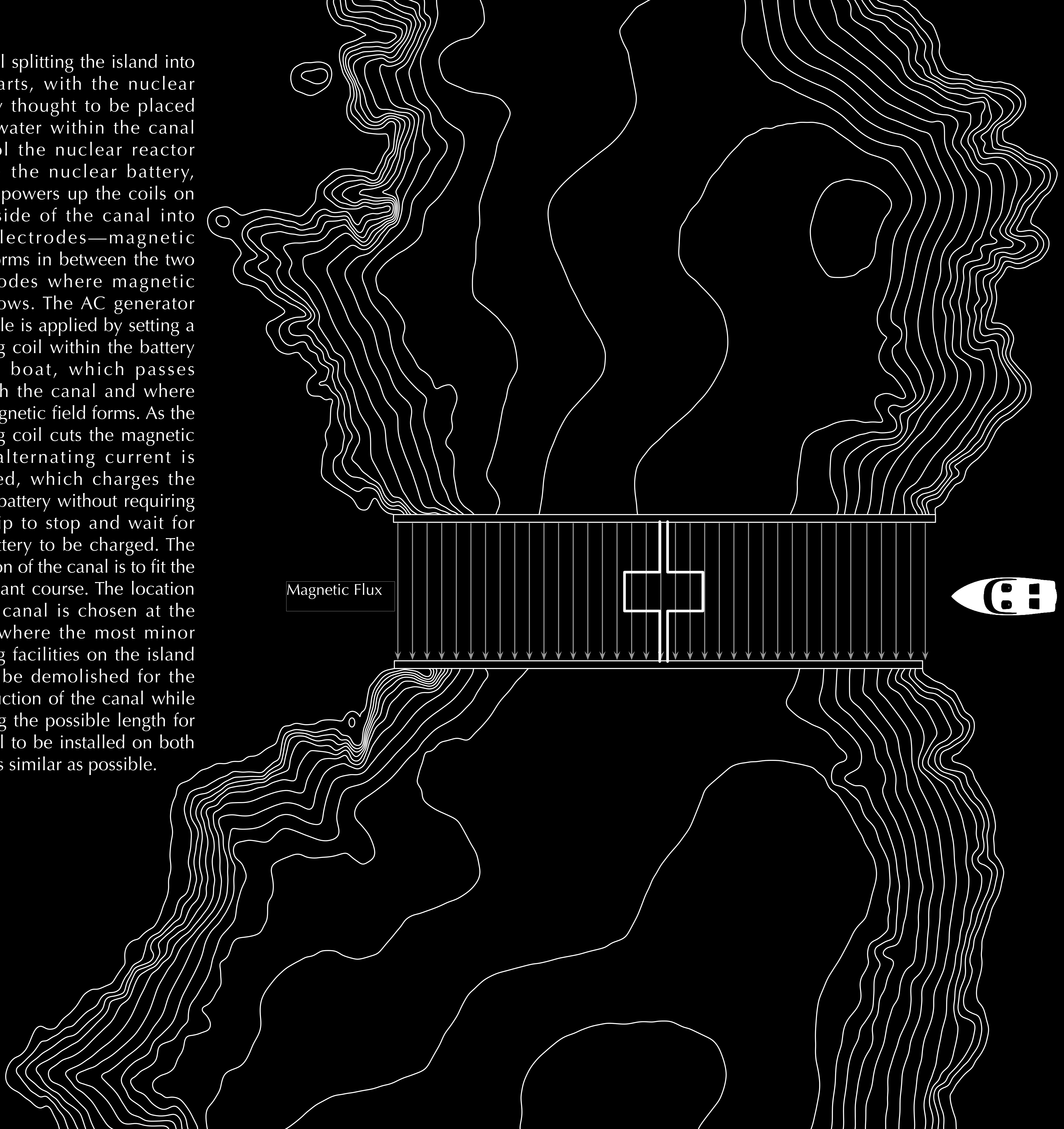
The pier at which the nuclear battery is installed is the refurbished pier of the existing one at Lundy, located at the island's southeast corner. The plans and sections of the nuclear battery and the pier are as follows.

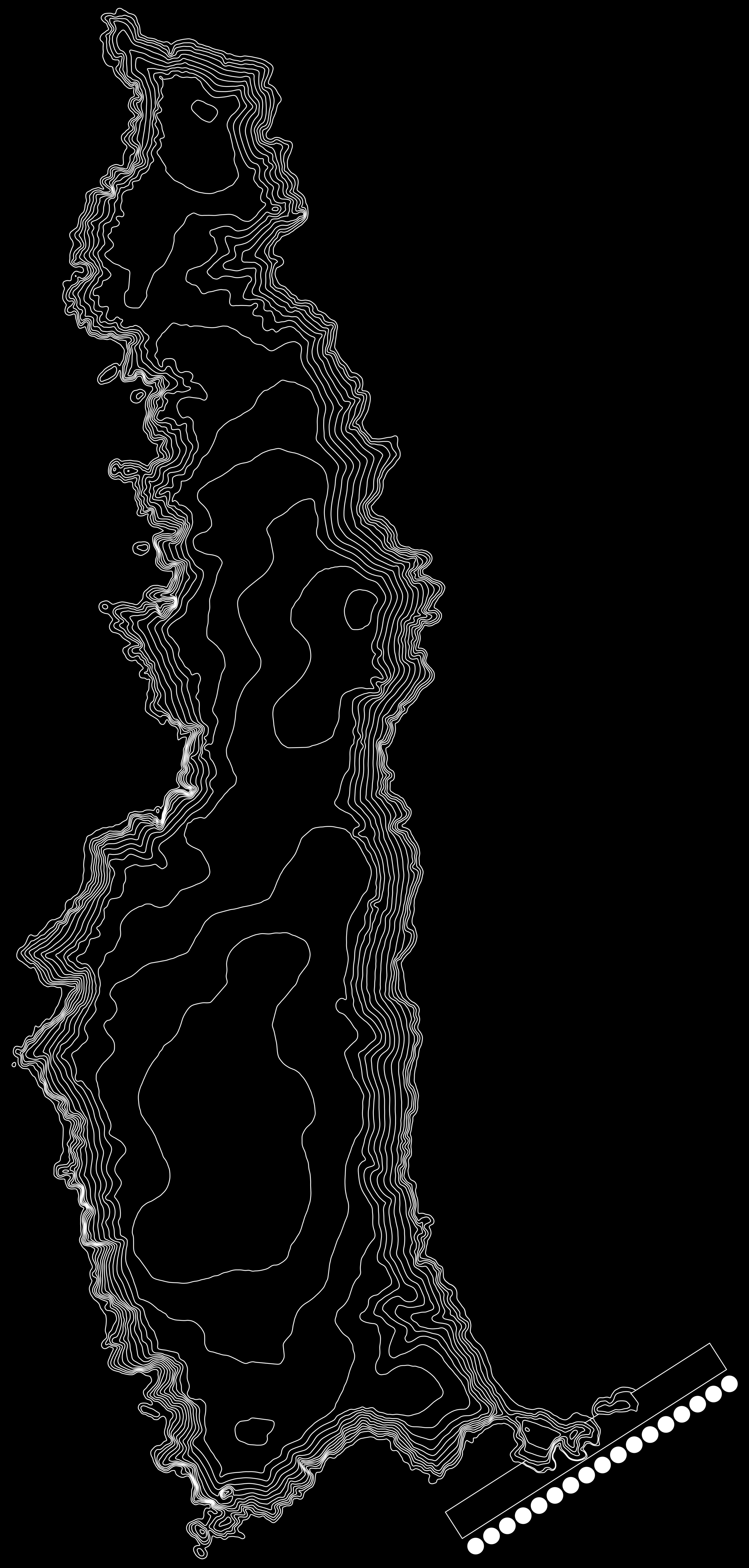

Lead Glass
Fluorite
Nuclear Reactor
Electric Generator

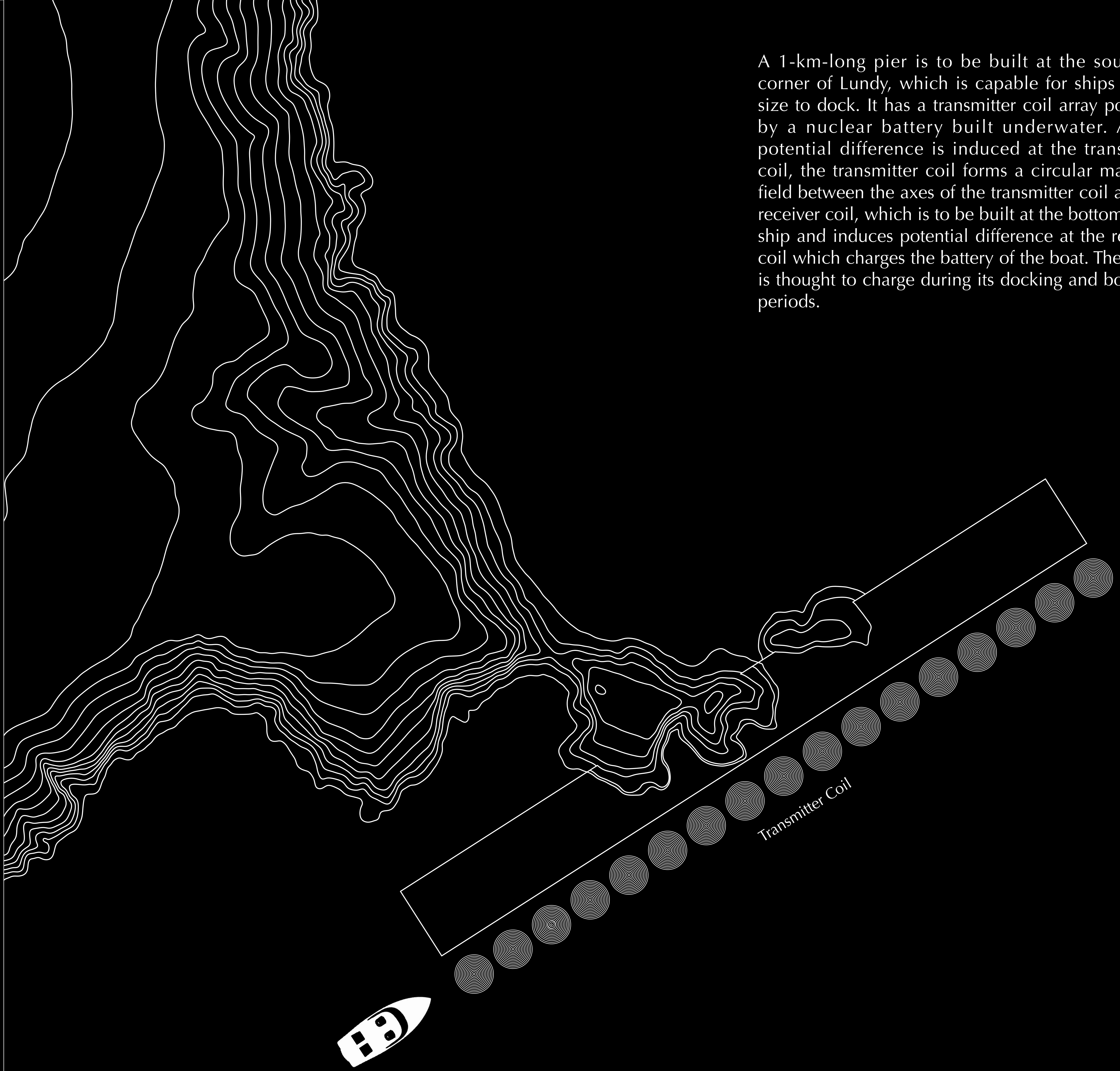
Initial Proposals



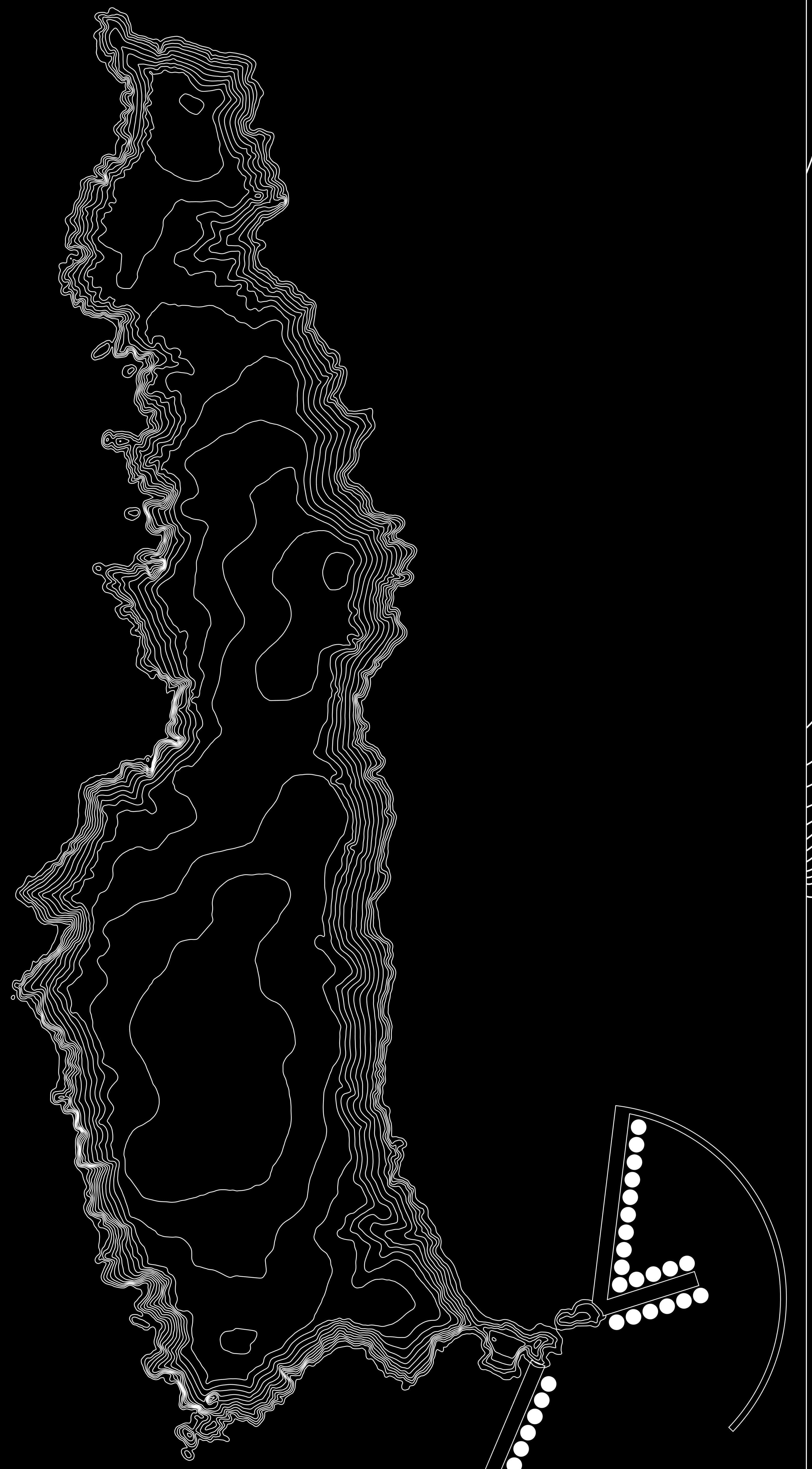
A canal splitting the island into two parts, with the nuclear battery thought to be placed underwater within the canal to cool the nuclear reactor within the nuclear battery, which powers up the coils on each side of the canal into two electrodes—magnetic field forms in between the two electrodes where magnetic flux flows. The AC generator principle is applied by setting a rotating coil within the battery of the boat, which passes through the canal and where the magnetic field forms. As the rotating coil cuts the magnetic flux, alternating current is induced, which charges the boat's battery without requiring the ship to stop and wait for the battery to be charged. The direction of the canal is to fit the significant course. The location of the canal is chosen at the point where the most minor existing facilities on the island are to be demolished for the construction of the canal while keeping the possible length for the coil to be installed on both sides as similar as possible.

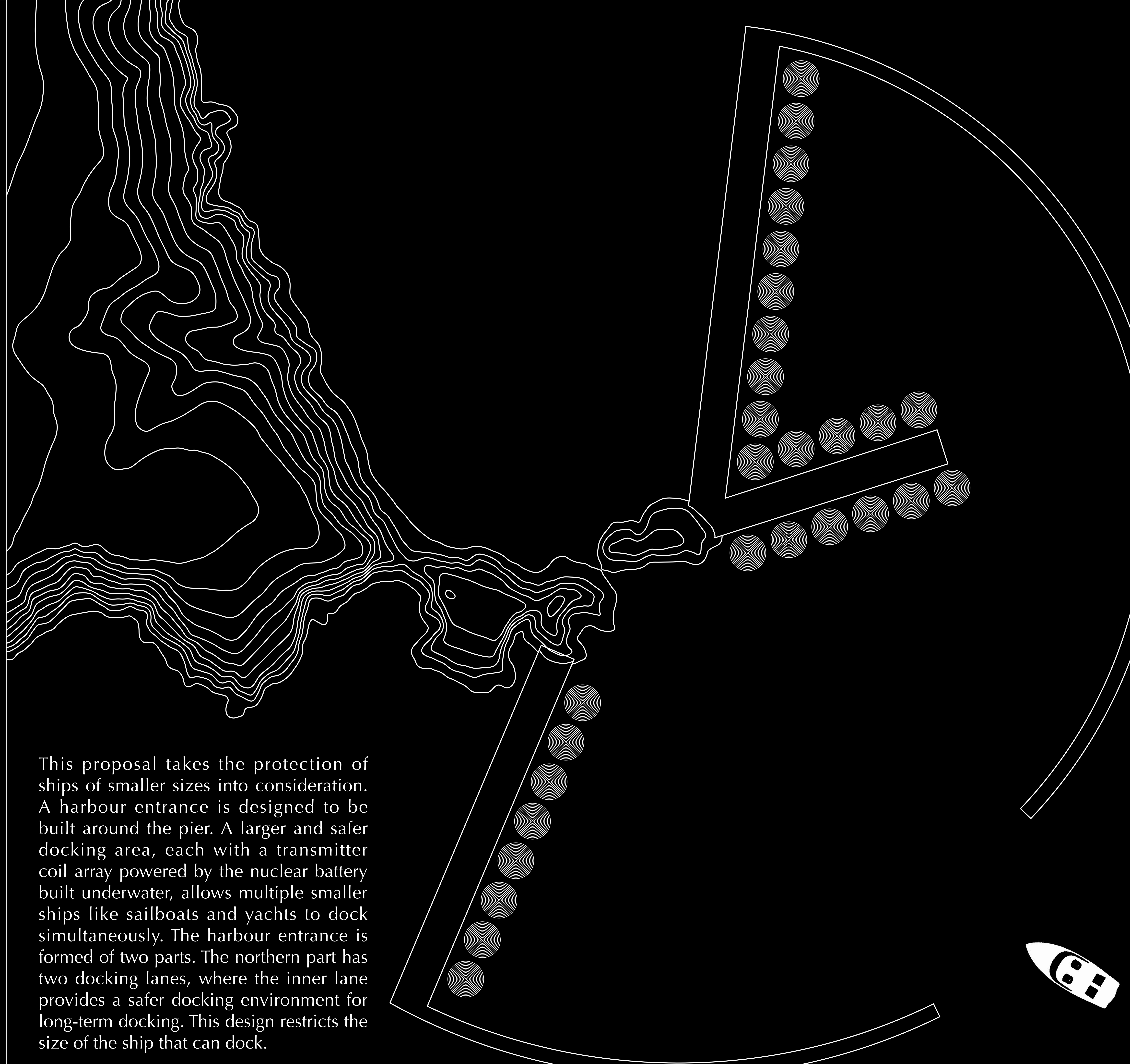




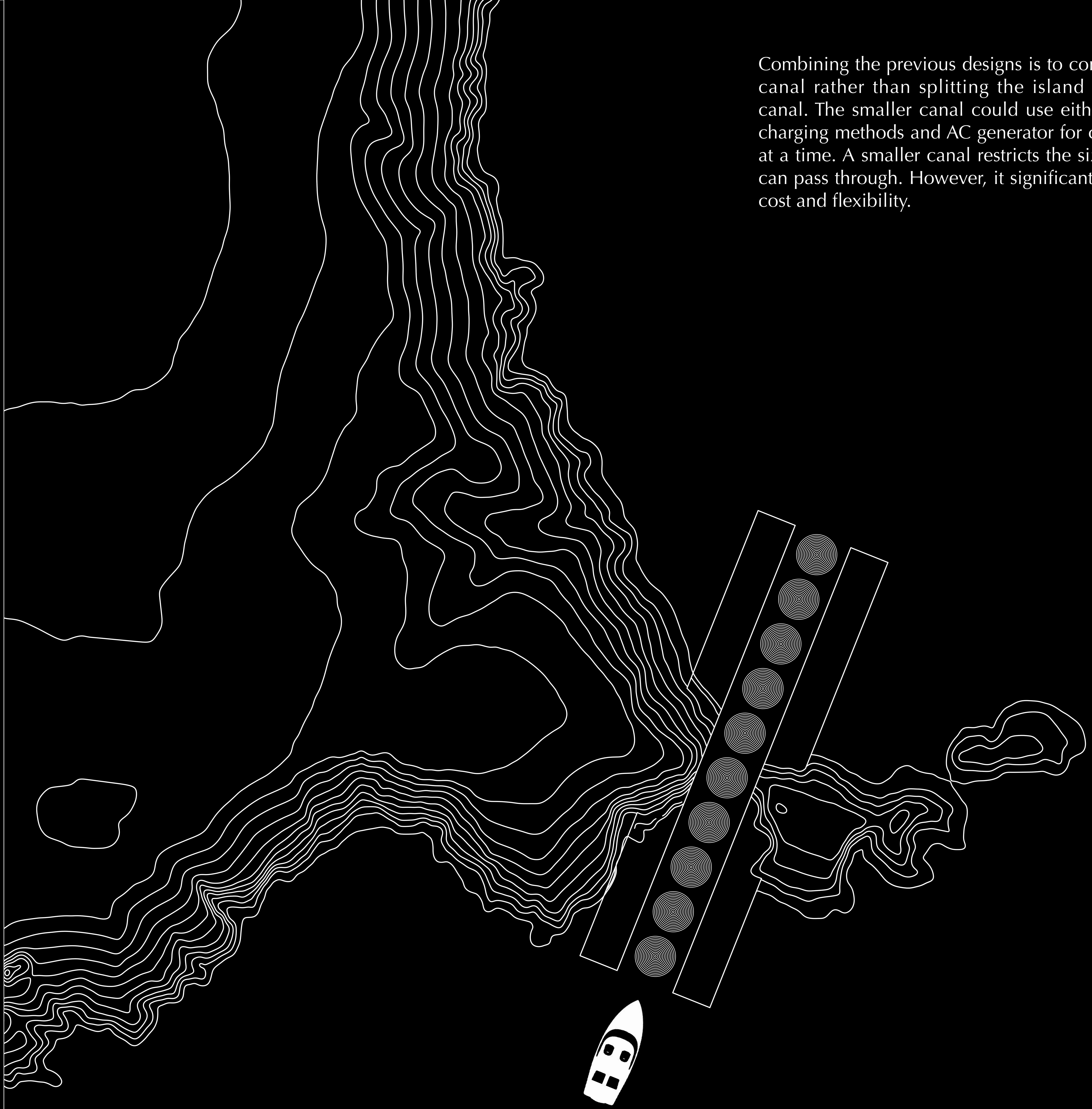


A 1-km-long pier is to be built at the southeast corner of Lundy, which is capable for ships of any size to dock. It has a transmitter coil array powered by a nuclear battery built underwater. As the potential difference is induced at the transmitter coil, the transmitter coil forms a circular magnetic field between the axes of the transmitter coil and the receiver coil, which is to be built at the bottom of the ship and induces potential difference at the receiver coil which charges the battery of the boat. The vessel is thought to charge during its docking and boarding periods.





This proposal takes the protection of ships of smaller sizes into consideration. A harbour entrance is designed to be built around the pier. A larger and safer docking area, each with a transmitter coil array powered by the nuclear battery built underwater, allows multiple smaller ships like sailboats and yachts to dock simultaneously. The harbour entrance is formed of two parts. The northern part has two docking lanes, where the inner lane provides a safer docking environment for long-term docking. This design restricts the size of the ship that can dock.



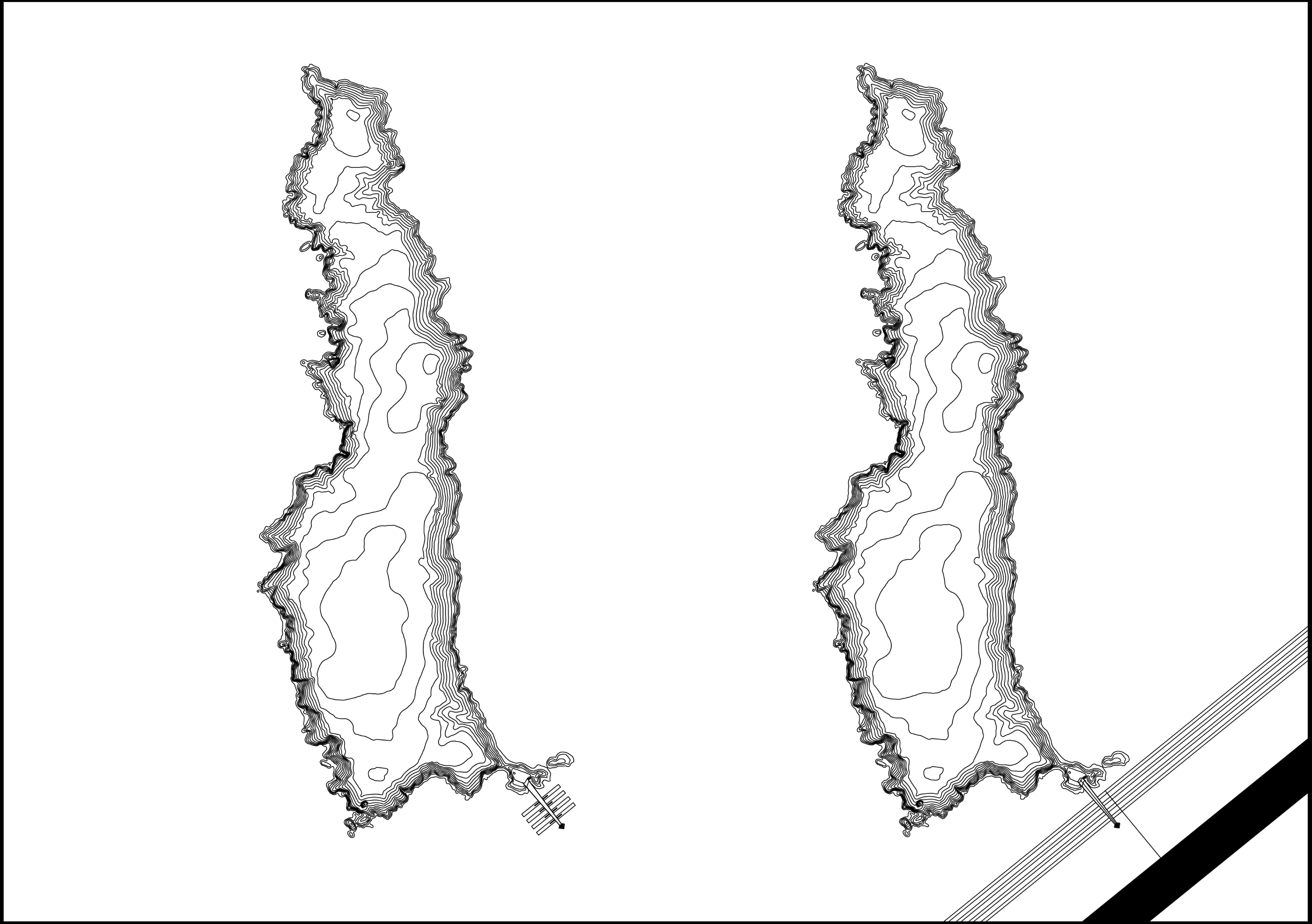
Combining the previous designs is to construct a smaller canal rather than splitting the island with a massive canal. The smaller canal could use either the inductive charging methods and AC generator for charging or both at a time. A smaller canal restricts the size of a ship that can pass through. However, it significantly decreases the cost and flexibility.

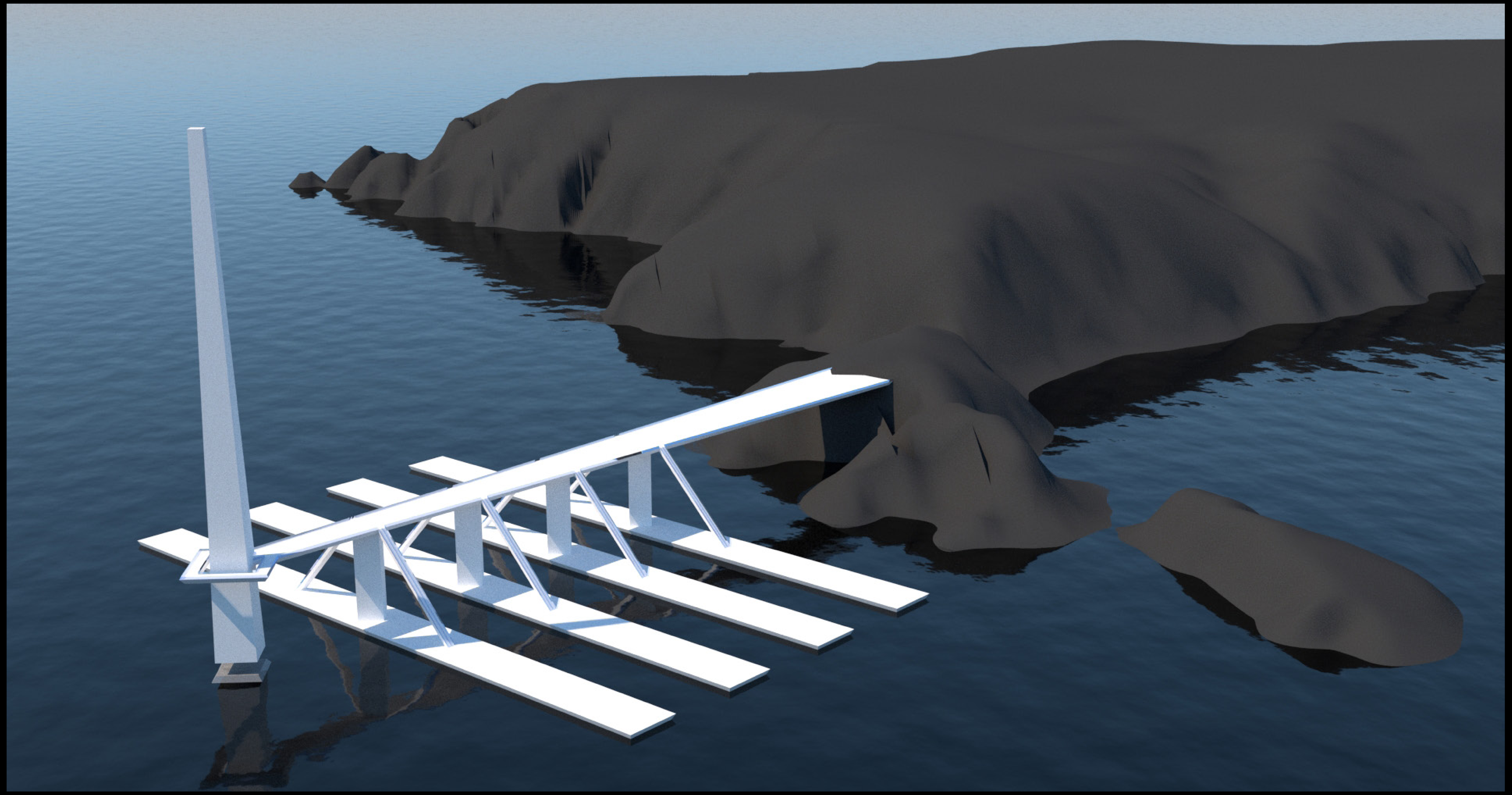
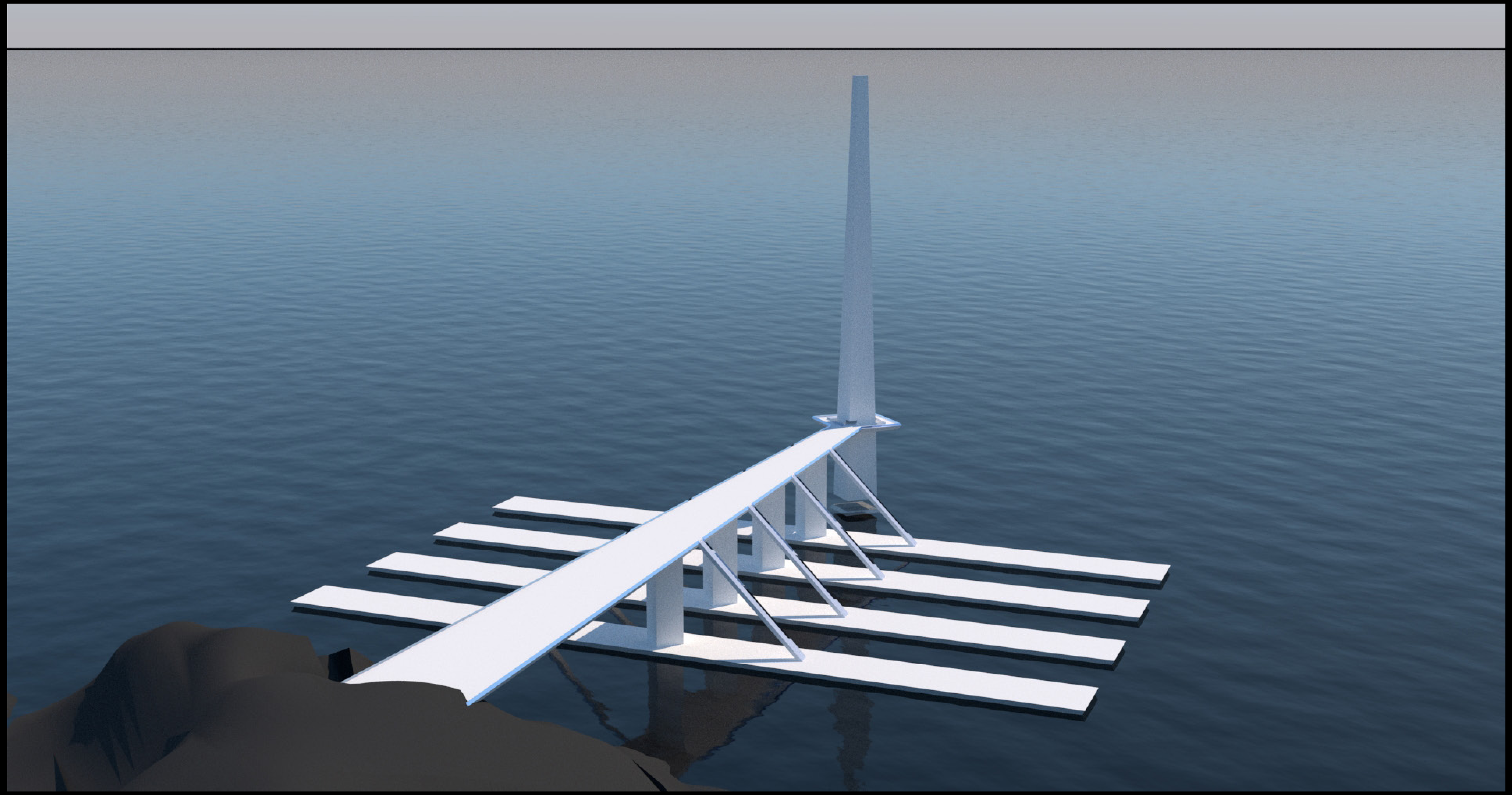
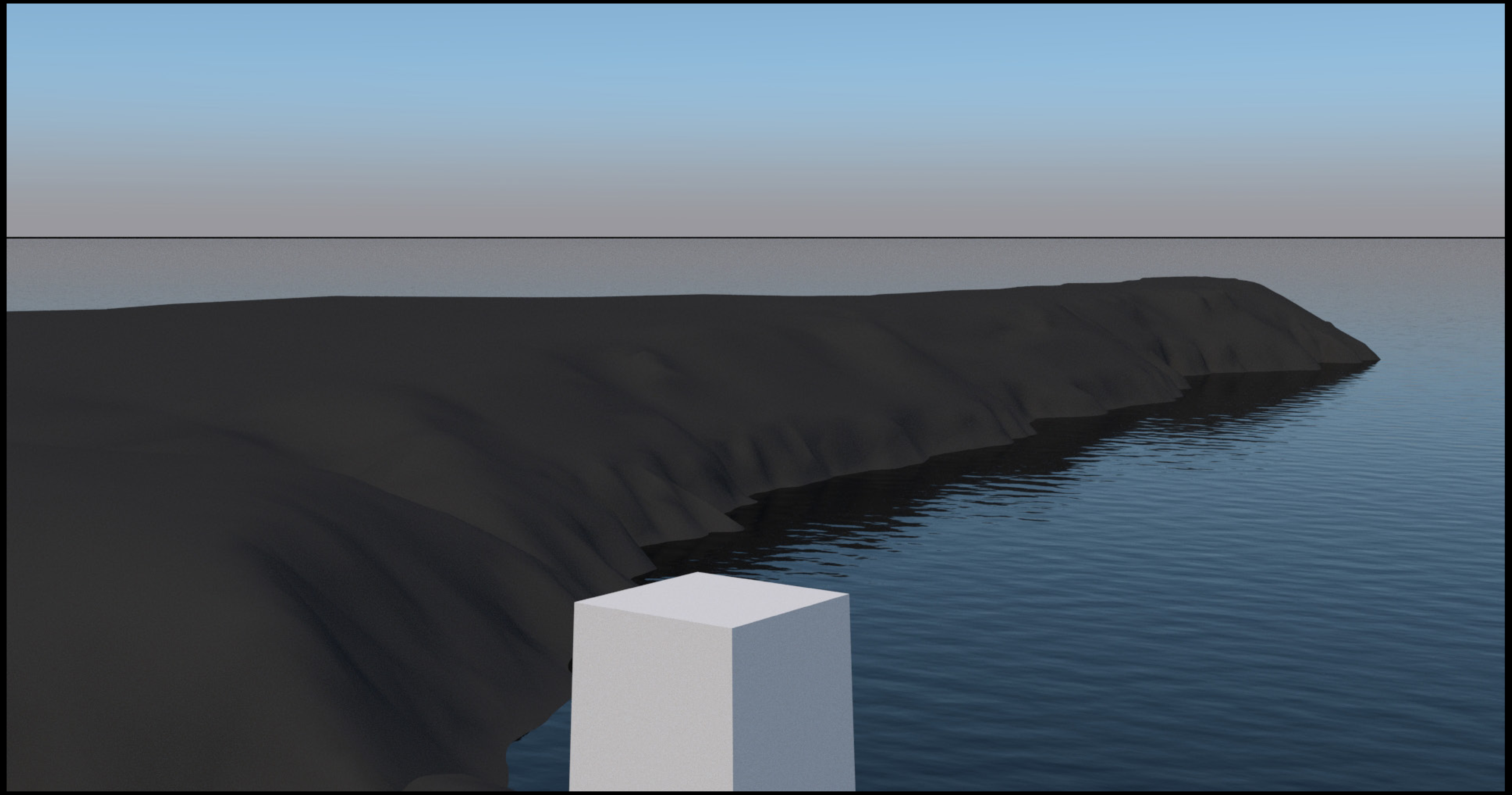
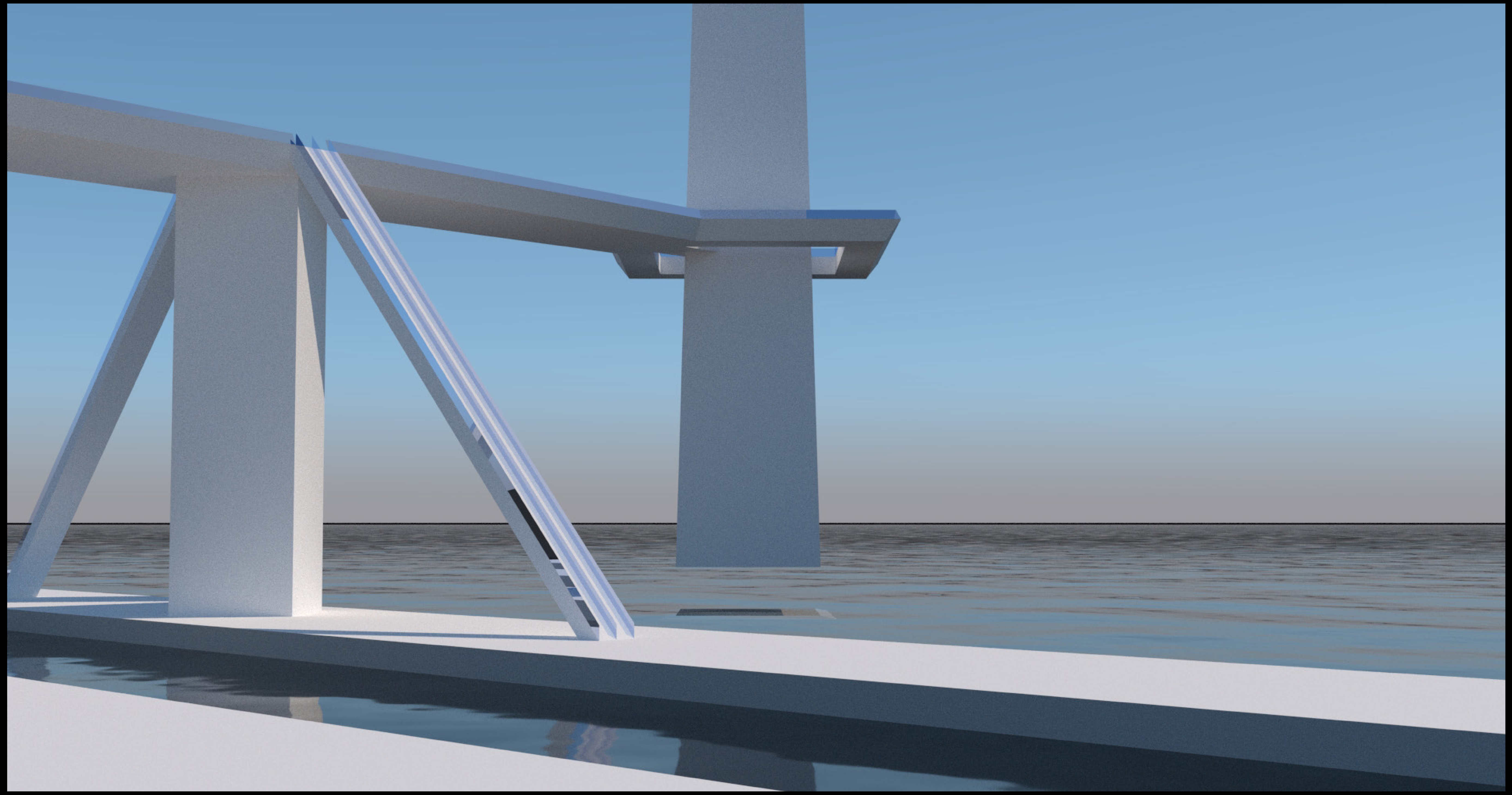
By converting energy from the nuclear battery into gravitational energy transferred into the aircraft via a magnetic field, assuming the efficiency to be 50%, the maximum mass of the plane that can be lifted to a height of 100m within 1 minute is up to 407,747 kg (mass of Boeing 747 is 183,500 kg). This design enables aircraft to perform vertical takeoff, which saves enormous space by deleting the runway and enabling more aircraft to land on Lundy.

Developed Initial Proposal

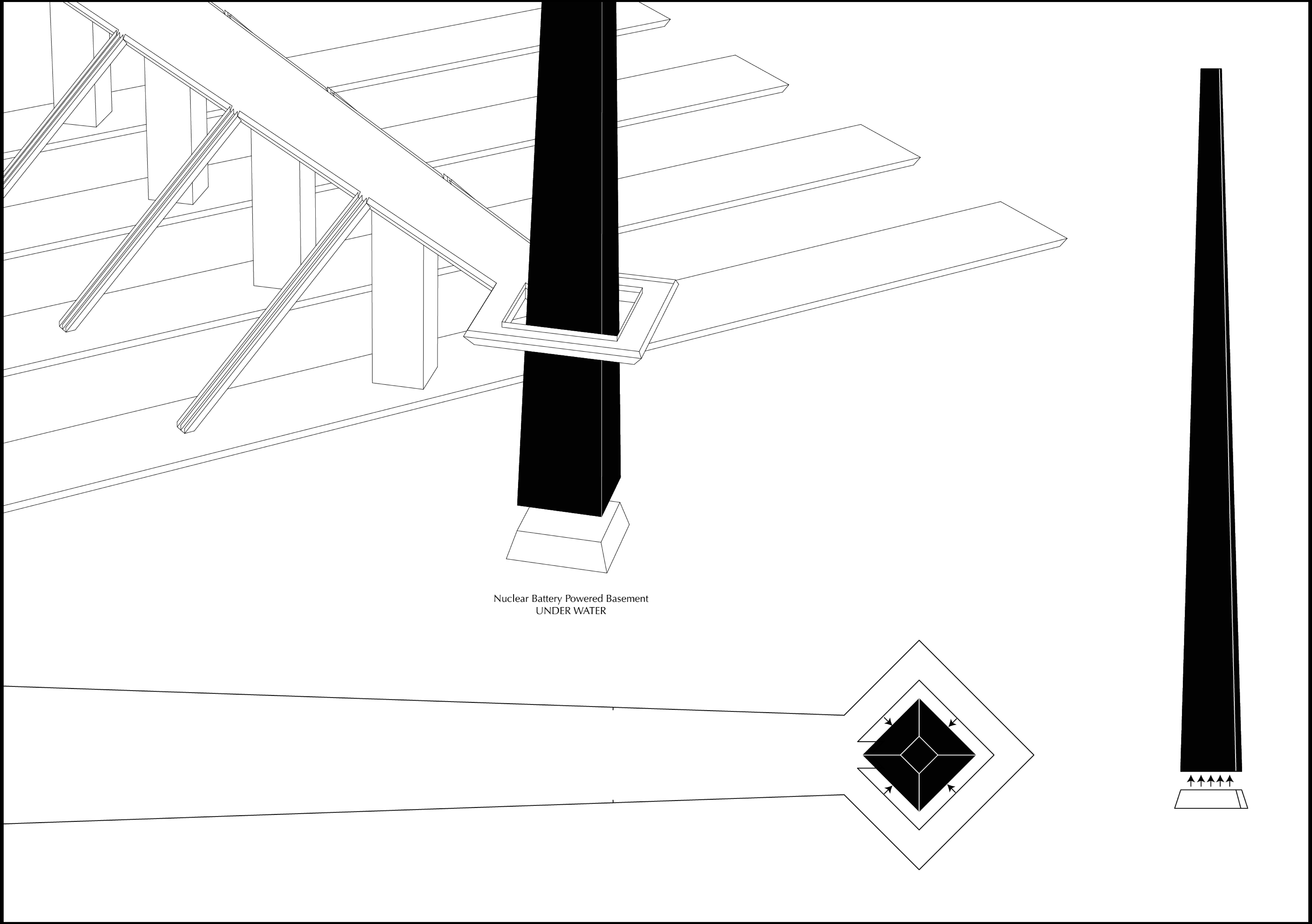
The second initial proposal was brought forward and developed. A series of platforms for passengers to board ships were aligned parallel to the main vessel route, interconnected via a bridge that connects to the island and the lighthouse at the end of the bridge.

By aligning the platforms parallel to the main vessel route, the ships and ferries may dock and pass through in linear routes that reduce the time required to dock and the difficulty to enter and exit the pier. The platform system is learned from the arrangement of train stations.

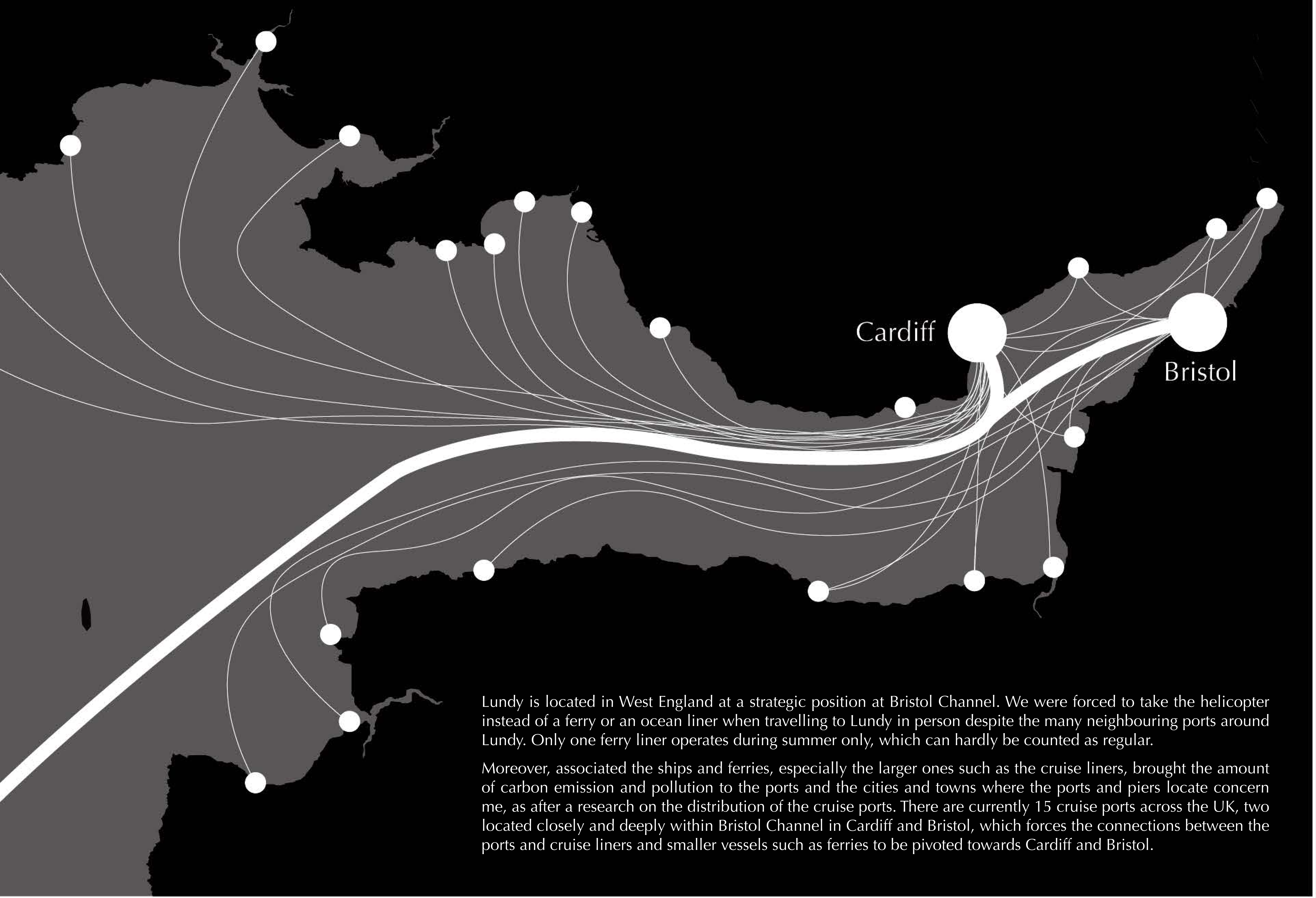


The lighthouse is thought to be levitating above water with a basement constructed underwater that forms a magnetic field repelling the lighthouse. The end of the bridge surrounds the lighthouse to maintain its standability via a respective magnetic field that equally repels the lighthouse toward its centre and gives access to it. The new lighthouse forms a new beacon for Lundy while replacing the old existing lighthouses.



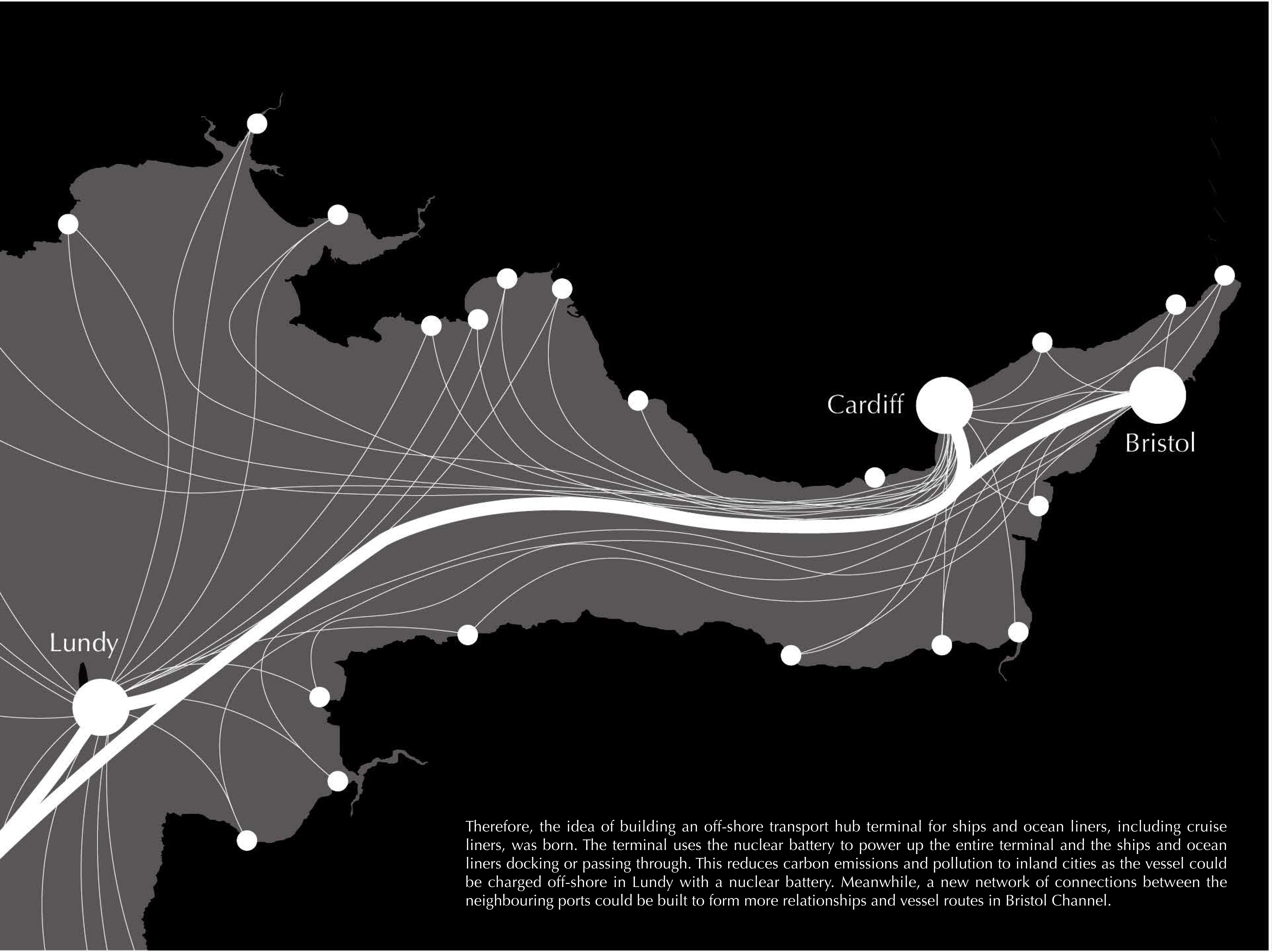
Environmental Analysis I - Site Analysis & Design Concept



Lundy is located in West England at a strategic position at Bristol Channel. We were forced to take the helicopter instead of a ferry or an ocean liner when travelling to Lundy in person despite the many neighbouring ports around Lundy. Only one ferry liner operates during summer only, which can hardly be counted as regular.

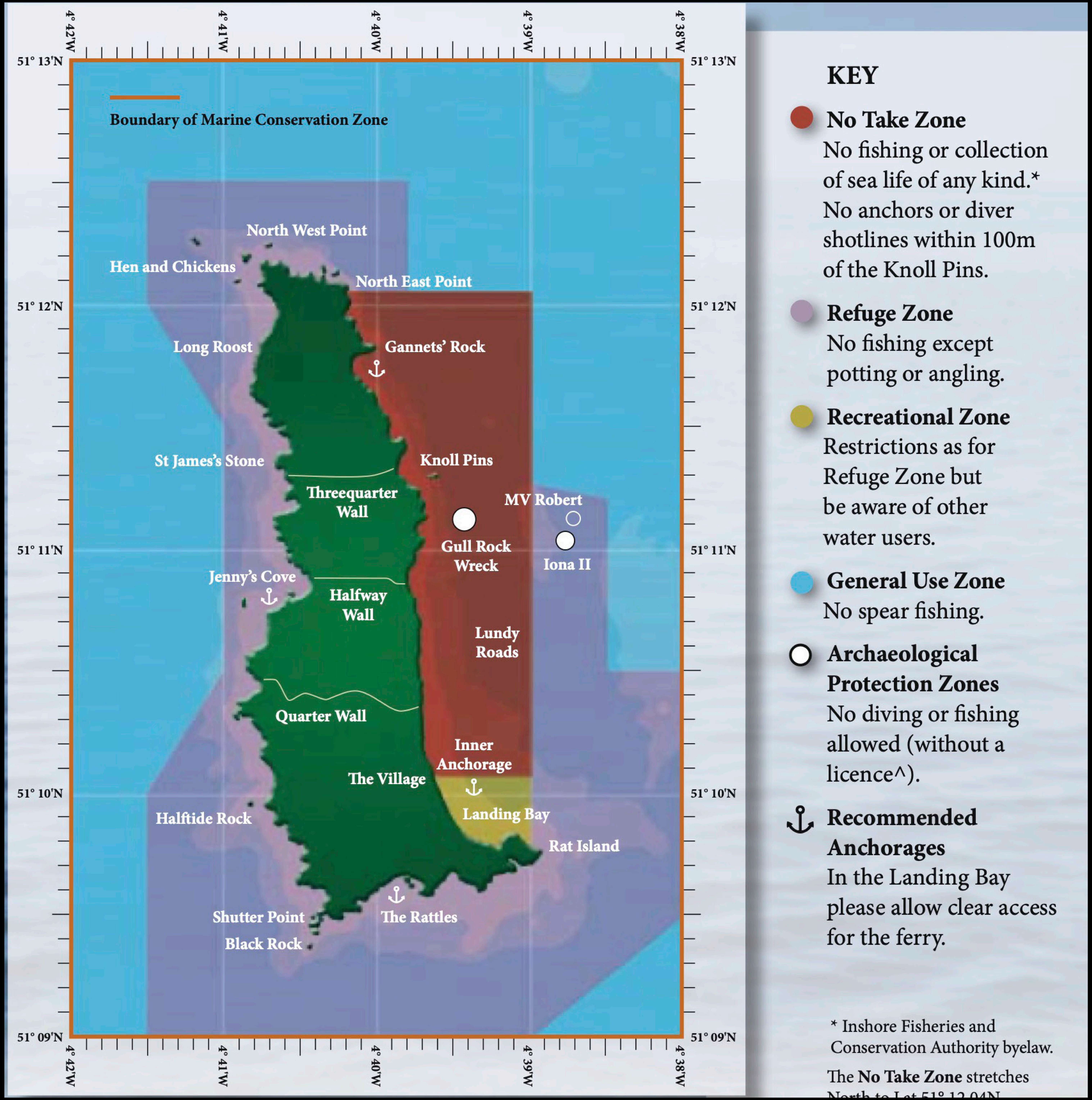
Moreover, associated the ships and ferries, especially the larger ones such as the cruise liners, brought the amount of carbon emission and pollution to the ports and the cities and towns where the ports and piers locate concern me, as after a research on the distribution of the cruise ports. There are currently 15 cruise ports across the UK, two located closely and deeply within Bristol Channel in Cardiff and Bristol, which forces the connections between the ports and cruise liners and smaller vessels such as ferries to be pivoted towards Cardiff and Bristol.

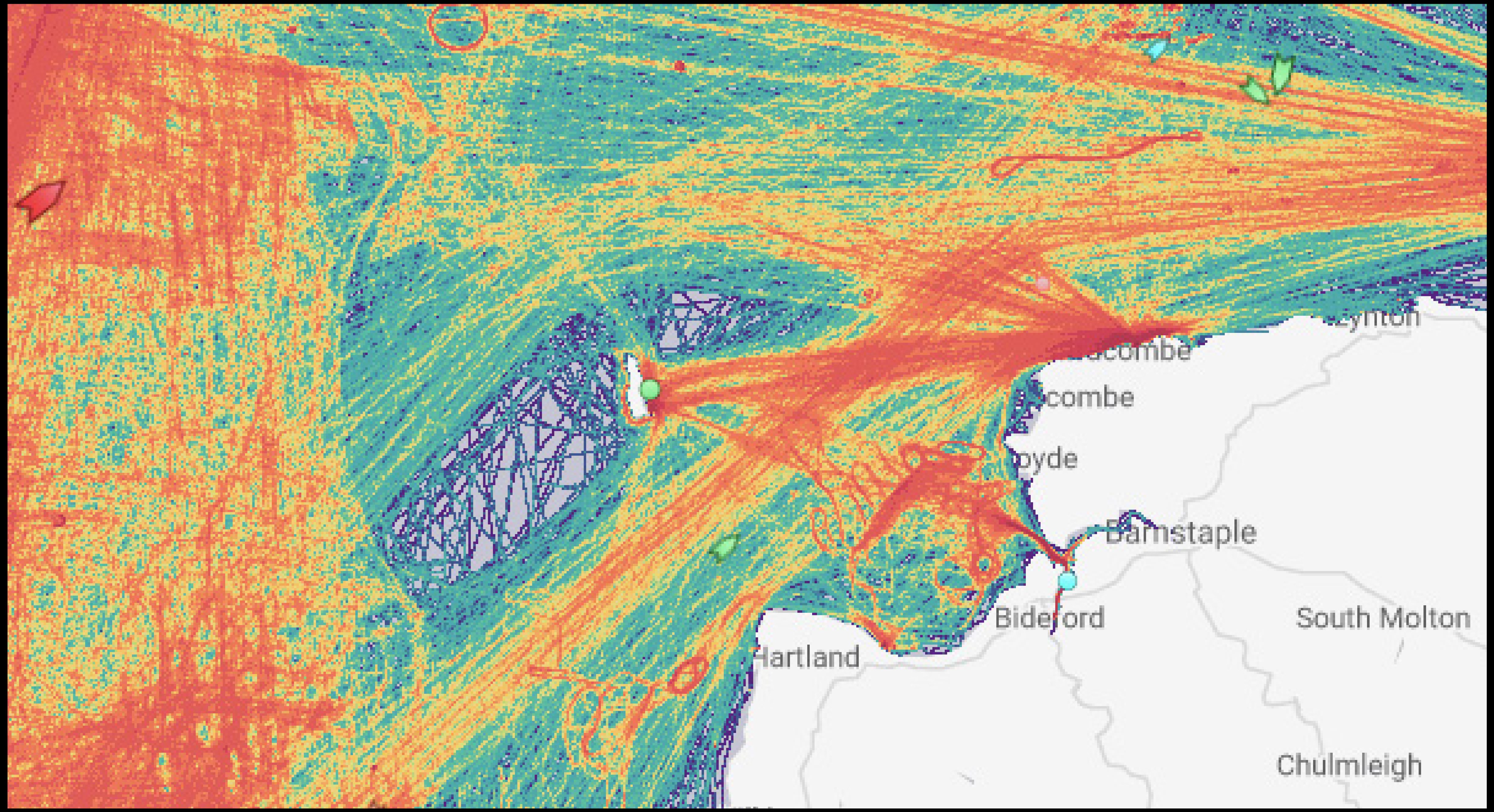
Current UK Cruise Port Distribution



Therefore, the idea of building an off-shore transport hub terminal for ships and ocean liners, including cruise liners, was born. The terminal uses the nuclear battery to power up the entire terminal and the ships and ocean liners docking or passing through. This reduces carbon emissions and pollution to inland cities as the vessel could be charged off-shore in Lundy with a nuclear battery. Meanwhile, a new network of connections between the neighbouring ports could be built to form more relationships and vessel routes in Bristol Channel.

Proposed UK Cruise Port Distribution





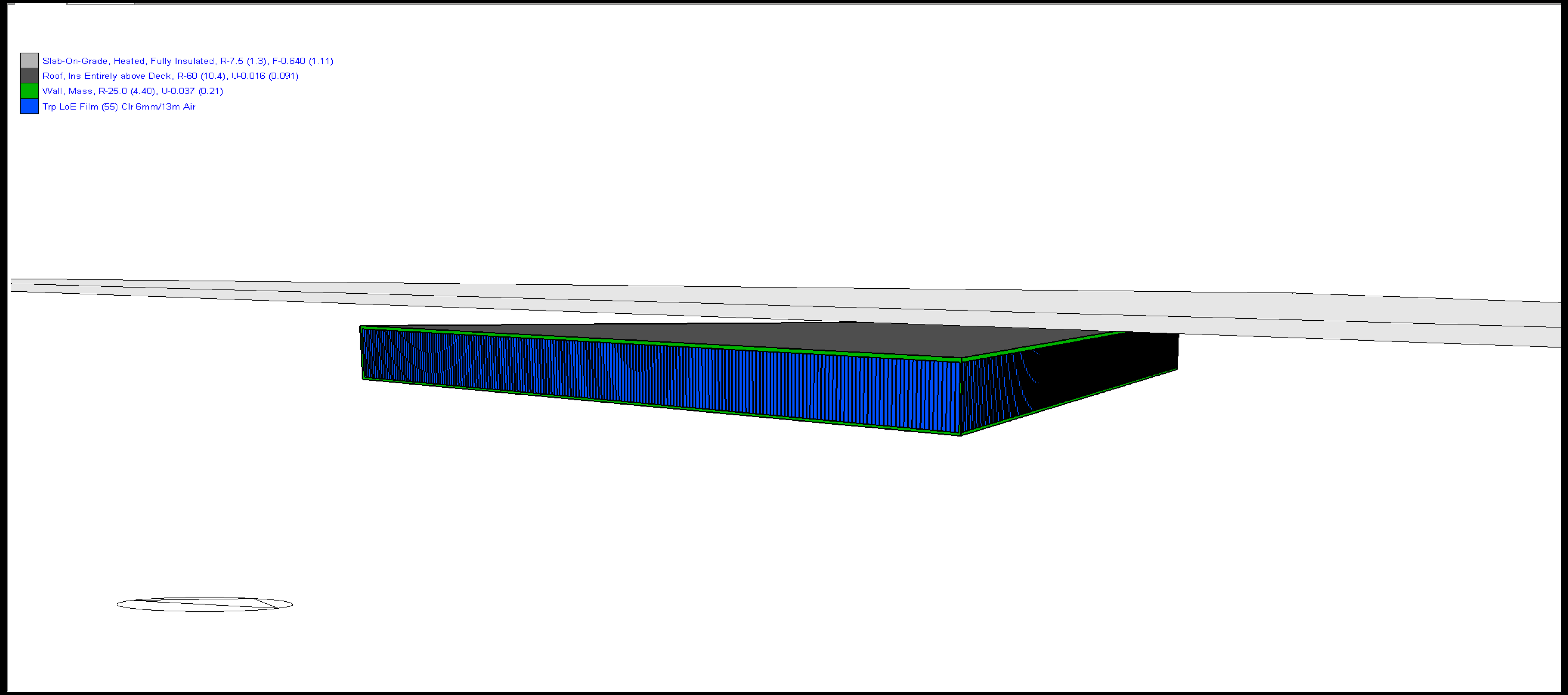
The main vessel route is defined by the HM Government, showing an apparent pattern southeast to the island, at an angle of bearing 50°. The east of the island is prohibited by a No Take Zone, leaving the best location to construct the terminal to be at the southeast corner of the island, where the shortest perpendicular path towards the main vessel route could be formed, which consists of the best bridging path for the bridge connecting the terminal to the island. The water depth required for the cruise liner to pass through safely is brought into consideration the length of the bridge.


Best Bridging Path
~830m
Proposal Cruise Route
Main Vessels Route
0 200 400 600 800 1000 1200 1400 1600 1800 2000 m

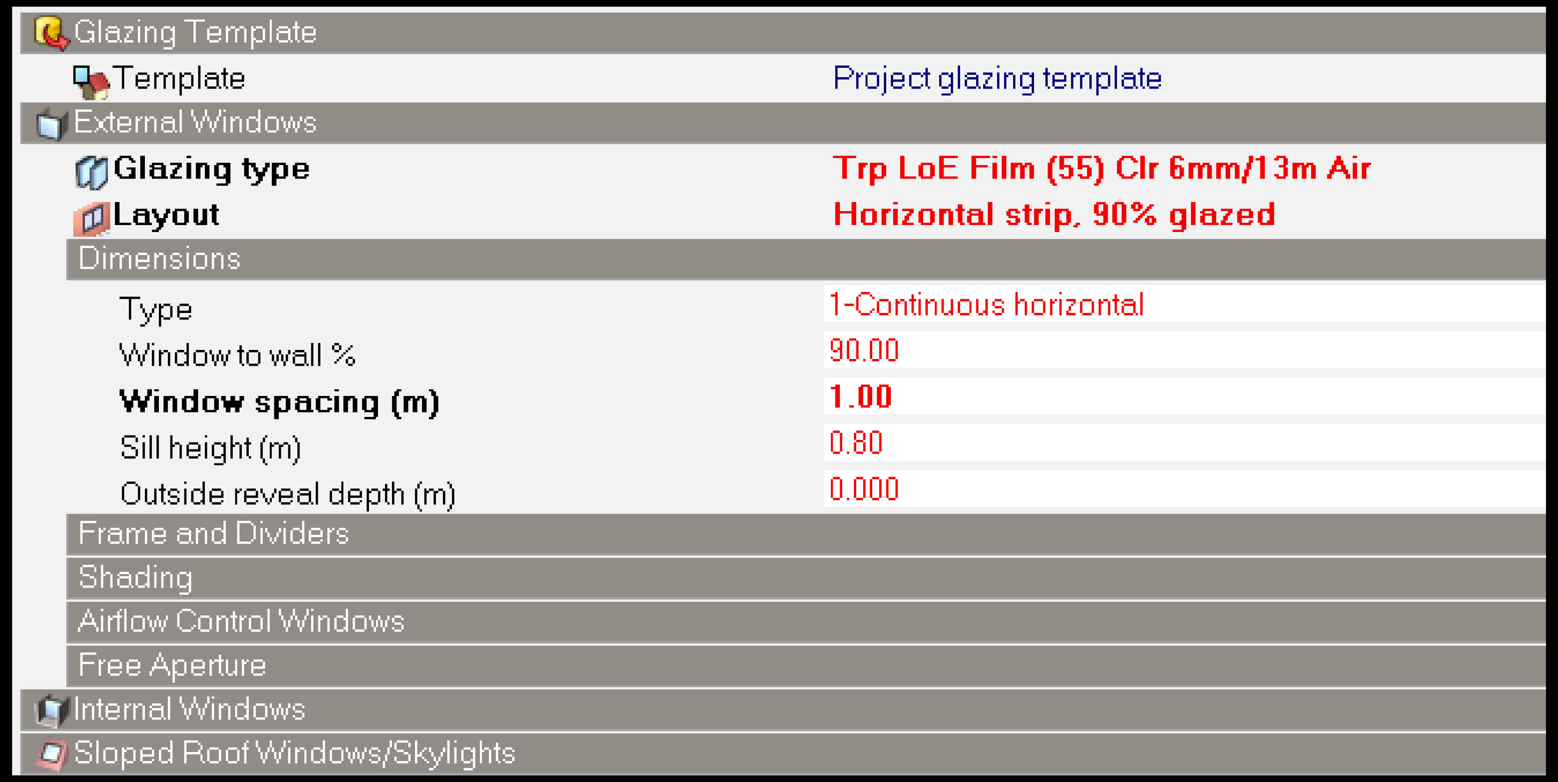
Environmental Analysis II - Shoebox Modelling & Goal

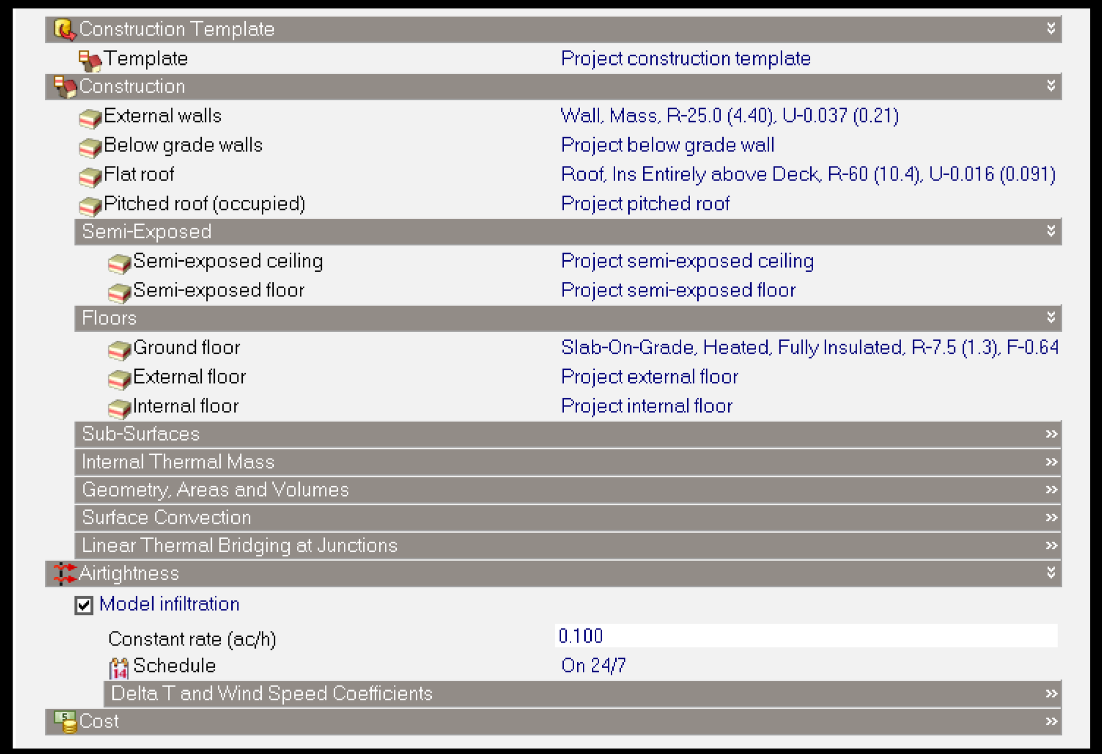
A shoebox model in DesignBuilder was built as the base model for environmental analysis. An off-shore terminal is thought to be modelled with a triangular shape with a size of 200m wide and 150m in length. The main focus of this stage was the construction material, mechanical ventilation system, and energy balance, including heating/cooling load and electricity consumption for lighting and equipment.

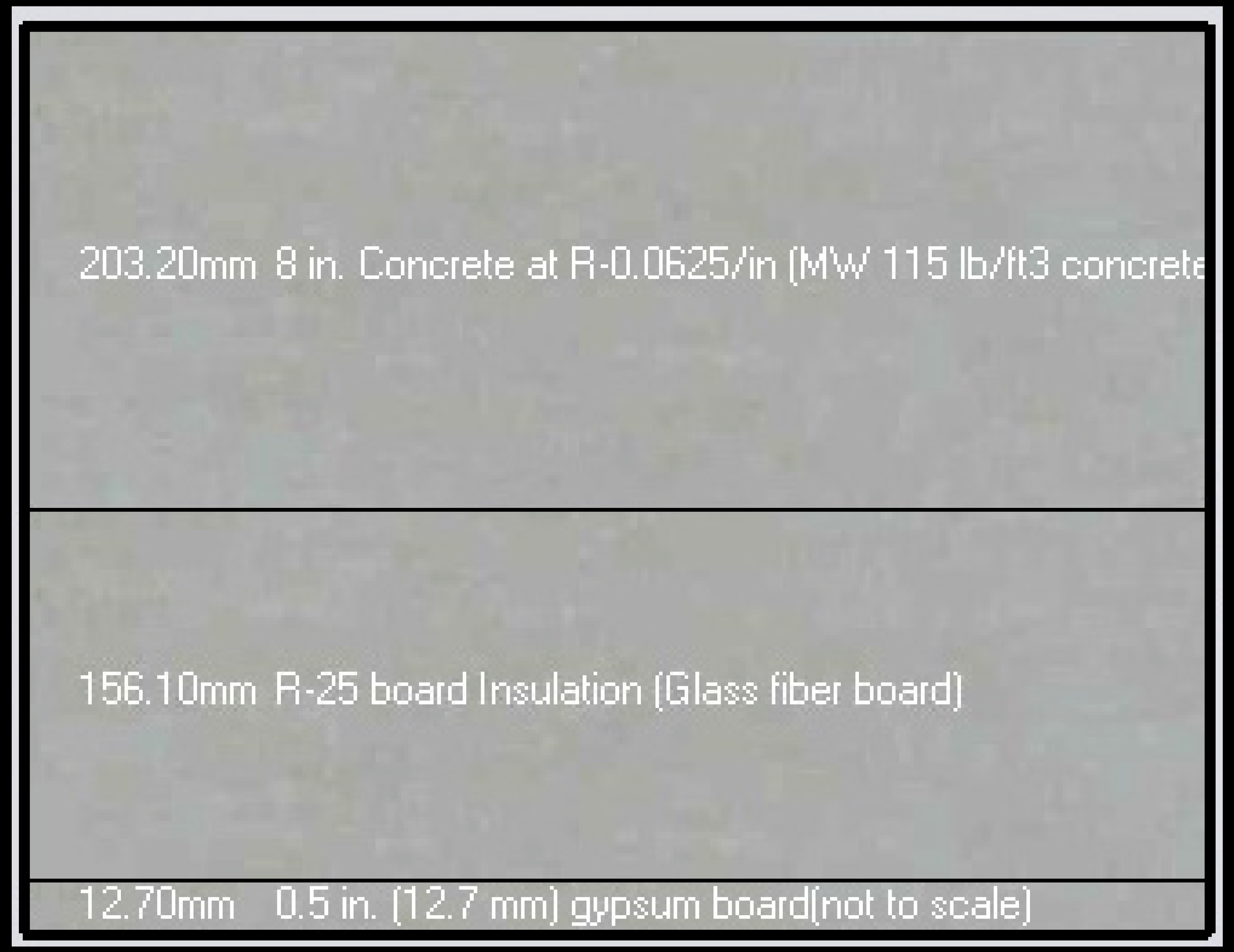
Overall, the model is as shown below. The main block at the bottom is the modelled building, with a transparent component set above it as the shading of the building.



The glazing area (window to wall%) was set to be 90% for aesthetic purposes, forcing all construction elements to be made with the ones of the material with extremely low U-values. The glazing type was Triple LoE Film with a U-value of 1.211. The external walls were chosen to be made with the shown configuration, with a U-value of 0.209. The roof was selected to be made with the shown structure, with a U-value of 0.091. The floor uses heated, fully-insulated Slab-on-Grade to ensure the best insulation performance. The constant rate remains 0.800 (default).



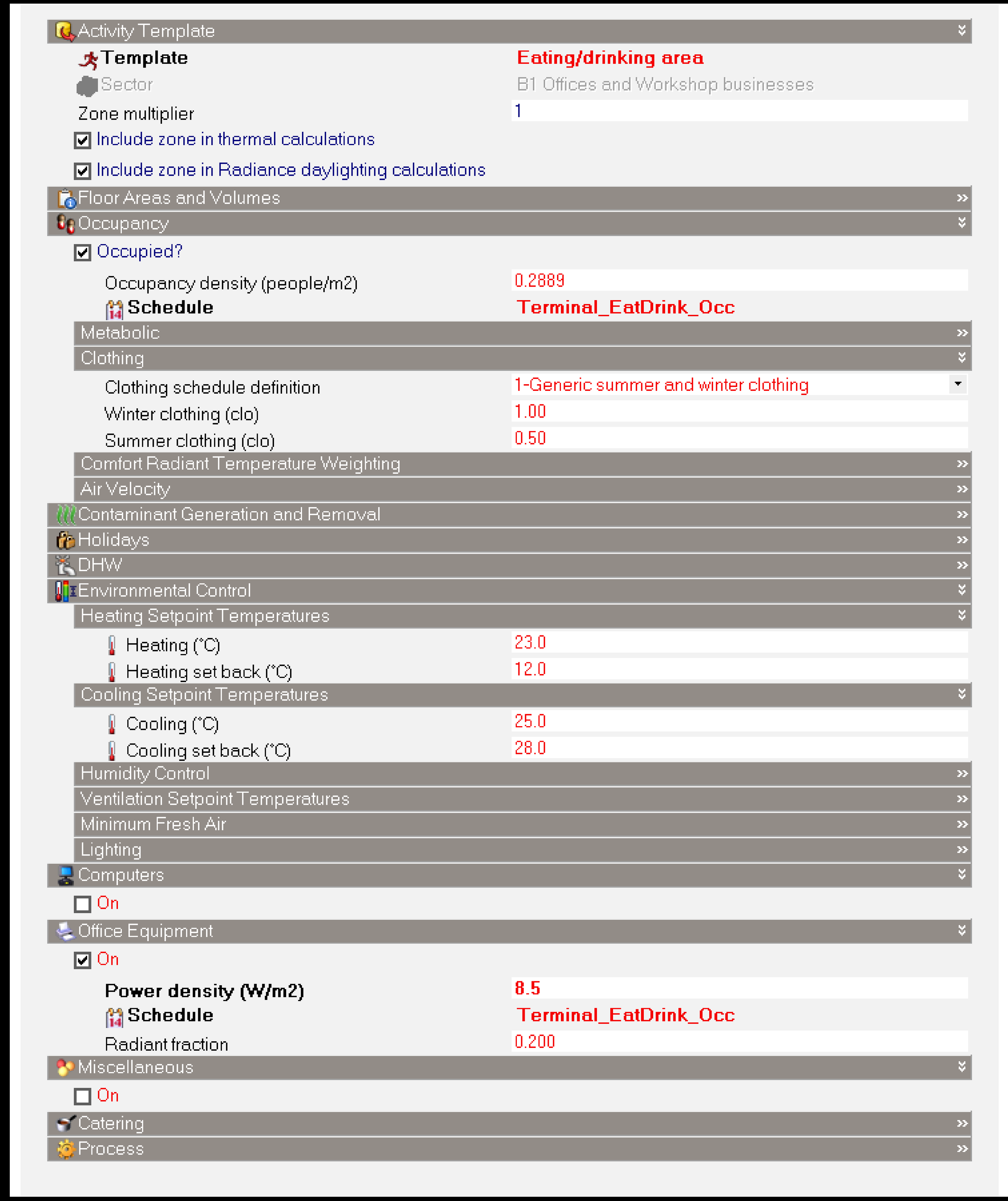


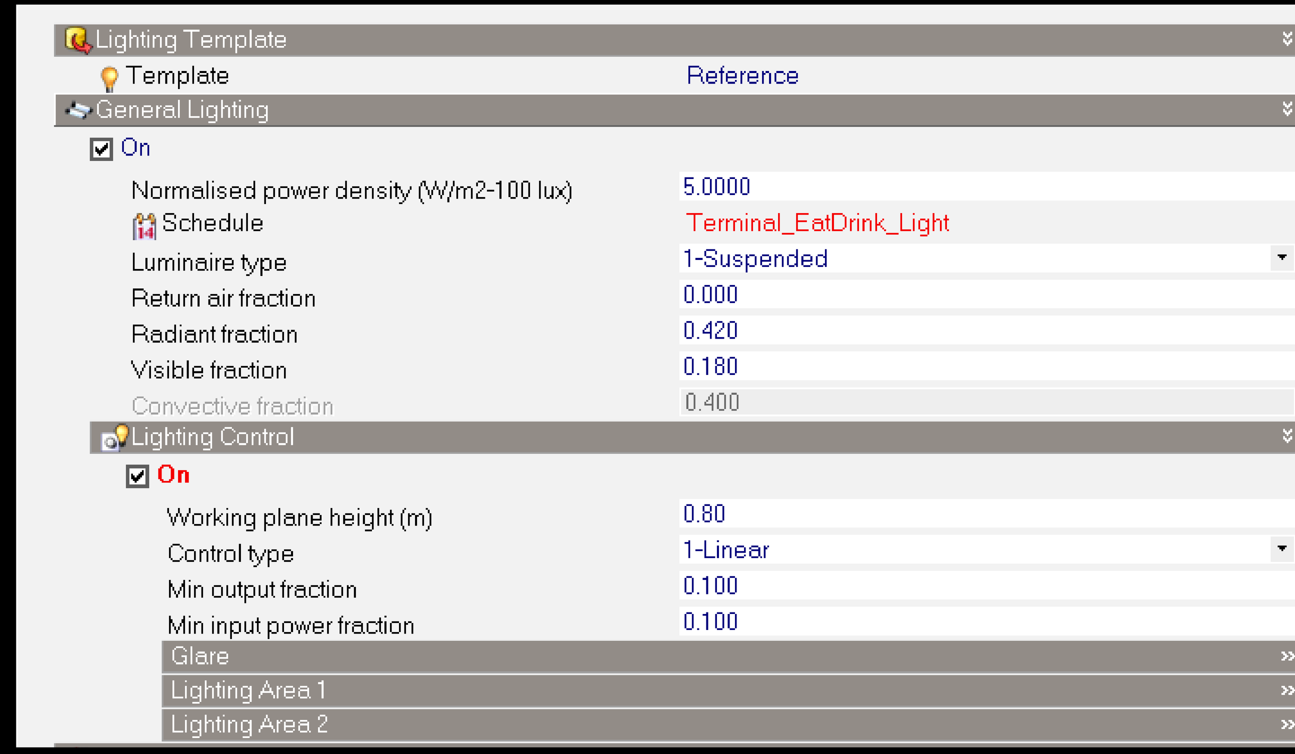


External Wall Structure

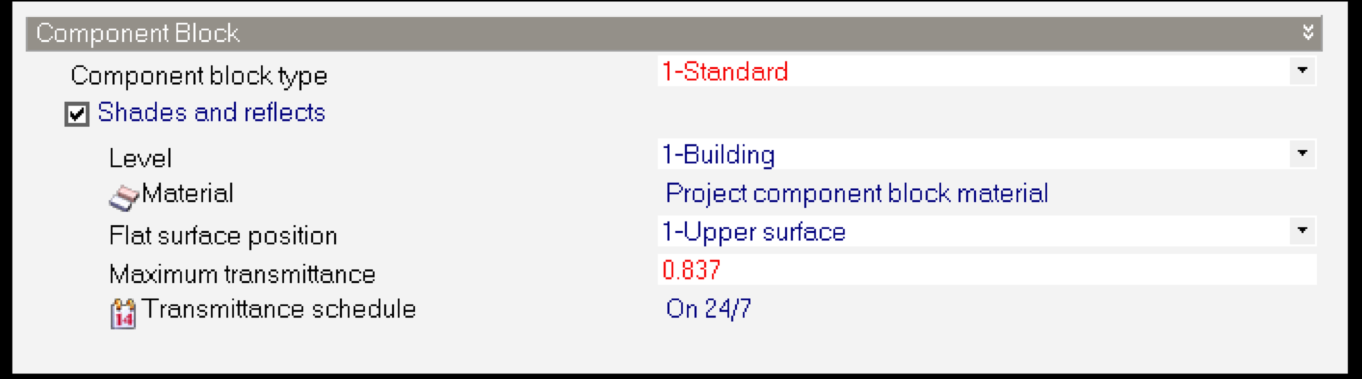
Roof Structure

The activity/occupancy schedule of the building follows the template of Terminal_EatDrink, as the primary purpose of this area is thought to be dining halls/restaurants. The temperature was supposed to be controlled to fall in a range of 23°~25° according to the recommendation from CIBSE Guide A Table 1.5. The office equipment setting in this model represents the general equipment setting, including the radiation from both the dining area and the kitchen. The power density input into the model is the weighted average of the power density from all areas within the building, which is 8.5 W/m².

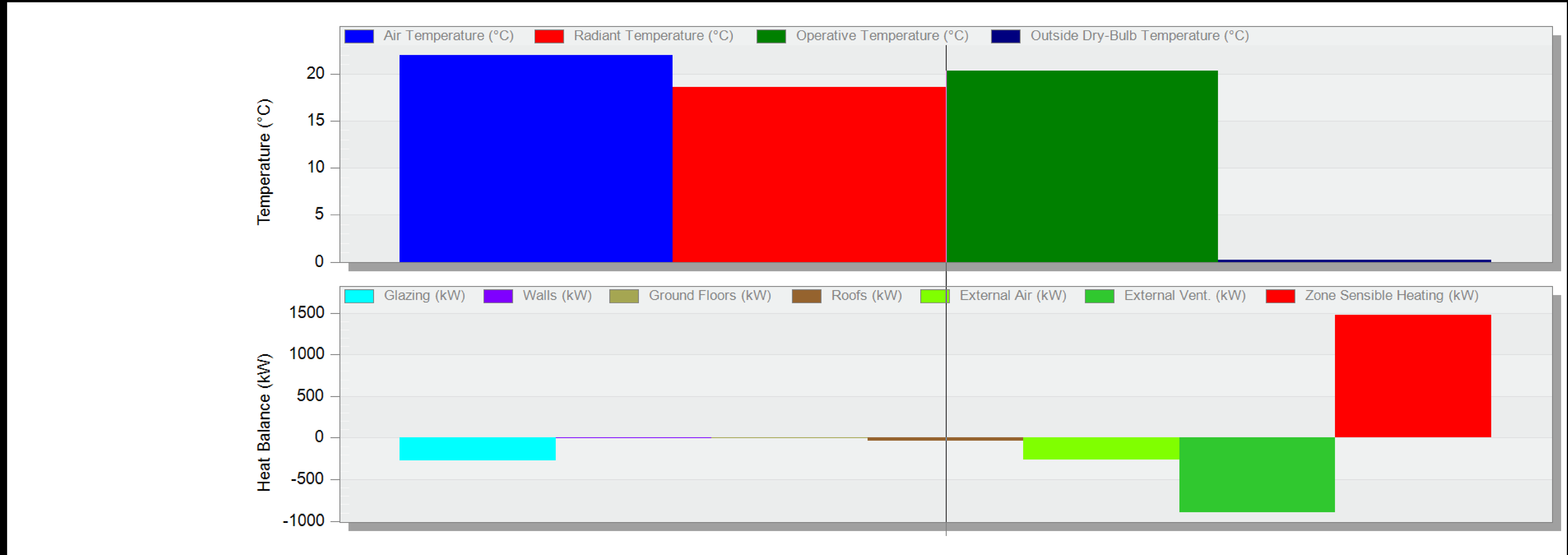




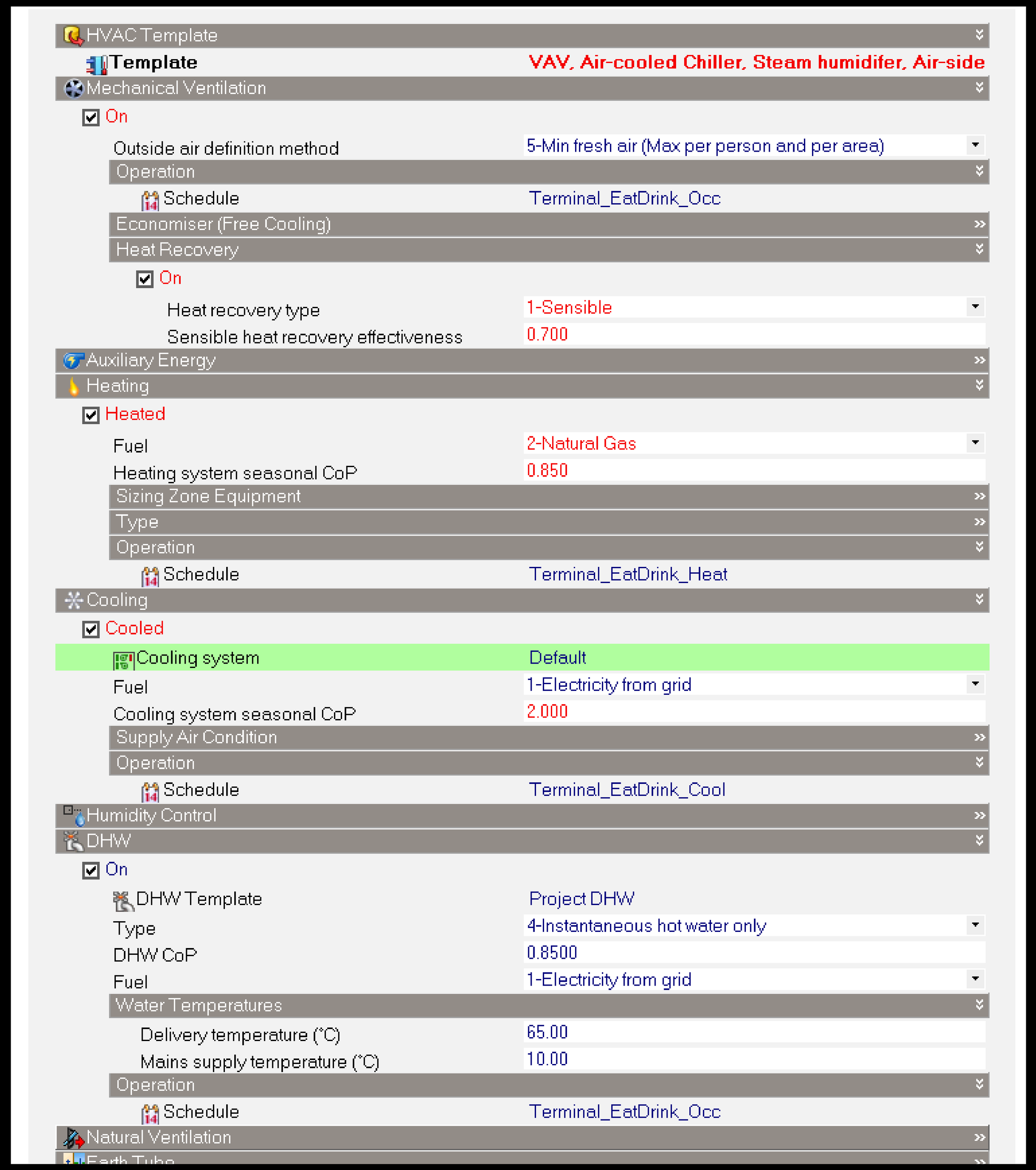
As the shading of the building was designed to be glass/transparent fabric, the transmittance of the transparent component is set to be 0.7 overall as the transmittance setting would apply to the lighting analysis twice, the transmittance setting of the component = √0.7.

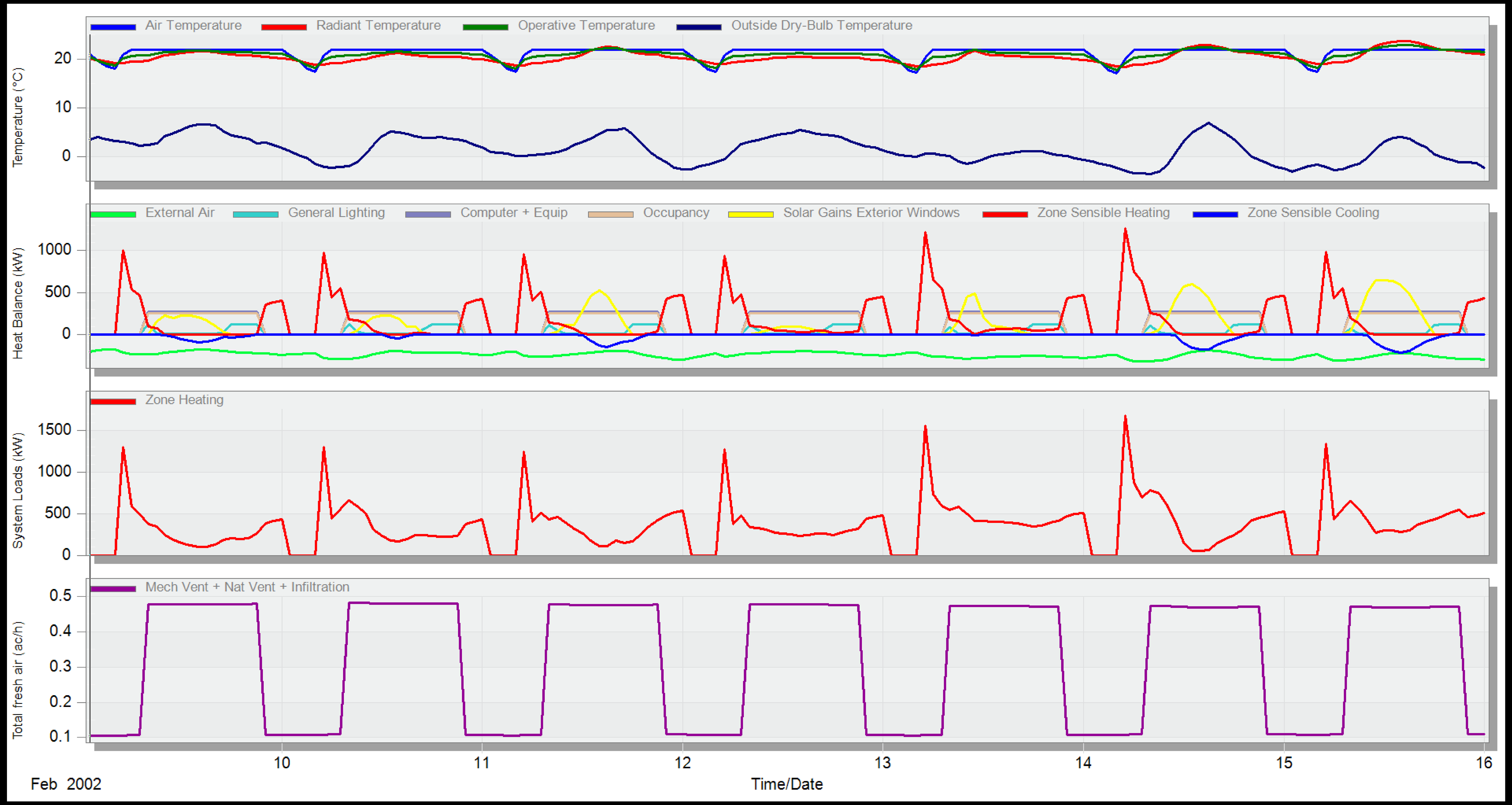


The heating design simulation was run to determine the energy balance situation in terms of heating. Thanks to the strong insulation applied to the windows, heat loss due to glazing fall into a tolerable range despite the vast glazing area. The most significant heat loss is through external ventilation.

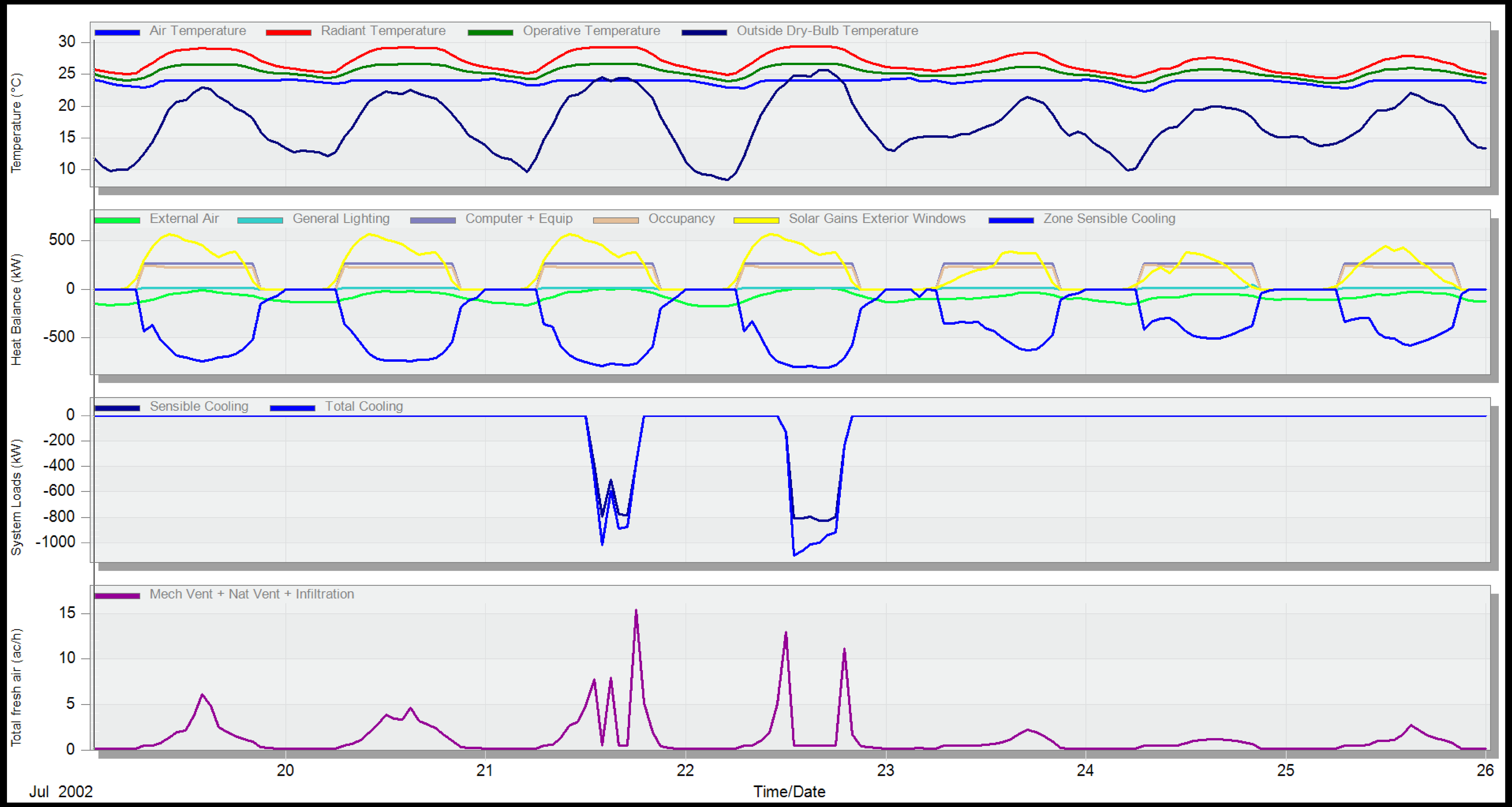


Air Temperature (°C)	22.00
Radiant Temperature (°C)	18.61
Operative Temperature (°C)	20.31
Outside Dry-Bulb Temperature (°C)	0.20
Glazing (kW)	-276.07
Walls (kW)	-5.96
Ground Floors (kW)	-10.01
Roofs (kW)	-32.81
External Air (kW)	-265.85
External Vent. (kW)	-890.02
Zone Sensible Heating (kW)	1480.29





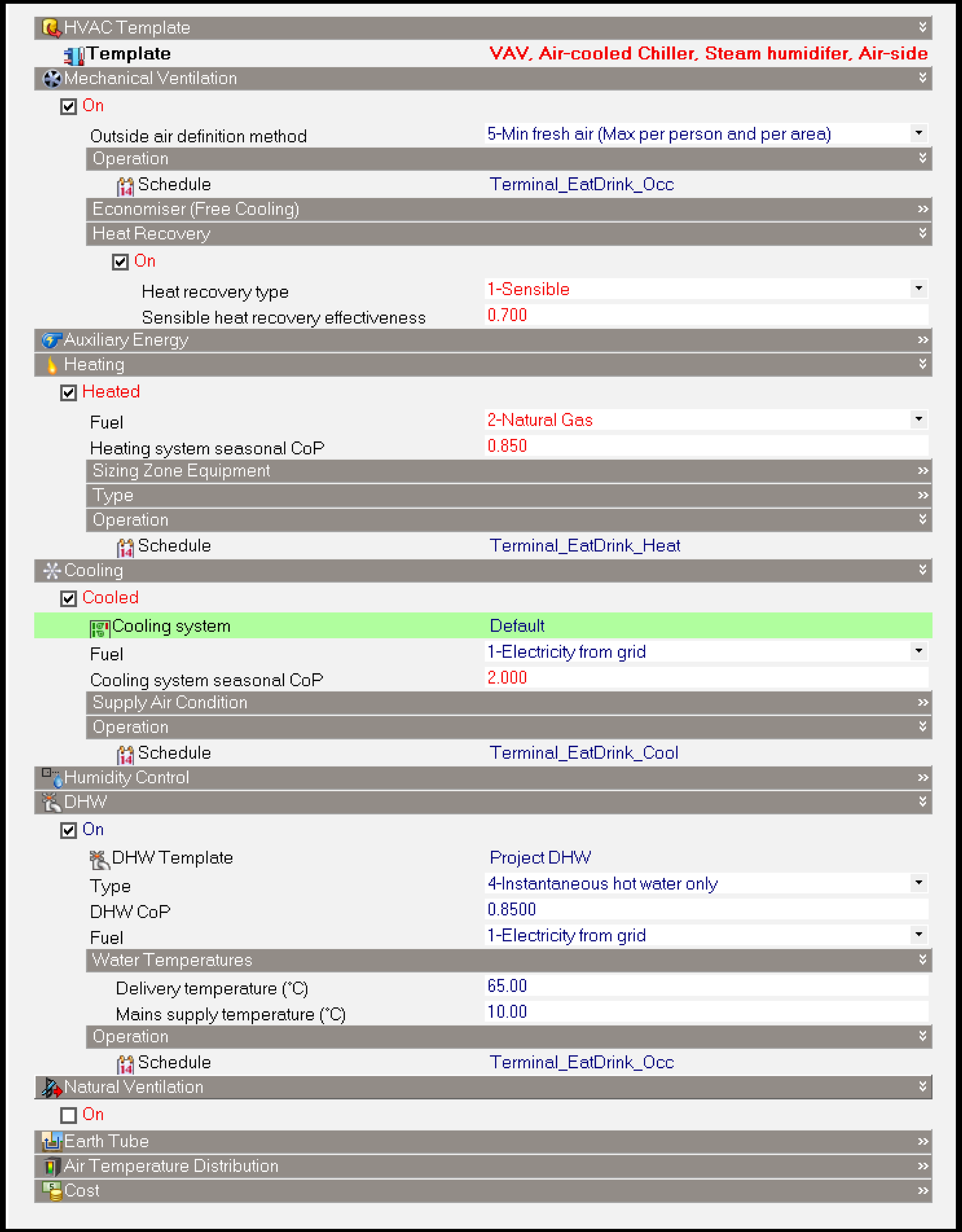
Winter Design Week Results

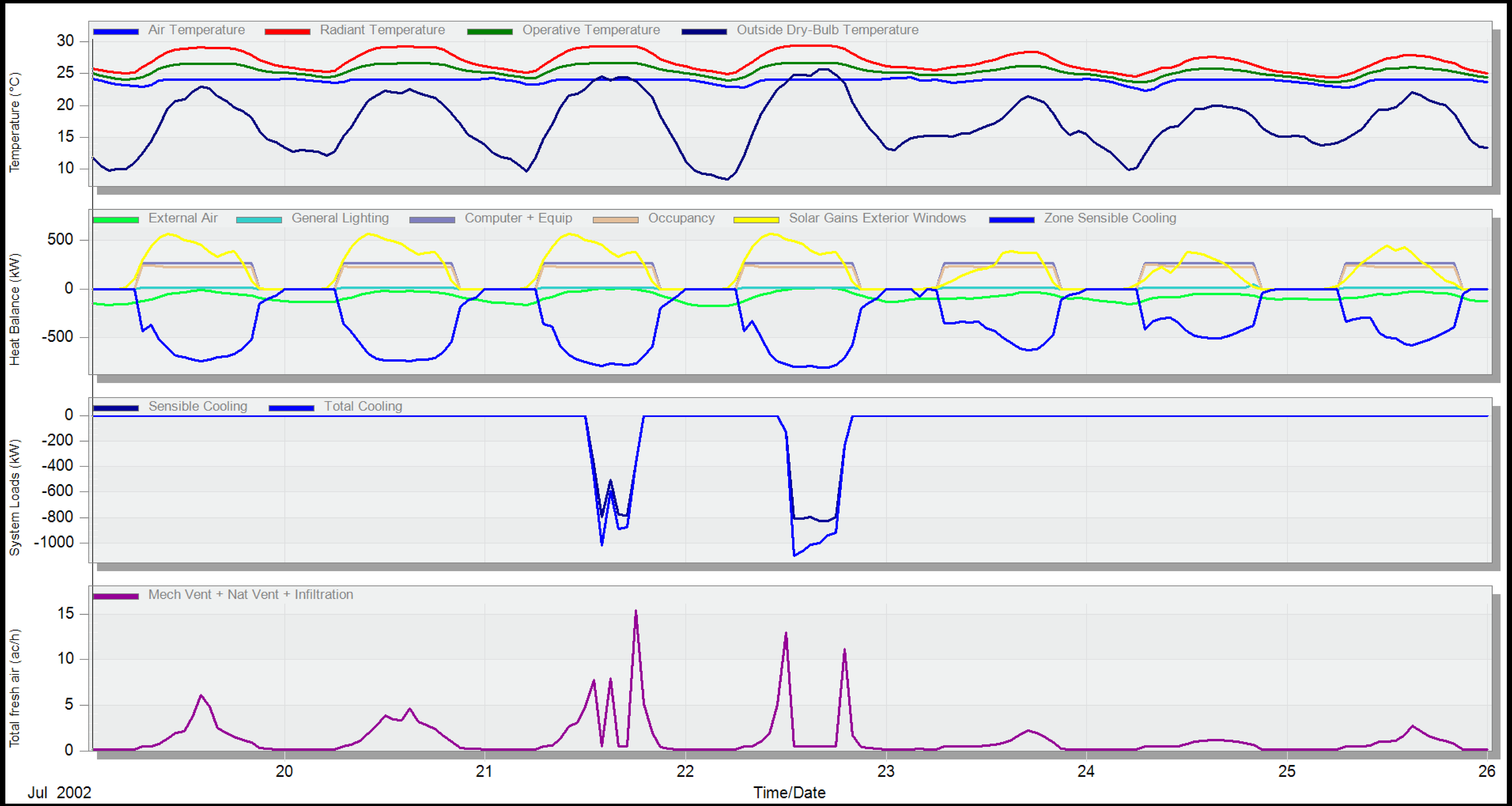


Summer Design Week Results

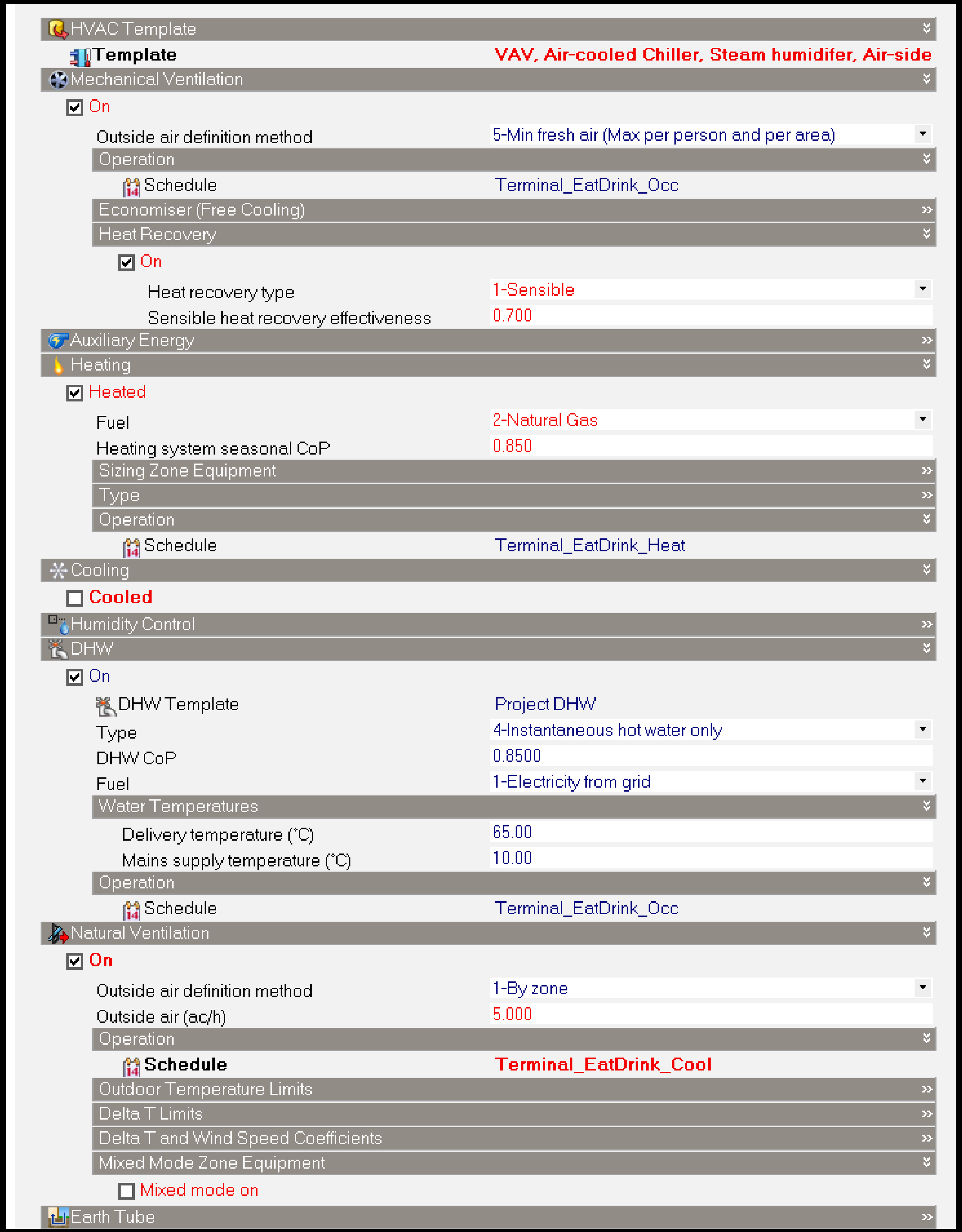
Environmental Analysis III - Mechanical Ventilation System

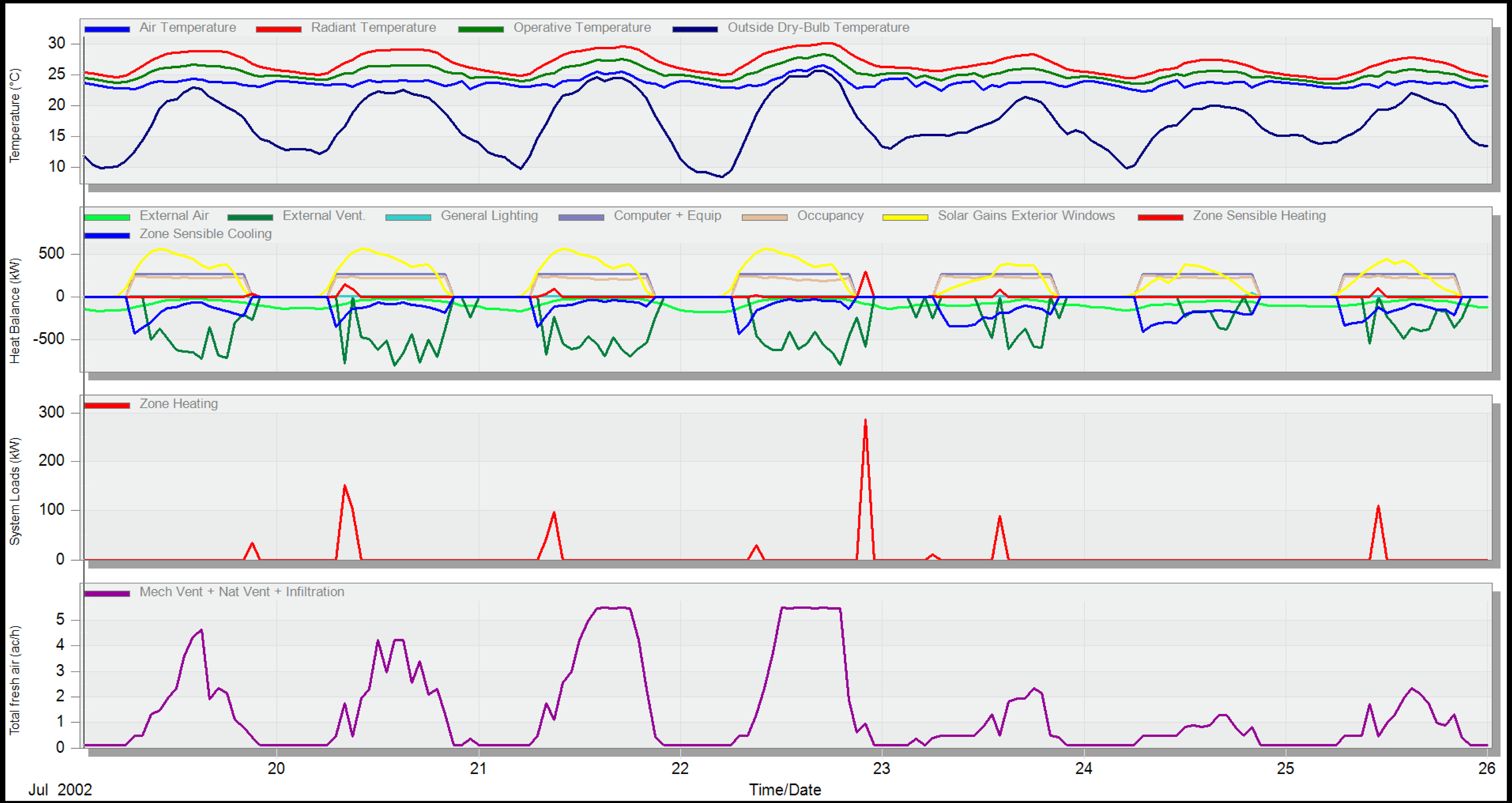
Lundy has a relatively low average temperature during summer due to its location and climate. Simulations were run to determine whether mechanical ventilation was required during summer. When applying a mechanical ventilation system generally to the design, the results are as shown on this page. During summer design week, the air temperature is perfectly maintained at the set temperature.





When replacing the cooling function of the mechanical ventilation system with natural ventilation, the air temperature may exceed 25° sporadically during summer, with an inconsistent air temperature pattern. Since the terminal is nuclear powered, the necessity of a mechanical ventilation system may remain acceptable and favoured. However, if the terminal were powered otherwise, replacing the cooling function with natural ventilation would be a notable solution to reduce carbon emissions and save energy.

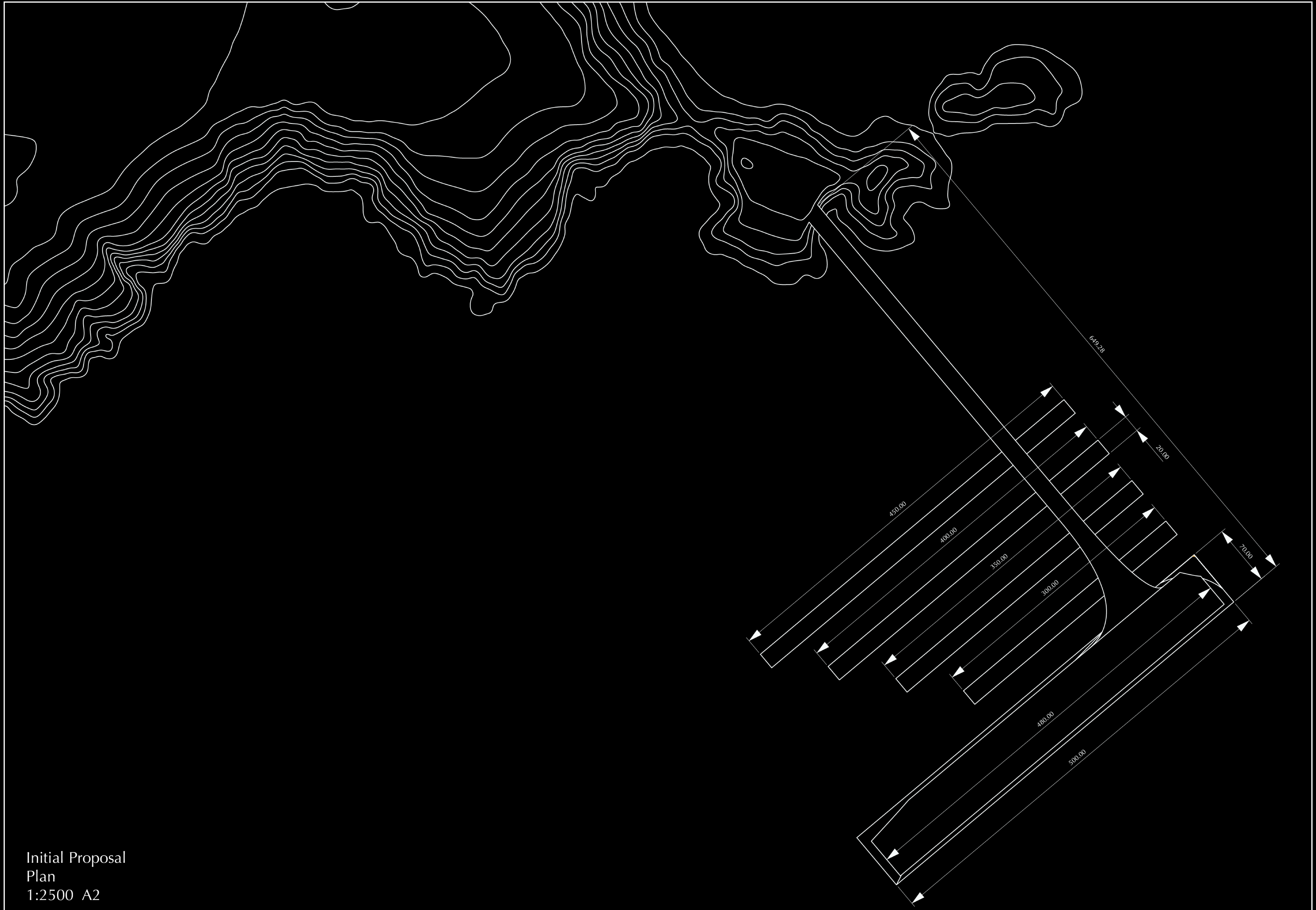




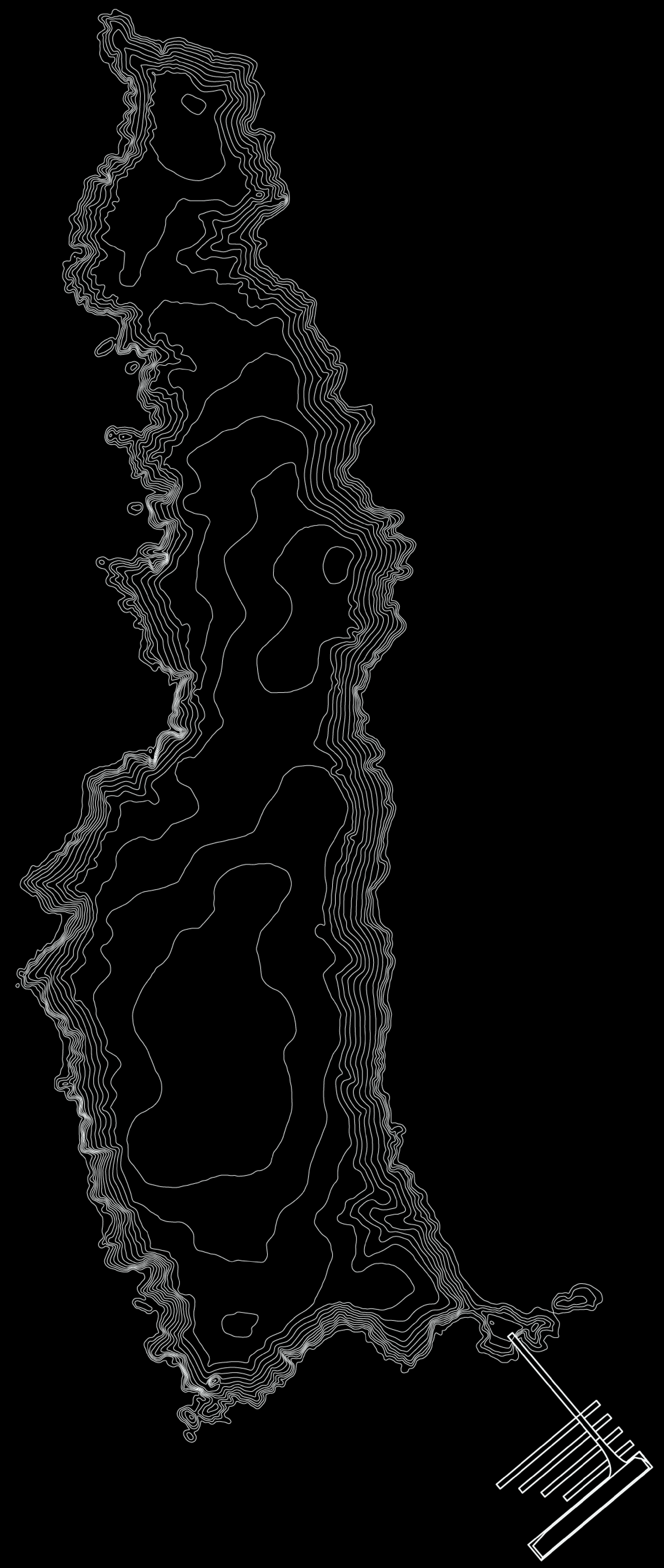
Iteration I - Defining Functions

Iteration I defined the functions of the terminal. The terminal is divided into levels, an upper level acting as the cruise terminal and the heliports, and a lower level acting as the pier, platforms, service station, and the lighthouse. All function sections are connected via the bridge which also connect to Lundy. The gist of this iteration is the application of vertical space to merge the cruise terminal with the pier and platforms for regular ships by placing them on different levels.


Lighthouse
Observation Deck
Upper Level
Service Station
Heliport
Lower Level
Towards Lundy
Regular Platforms



Initial Proposal
Plan
1:2500 A2



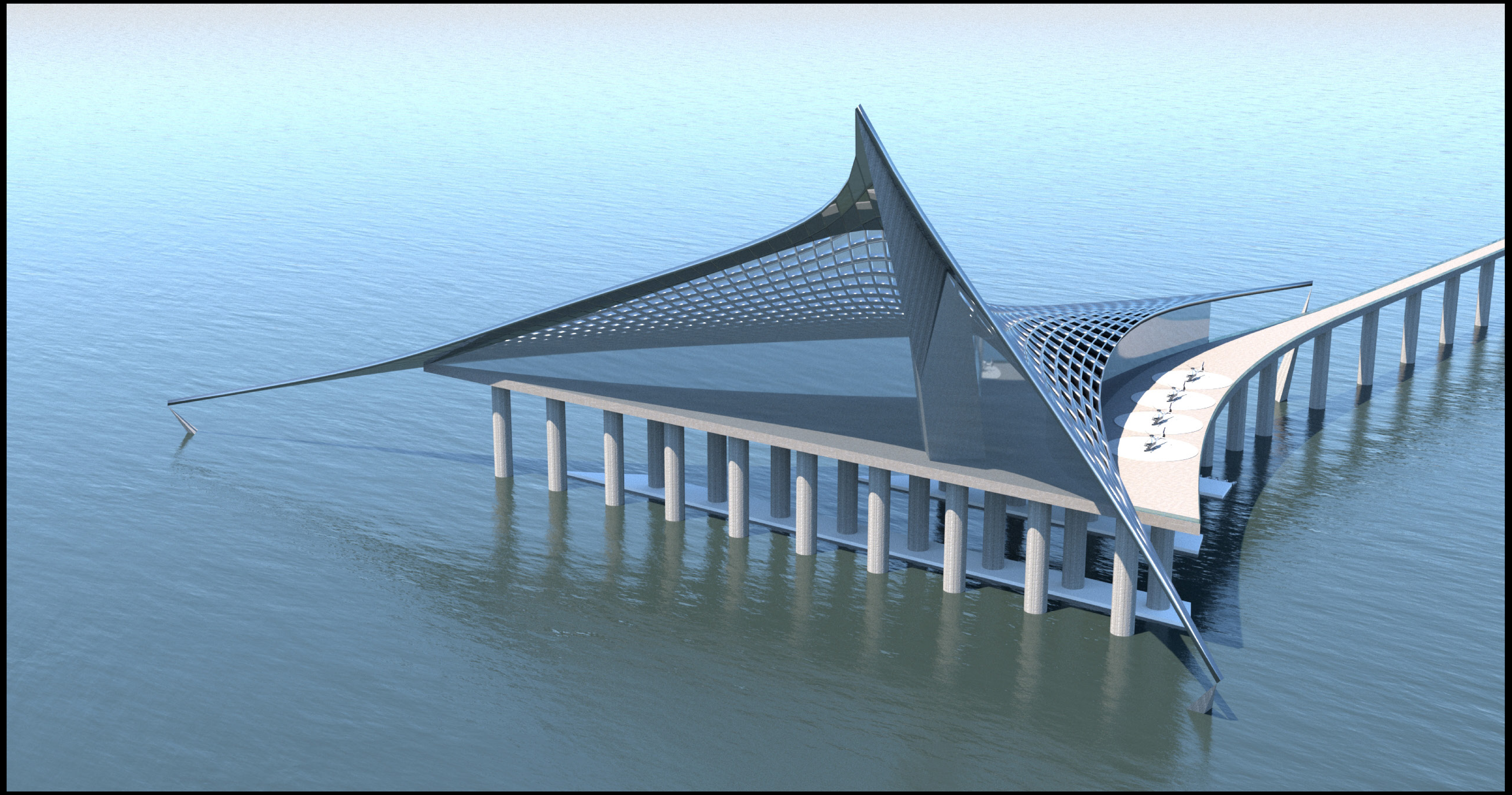
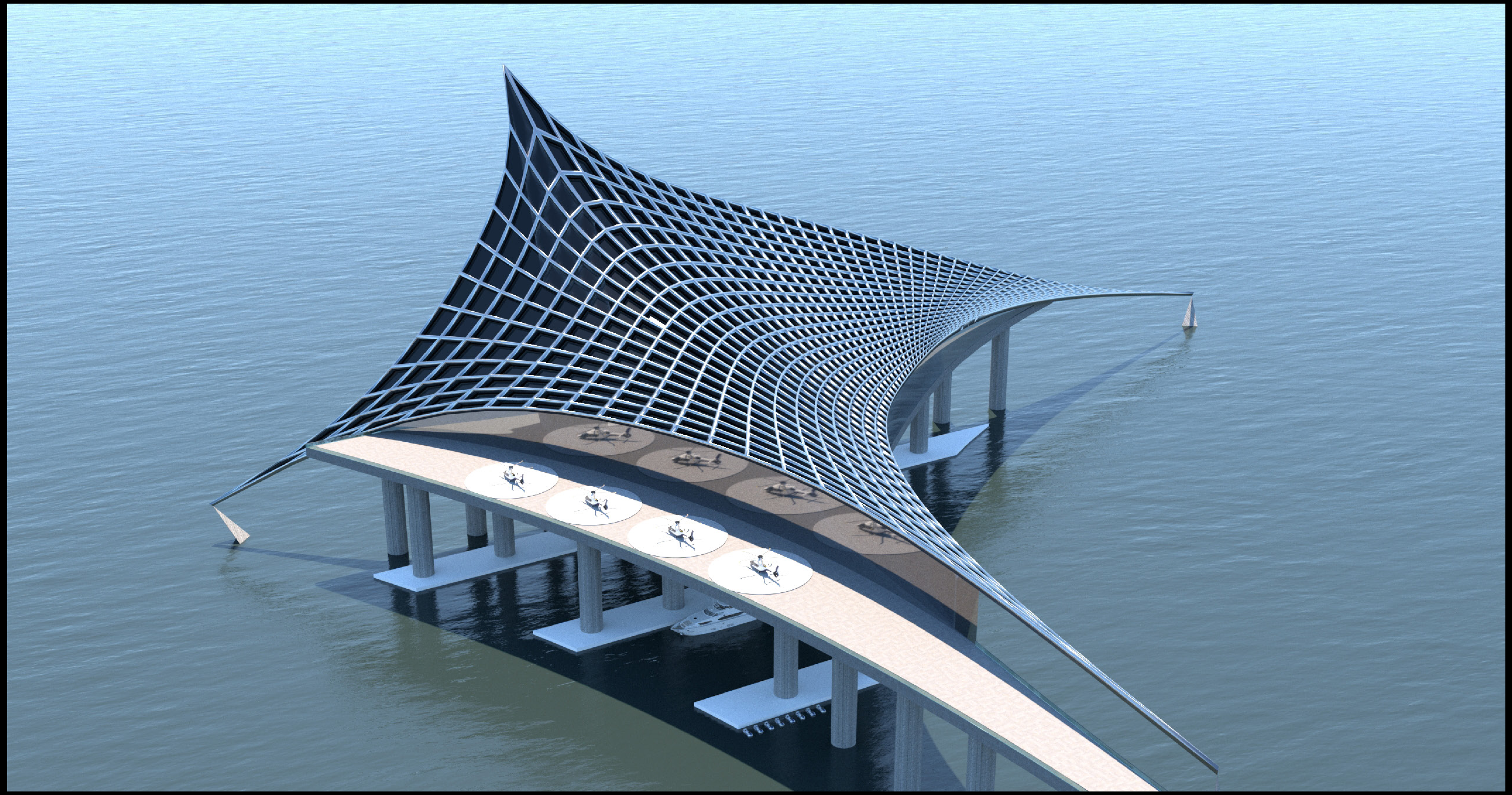
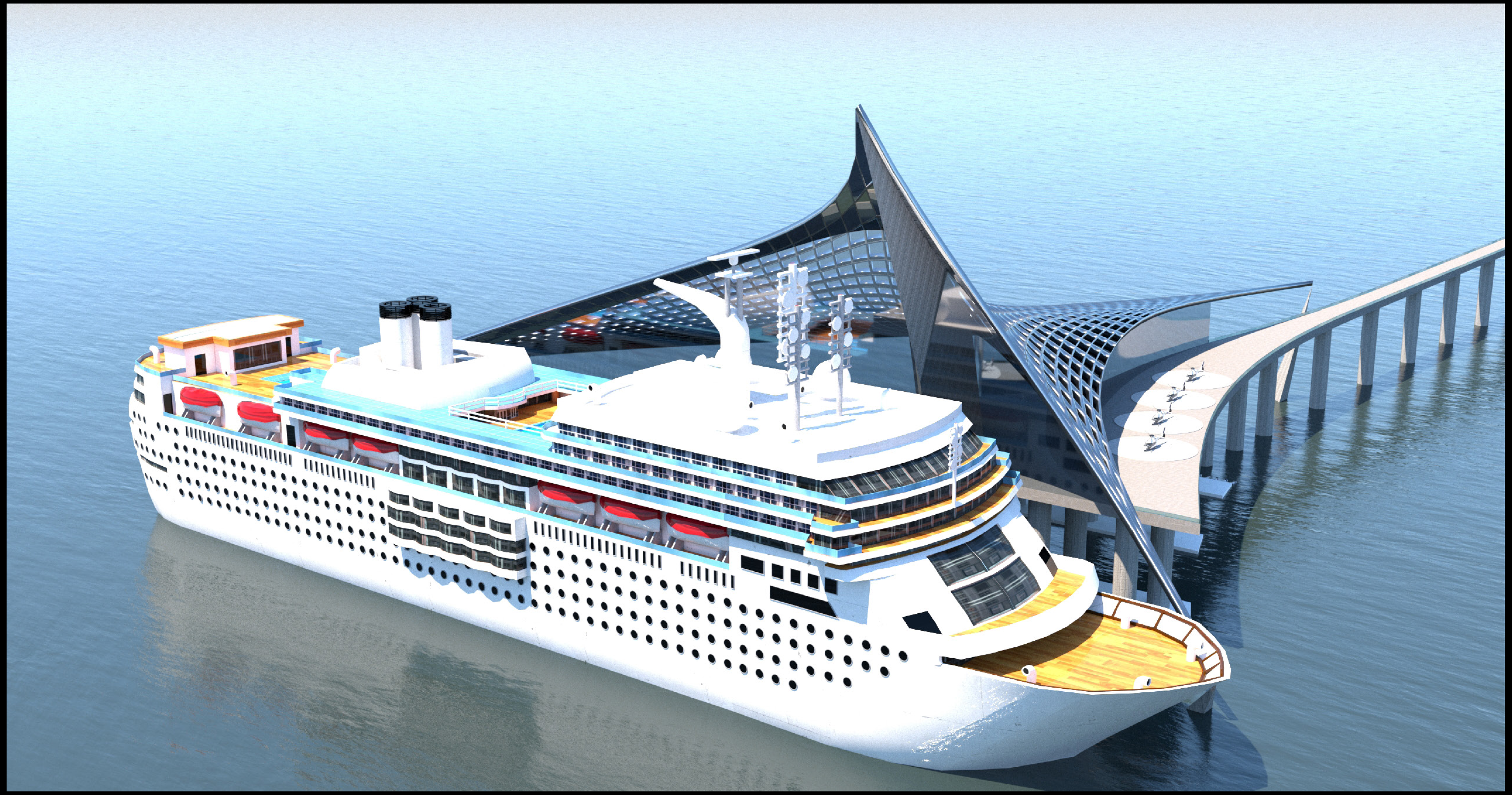
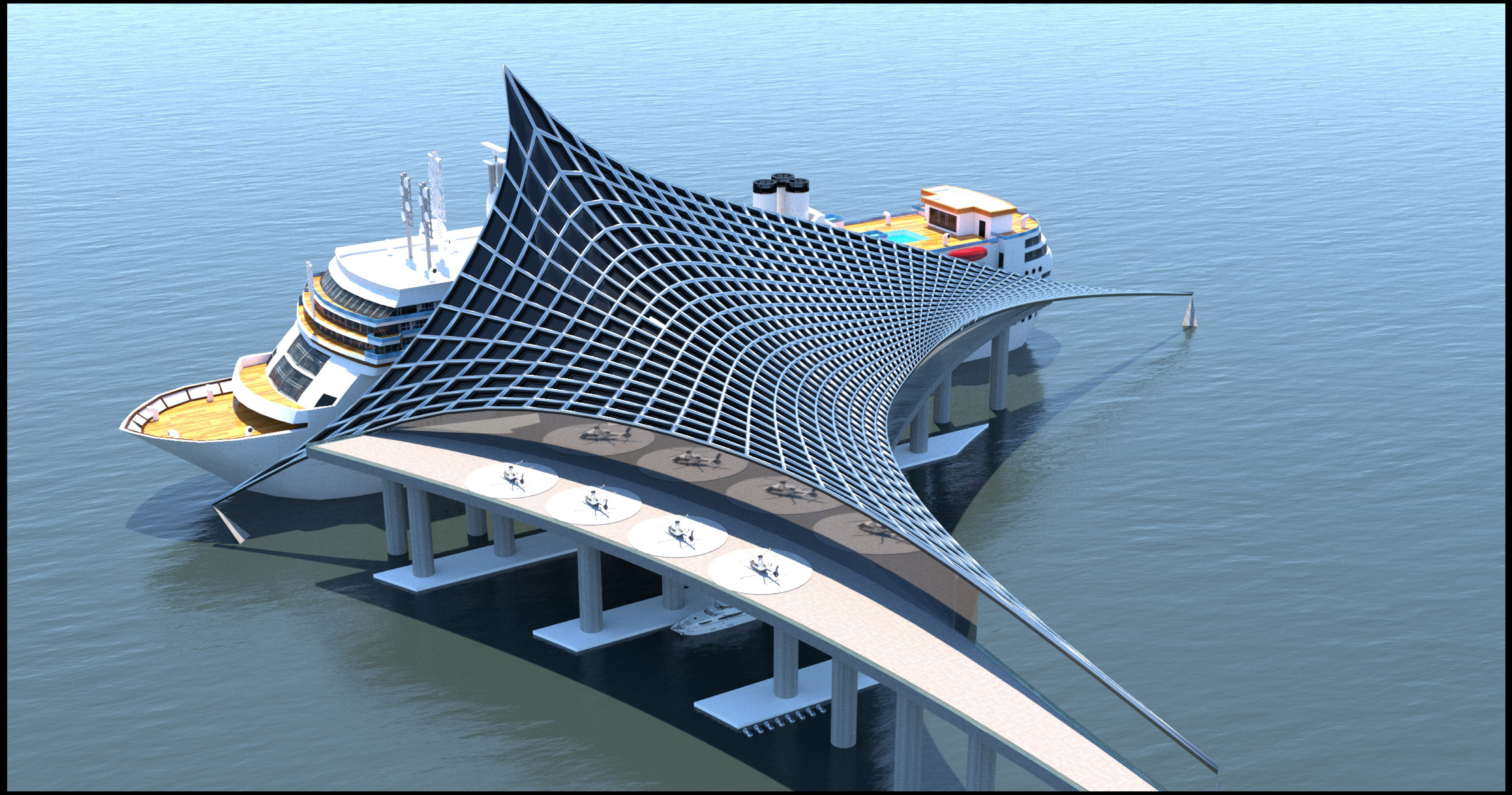
Initial Proposal
Site Plan
1:12500 A2

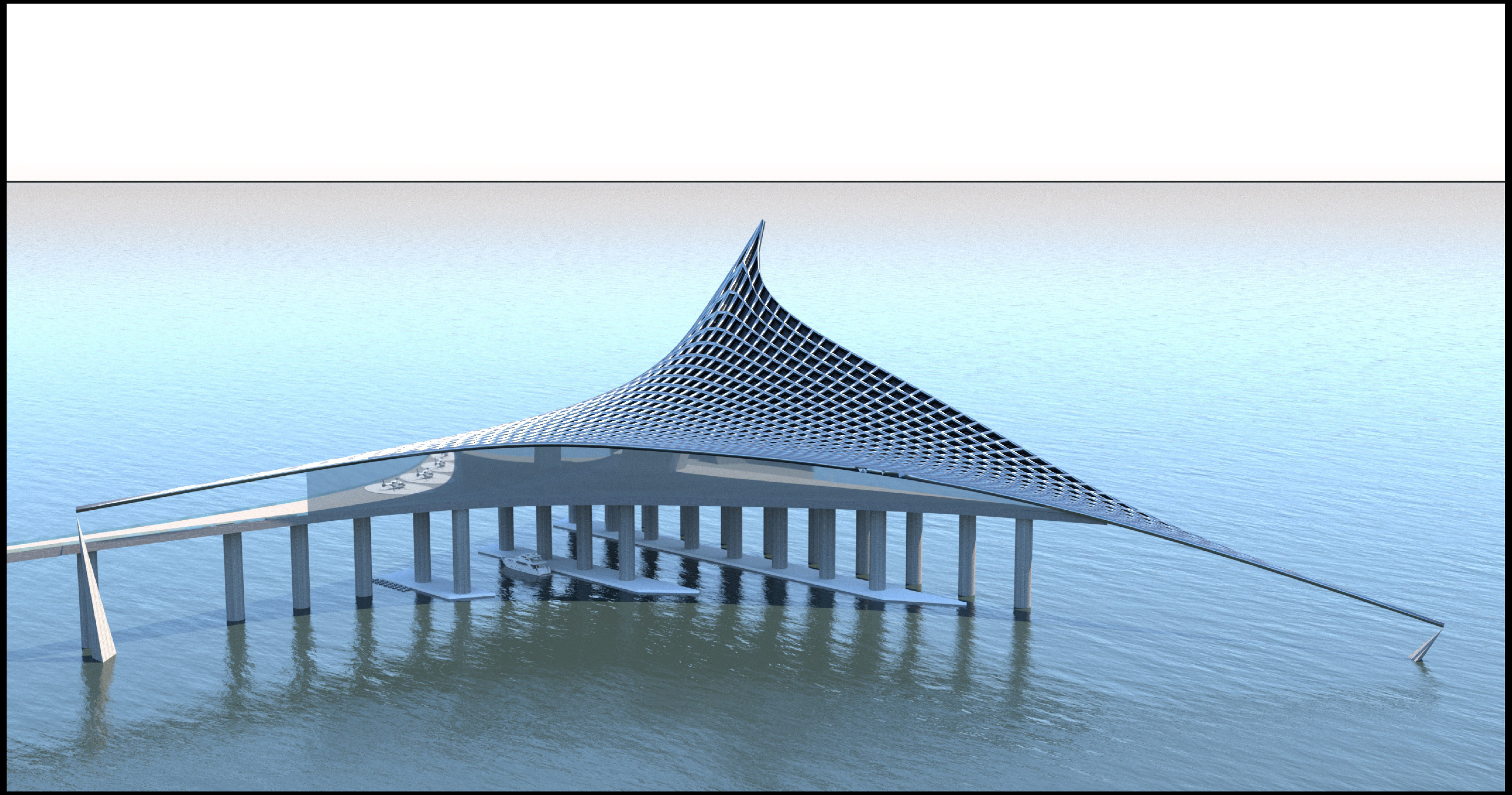
Phase 2 - Research & Development

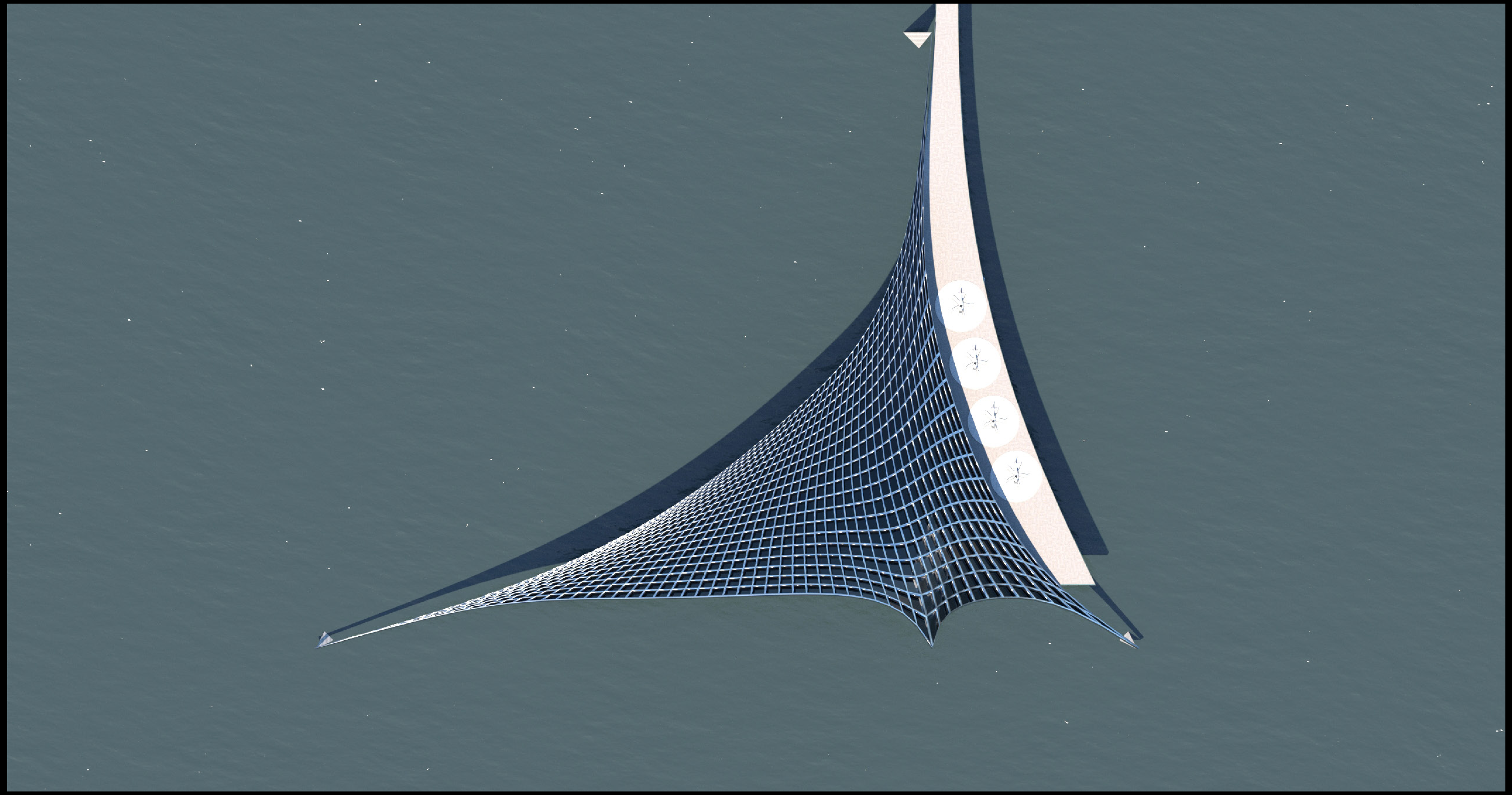
Iteration II - Shape Finding

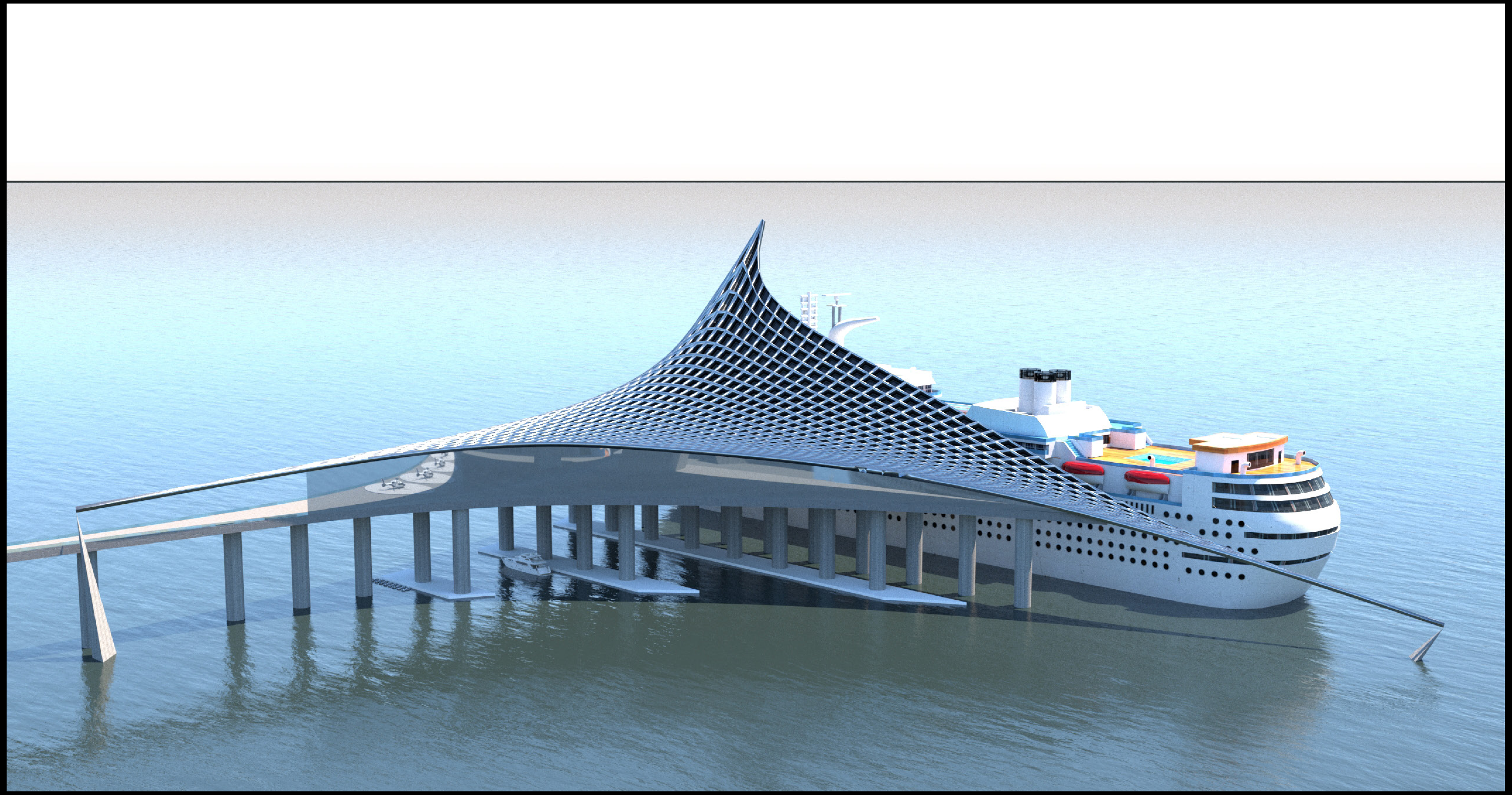
Based on the best bridging path found in environmental analysis, a structure stacking the cruise terminal upon the pier/platform was formed, covered by a tensile structure determined using grasshopper, covering the main structure while leaving a curved area acting as the heliports. The entertaining and leisure areas are located on the upper level. The tensile structure forms the roof and fully encloses the entire upper level to achieve a fully controlled indoor environment. The upper level has a height of 40 meters above the sea level during low tide to allow majority of ships/ocean liners to access the lower level.

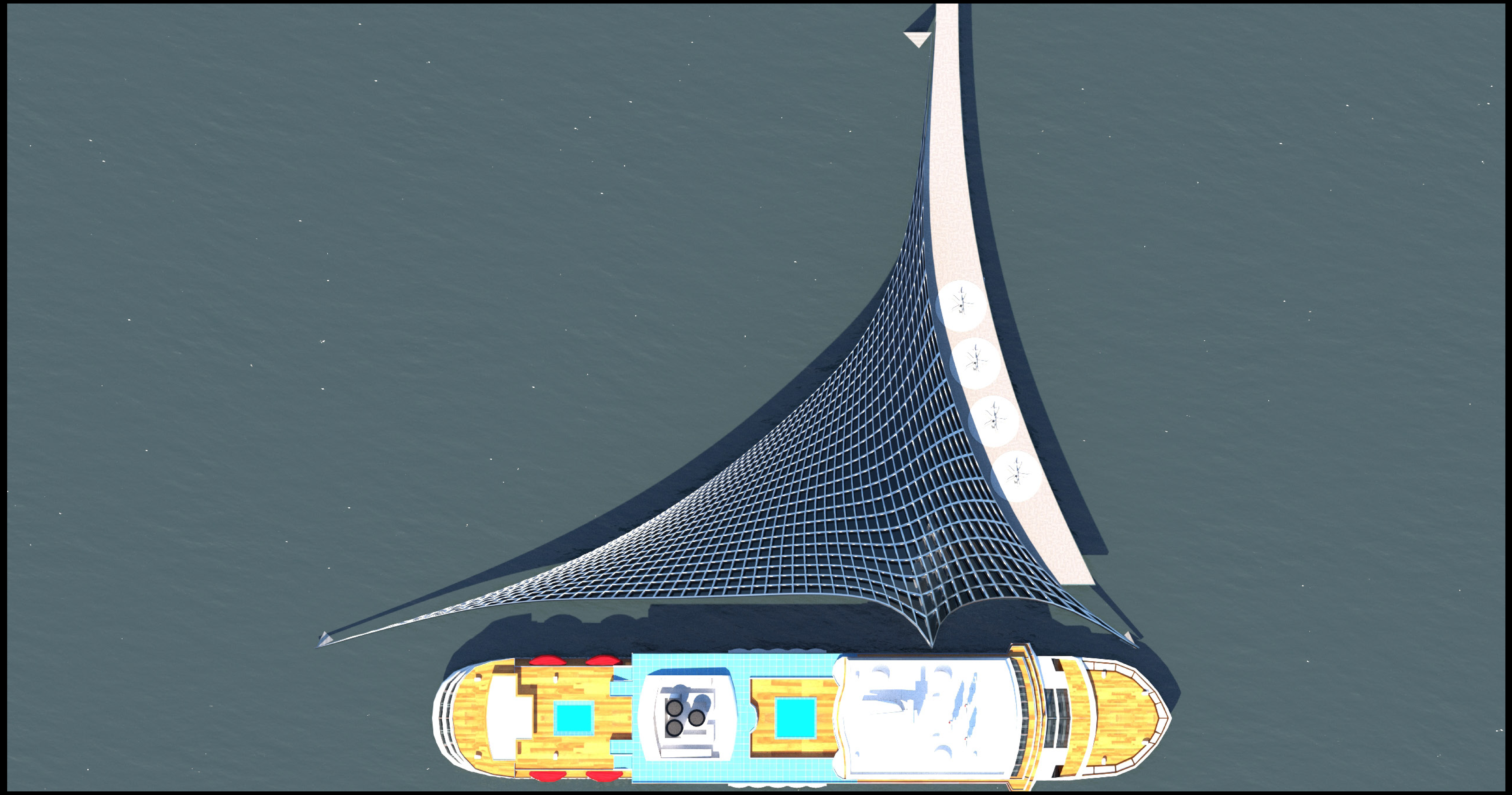

Best Bridging Path
~830m
400m
0 200 400 600 800 1000 1200 1400 1600 1800 2000 m









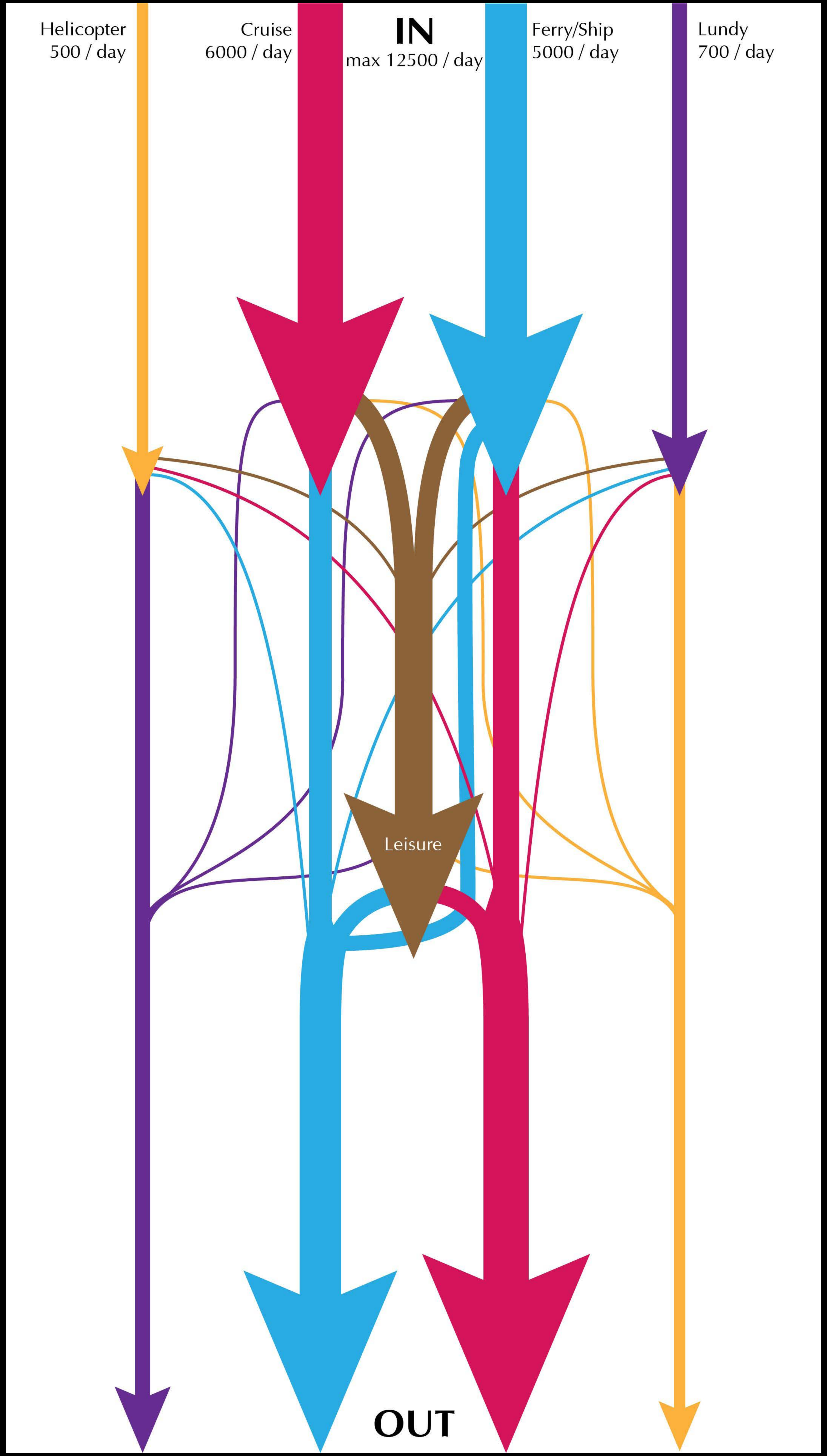
Environmental Analysis IV - Flow of People & Key Space

According to CIBSE Guide A Table 6.2, the recommended floor area per person is 10 square meters for circulation spaces, which is the primary purpose of the terminal, circulation of the passengers between the ocean liners and helicopters.

The source of passengers was determined, and the flow, which showed their possible route and activities, was illustrated to determine the maximum possible number of passengers on the terminal at the same time and the potential distribution of passengers around the terminal to determine the required floor area of different section of the terminal. Followed by a detailed visualisation diagram of the maximum possible number of passengers from different sources in each operating hour of the day, with each square representing 10 people.

Table 6.2 Benchmark allowances for internal heat gains in typical buildings

Building type	Use	Floor area per person / m^{-2}	Sensible heat gain / $W \cdot m^{-2}$			Latent heat gain / $W \cdot m^{-2}$	
			People	Lighting*	Equipment†	People	Other
Offices	General	12	6.7	8–12	15	5	—
		16	5	8–12	12	4	—
	City centre	6	13.5	8–12	25	10	—
		10	8	8–12	18	6	—
	Trading/dealing	5	16	12–15	40+	12	—
	Call centre floor	5	16	8–12	60	12	—
	Meeting/conference	3	27	10–20	5	20	—
	IT rack rooms	0	0	8–12	200	0	—
Airports‡ and stations	Airport concourse	0.83	75	12	5	4	—
	Check-in	0.83	75	12	5	50	—
	Gate lounge	0.83	75	15	5	50	—
	Customs/ immigration	0.83	75	12	5	50	—
	Circulation spaces	10	9	12	5	6	—
Retail	Shopping malls	2–5	16–40	6	0	12–30	—
	Retail stores	5	16	25	5	12	—
	Food court	3	27	10	†	20	§
	Supermarkets	5	16	12	†	12	§
	Department stores:						
	— jewellery	10	8	55	5	6	—
	— fashion	10	8	25	5	6	—
	— lighting	10	8	200	5	6	—
	— china/glass	10	8	32	5	6	—



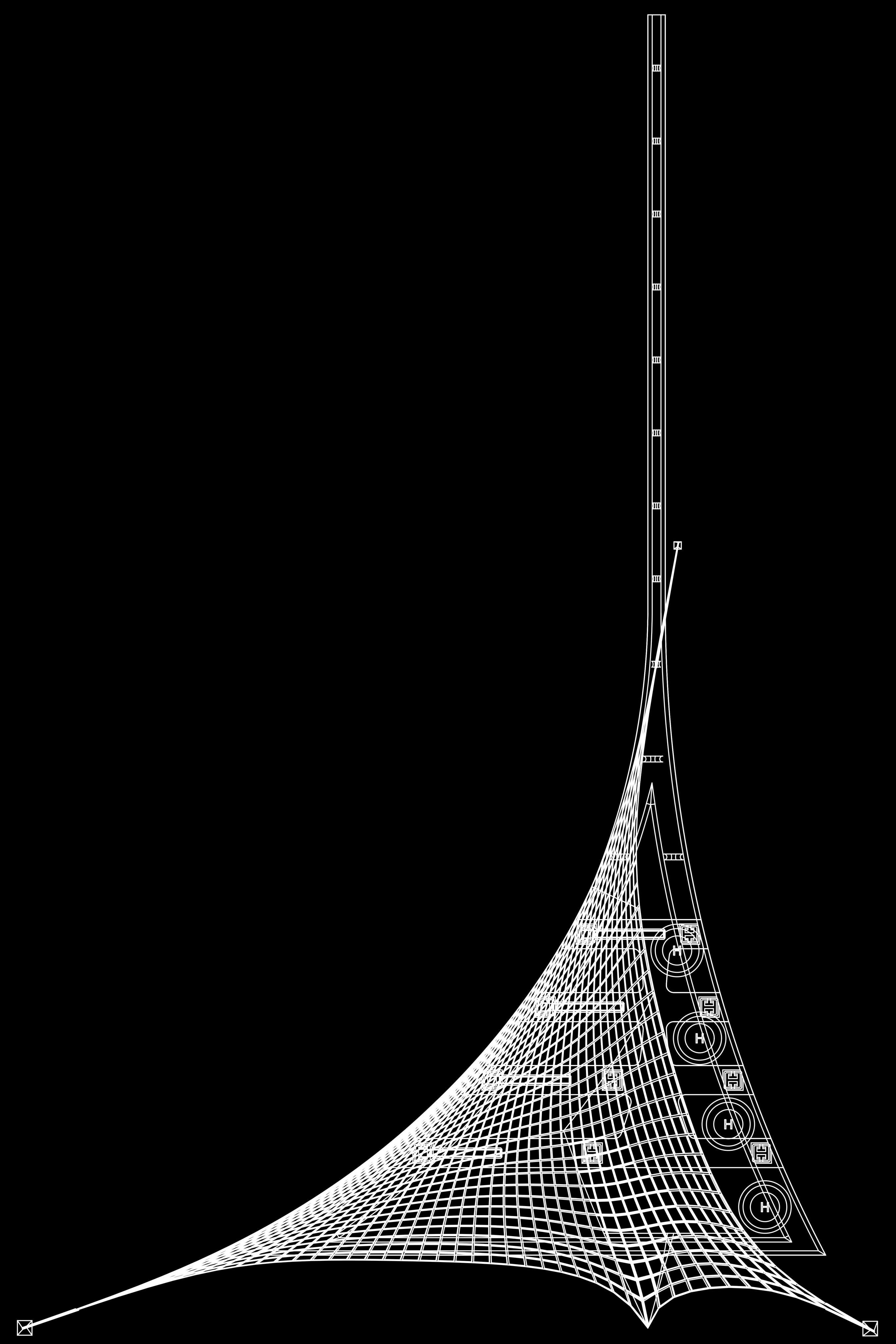

Max Persons
4070
4950
5800
5850
5900
5900
5900
5850
5850
5850
5350
4900
Ferryline 1
Ferryline 2
Ferryline 3
Ferryline 4
Ferryline 5
Other Ships
Staff
Cruise Liner
Helicopter
Lundy
08:00
09:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00

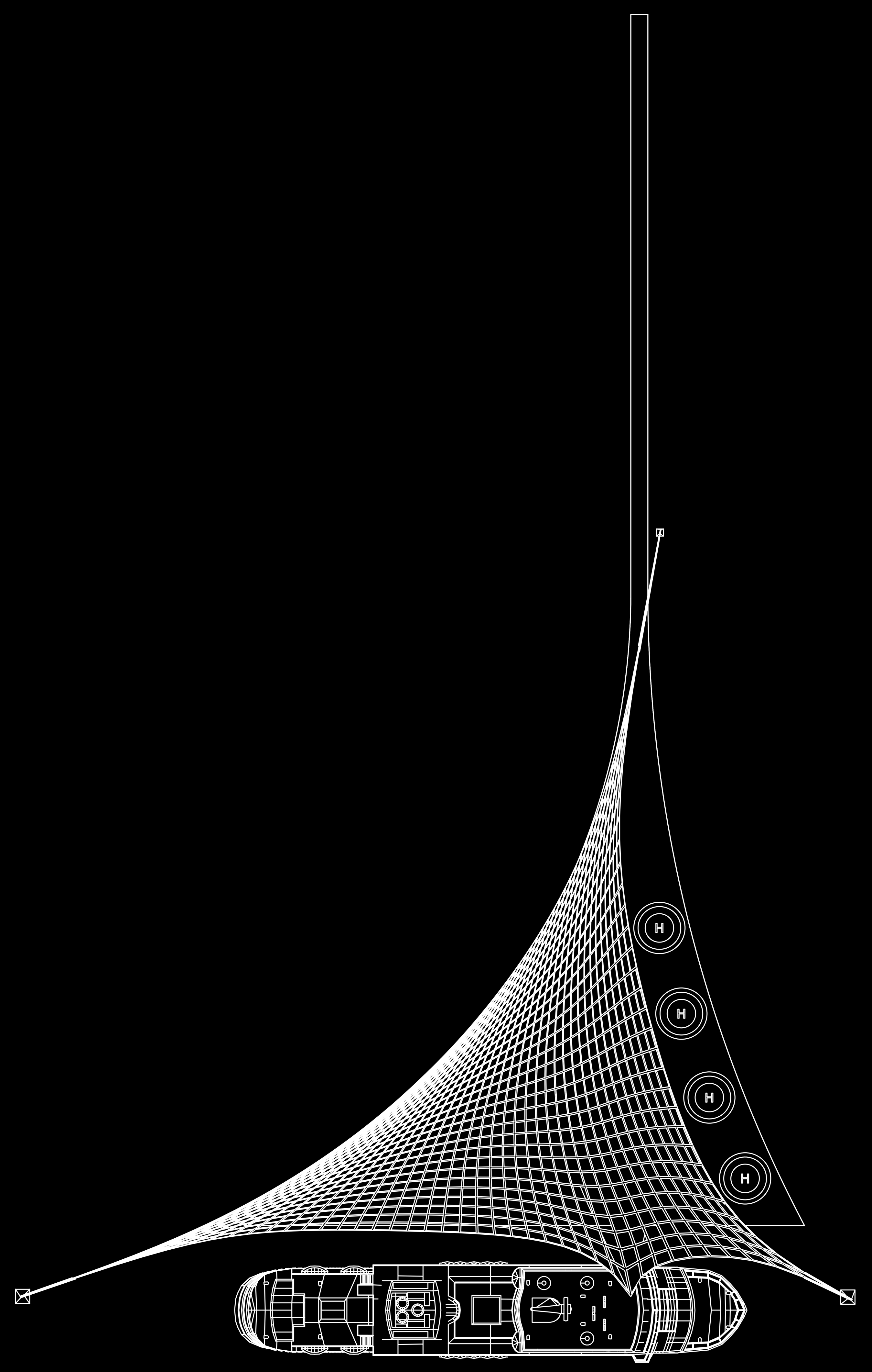
Parametric Modelling

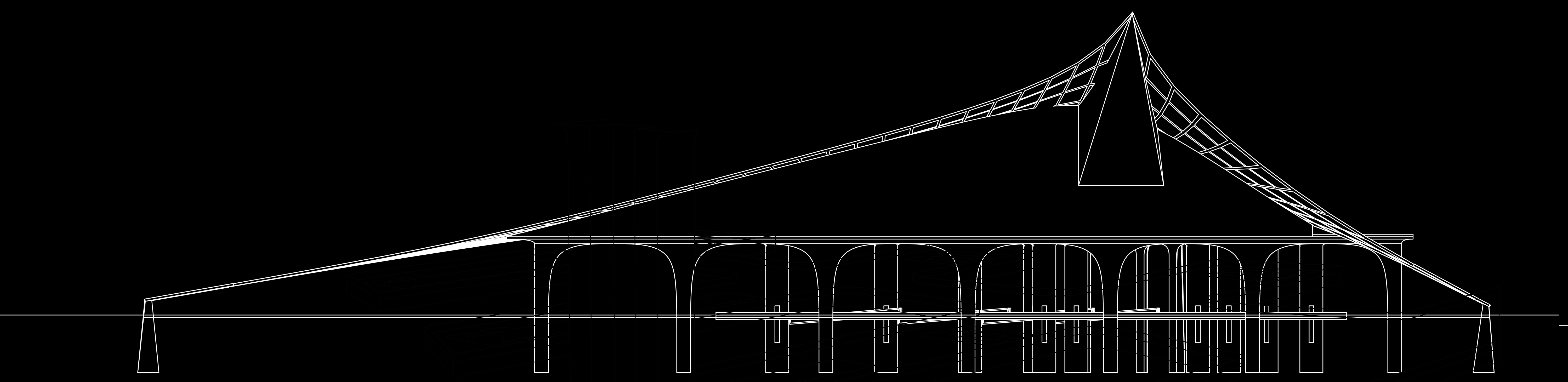
By further developing the grasshopper script, every single parameter and dimension of the main structure and the tensile structure were defined and interconnected. Adjustment on a single parameter may immediately affect all the dependent variables. By bringing parametric modelling into the structural design, the shape and the dimensions of the structure carry a sensible logic, while instant form finding became available, which eased detailed adjustment.

Curve Surface SubD Solid Mesh Dimension Transform Tools Analyze Render Panels V-Ray Help
Set View Display Select Viewport Layout Visibility Transform Curve Tools Surface Tools Solid Tools SubD Tools Mesh Tools Render Tools Drafting
Top Front Right
Point Mid Cen Int Perp Tan Quad Knot Vertex Project Disable
y 369.96 z 0.00 Meters Default Grid Snap Ortho Planar Osnap SmartTrack Gumball Record History Filter Available physical memory: 8289 M
File Edit View Display Solution Help
Tensile Shape Roof V2*
Params Maths Sets Vector Curve Surface Mesh Intersect Transform Display Dragonfly Wb HB-Energy Ladybug Kangaroo2 HB-Radiance Honeybee V-Ray Karamba3D
Analysis Division Primitive Spline Util
17%
36
1.0.0007

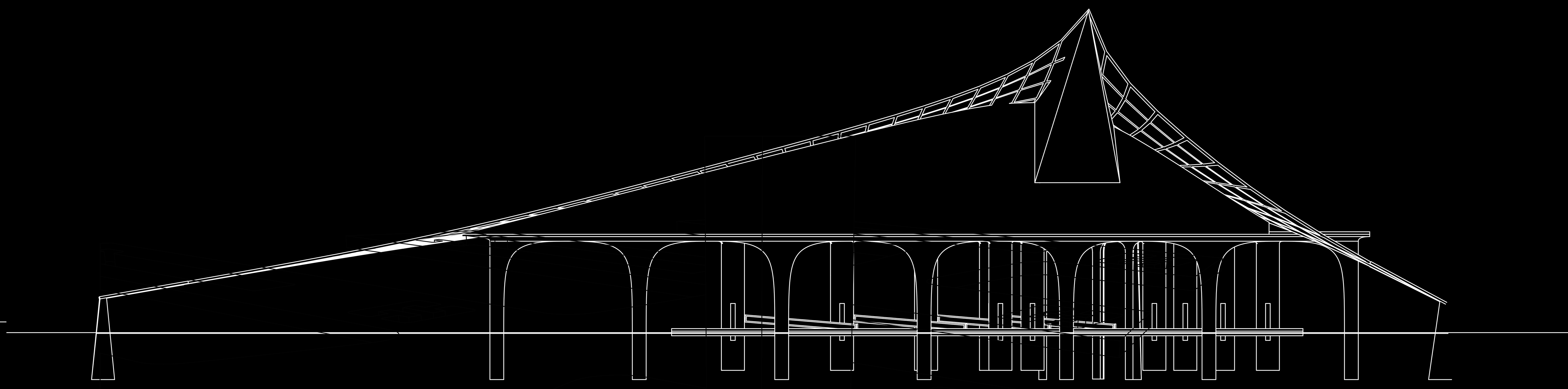

905m
590m
0
200
400
600
800
1000
1200
1400
1600
1800
2000 m





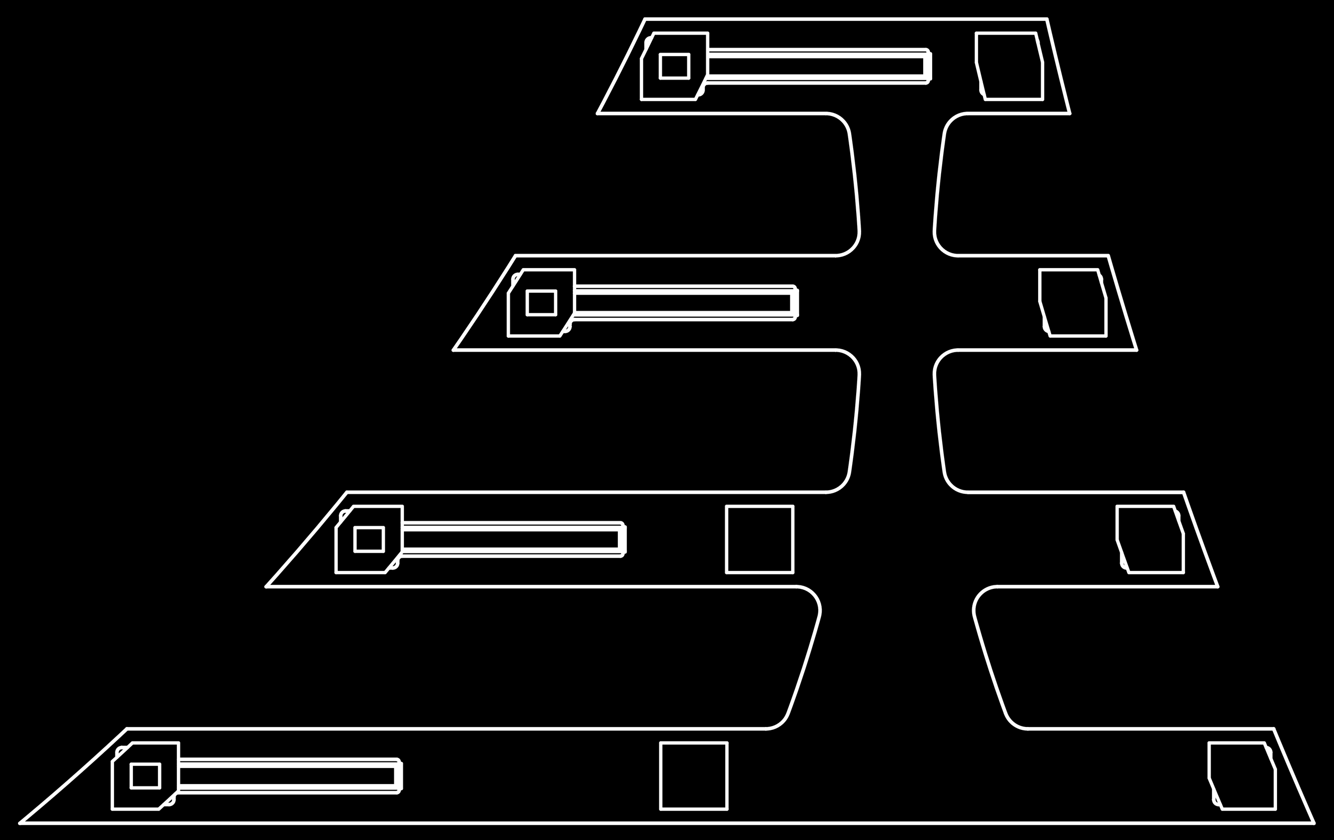


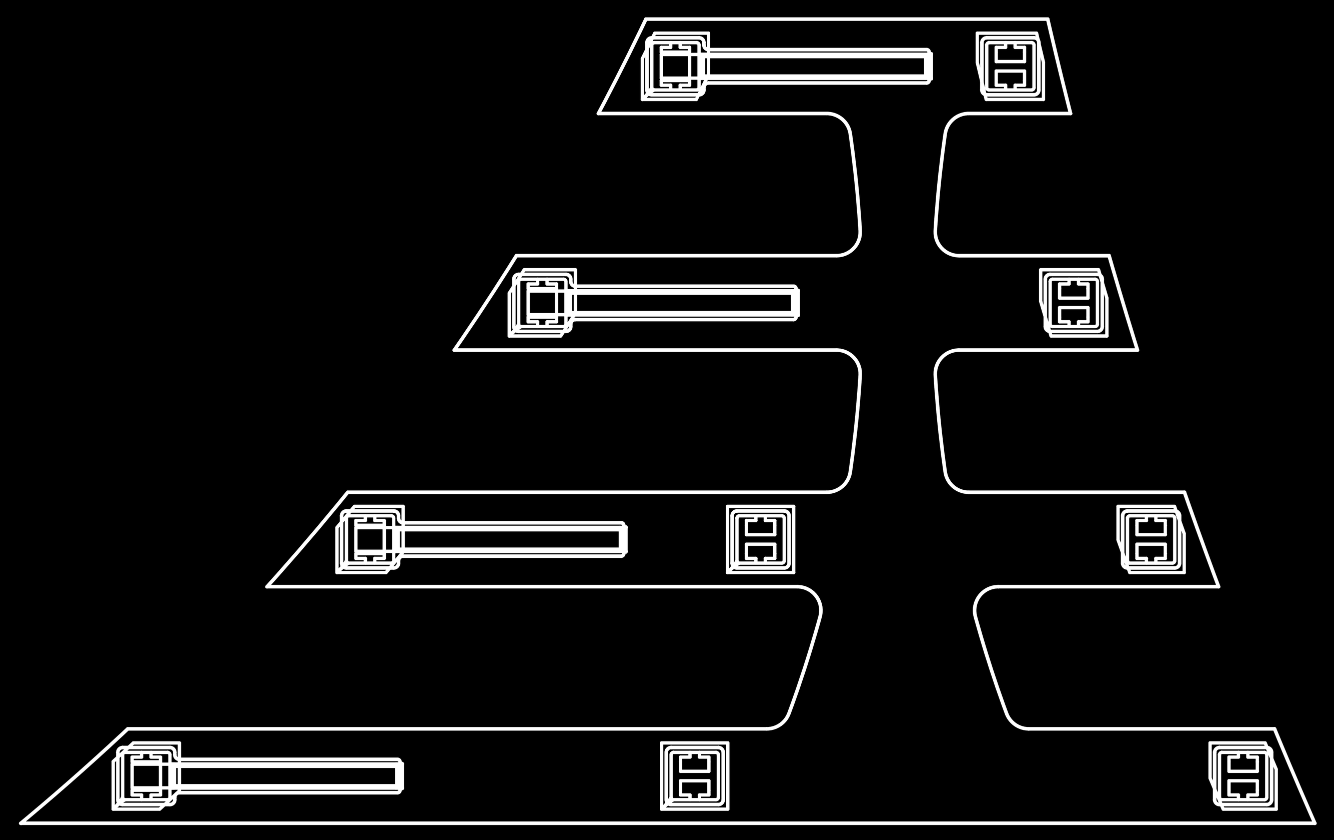
High Tide

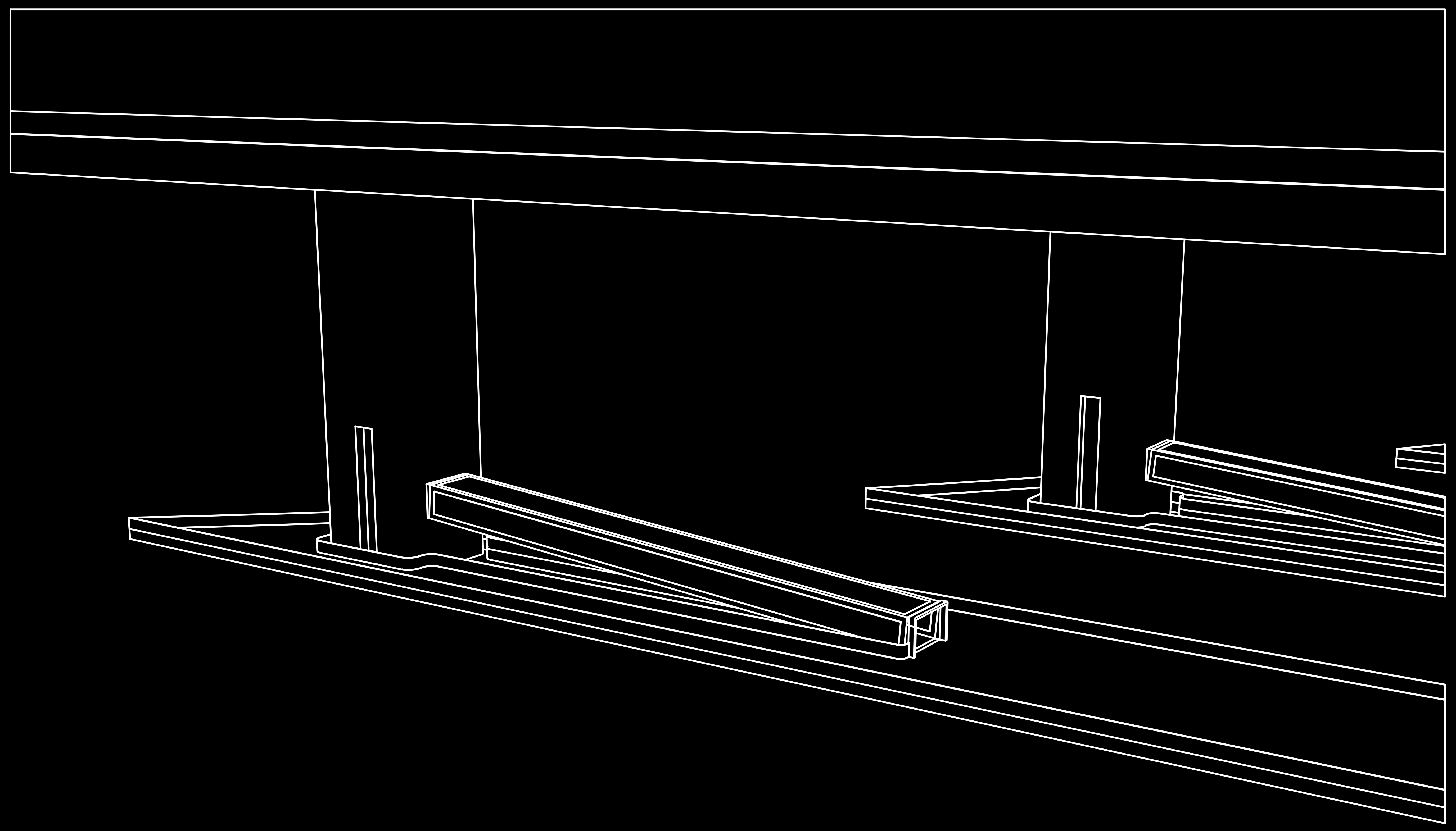


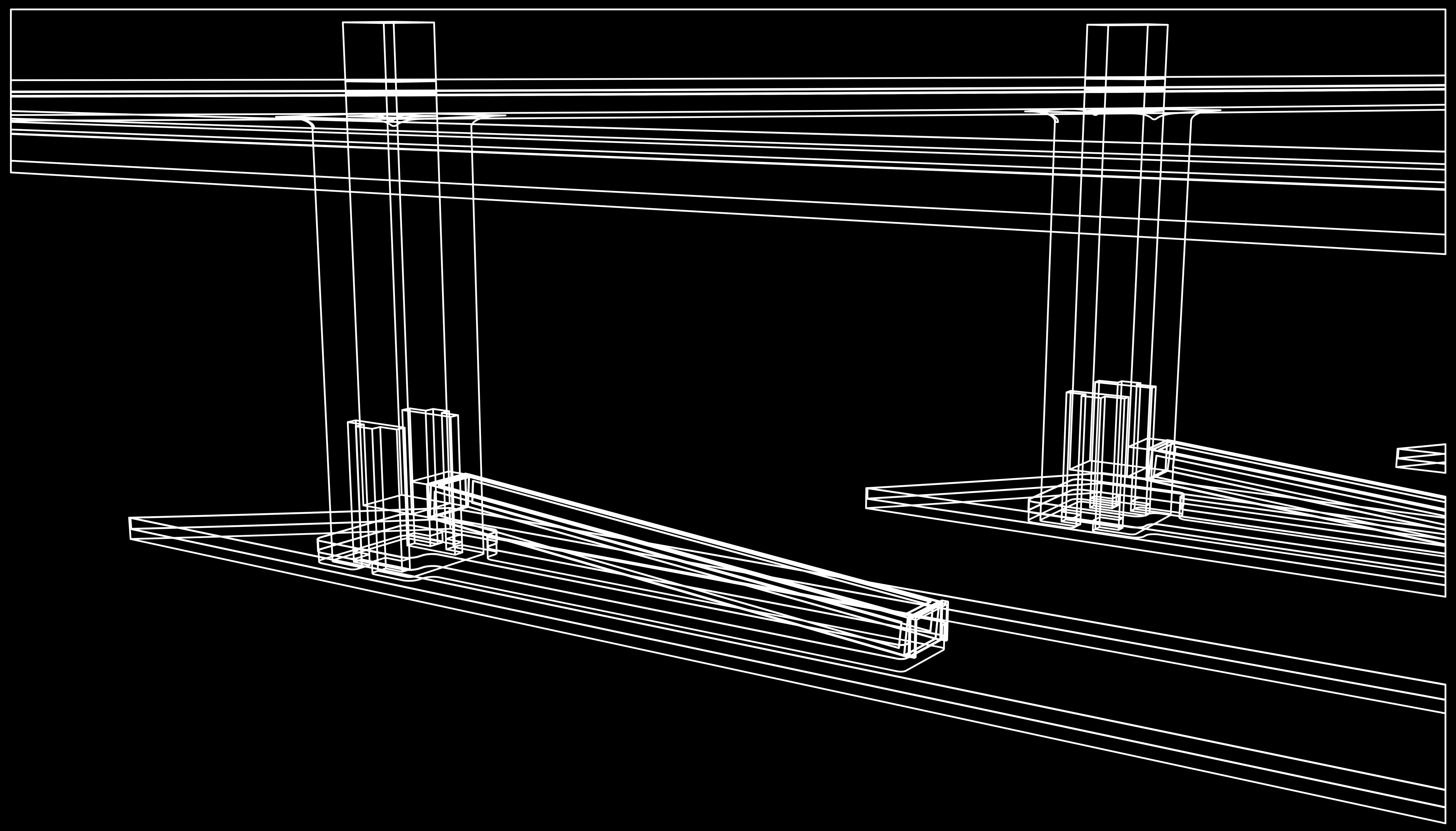
Low Tide

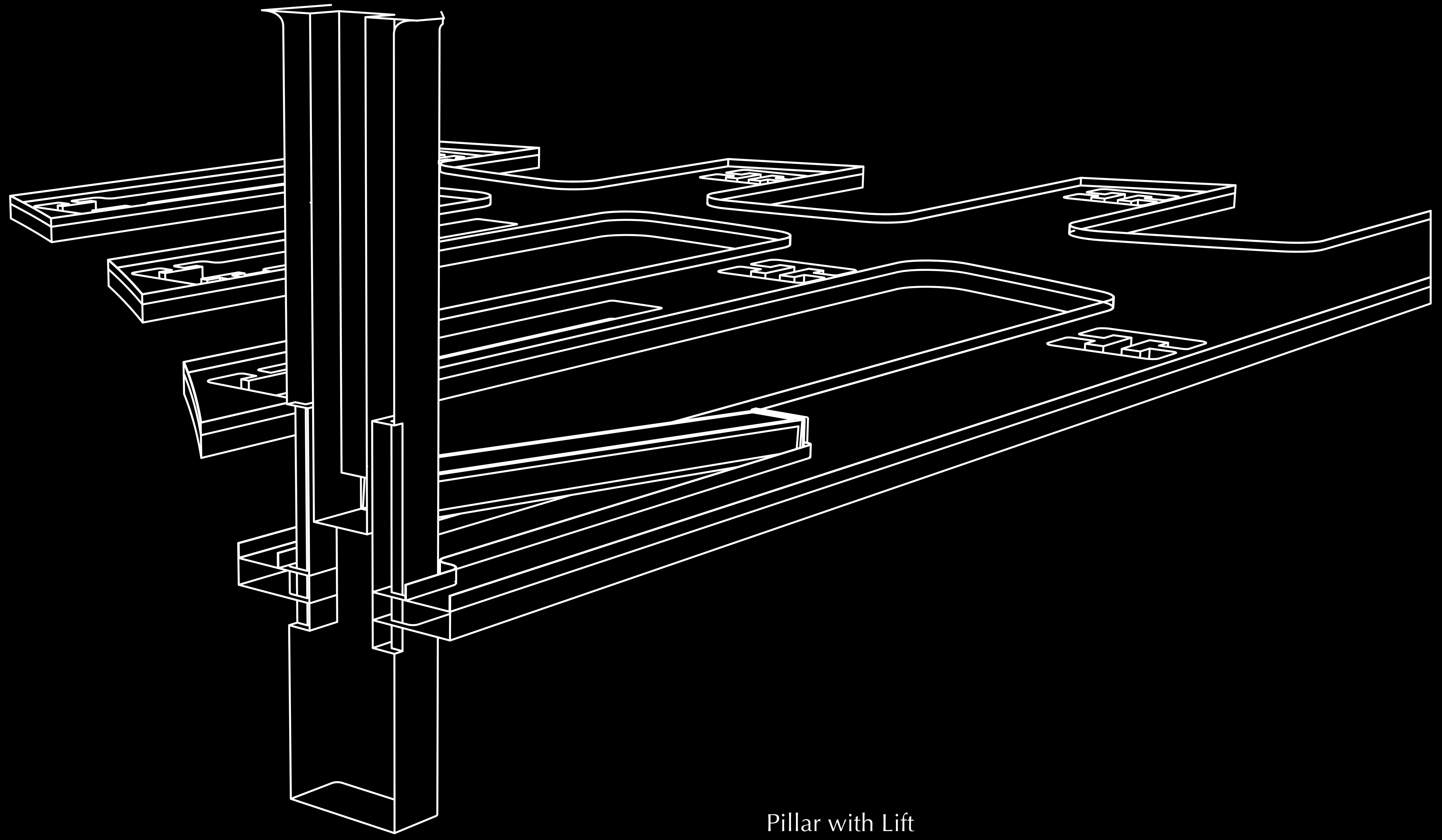
Due to the vast tide difference, the lower level was designed to be floating with the tide. The connection between the two levels was designed to be fixed lifts, each followed by an adjustable ramp that connects the lower level with the lift. The lower level no longer provides liner platforms as interconnections between the platforms were added for more convenience.



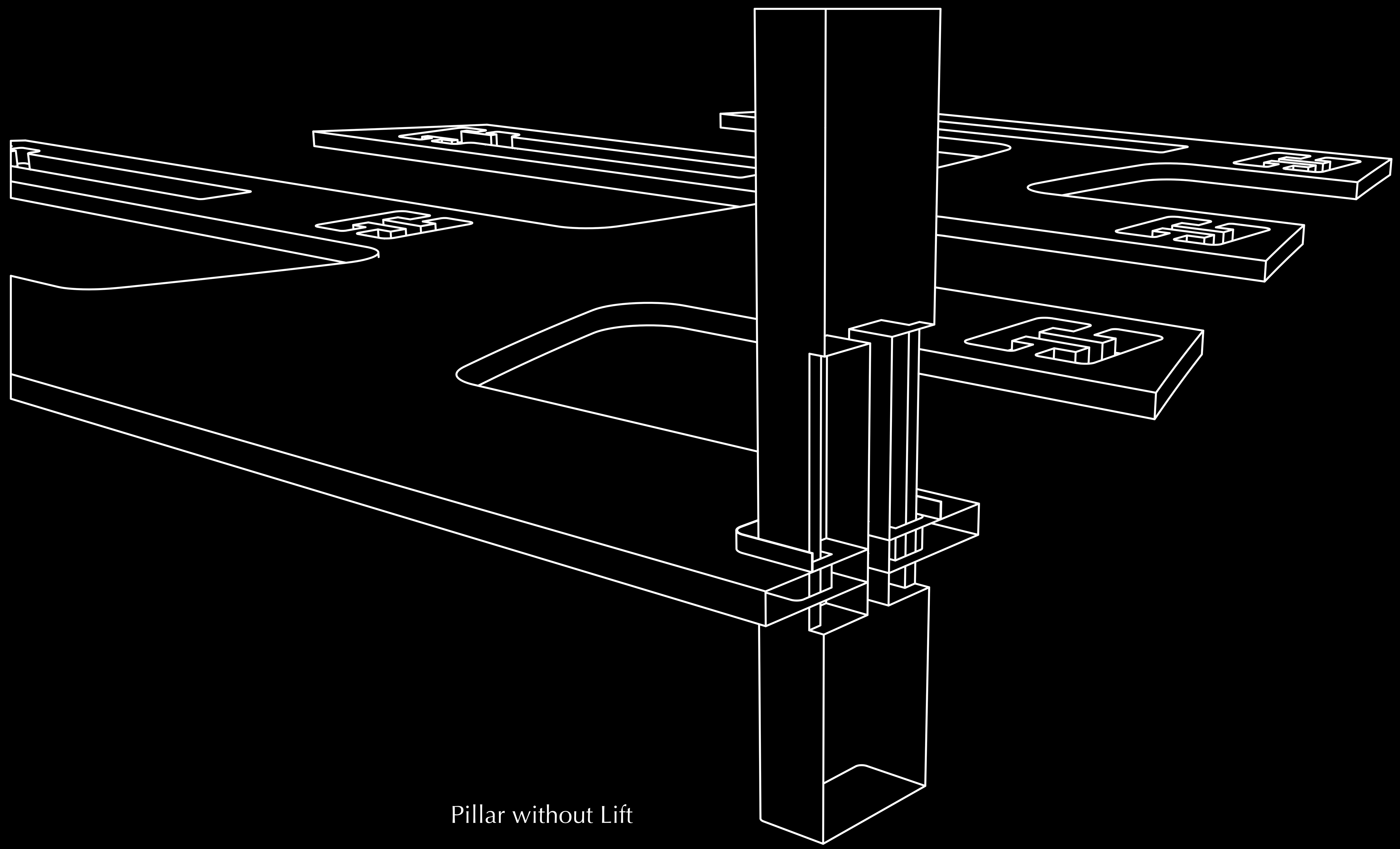








Pillar with Lift



Pillar without Lift

Iteration IIS - Redefining Roof

Based on iteration II with parametric modelling applied, iteration IIS with reference to Frei Otto explored more possible shapes of the tensile structure. A symmetrical shape with an opening at the centre was tested, as well as stretching the tensile structure toward the island end of the bridge to cover the entire bridge to enhance the consistency of the entire structure. The building located on the upper level was also explored by associating it with spheres to form separate buildings with consistency.

Offset terminal edge

Form shapes from offsets & circulation circle

Plan View

Isolate Buildings

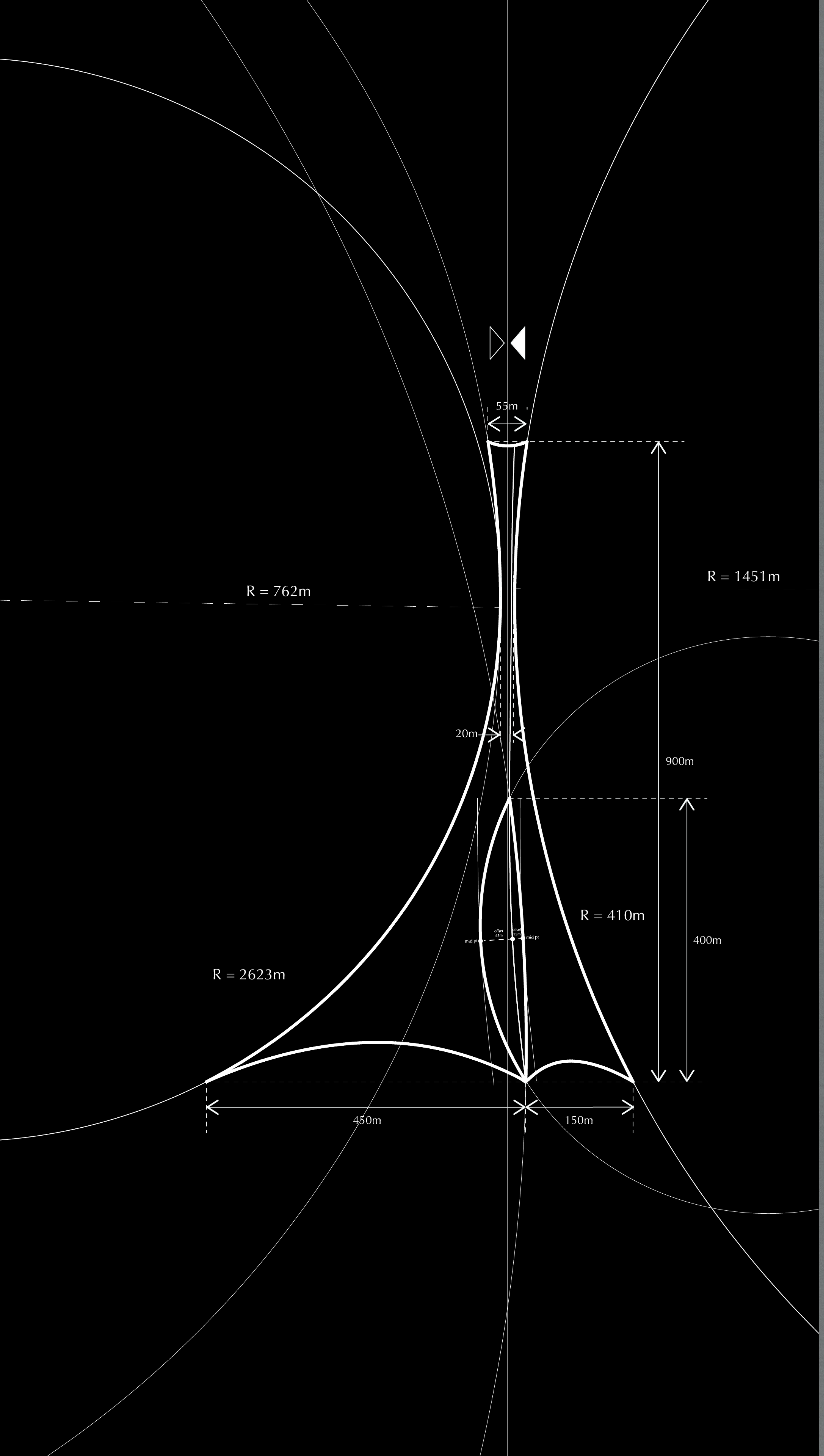
Cut all by sphere for consistency

Three coorelated buildings

Plan

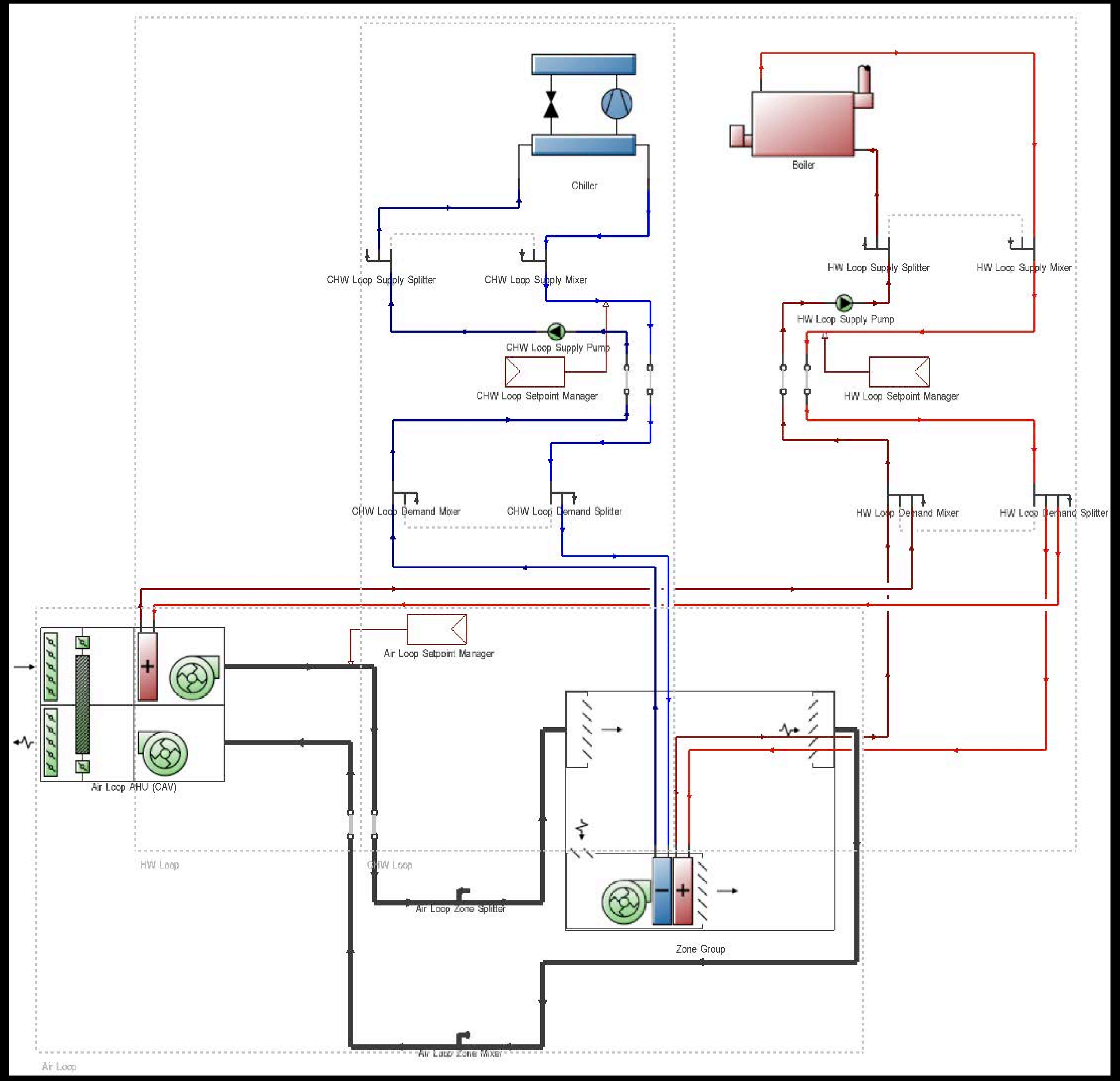
Iteration III - Standardising Shape

Combining the opening and the stretch of the tensile structure, a consistent, more realistic design was generated. By moving the heliports to the top of the intruding columns within the opening, the main structure was fully covered by the tensile structure, forming a consistent shape defined by the frame of the tensile structure. A respective opening on the upper level activates the use of vertical space by adding ramps to connect the two levels while providing natural lighting to the lower level.

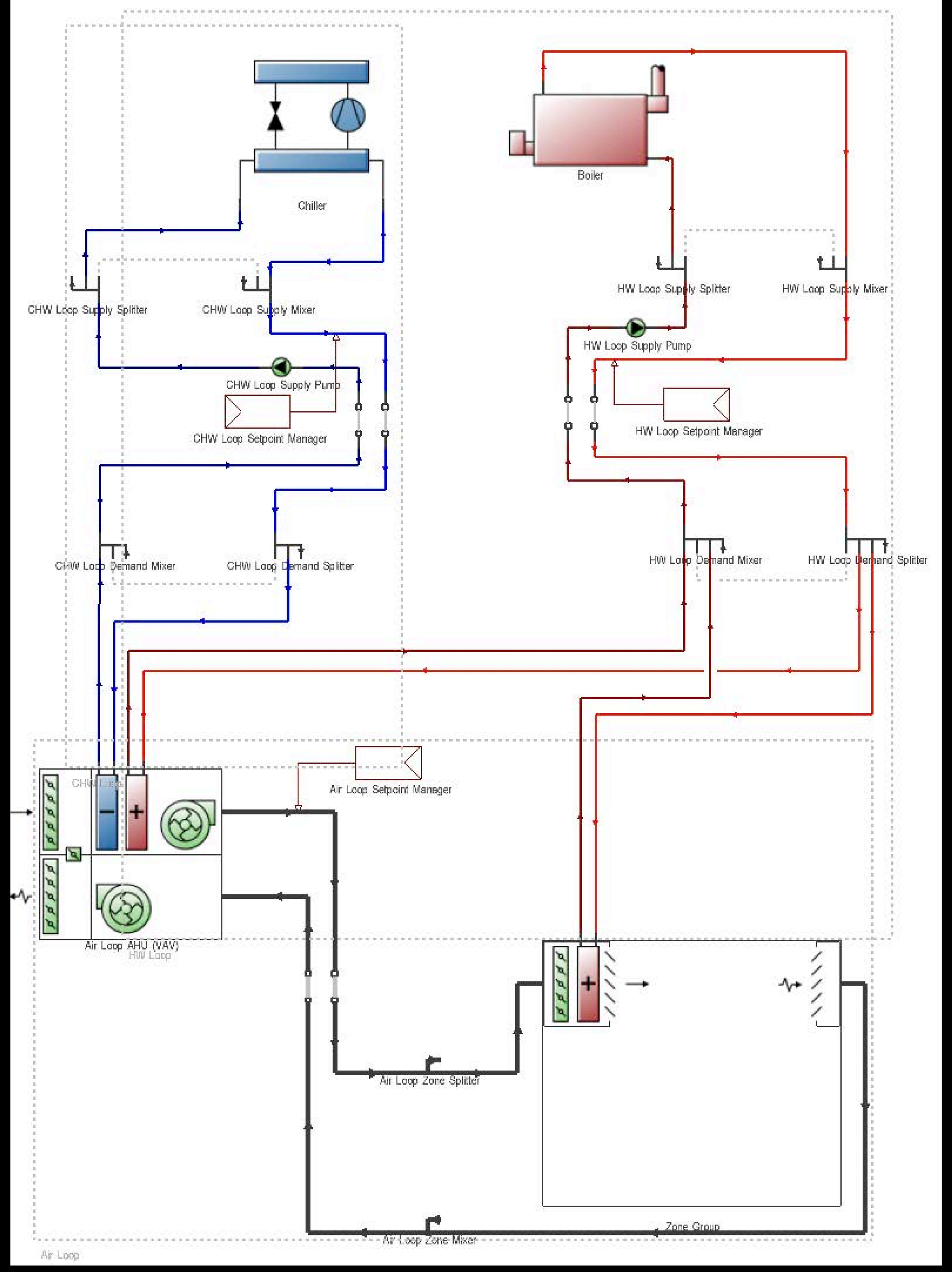

55m
R = 762m
R = 1451m
20m
900m
R = 410m
400m
R = 2623m
450m
150m

Environmental Analysis V - HVAC System

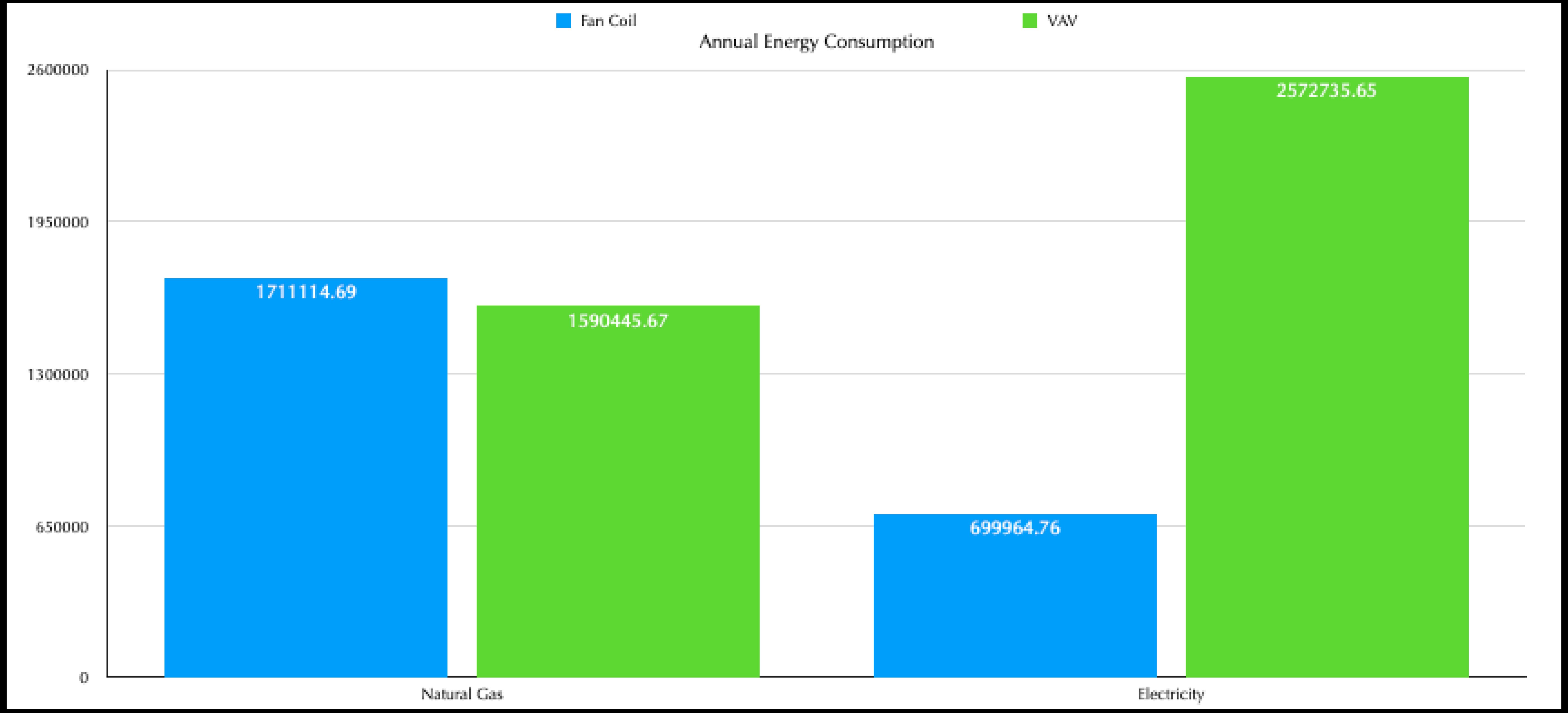
Using the model from shoebox modelling, a single zone building was tested with two HVAC systems: VAV and Fan-Coil systems, the configuration of both are as shown.



Fan-Coil System

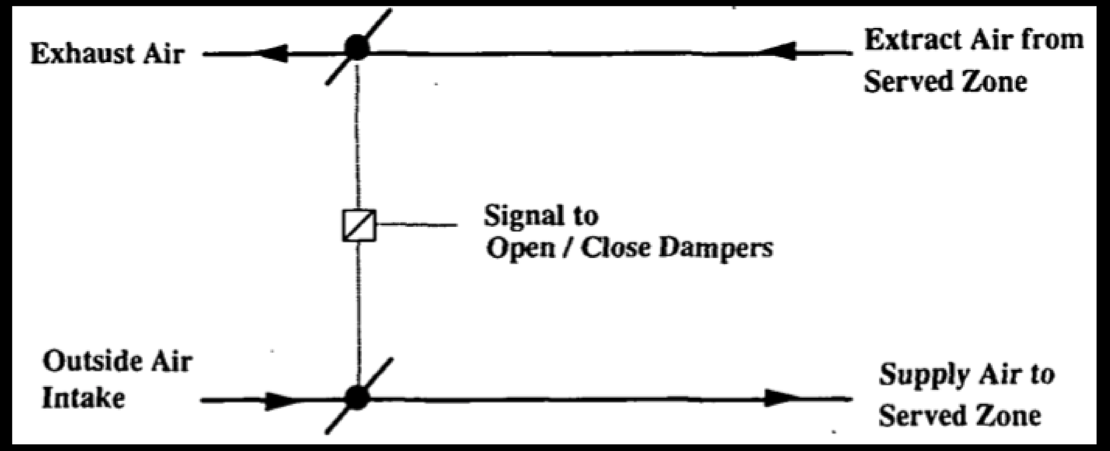


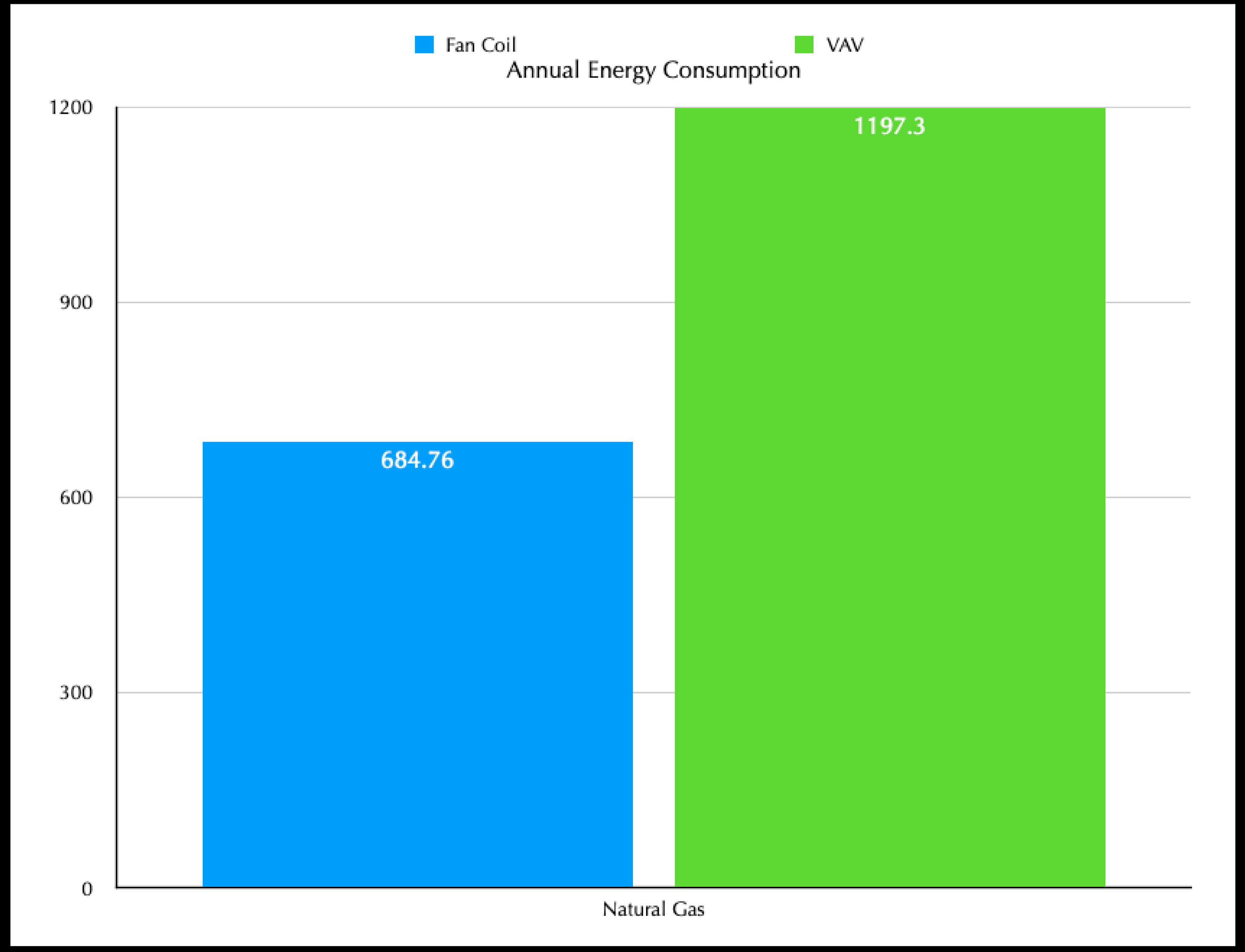
VAV System

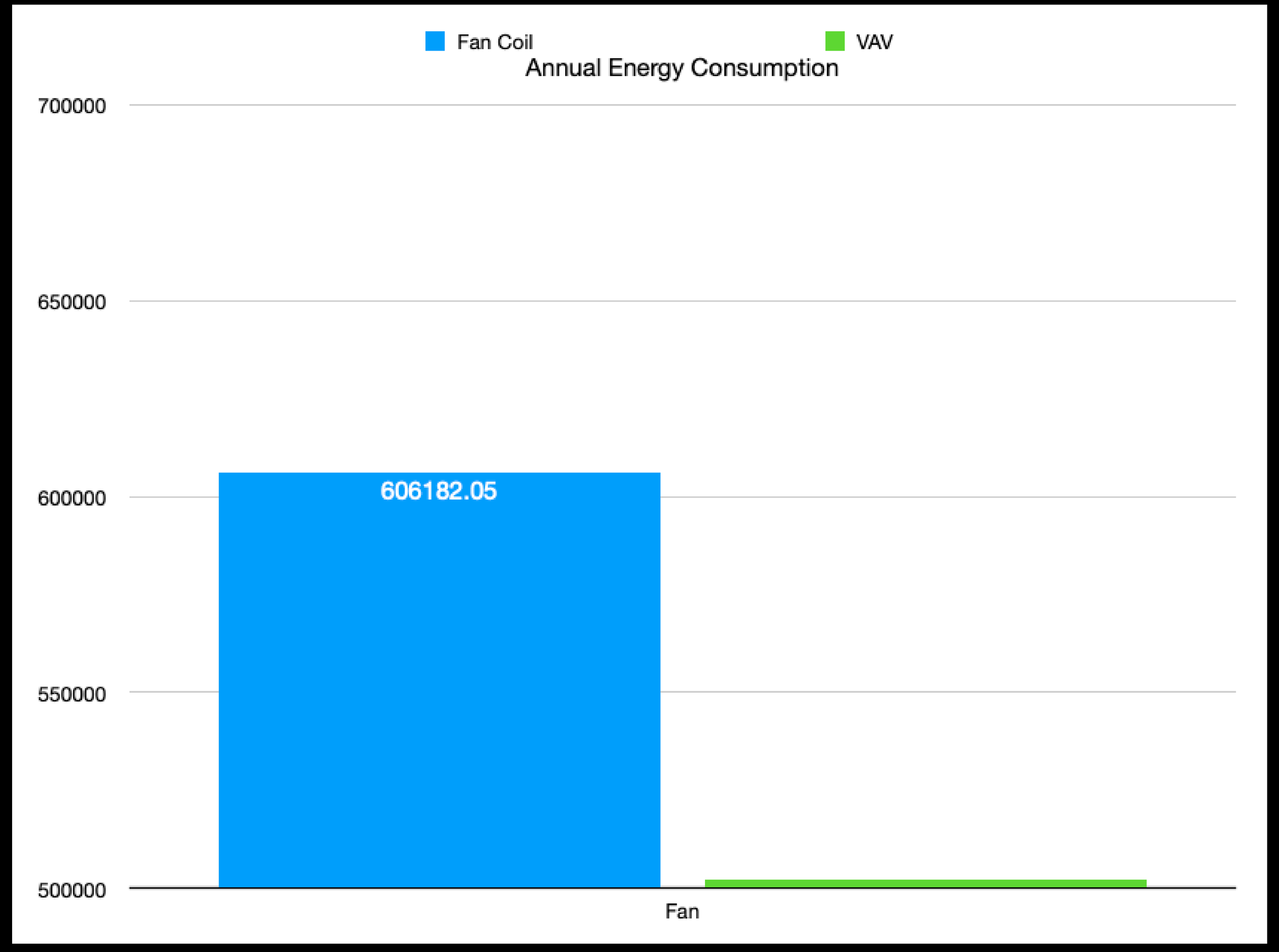


Fan-coil system shows a significantly less energy consumption than the VAV system, which mainly uses energy from fans.

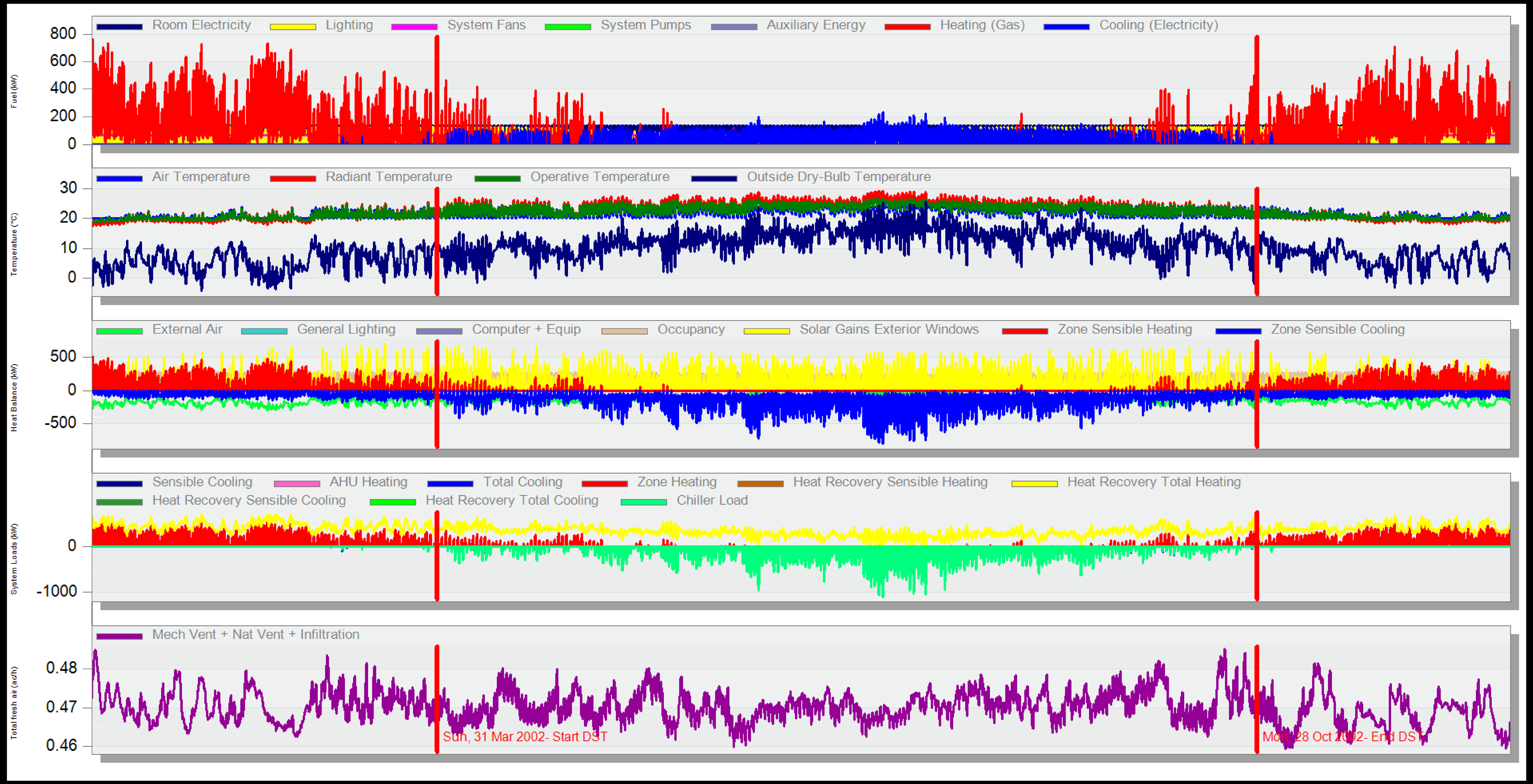
In terms of improvements, the current configuration does not have any sensors within the system that provide set-point temperature data at specific points (exist of AHU, end of the chiller, end of the heater, end of humidifier, etc.) for real-time adjustment to the load of different component of the system. Moreover, the strategy of installing a complete outside air damper system could be added, with an example as shown. The outside air could be allowed to enter the inside of the space to maintain the occupant's well-being by assisting the adjustment toward the ideal indoor condition through the control of the outside air damper. Vice versa, the control of the exhaust air damper allows the inside air to be extracted to the outside for the same aim. The outside air damper remains fully opened when occupied and fully closed during the unoccupied periods, along with the exhaust air damper to balance the system. Both dampers are only opened when the switch at the end of the respective damper was made, which has a linked hardwired interlock to provide its ability to enable the supply fan.



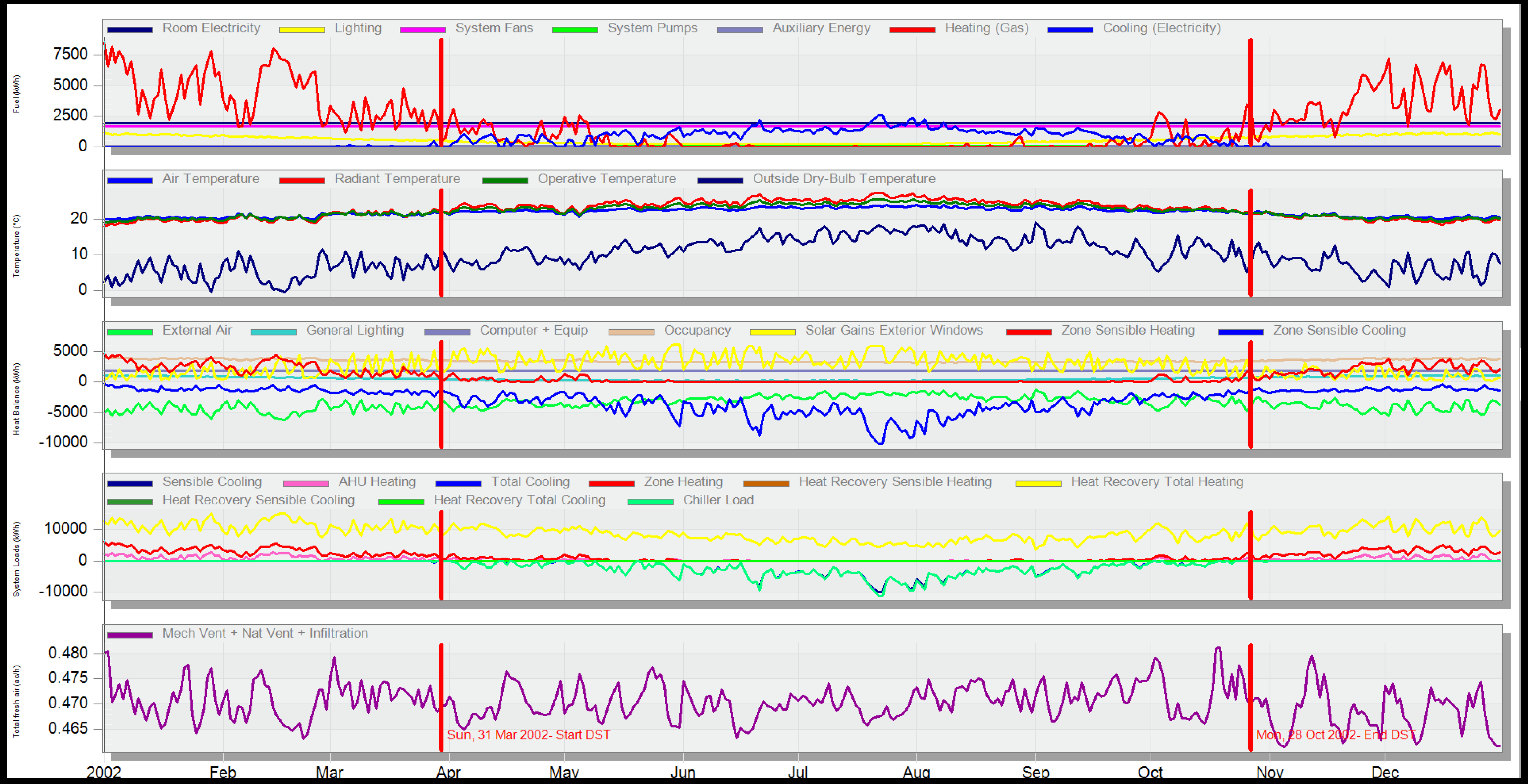




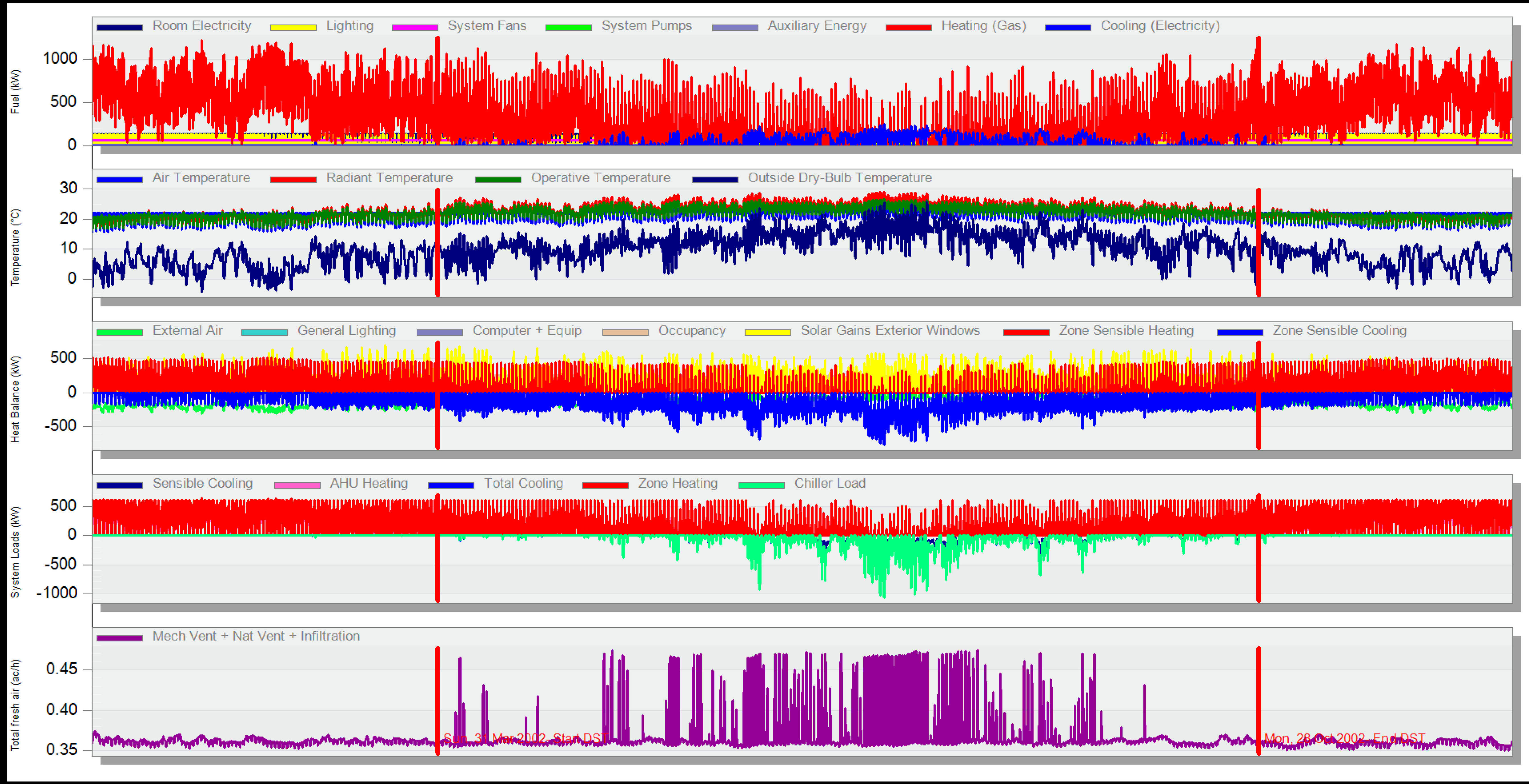
The fan-coil system shows constant activities throughout the year; in contrast, the VAV system shows more muscular activities during the summer. As the air temperature pattern shows a similar pattern, the Fan-coil system with its dominating less energy consumption was chosen.



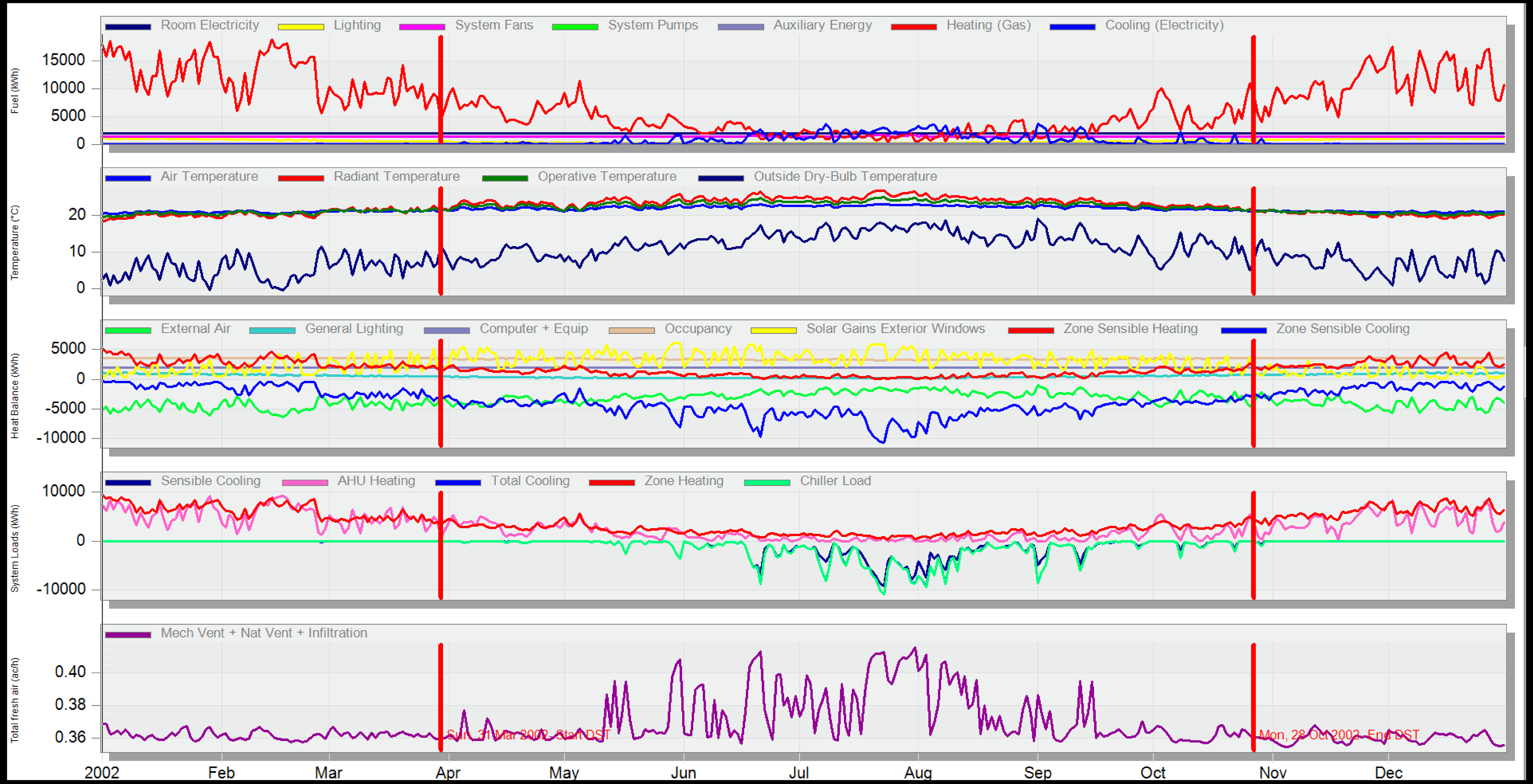
Fan-Coil Hourly Results



Fan-Coil Daily Results



VAV Hourly Results



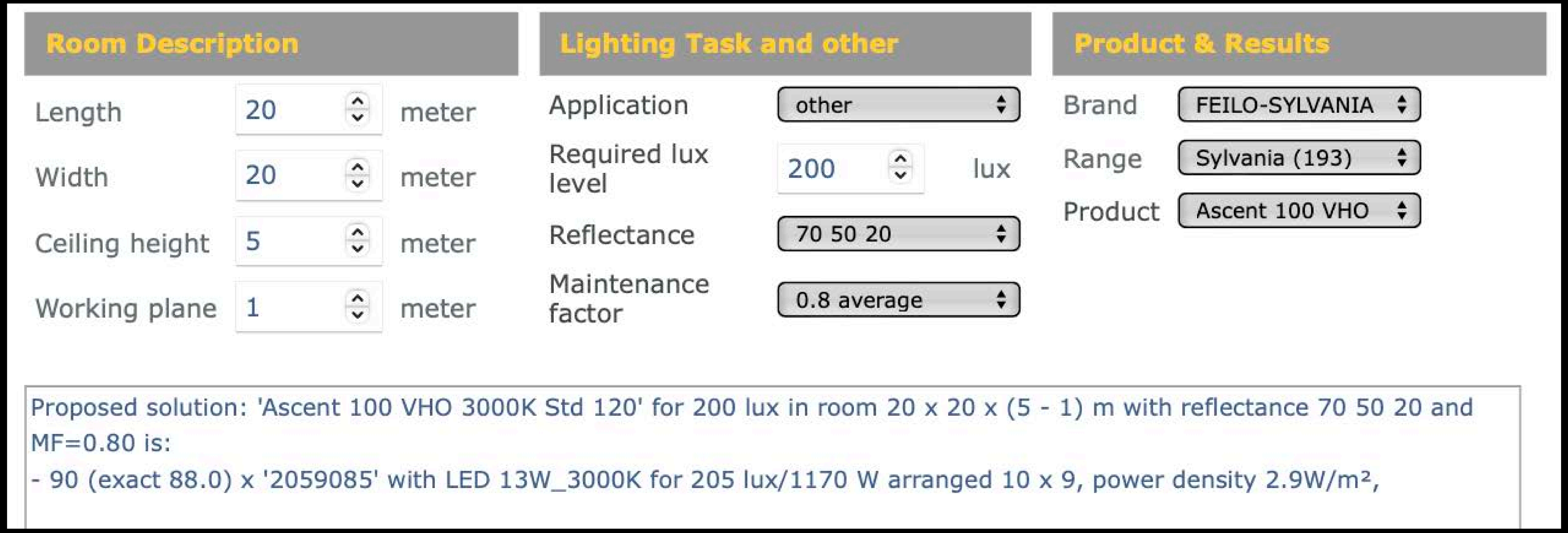
VAV Daily Results

Phase 3 - Resolution

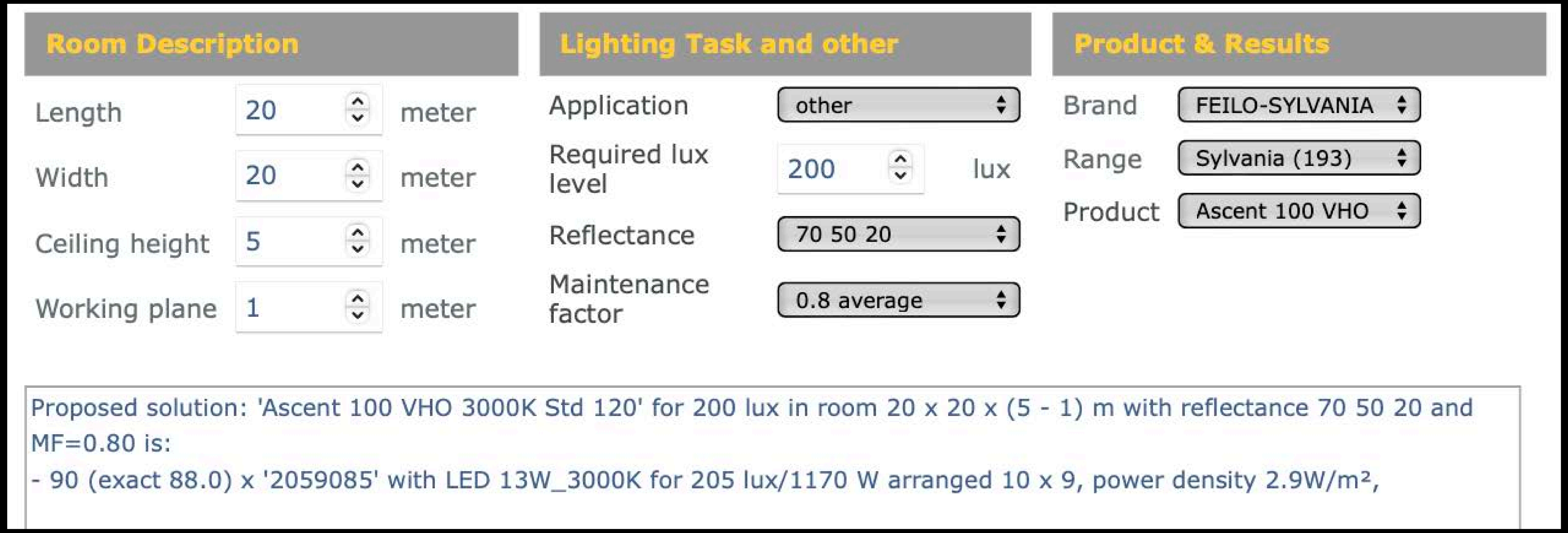
Environmental Analysis VI - Electircal Lighting

Three areas in the terminal are identified to be with different lighting requirements based on their functions and occupancy types. By utilising the java script for rapid lighting design provided by fold1 and following the guidance on the recommended illuminance for different purposes according to CIBSE Guide A Table 1.5, the following list of lighting equipment specifications could be classified for each area.

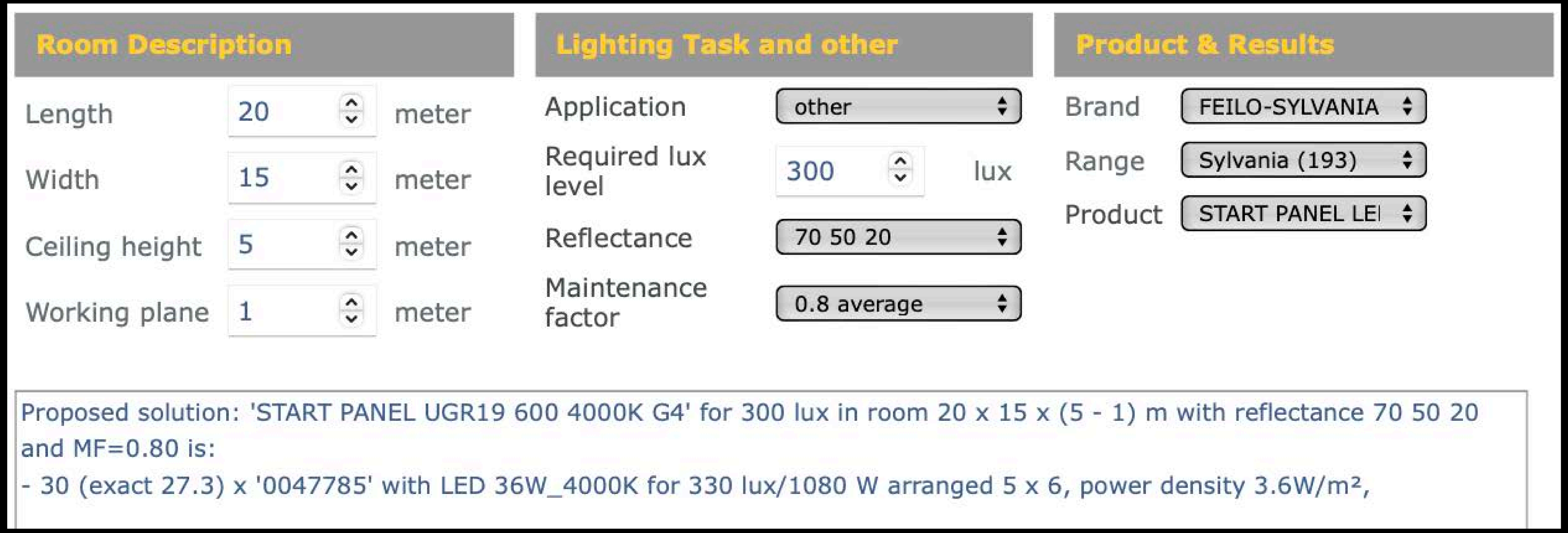
The first area is the circulation area on the upper level, estimated to have a length of 200 meters and a width of 150 meters. The ceiling height is thought to be 10 meters to form an immense sense for the terminal. The working plane is set to be 1 meter to fulfil any lighting equipment requirements. The colour temperature is set to be maintained at 6500K. This area was defined as “departure lounge” with 200 lux of recommended illuminance. A large LED panel is thought to be the most energy-efficient type of light to be utilised to illuminate such a vast area. The results are listed below, showing that approximately 300 sets of ‘Start Waterproof LED 80W 1565mm 6500K’ are required.



The second area is a single dining area within the restaurant building on the upper level, estimated to have a length of 20 meters and a width of 20 meters. The ceiling height is thought to be 5 meters. The working plane is set to be 1 meter to fulfil any lighting equipment requirements. The colour temperature is maintained at 3000K to create a relaxing atmosphere. This area was defined as “restaurant/dining rooms” with 200 lux of recommended illuminance. The downlight is thought to be the most appropriate light to be utilised. The results are listed below, showing that approximately 90 sets of ‘Ascent 100 VHO 3000K Std 120’ are required.



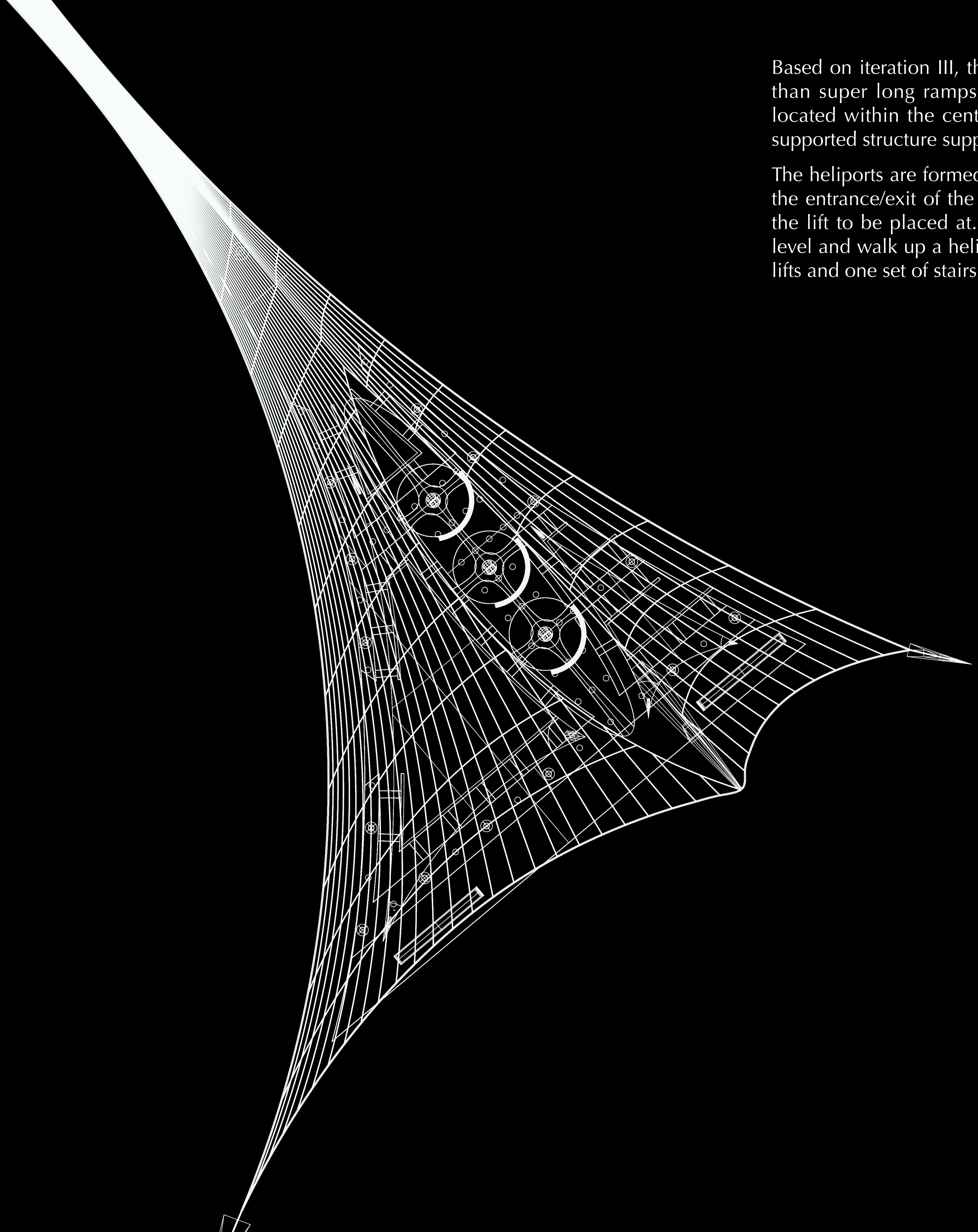
The third area is the ticket office located on the upper level, estimated to have a length of 20 meters and a width of 10 meters. The ceiling height is thought to be 5 meters to form an immense sense for the terminal. The working plane is set to be 1 meter to fulfil any lighting equipment requirements. The colour temperature is set to be maintained at 4000K. This area was defined as “ticket office” with 300 lux of recommended illuminance. To illuminate such an office-like area, an LED panel is thought to be the most energy efficient type of light to be utilised. The results are listed below, showing that approximately 30 sets of ‘START PANEL UGR19 600 4000K G4’ are required.



Final Iteration


500 m

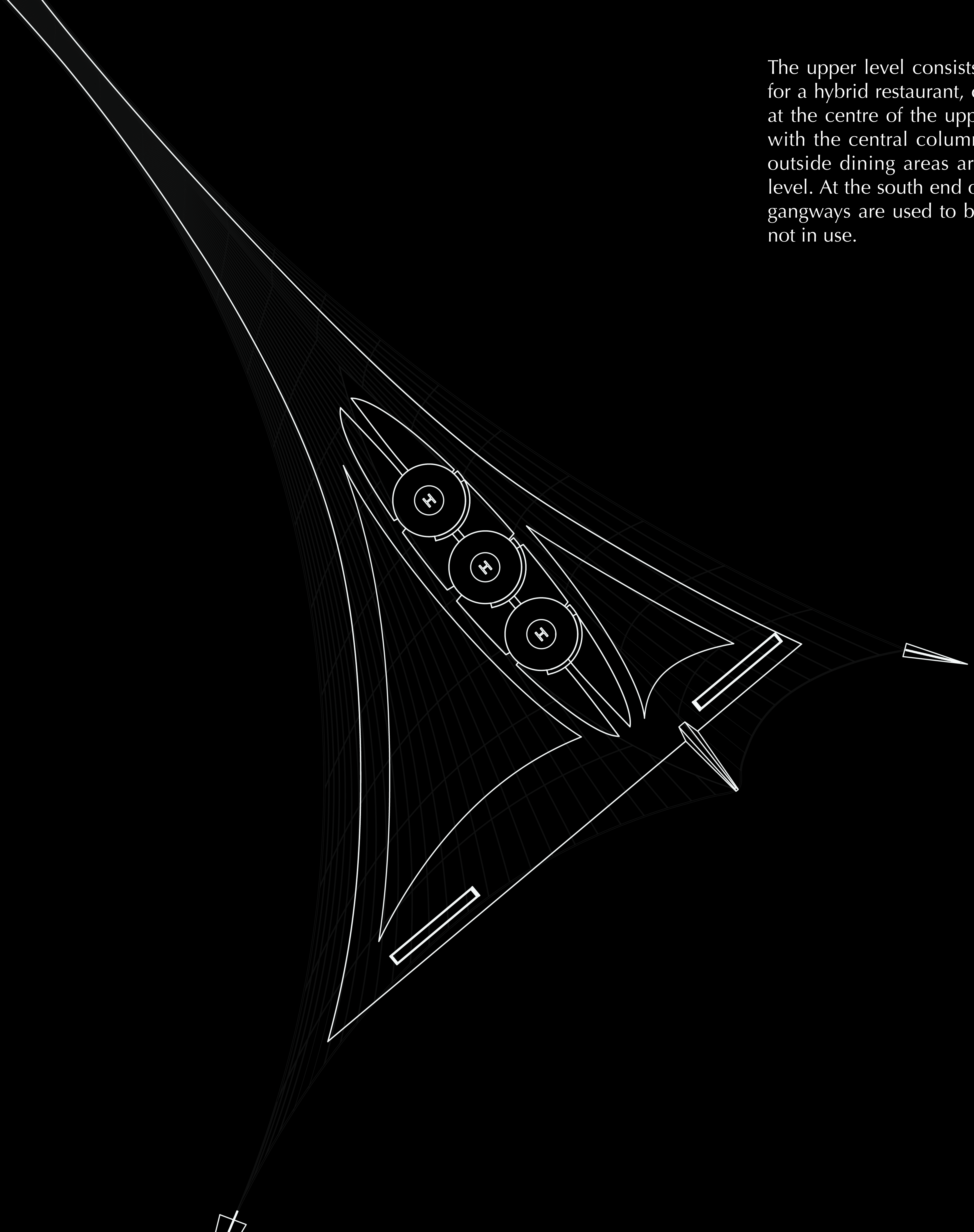

500 m



Based on iteration III, the logic of connection between the levels was improved. Rather than super long ramps, all levels are connected through rigid lifts and sets of stairs located within the central columns. The lower level becomes a solid pile-foundation-supported structure supporting the upper level.

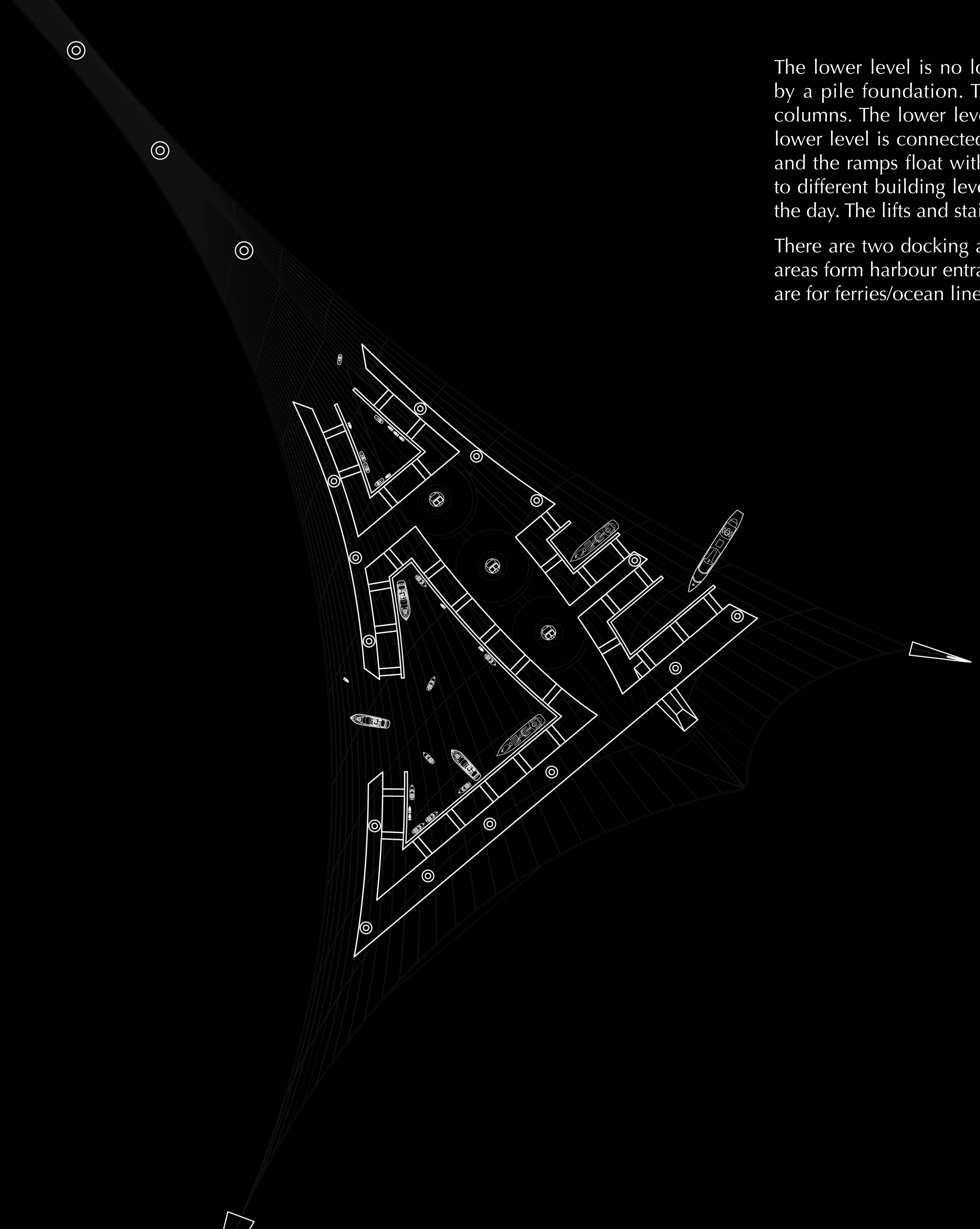
The heliports are formed with a heliport level and a sub level right under which to place the entrance/exit of the lifts since there is no intrusion allowed on the heliport level for the lift to be placed at. All passengers travelling for helicopters exit the lift on the sub level and walk up a helix ramp to the heliport level. Each central column consists of two lifts and one set of stairs.

The upper level consists of two buildings with parabolic-design roofs and layouts, both for a hybrid restaurant, cafe, ticket office, shops, and circulation areas. The oval opening at the centre of the upper level contains a series of bridges connecting the upper level with the central columns to access the lifts and stairs toward the other levels. Curved outside dining areas are reserved for the restaurants at the east and west ends of the level. At the south end of the upper level is the cruise liner boarding area. The telescopic gangways are used to board the cruise liners. They could be rotated to be folded when not in use.



The lower level is no longer floating but a three-storey rigid building firmly supported by a pile foundation. The lower level supports the upper level along with the bridge columns. The lower level is divided into four floors, three storeys plus a roof level. The lower level is connected with the docking bays with numerous ramps. The docking bays and the ramps float with the tide. Depending on the tide height, the ramps are attached to different building levels. Part of the lower level is underwater for some periods during the day. The lifts and stairs give access to all levels.

There are two docking areas and two platform areas set on the lower level. The docking areas form harbour entrances to protect the ships docked within them. The platform areas are for ferries/ocean liners for short stays and rapid boardings.




Section - High Tide


Section - Low Tide

Upper Level

Lower Level

Perspective - Low Tide

Perspective - High Tide

Perspective - Low Tide

Perspective - High Tide

Environmental Analysis VII - Acoustics

To carry out acoustic analysis, the source was first identified; the loudest source in my project is the helicopters on the heliports. And the three most affected areas are the sub level of the heliport, the upper level of the terminal, and the building located on the upper level. The noise from the helicopter is significantly greater than the noise from the duct and the mechanical system. Therefore, the analysis focuses on the external noise made by the helicopter.

The sound reduction data was gathered using the acoustic calculator provided by ROCKWOOL, as shown below. The materials of the construction were approximated to the closest similar choices.

Sound Insulation Prediction (v8.0.1)

Program copyright Marshall Day Acoustics 2014

Rockwool International A/S - Key No. 2586

Margin of error is generally within Rw +/- 3 dB

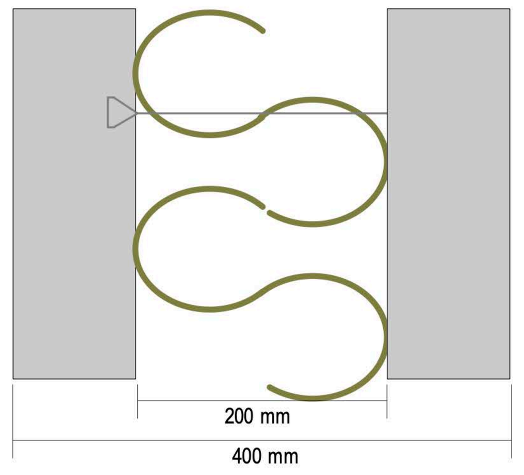
Job Name: A02

Job No.: 1122 Page No.:

Date: 7 Jul 16 Initials:

File Name: A02.ixl

Notes:



Rw 54 dB
C -1 dB
C_{tr} -4 dB
D_{nTw} 56 dB [V:50m3] [A:11m2]

System description

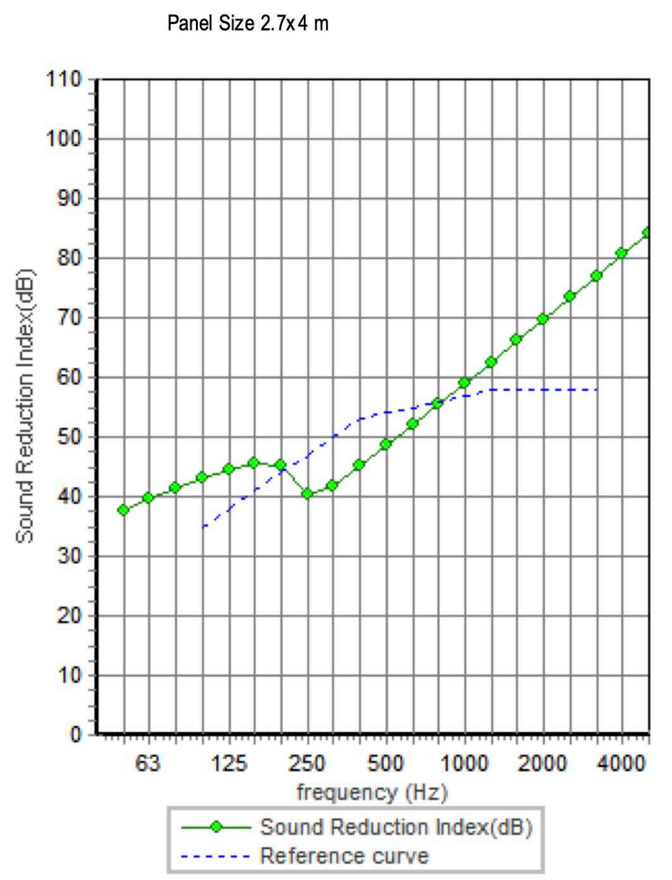
Panel 1 : 1 x 100.0 mm Concrete Block (Medium Dense) (ρ:1450 kg/m3,E:8.3GPa,η:0.02)

Cavity: Butterfly Tie ,Stud spacing 455 mm , Infill ROCKWOOL Cavity Thickness 200 mm (ρ:38 kg/m3, Rf:15421 Pa.s/m2)
Panel 2 + 1 x 100.0 mm Concrete Block (Medium Dense) (ρ:1450 kg/m3,E:8.3GPa,η:0.02)

Mass-air-mass resonant frequency =13 Hz

frequency (Hz)	R(dB)	R(dB)
50	38	
63	40	39
80	41	
100	43	
125	45	44
160	45	
200	45	
250	40	42
315	42	
400	45	
500	49	48
630	52	
800	55	
1000	59	58
1250	63	
1600	66	
2000	70	69
2500	73	
3150	77	
4000	81	80
5000	84	

Panel Size 2.7x4 m

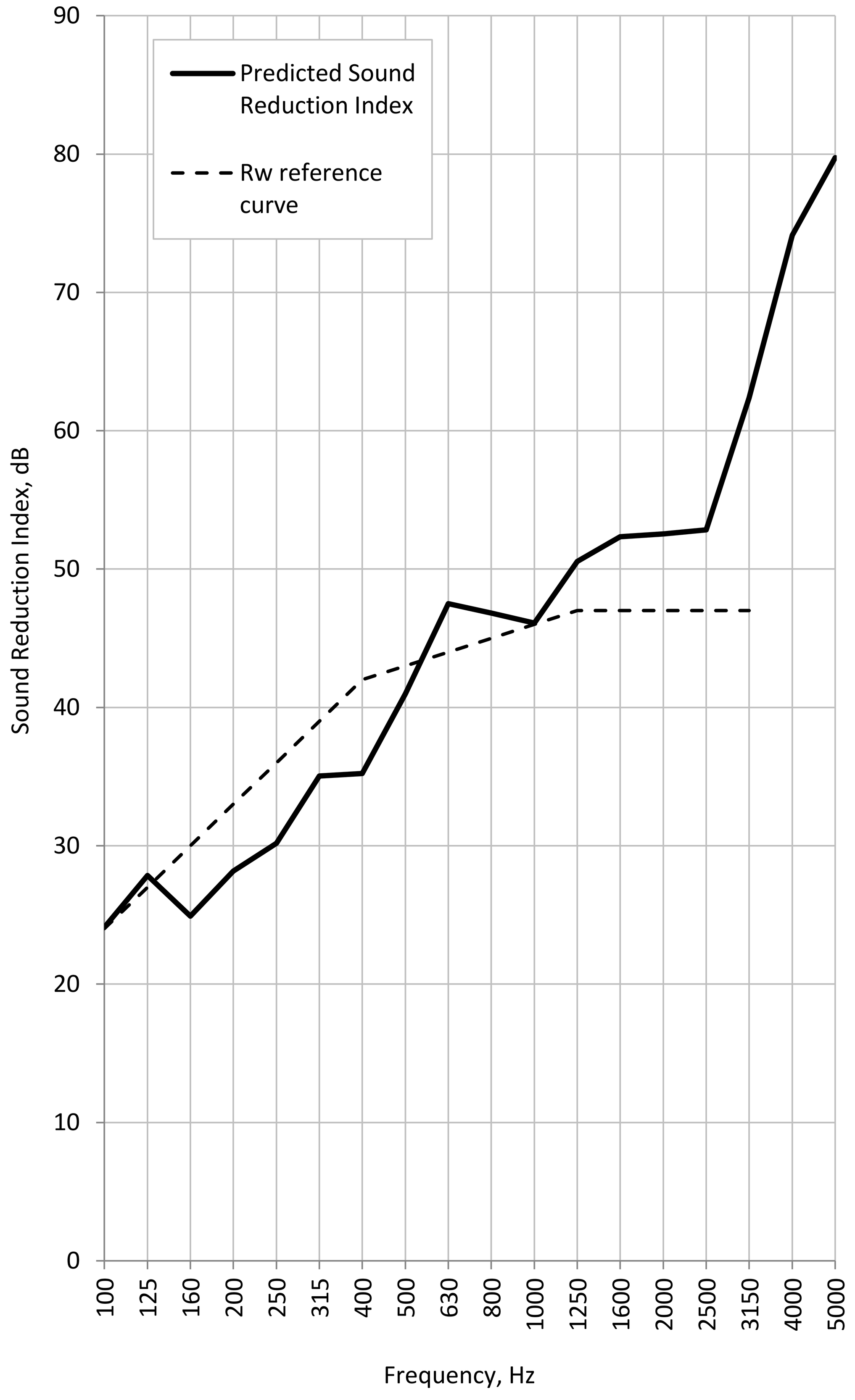


Building Wall

Reference: A08-0017
Deck Type: [redacted]
Thickness: 0.7mm
Mass Layer: [None]
Waterproofing: [redacted]
Insulation: 150mm ROCKWOOL Hardrock (DD) Multi-Fix
Weight: 40 kg/m² (approx.)

Freq f Hz	Predicted Sound Reduction Index, dB 1/3 Oct	1/1 Oct
50+	27.6	
63+	31.2	29.2
80+	29.3	
100	24.1	
125	27.9	25.4
160	24.9	
200	28.2	
250	30.2	30.3
315	35.1	
400	35.2	
500	41.0	38.8
630	47.5	
800	46.8	
1000	46.1	47.4
1250	50.6	
1600	52.3	
2000	52.6	52.6
2500	52.8	
3150	62.4	
4000	74.1	66.8
5000	79.7	
6300+	76.4	
8000+	72.0	69.2
10000+	65.6	
Average 100-3150	41.1	

+ increased uncertainty



Rating according to BS EN 717-1:2013

R_w (C;C_{tr}) = **43 (-2;-6) dB**

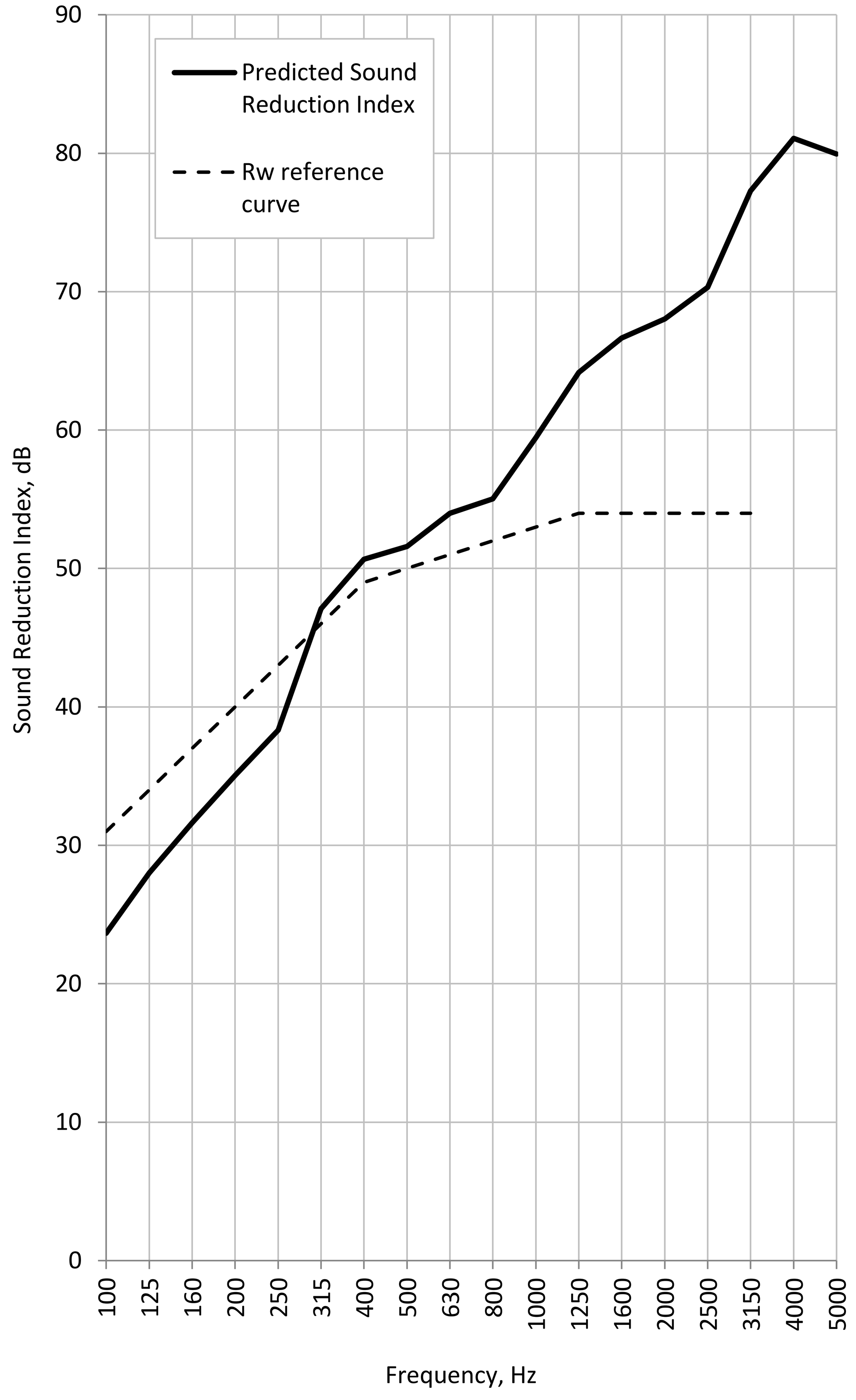
Predicted using data from test report:
DPA Cauberg-Huygen 20151078-03

Building Roof

Reference: A08-0032M
Deck Type: [redacted]
Thickness: 0.7mm
Mass Layer: ROCKWOOL Acoustic Membrane 5kg
Waterproofing: [redacted]
Insulation: 380mm ROCKWOOL Hardrock (DD) Multi-Fix
Weight: 80 kg/m² (approx.)

Freq f Hz	Predicted Sound Reduction Index, dB 1/3 Oct	1/1 Oct
50+	28.9	
63+	31.3	29.8
80+	29.7	
100	23.6	
125	28.0	26.6
160	31.6	
200	35.0	
250	38.3	38.0
315	47.1	
400	50.7	
500	51.6	51.9
630	54.0	
800	55.0	
1000	59.5	58.1
1250	64.2	
1600	66.6	
2000	68.0	68.1
2500	70.3	
3150	77.3	
4000	81.1	79.1
5000	79.9	
6300+	75.2	
8000+	70.3	67.0
10000+	63.2	
Average 100-3150	51.3	

+ increased uncertainty



Rating according to BS EN 717-1:2013

R_w (C;C_{tr}) = **50 (-3;-9) dB**

Predicted using data from test report:
DPA Cauberg-Huygen 20151078-03

Heliport Floor (Roof)

The sub level of the heliport only has the heliport level acting as its roof; it is then modelled with only the roof as the insulation and blocking material. 55.7 dB is estimated in this area, which is significantly loud. However, passengers are thought to only spend a concise period in this area, which would not lead to a significant health issue.

	Road Traffic Noise Intrusion Analysis																
	Room Properties																
	Project:	Design Practice 2															
	Space:	Sub Level															
			Height:	Width:	Length:		Volume =	500	**Octave Band Center Frequency - Hz**								
Step 1:		**Room Dimensions (m):**	5	10	10		Surface =	400	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**	**A-wtd**
	Room Average Absorption Coefficient	Hard							0.05	0.07	0.1	0.15	0.2	0.2	0.2	0.2	
	Total Absorption (S * alpha)								20	28	40	60	80	80	80	80	
	RT60:								1.23	0.88	0.61	0.41	0.31	0.31	0.31	0.31	
	Source Definition(s)																
							Ref Dist (m)										
	Source 1:	Helicopter Noise					5		98	94	97	94	90	87	81	79	
	Src1 A-wtd								71.8	77.9	88.4	90.8	90.0	88.2	82	77.9	**95.9**
Step 2:	Src1 Adjustment	None	0														
	Source 2:						1		0	0	0	0	0	0	0	0	
	Src2 A-wtd																#####
	Src2 Adjustment	None	0														
	Façade Definition(s)																
	Façade 1	Roof					Dist to Src	Visible Φ									
						Src1	0.1	1	92.4	88.4	91.4	88.4	84.4	81.4	75.4	73.4	
						Src2	0.1	1	-12.6	-12.6	-12.6	-12.6	-12.6	-12.6	-12.6	-12.6	
			Height:	Width:	Area	Composite			92.4	88.4	91.4	88.4	84.4	81.4	75.4	73.4	
		Overall Dimensions (m):	10	10	100	Composite A-wtd			66.2	72.3	82.8	85.2	84.4	82.6	76.4	72.3	**90.3**
	Element	**Description:**															
					0												
					0												
					0												
					0												
					0												
					0												
	Wall	Heliport Floor			100				29.8	26.6	38	51.9	58.1	68.1	79.1	67	
	Composite SRI								29.8	26.6	38.0	51.9	58.1	68.1	79.1	67.0	
	Direct sound								62.6	61.8	53.4	36.5	26.3	13.3	-3.7	6.4	
Step 3:	Reverb sound								70.6	68.4	58.4	39.8	28.3	15.3	-1.7	8.4	
	Façade 2	/					Dist to Src	Visible Φ									
						Src1											
						Src2											
			Height:	Width:	Area	Composite											
		Overall Dimensions (m):			0	Composite A-wtd											
	Element	**Description:**															
					0												
					0												
					0												
					0												
					0												
					0												
					0												
	Composite SRI																
	Direct sound																
	Reverb sound																
Final	**Total Internal Level**								71.3	69.2	59.6	41.4	30.5	17.6	4.9	11.2	
Calc:	**A-weighted**								**45.1**	**53.1**	**51.0**	**38.2**	**30.5**	**18.8**	**5.9**	**10.1**	**55.7**

The upper level of the terminal has no roof or walls. It has the heliport level and the sub level of the heliport blocking the sound from this area. The materials of the sub level and the heliport level are the same. Therefore two layers of the roof were added to the calculation. 34.9 dB is estimated in this area, which is acceptable considering such a noise level is only reached when the helicopter operates, which is not constant.

	Road Traffic Noise Intrusion Analysis																
	Room Properties																
	Project:	Design Practice 2															
	Space:	Upper Level															
			Height:	Width:	Length:		Volume =	9000000	**Octave Band Center Frequency - Hz**								
Step 1:		**Room Dimensions (m):**	150	200	300		Surface =	270000	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**	**A-wtd**
	Room Average Absorption Coefficient	Hard							0.05	0.07	0.1	0.15	0.2	0.2	0.2	0.2	
	Total Absorption (S * alpha)								13500	18900	27000	40500	54000	54000	54000	54000	
	RT60:								32.67	23.33	16.33	10.89	8.17	8.17	8.17	8.17	
	Source Definition(s)																
							Ref Dist (m)										
	Source 1:	Helicopter Noise					150		98	94	97	94	90	87	81	79	
	Src1 A-wtd								71.8	77.9	88.4	90.8	90.0	88.2	82	77.9	**95.9**
Step 2:	Src1 Adjustment	None	0														
	Source 2:						1		0	0	0	0	0	0	0	0	
	Src2 A-wtd																#####
	Src2 Adjustment	None	0														
	Façade Definition(s)																
	Façade 1	Roof					Dist to Src	Visible Φ									
						Src1	150	1	75.4	71.4	74.4	71.4	67.4	64.4	58.4	56.4	
						Src2	1	1	-22.6	-22.6	-22.6	-22.6	-22.6	-22.6	-22.6	-22.6	
			Height:	Width:	Area	Composite			75.4	71.4	74.4	71.4	67.4	64.4	58.4	56.4	
		Overall Dimensions (m):	10	10	100	Composite A-wtd			49.2	55.3	65.8	68.2	67.4	65.6	59.4	55.3	**73.3**
	Element	**Description:**															
					0												
					0												
					0												
					0												
					0												
					0												
	Wall	Heliport Floor			100				29.8	26.6	38	51.9	58.1	68.1	79.1	67	
	Composite SRI								29.8	26.6	38.0	51.9	58.1	68.1	79.1	67.0	
	Direct sound								45.6	44.8	36.4	19.5	9.3	-3.7	-20.7	-10.6	
Step 3:	Reverb sound								25.3	23.1	13.1	-5.5	-17.0	-30.0	-47.0	-36.9	
	Façade 2	Roof					Dist to Src	Visible Φ									
						Src1	145	1	75.6	71.6	74.6	71.6	67.6	64.6	58.6	56.6	
						Src2											
			Height:	Width:	Area	Composite			75.6	71.6	74.6	71.6	67.6	64.6	58.6	56.6	
		Overall Dimensions (m):	10	10	100	Composite A-wtd			49.4	55.5	66.0	68.4	67.6	65.8	59.6	55.5	**73.5**
	Element	**Description:**															
					0												
					0												
					0												
					0												
					0												
					0												
	Wall	Heliport Floor			100				29.8	26.6	38	51.9	58.1	68.1	79.1	67	
	Composite SRI								29.8	26.6	38.0	51.9	58.1	68.1	79.1	67.0	
	Direct sound								45.8	45.0	36.6	19.7	9.5	-3.5	-20.5	-10.4	
	Reverb sound								25.5	23.2	13.3	-5.4	-16.8	-29.8	-46.8	-36.7	
Final	**Total Internal Level**								48.8	48.0	39.6	22.7	12.7	2.7	0.1	0.7	
Calc:	**A-weighted**								**22.6**	**31.9**	**31.0**	**19.5**	**12.7**	**3.9**	**1.1**	**0.0**	**34.9**

The building located on the upper level of the terminal has both a roof and walls. The material was designed to be thick for heat insulation purposes, along with outstanding sound insulation performance. Only 16.1 dB is estimated in this area when the helicopter operates.

Road Traffic Noise Intrusion Analysis

	Room Properties																
	Project:	Design Practice 2															
	Space:	Sub Level															
			Height:	Width:	Length:		Volume =	500	**Octave Band Center Frequency - Hz**								
Step 1:		**Room Dimensions (m):**	5	10	10		Surface =	400	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**	**A-wtd**
	Room Average Absorption Coefficient	Hard							0.05	0.07	0.1	0.15	0.2	0.2	0.2	0.2	
	Total Absorption (S * alpha)								20	28	40	60	80	80	80	80	
	RT60:								1.23	0.88	0.61	0.41	0.31	0.31	0.31	0.31	
	Source Definition(s)																
							Ref Dist (m)										
	Source 1:	Helicopter Noise					5		98	94	97	94	90	87	81	79	
	Src1 A-wtd								71.8	77.9	88.4	90.8	90.0	88.2	82	77.9	**95.9**
Step 2:	Src1 Adjustment	None	0														
	Source 2:						1		0	0	0	0	0	0	0	0	
	Src2 A-wtd																#####
	Src2 Adjustment	None	0														
	Façade Definition(s)																
	Façade 1	Roof					Dist to Src	Visible Φ									
						Src1	0.1	1	92.4	88.4	91.4	88.4	84.4	81.4	75.4	73.4	
						Src2	0.1	1	-12.6	-12.6	-12.6	-12.6	-12.6	-12.6	-12.6	-12.6	
			Height:	Width:	Area	Composite			92.4	88.4	91.4	88.4	84.4	81.4	75.4	73.4	
		Overall Dimensions (m):	10	10	100	Composite A-wtd			66.2	72.3	82.8	85.2	84.4	82.6	76.4	72.3	**90.3**
	Element	**Description:**															
					0												
					0												
					0												
					0												
					0												
					0												
	Wall	Heliport Floor			100				29.8	26.6	38	51.9	58.1	68.1	79.1	67	
	Composite SRI								29.8	26.6	38.0	51.9	58.1	68.1	79.1	67.0	
	Direct sound								62.6	61.8	53.4	36.5	26.3	13.3	-3.7	6.4	
Step 3:	Reverb sound								70.6	68.4	58.4	39.8	28.3	15.3	-1.7	8.4	
	Façade 2	/					Dist to Src	Visible Φ									
						Src1											
						Src2											
			Height:	Width:	Area	Composite											
		Overall Dimensions (m):			0	Composite A-wtd											
	Element	**Description:**															
					0												
					0												
					0												
					0												
					0												
					0												
					0												
	Composite SRI																
	Direct sound																
	Reverb sound																
Final Calc:	**Total Internal Level**								71.3	69.2	59.6	41.4	30.5	17.6	4.9	11.2	
	A-weighted								**45.1**	**53.1**	**51.0**	**38.2**	**30.5**	**18.8**	**5.9**	**10.1**	**55.7**