Graduation Presentation

Bernard Aukema

1 February 2012

Hydrogen Technology
Research & Business Center

NDSM Old Shipyard
Amsterdam North

aE

Architectural Engineering Lab06

Tutors:
J.F. Engels & A.A.J.F. van den Dobbelsteen

Presentation is in Dutch, Sheets are in English

Toyota FCV-R - Fuel Cell Concept Car (2015)

Electrolysis → Electrolyser

$$2\ H_2O + Energy = 2H_2 + O_2$$

Liquid, Electricity, Gas, Gas

← Oxidation — Fuel Cell

Why this fascination?

Hydrogen Technology

Experimental in Architecture

Research feasibility and usage in architecture

Energy self-sufficient (different than energy neutral)

Using the hydrogen technology

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Facts

- Lightest gas (H_2)
- Electrolysis: H_2O (Liq) > $2H_2$ (gas) + O_2 (gas)
- Water is abundant on the surface of Earth
- No CO_2 emission during the production and use of hydrogen

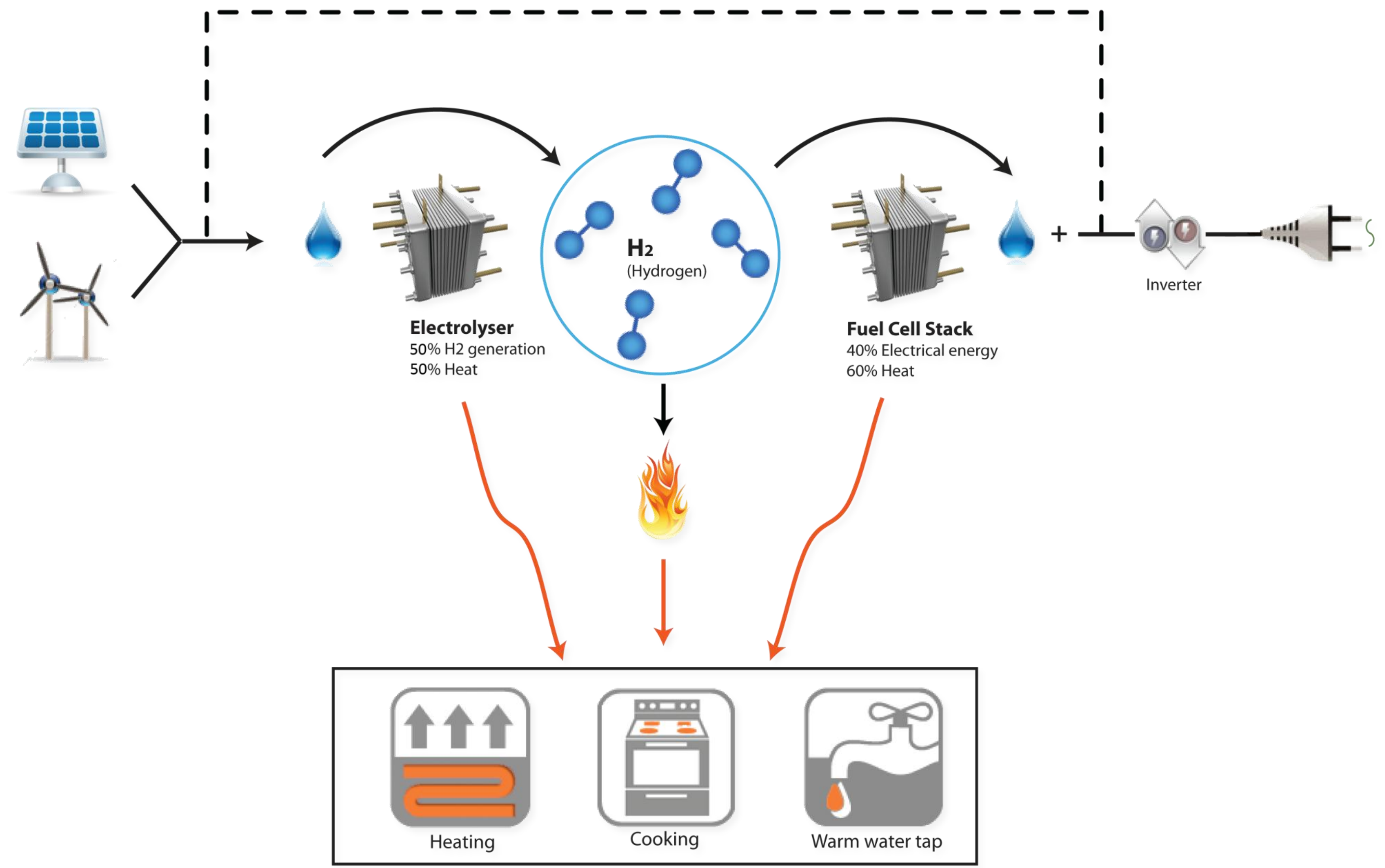
How? Energy Storage

- In combination with renewable energy (Solar, Wind)
- Lighter than battery system
- No toxic metals

- Large gas volume > Compression required
- Extremely explosive > Strong tank required, save place

Simple Principle

Hydrogen Technology in buildings



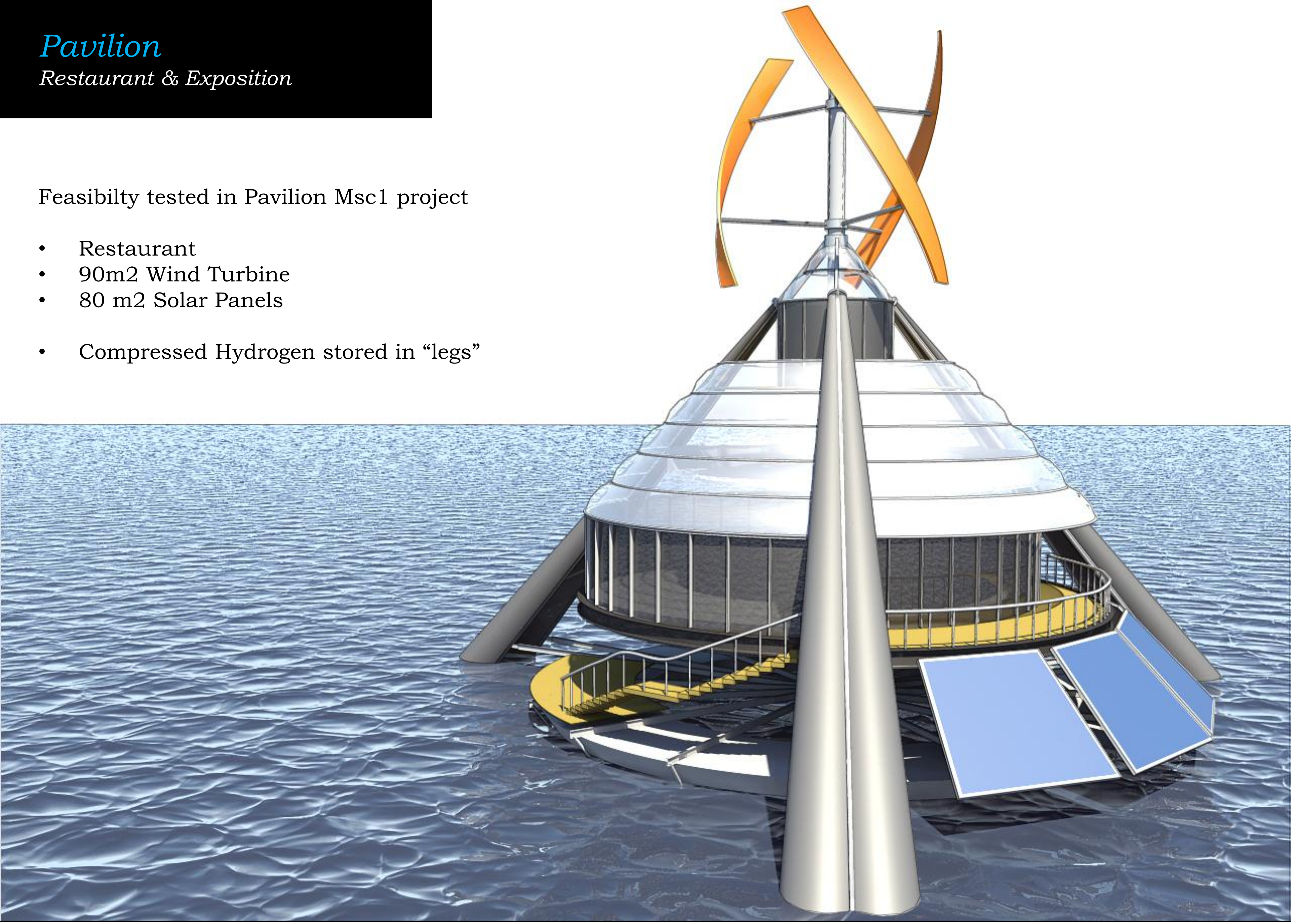
Pavilion

Restaurant & Exposition

Feasibilty tested in Pavilion Msc1 project

- Restaurant
- 90m2 Wind Turbine
- 80 m2 Solar Panels

- Compressed Hydrogen stored in “legs”



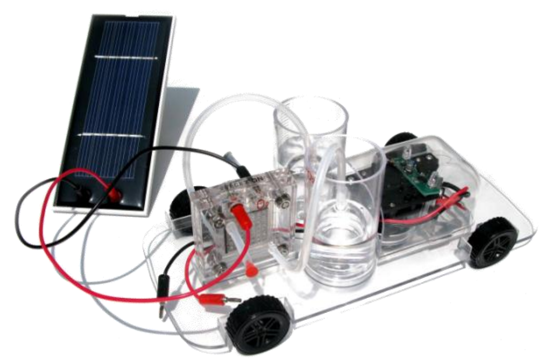
Progressive in hydrogen technology. *We want to become Hydrogen City!*

Projects:

Amsterdam
Hydrogen Technology - examples

Progressive in hydrogen technology. *We want to become Hydrogen City!*

Projects:



Map of Amsterdam

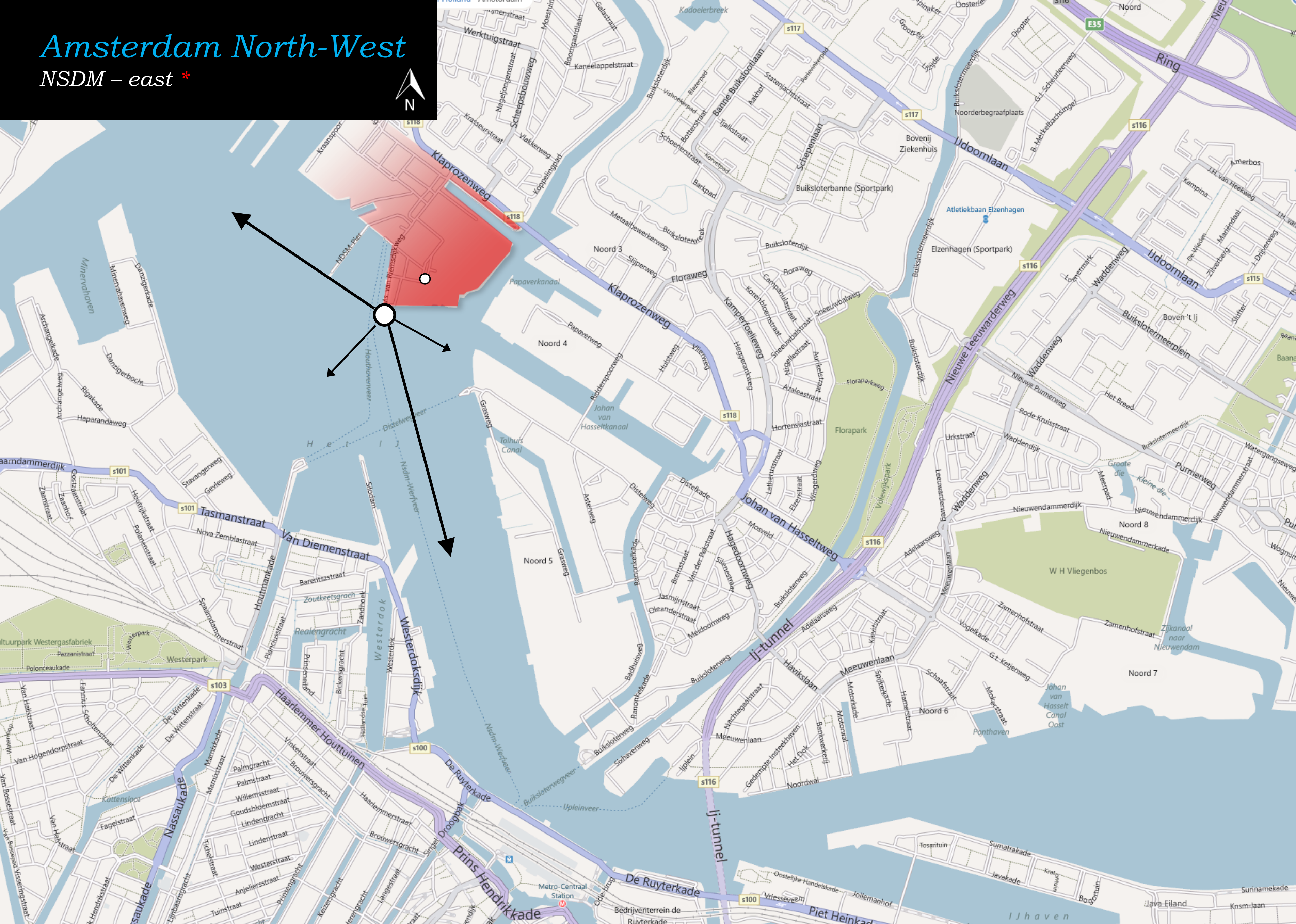
NDSM

Map of Amsterdam

NDSM

Amsterdam North-West

NSDM – east *



Old dockyard
NSDM – east

NDSM-East
Amsterdam North

Impressions

NDSM-East

Impressions
NDSM-East

Impressions
NDSM-East

Impressions
NDSM-East

Why the NDSM Area?
Energy experimental site

- 'De Broedplaats' wants to be energy self-sufficient :
- Energy experimental site > Kunst en energieroute
- There are already some projects
  - Heatpump & heating + cooling storage
  - Passive solar energy
  - Electric charging point
  - Bio fuel tank station
  - Wind turbine in the old crane
  - Heating network

De energie maatschappij, dat zijn wij!

Why the NDSM Area?

Energy experimental site

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De energie maatschappij, dat zijn wij!

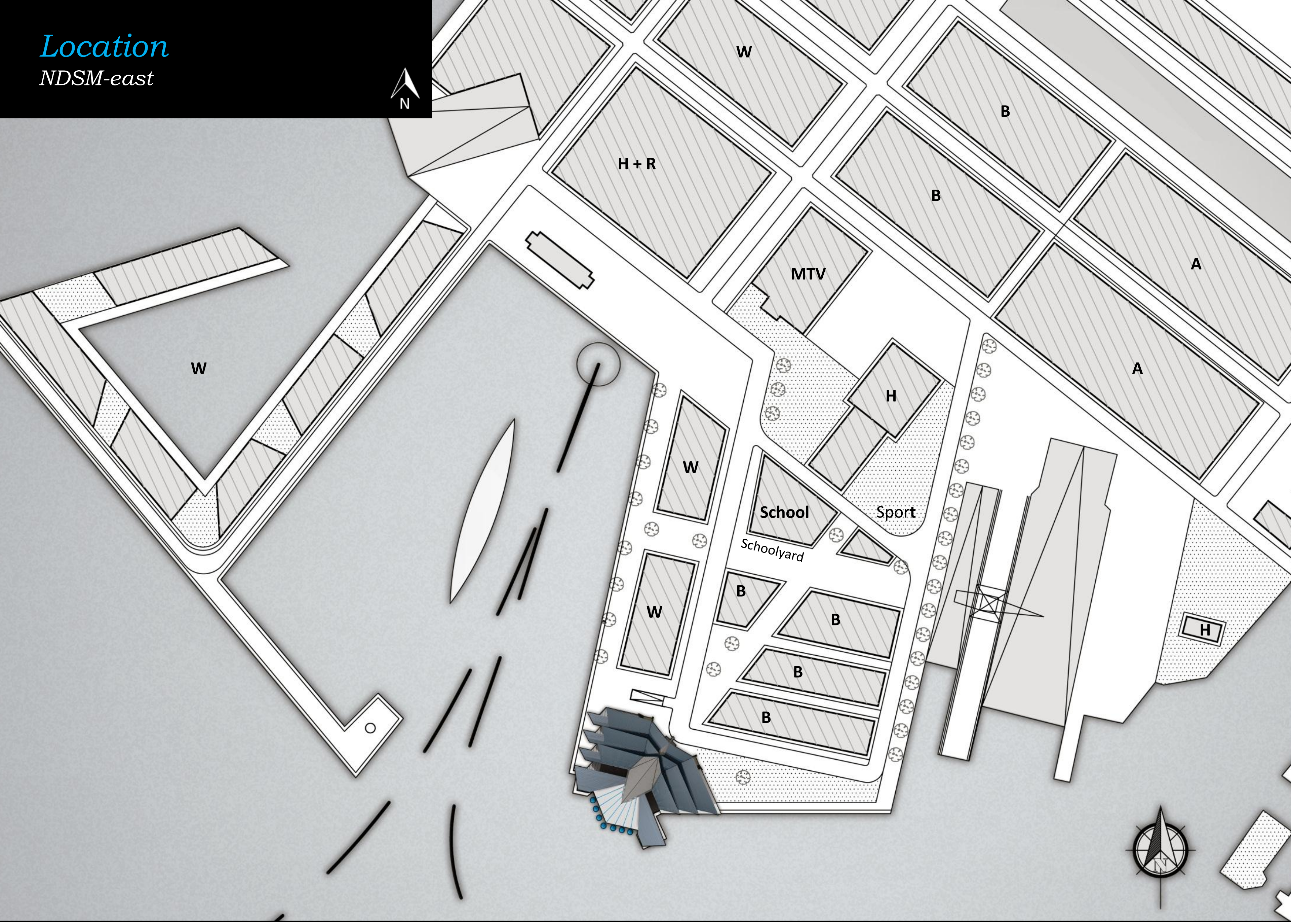
Environmental conditions

- \- Good view over the IJ-river, harbor, Amsterdam Center
- \- Open site: sun, wind, water > *energy experience*

Addition for NDSM-East
- Active Solar & Wind energy + Hydrogen Storage
- Hydrogen Research and Business Center

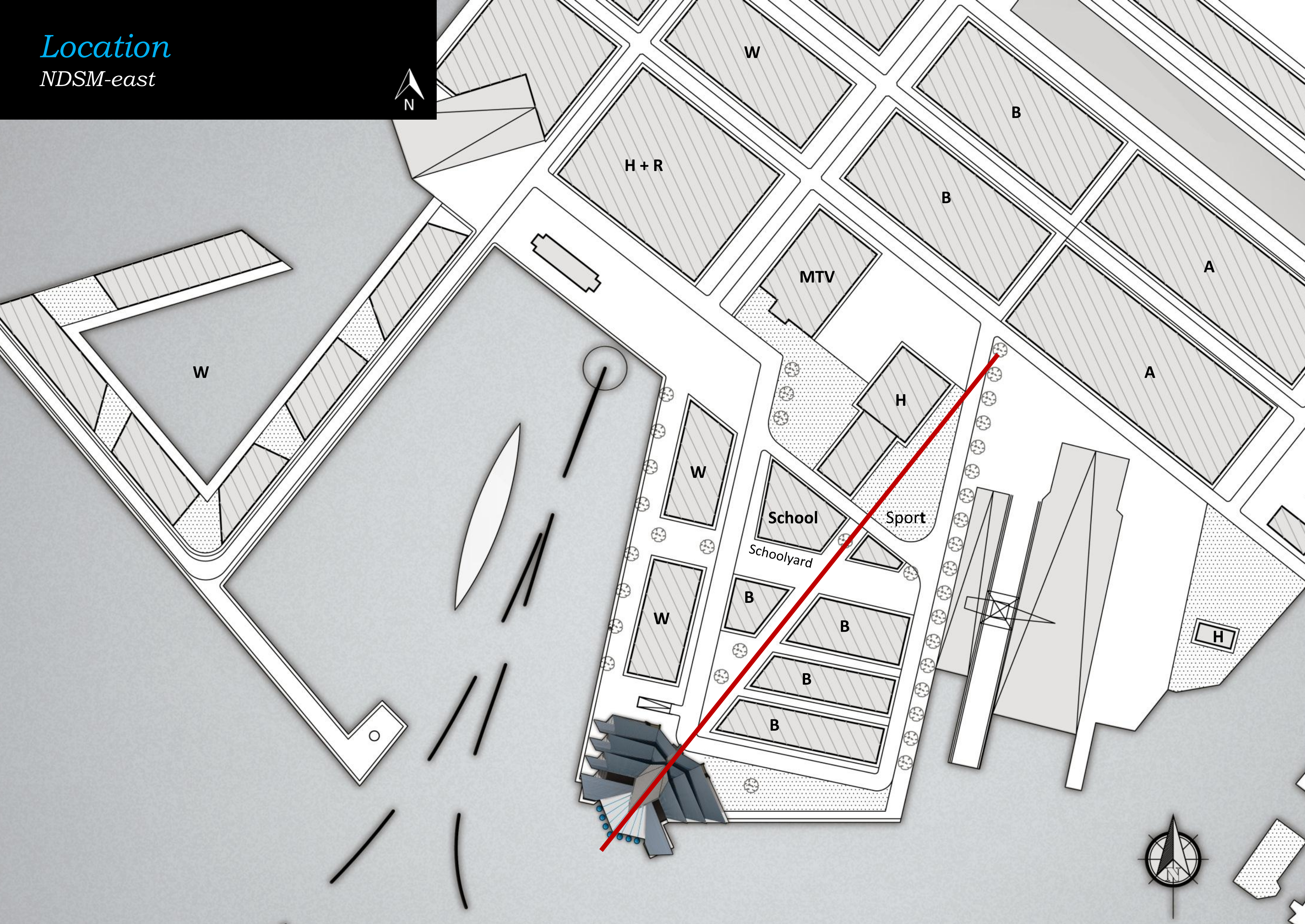
Location

NDSM-east



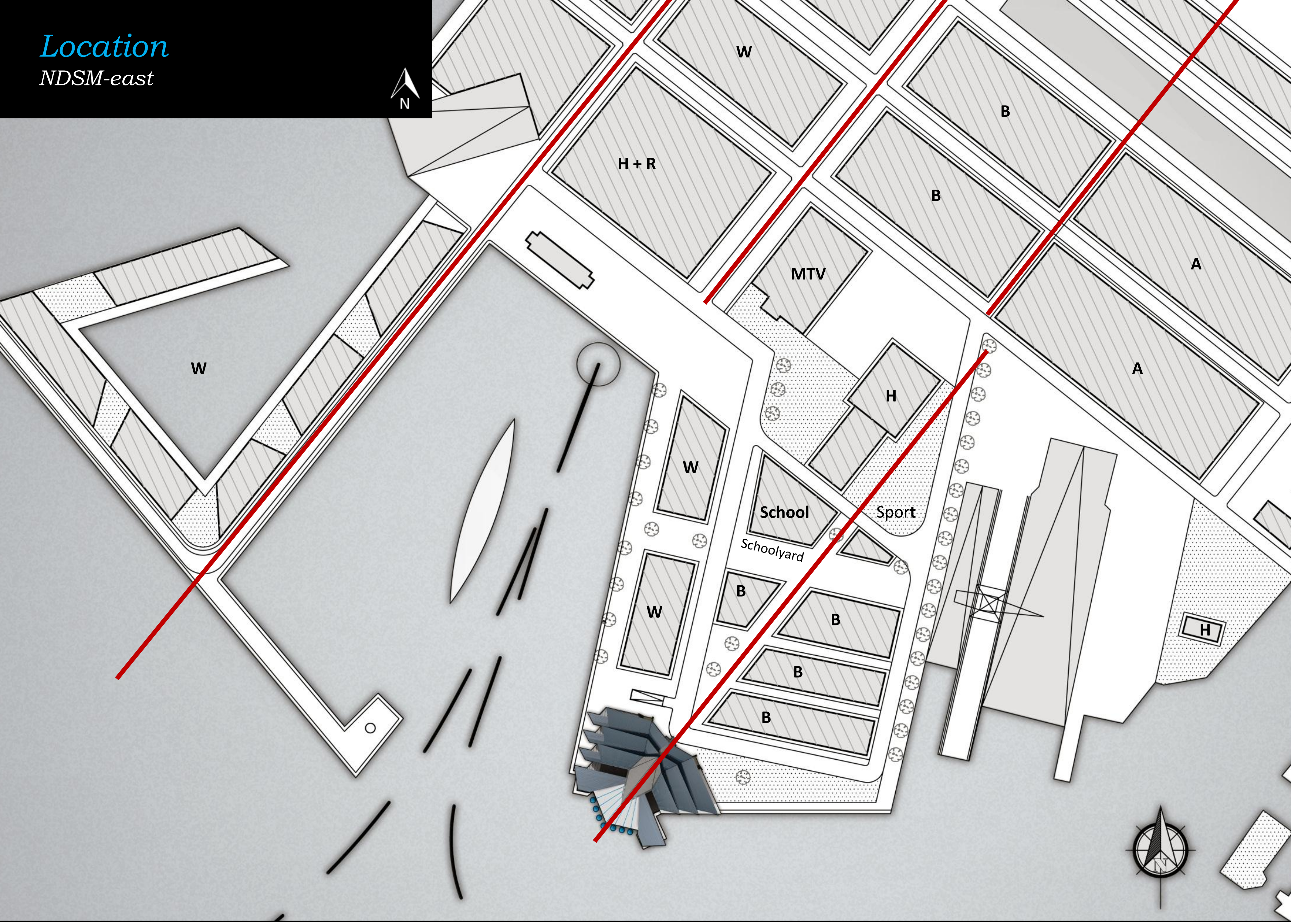
Location

NDSM-east



Location

NDSM-east



Location

NDSM-east

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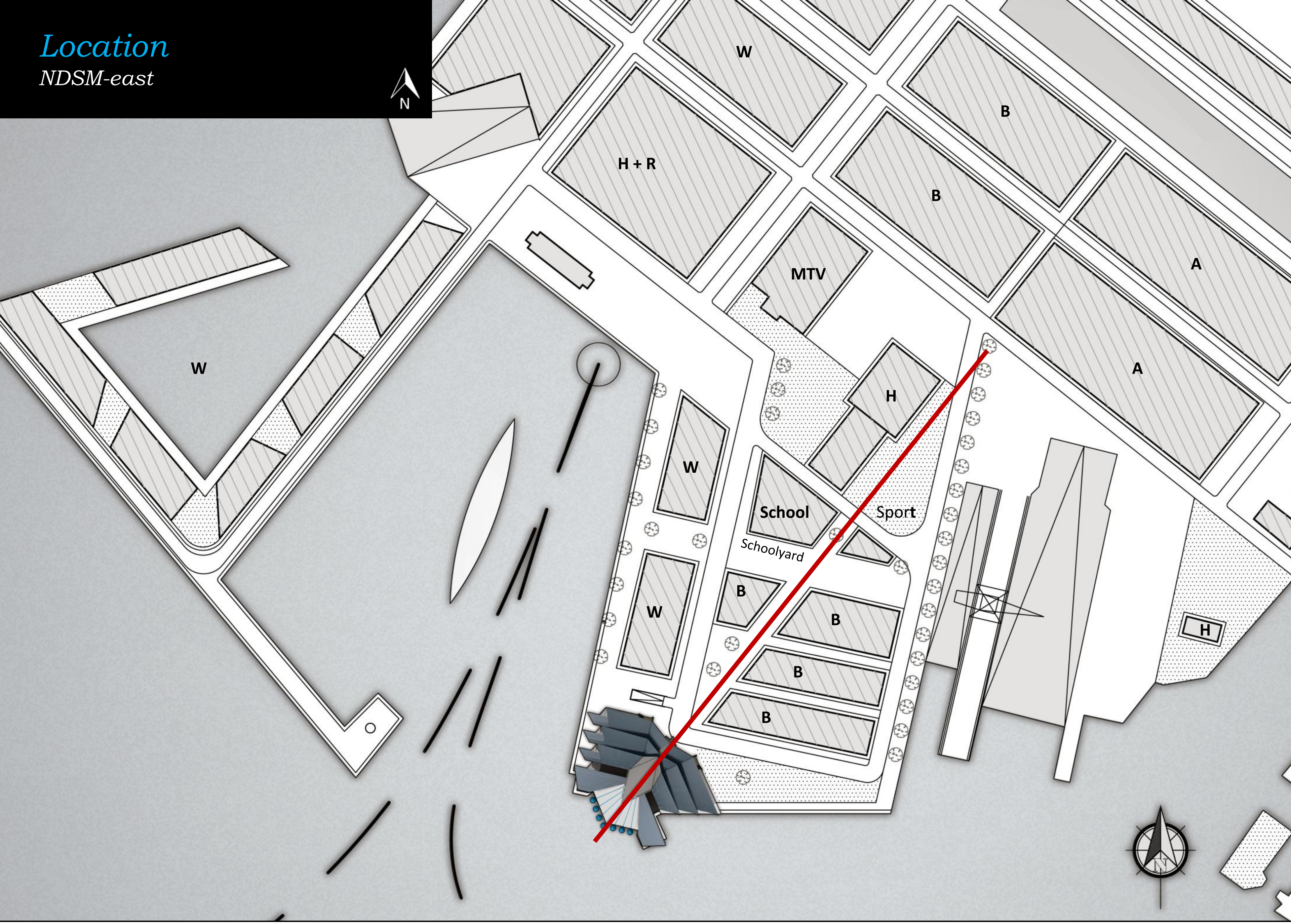
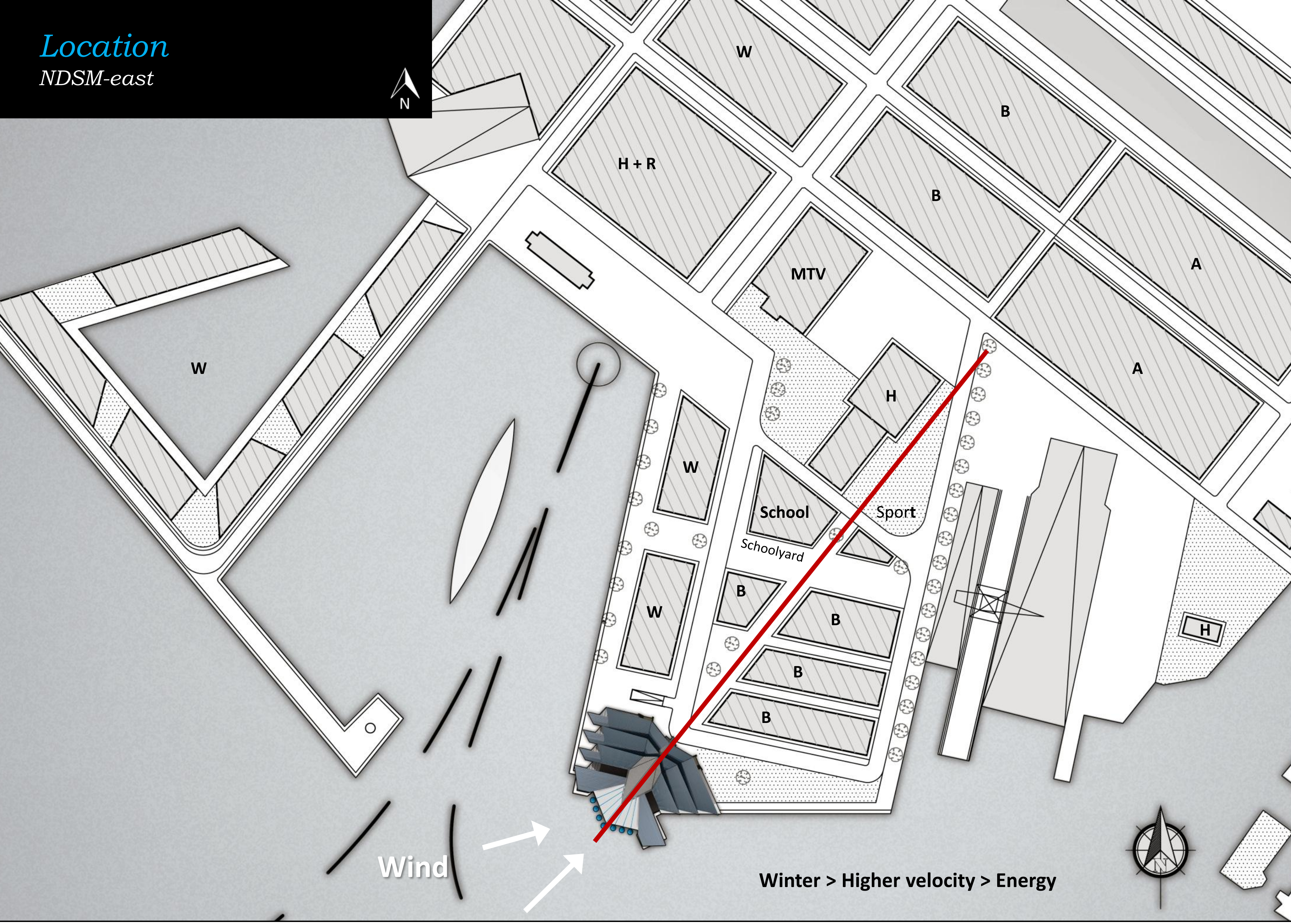
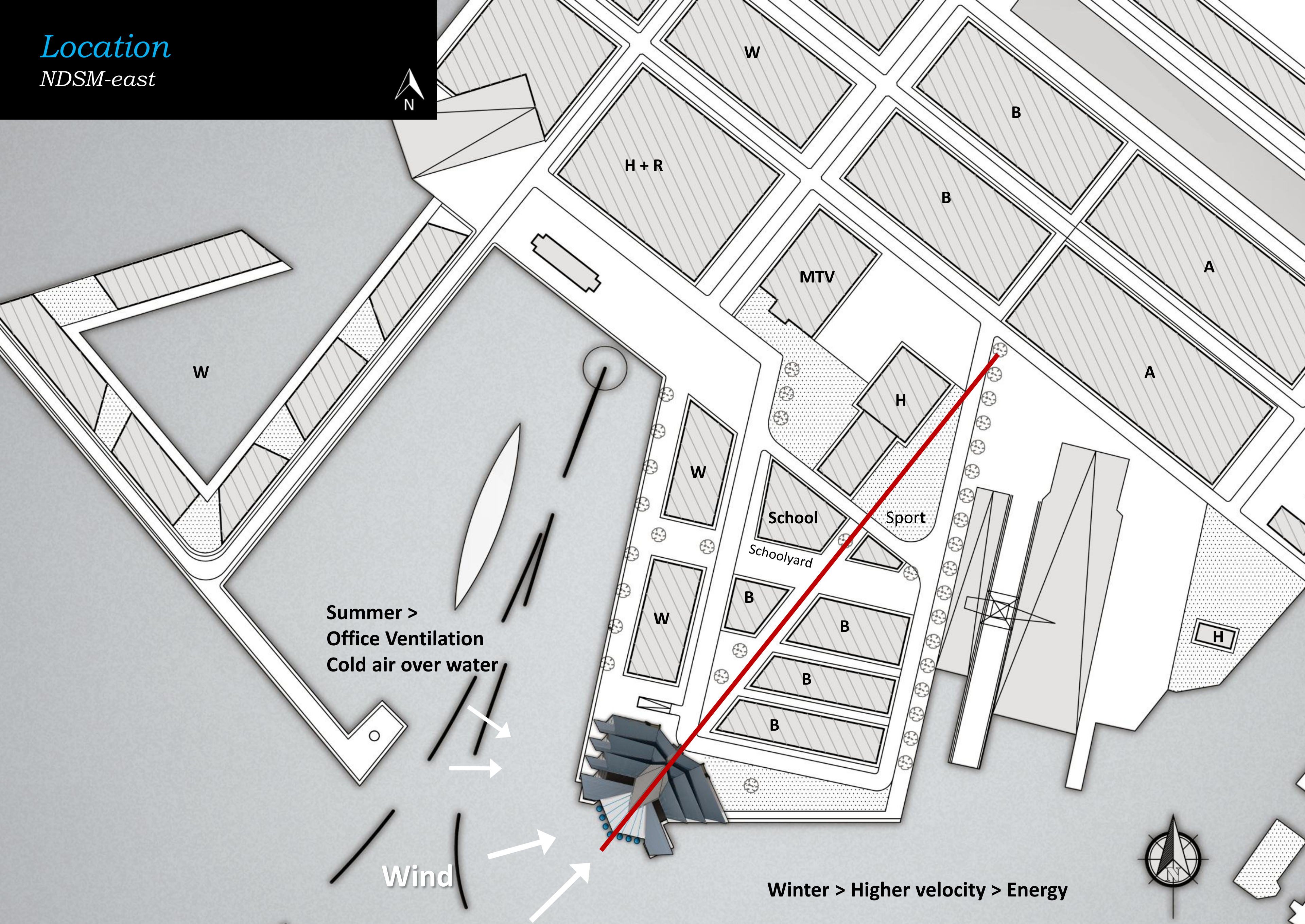


Location
NDSM-east



Location

NDSM-east



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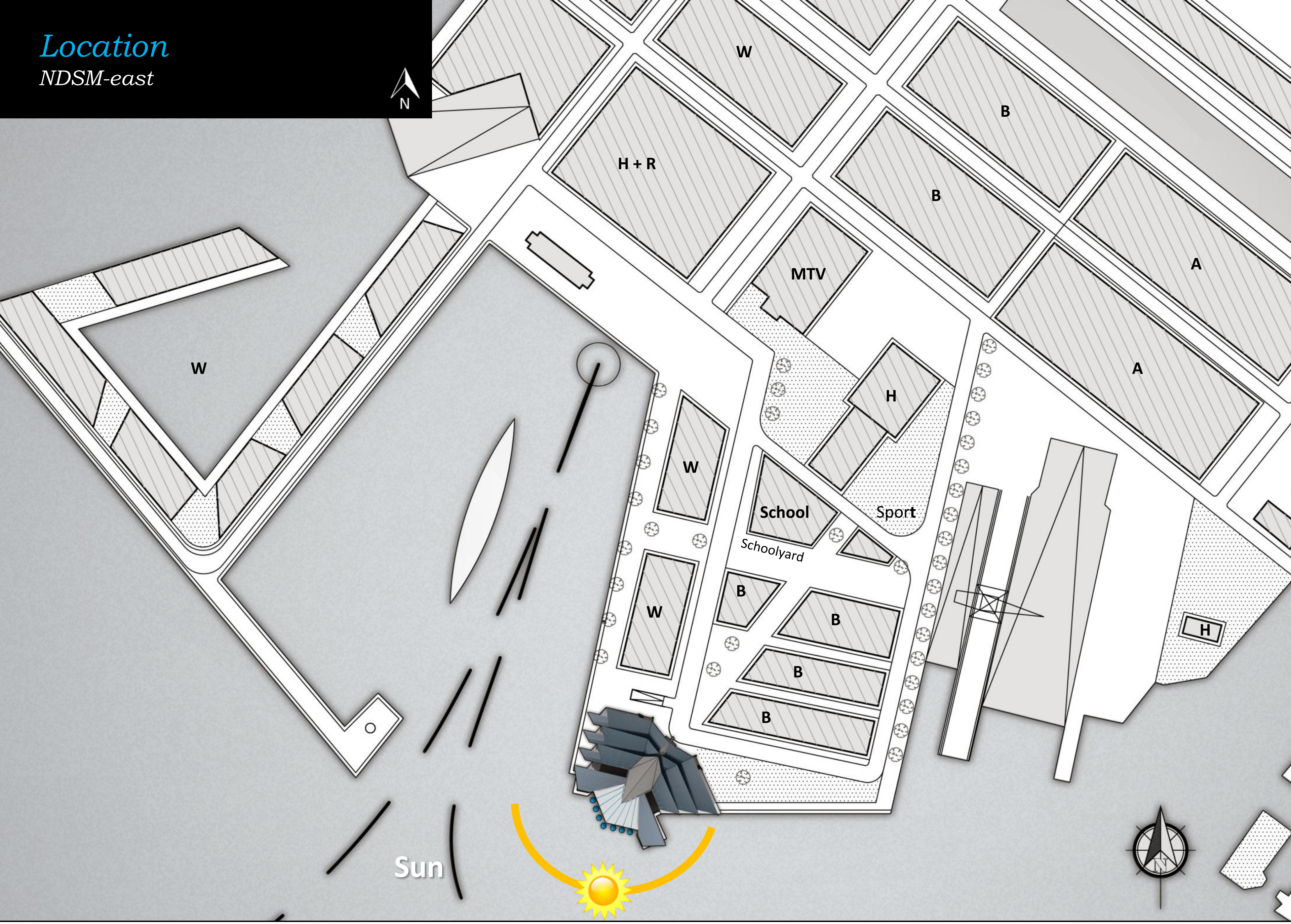
NDSM-east



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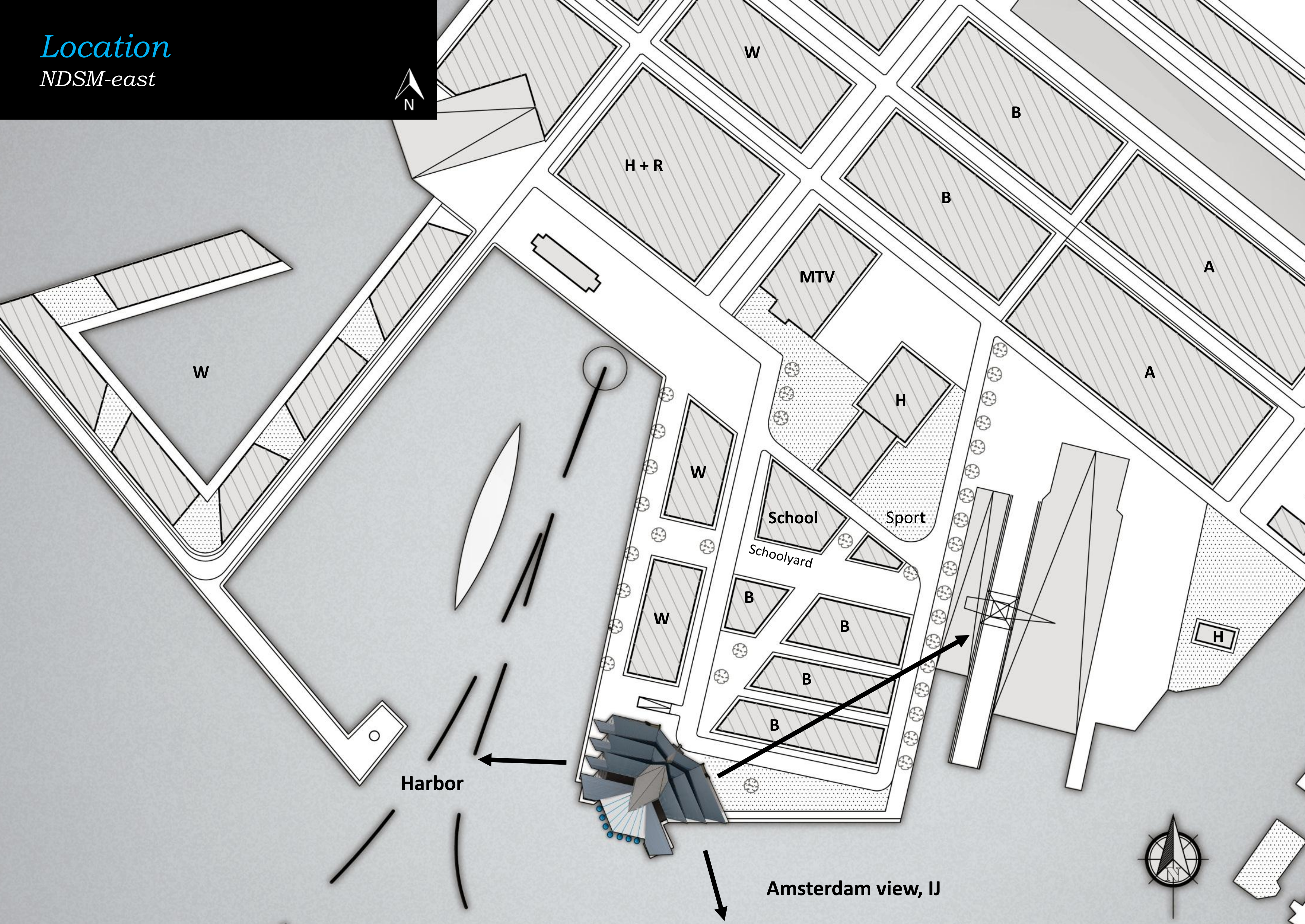
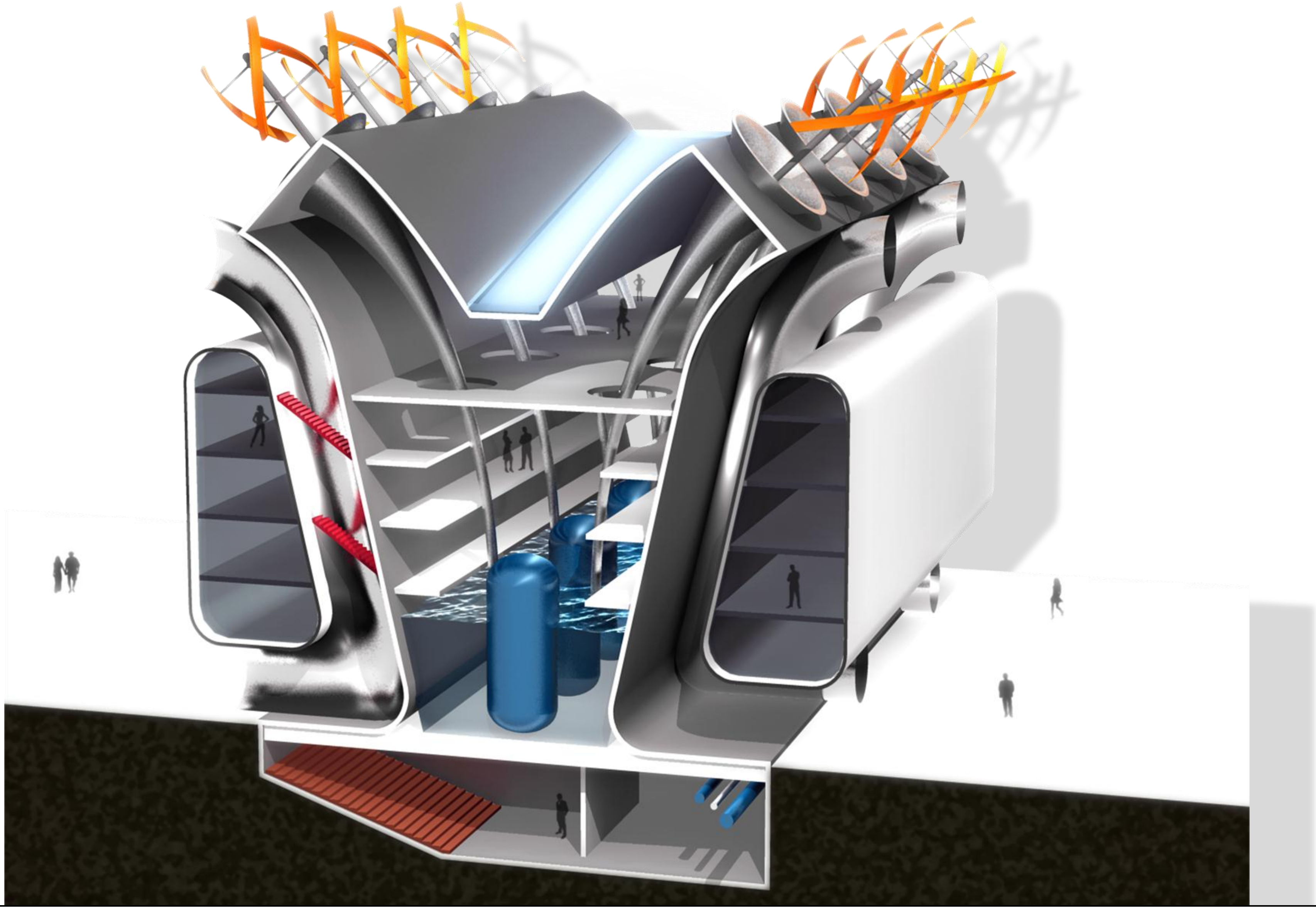
NDSM-east



Structuring ideas
Building



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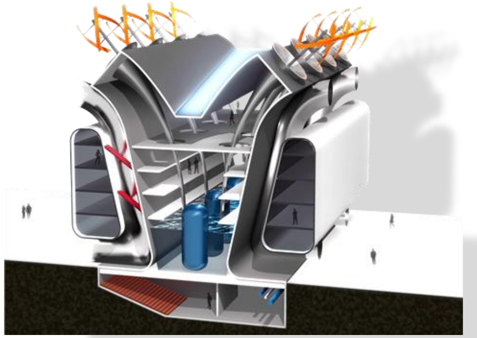
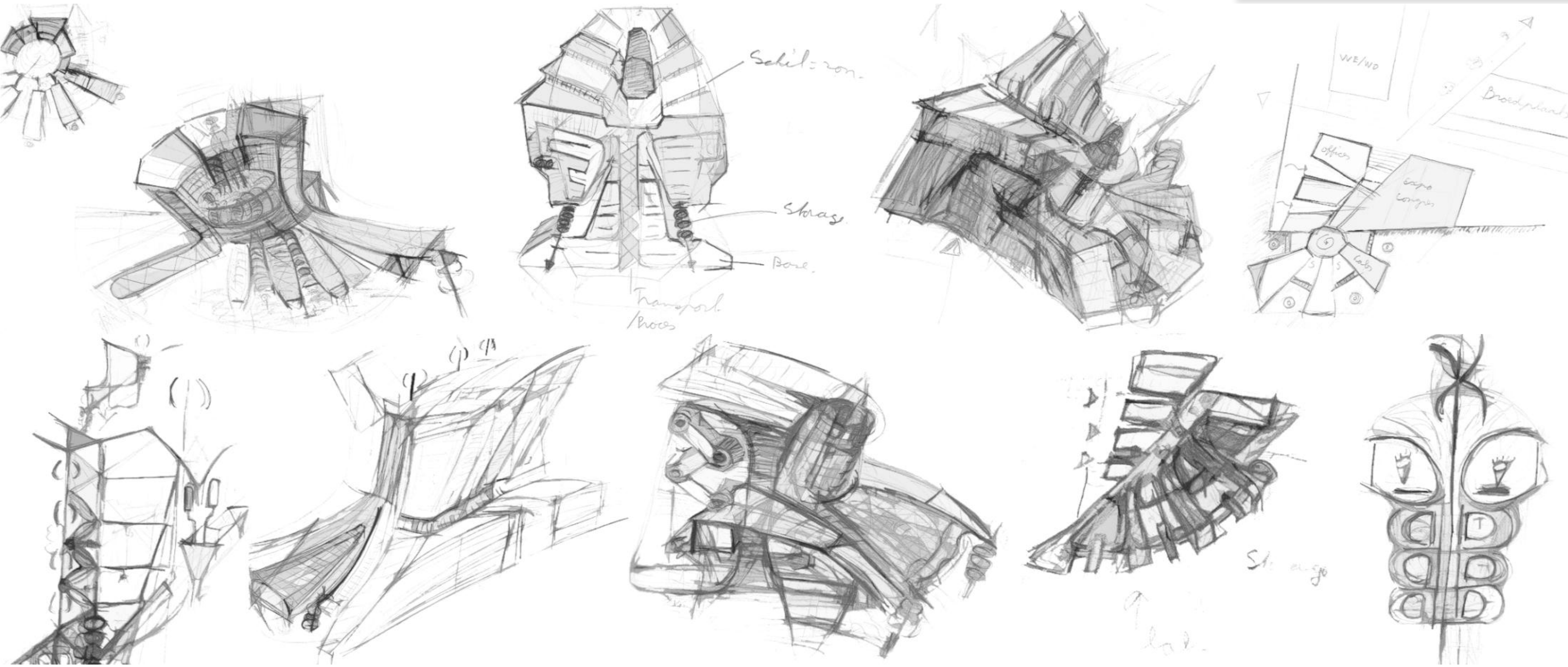


Concept
Building as a machine

What kind of machine?

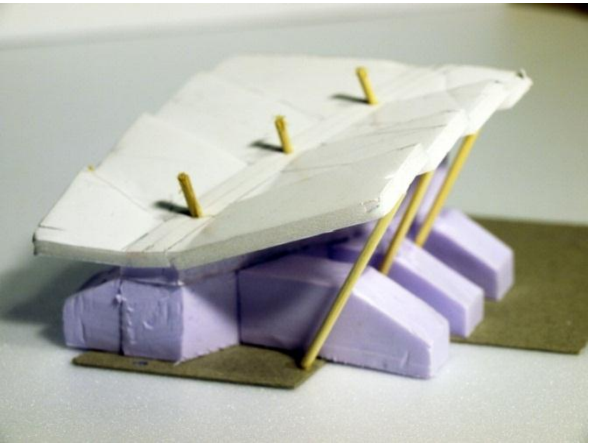
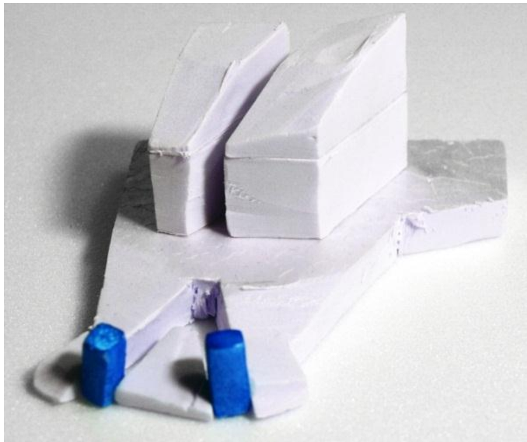
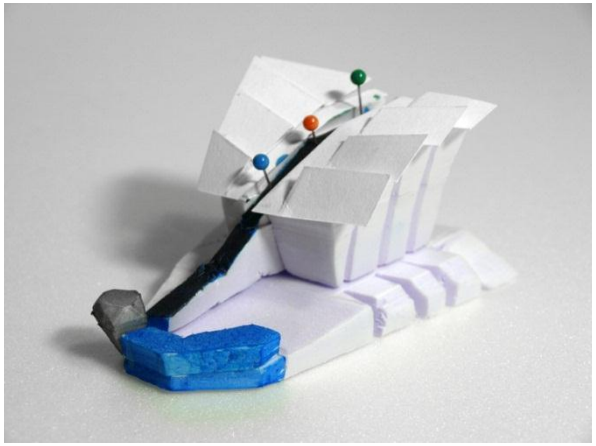
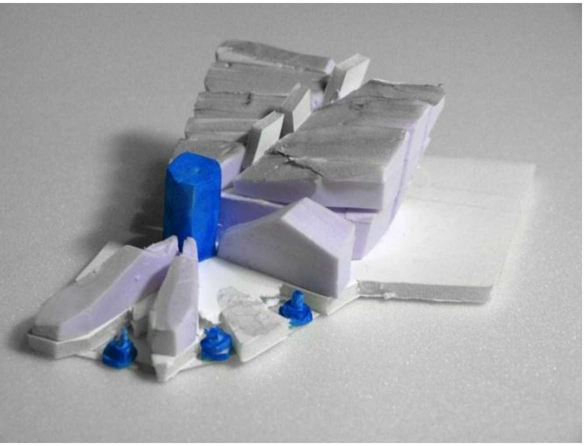
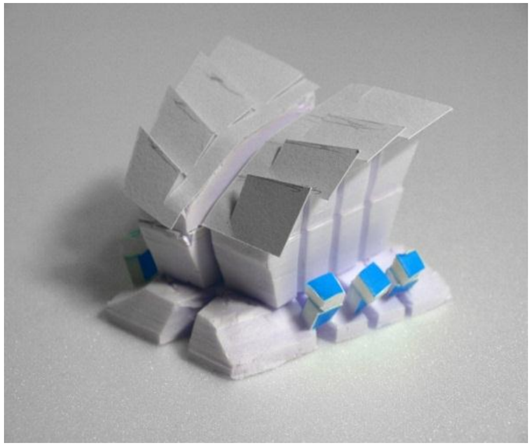
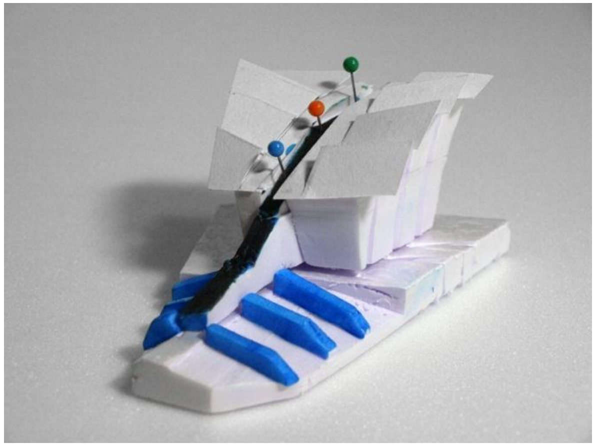
Energy machine



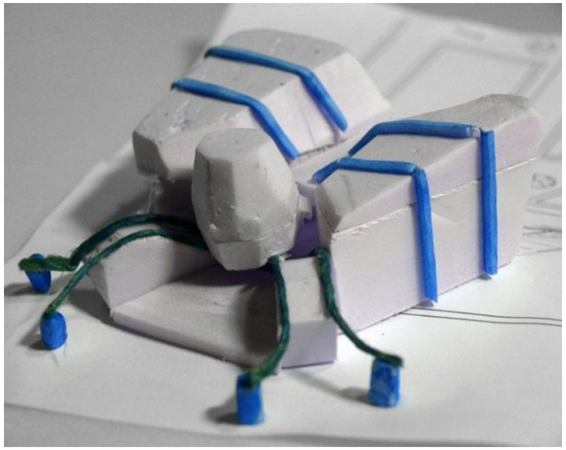
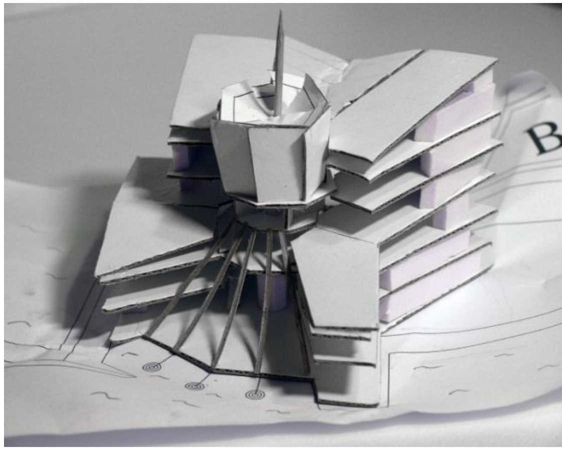
Specific:
Hydrogen Technology

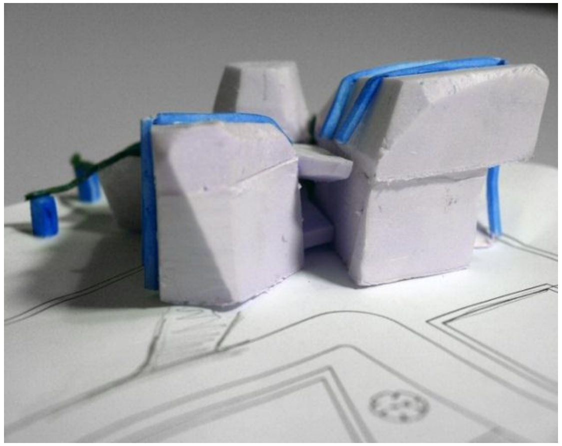
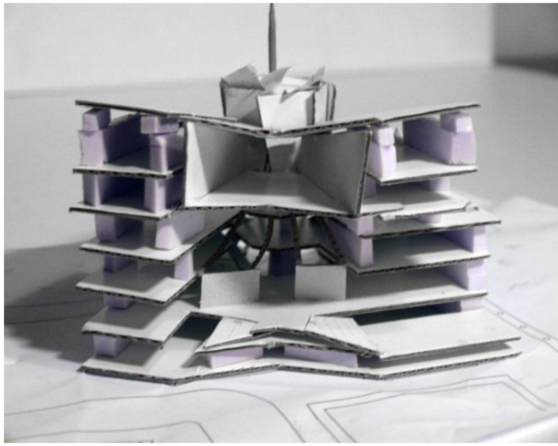
Structuring { *Works as* a machine &
Demonstrates the Hydrogen Technology

Small models
Start building desing

Small models
Wind blowing through building

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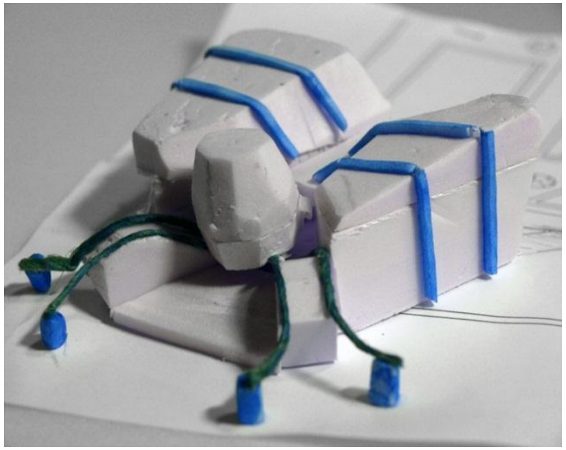

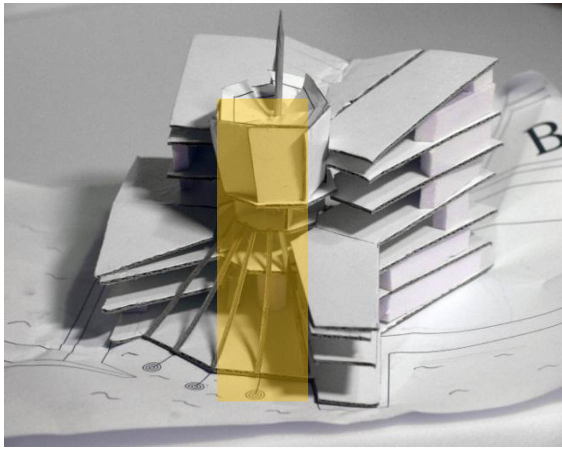

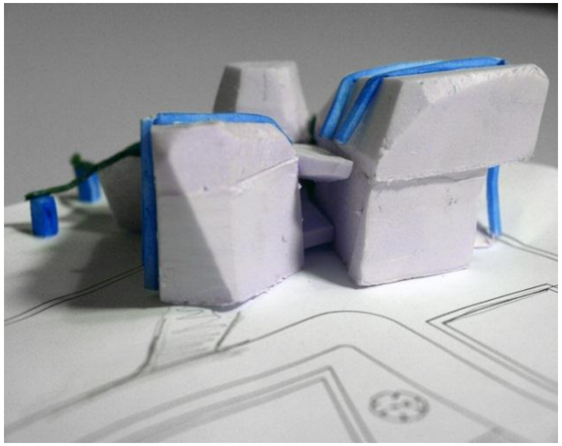

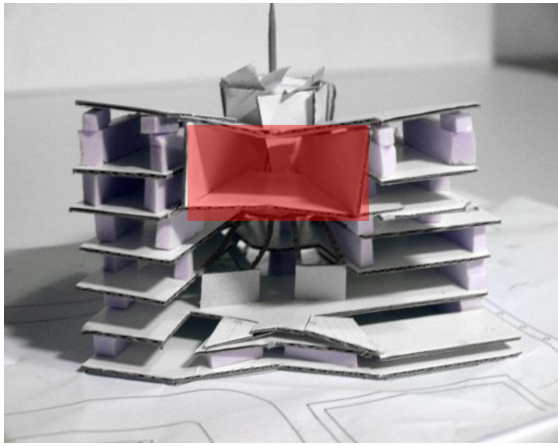

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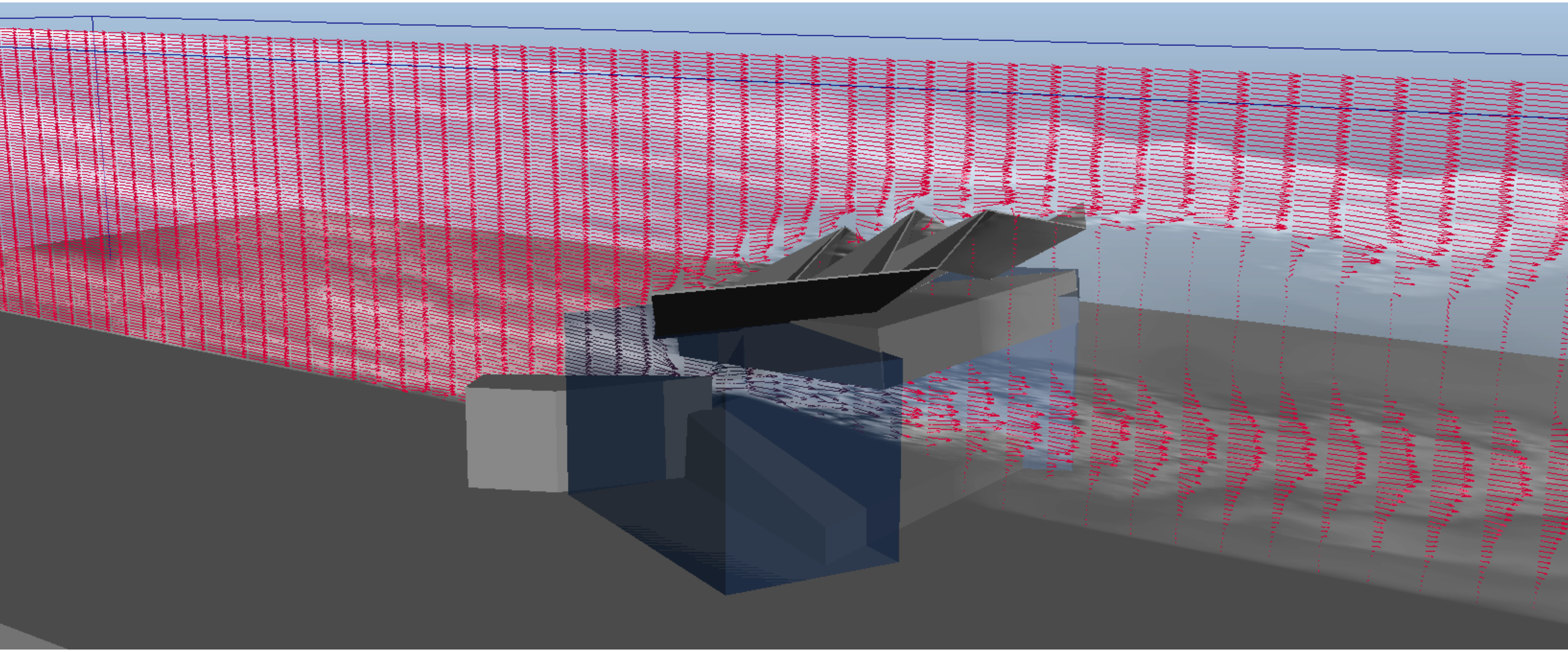
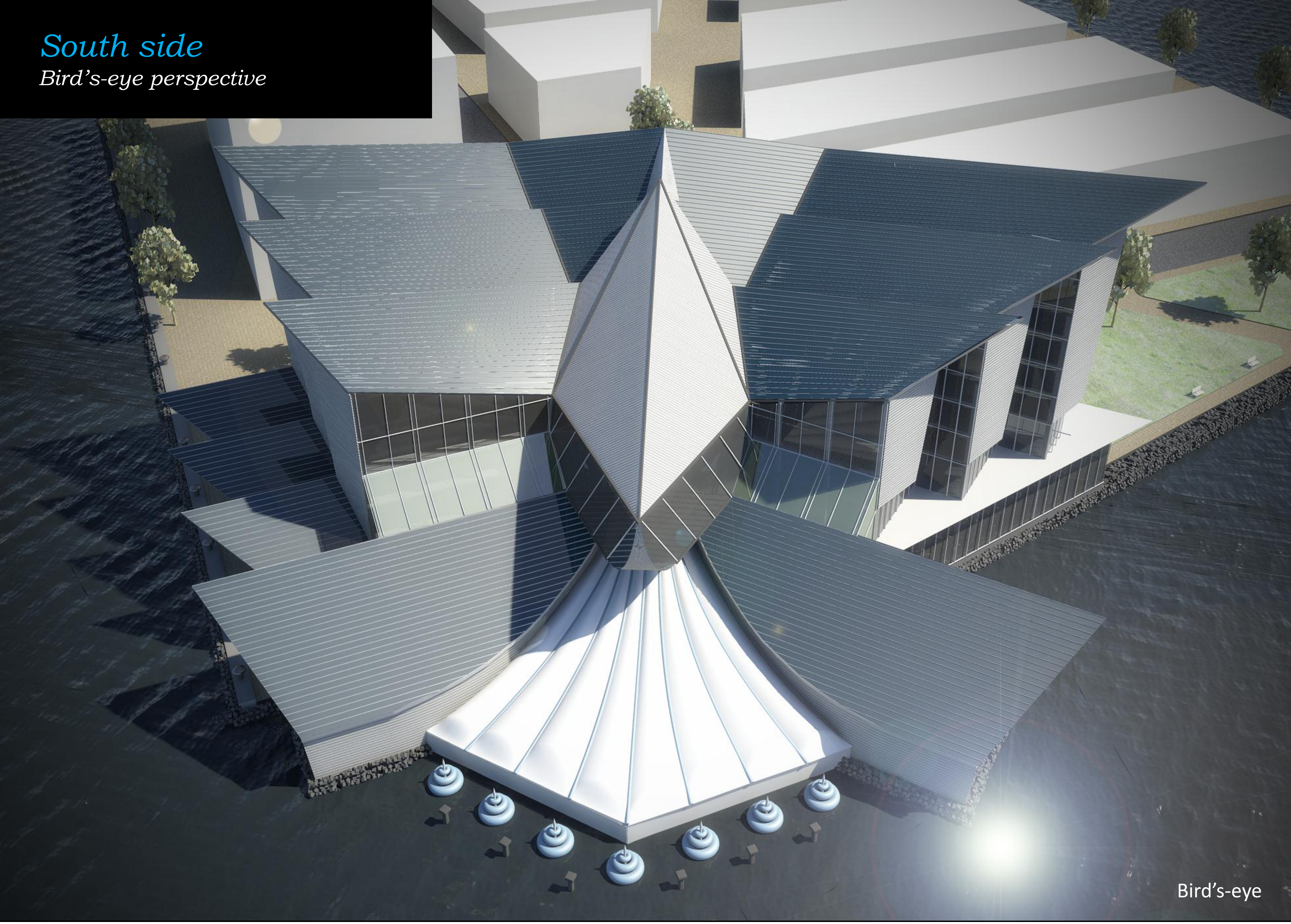


Wind simulation test

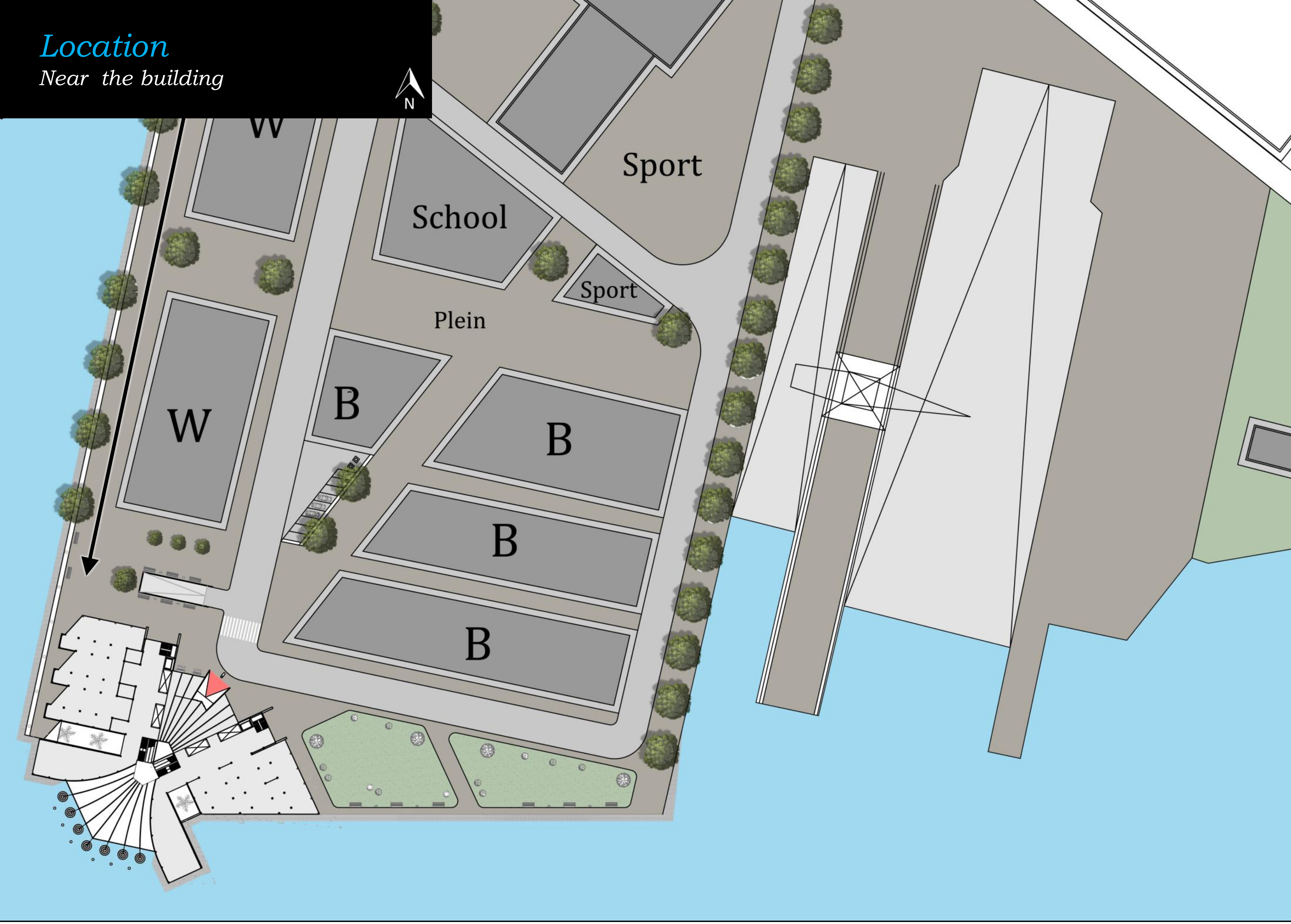
South side

Bird’s-eye perspective



Location

Near the building



Location
Near the building

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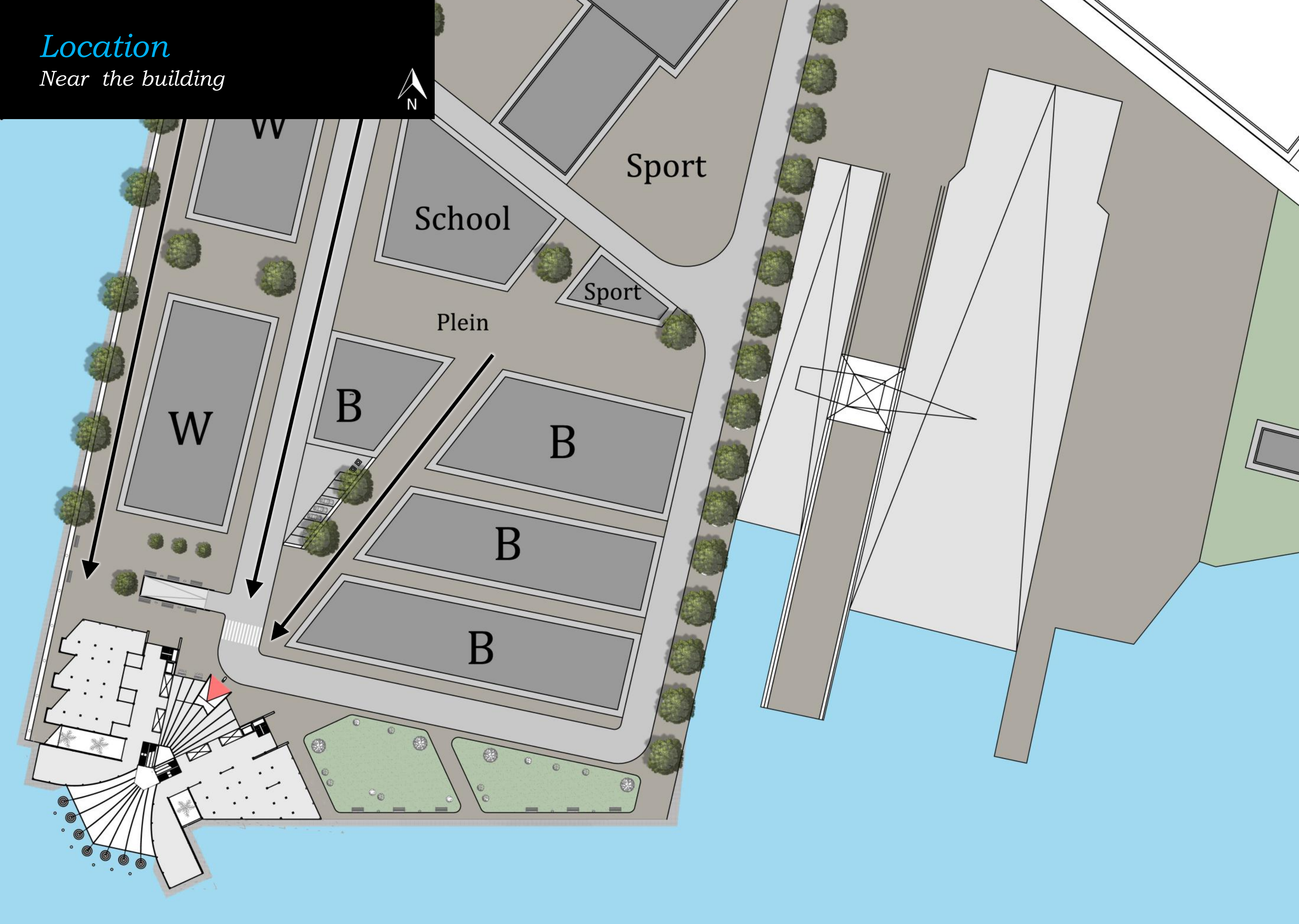

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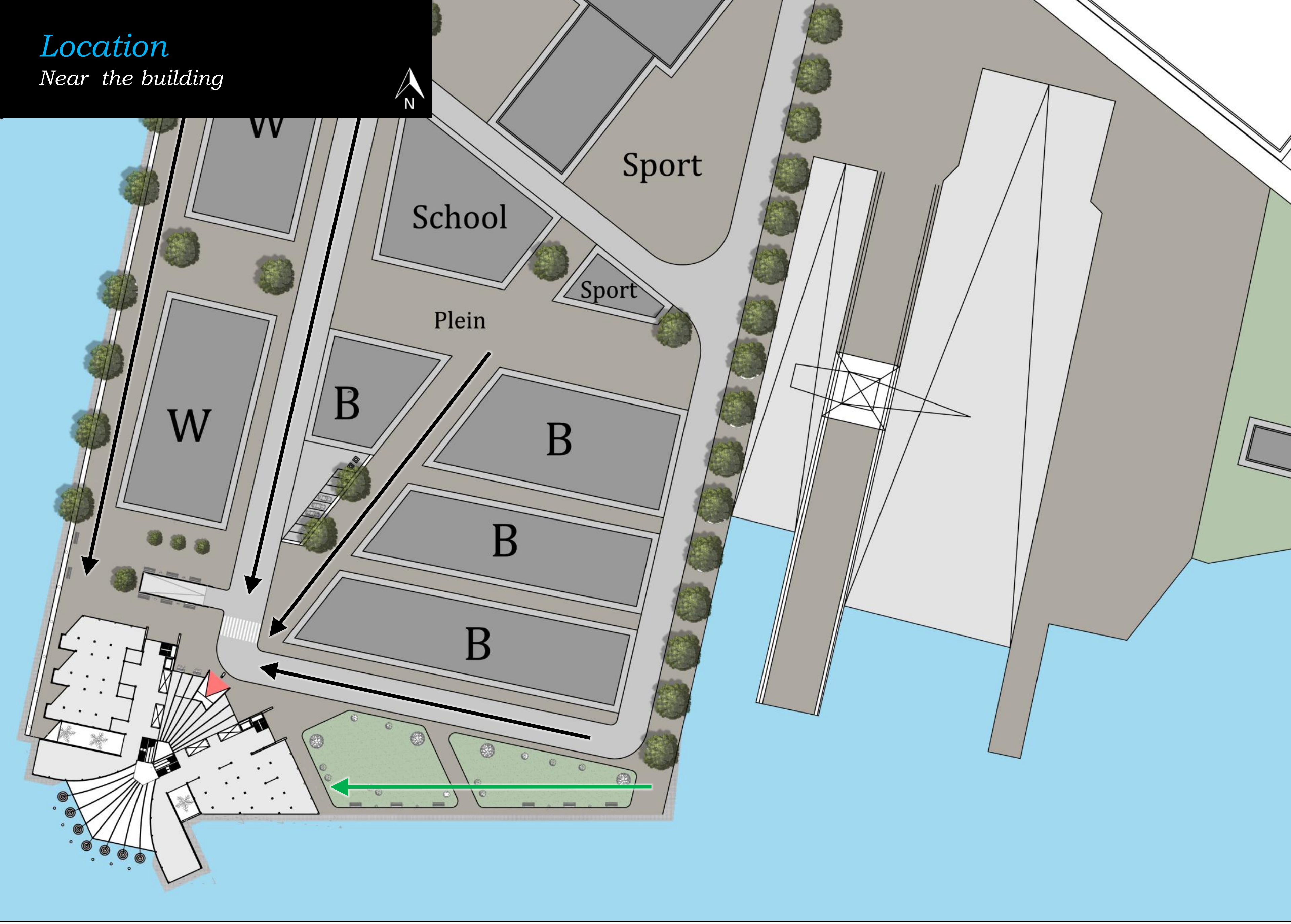


Location
Near the building

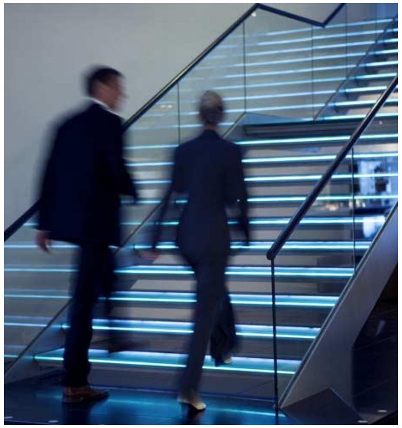
Organisation
Usage of the building

DutchHy

Collaboration between several companies, research centers and cities, *without a clear location.*

The goal of DutchHy it to *stimulate the hydrogen and fuel cell technology* in the Netherlands.

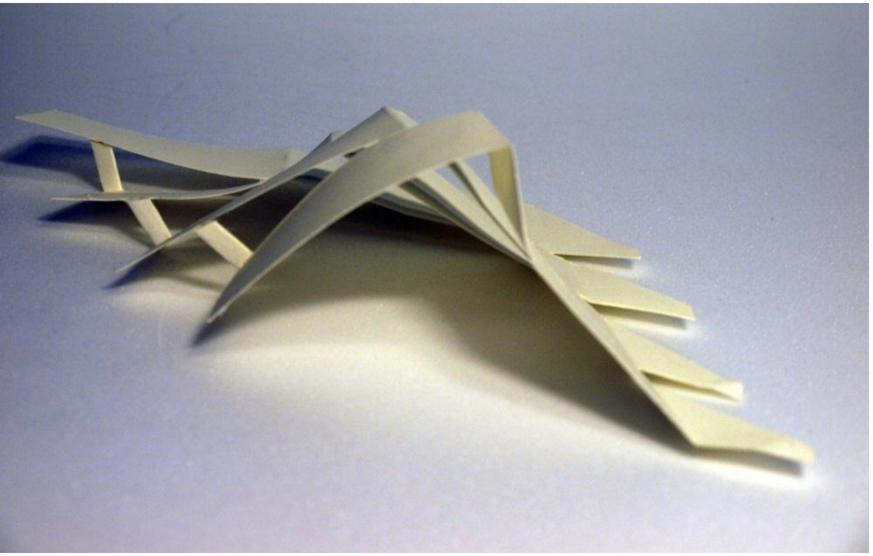


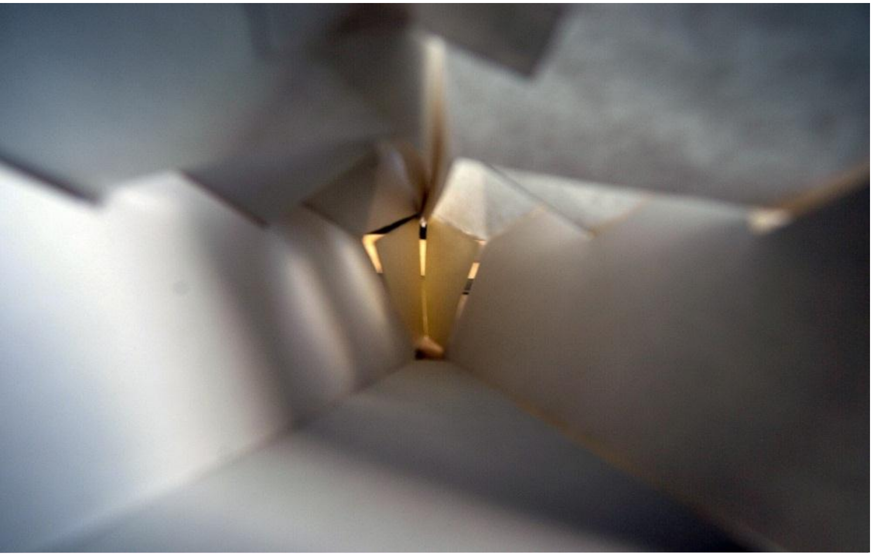


- Active developement of the hydrogen technology
- Support Dutch hydrogen iniatives
- Express the Dutch expertise in hydrogen technology
- Advice and information about the hydrogen technology

DutchHy

Roof
Quality & Functionality



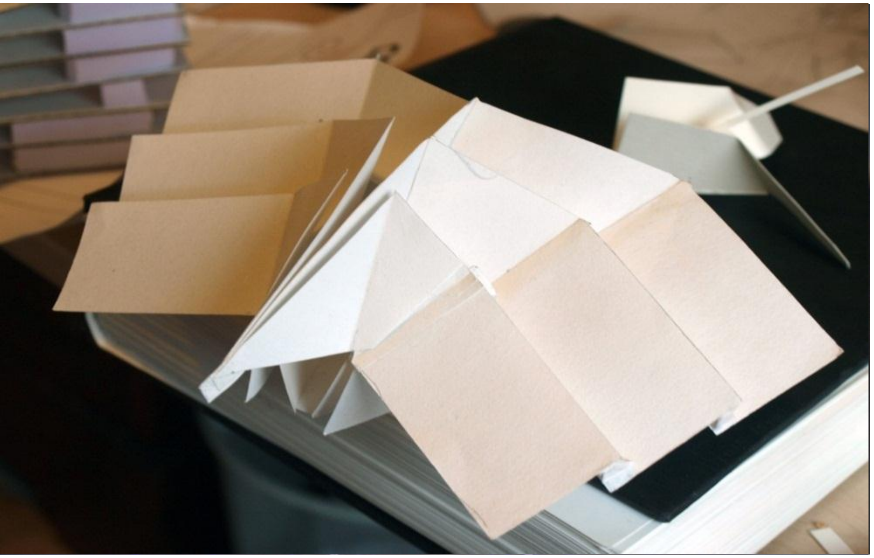


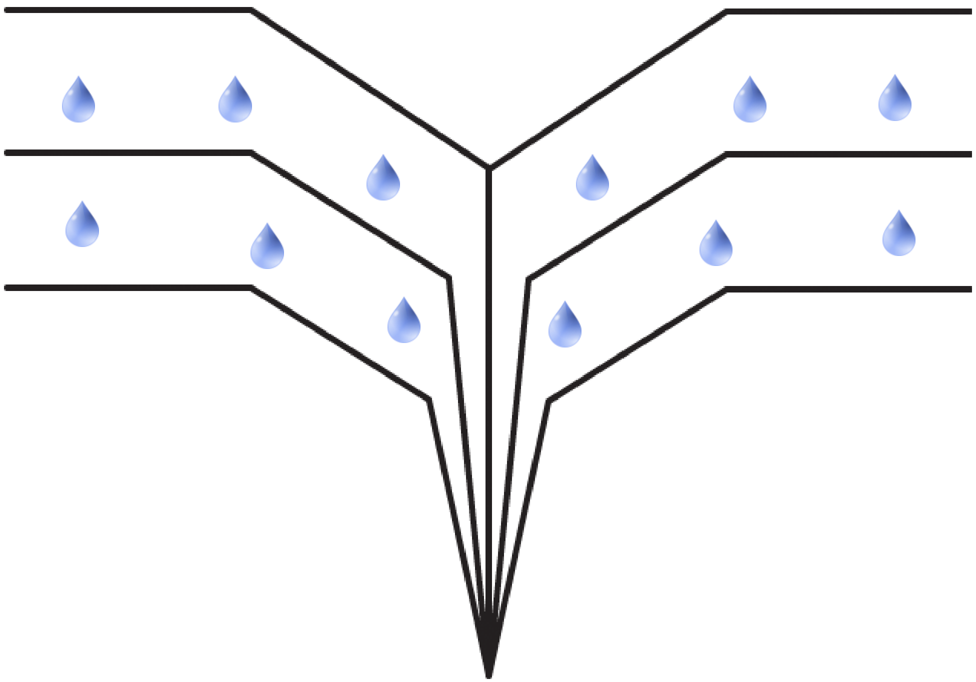
Quality:
- Light

Roof
Quality & Functionality

Quality:
- Light
- Materialisation

Roof
Quality & Functionality

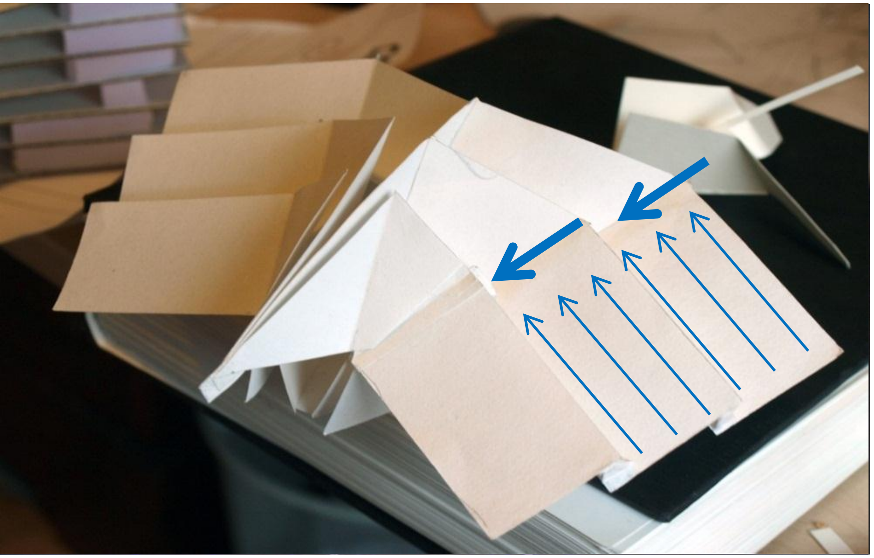


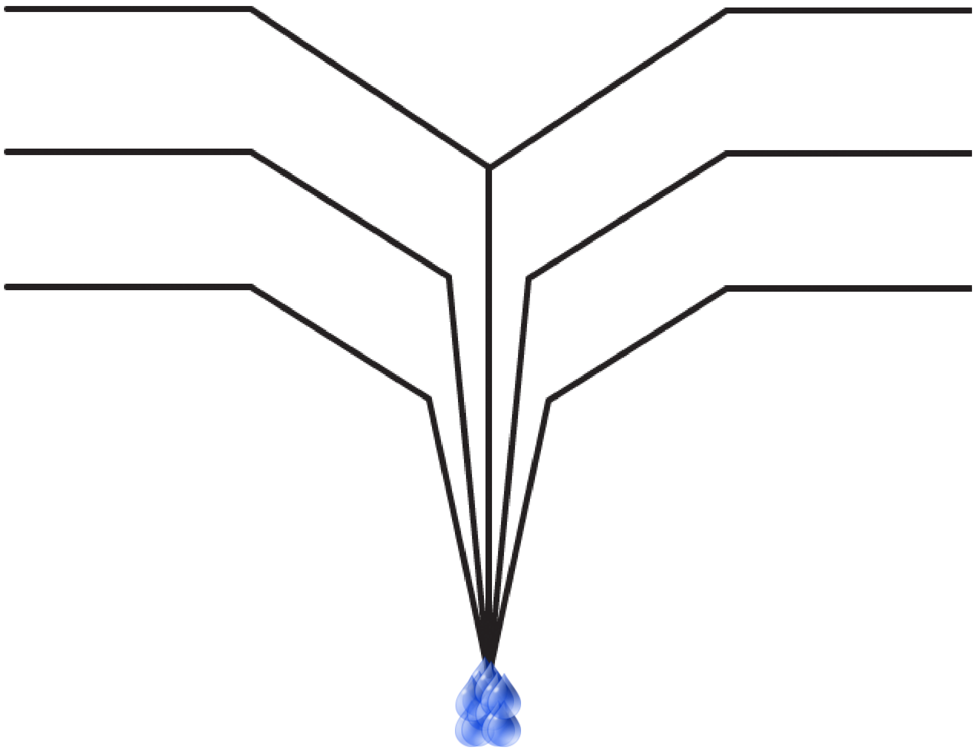


Quality:
- Light
- Materialisation

Functionality:
- Catch Rainwater = 6 Degrees

Roof
Quality & Functionality





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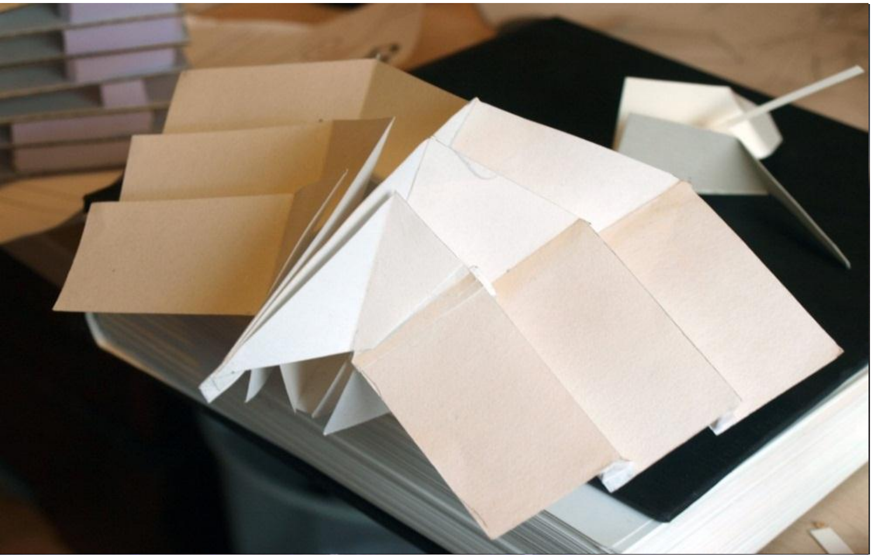
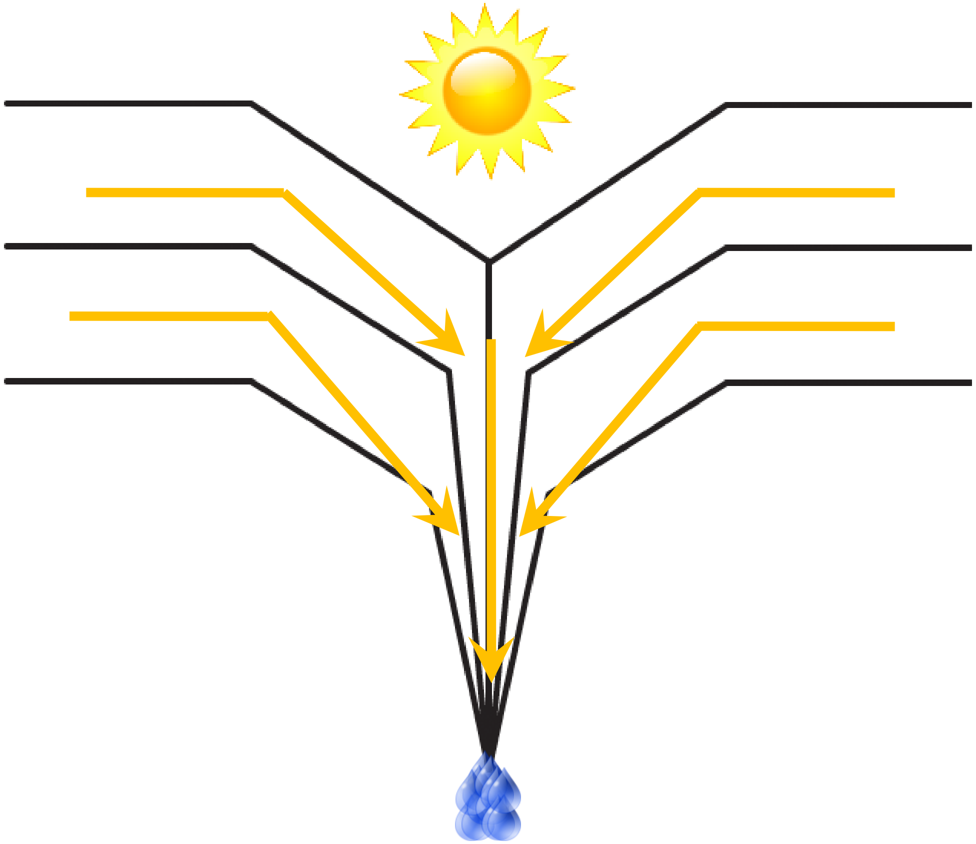
Roof
Quality & Functionality





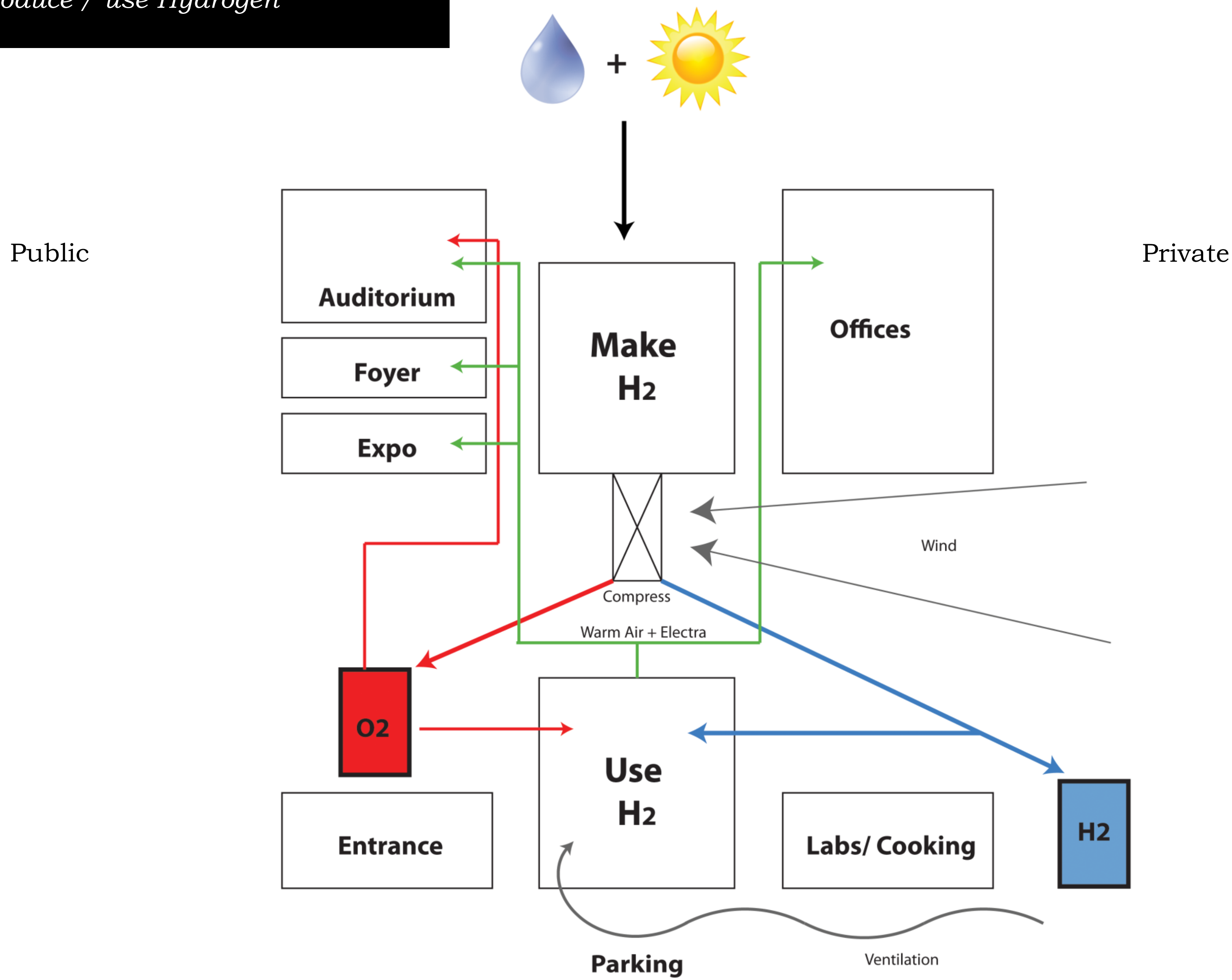
Quality:
- Light
- Materialisation

Functionality:
- Catch Rainwater = 6 Degrees
- Catch Solar Energy = 30 Degrees south

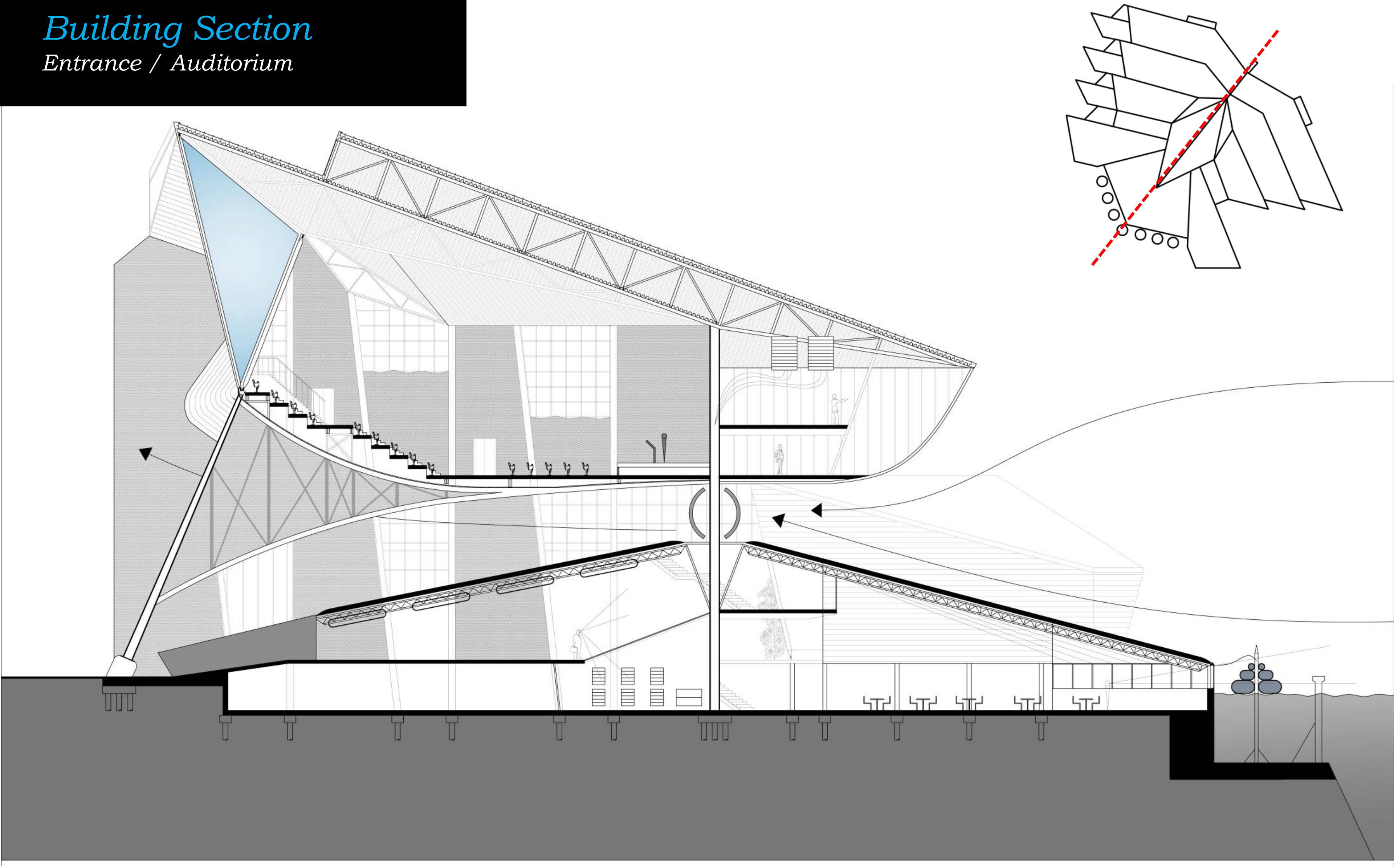
Bring to the core
- Purify H2O
- Electrolize to H2 & O2

Schematic Section

Produce / use Hydrogen



Building Section
Entrance / Auditorium



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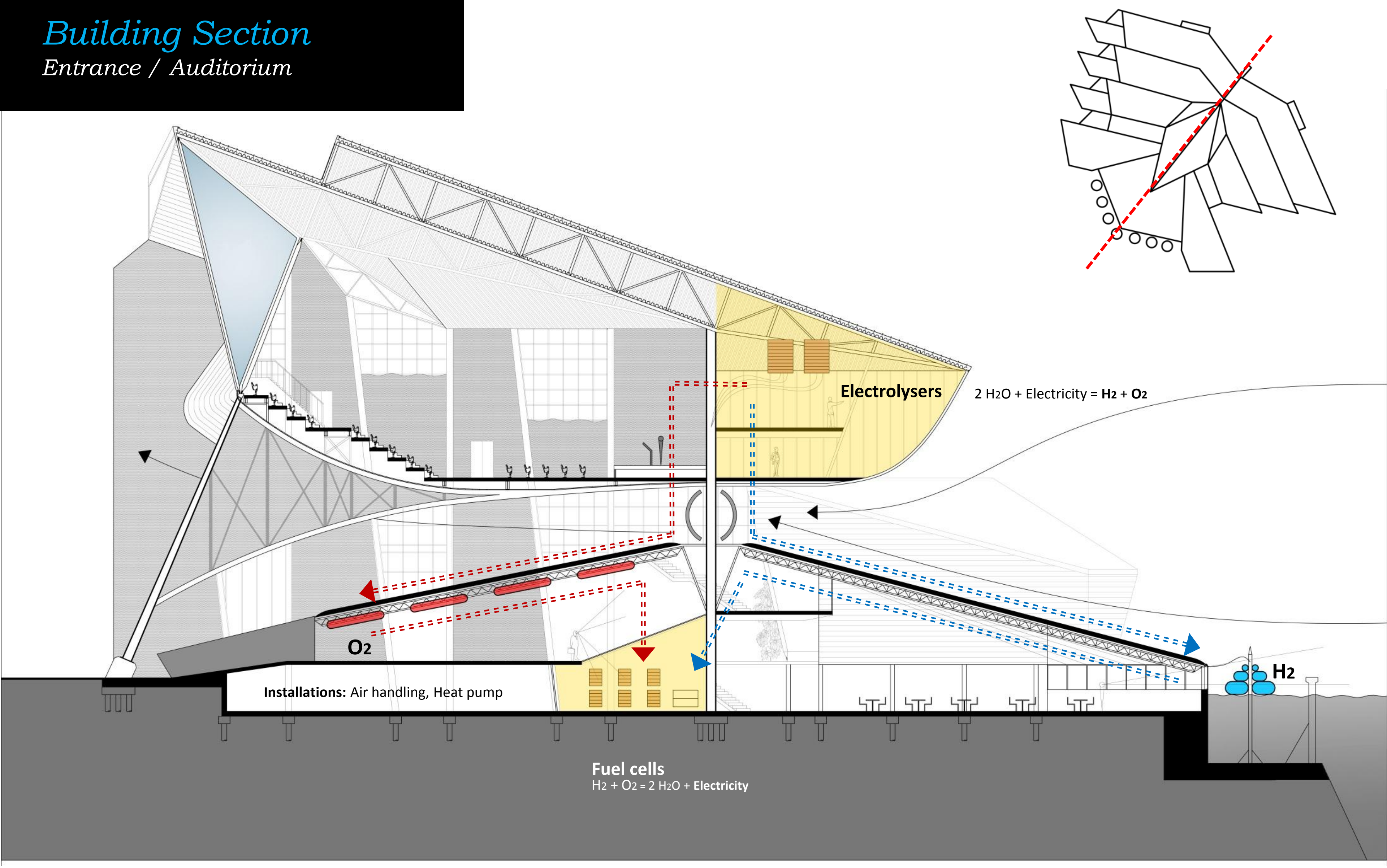

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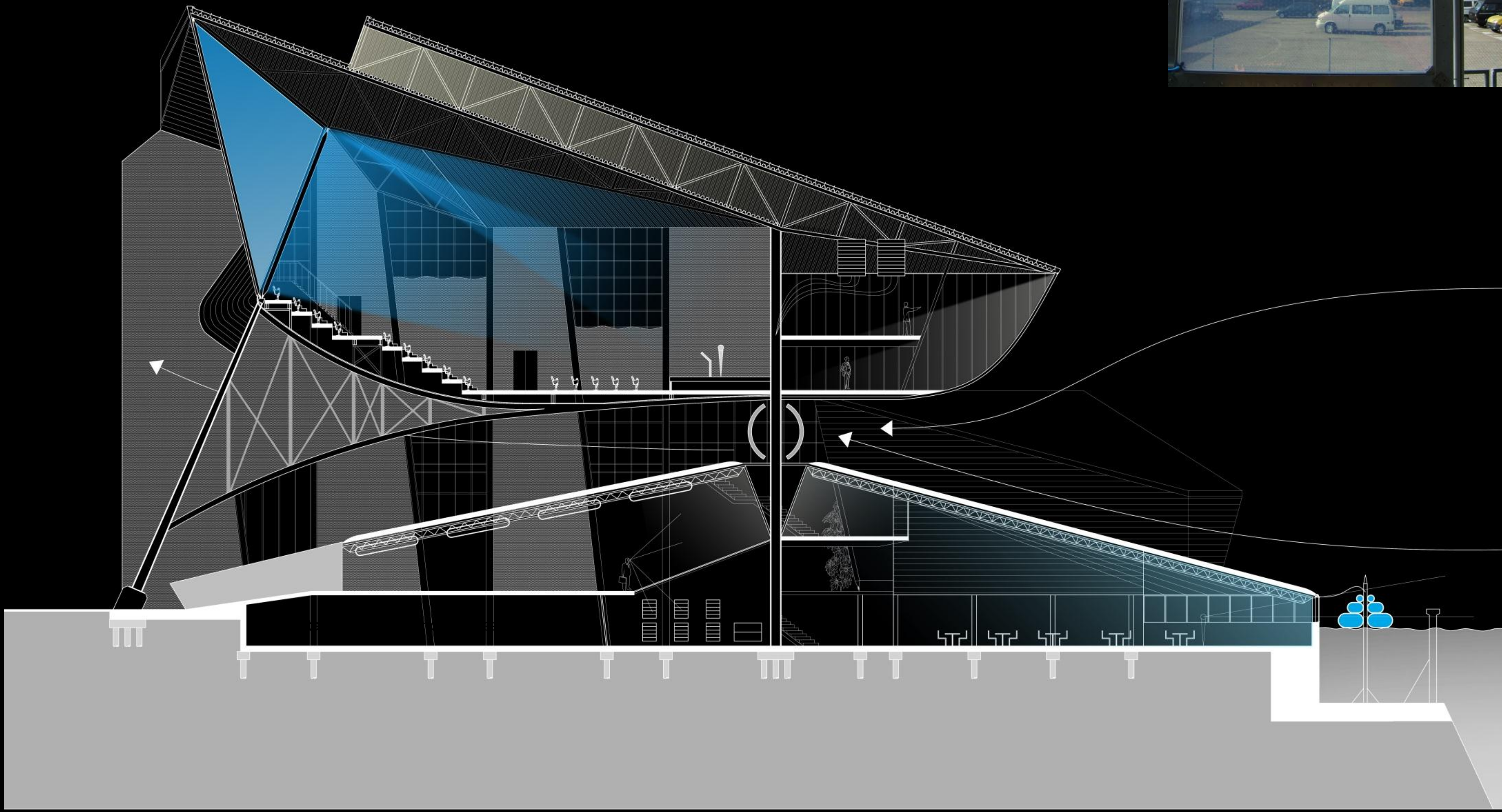

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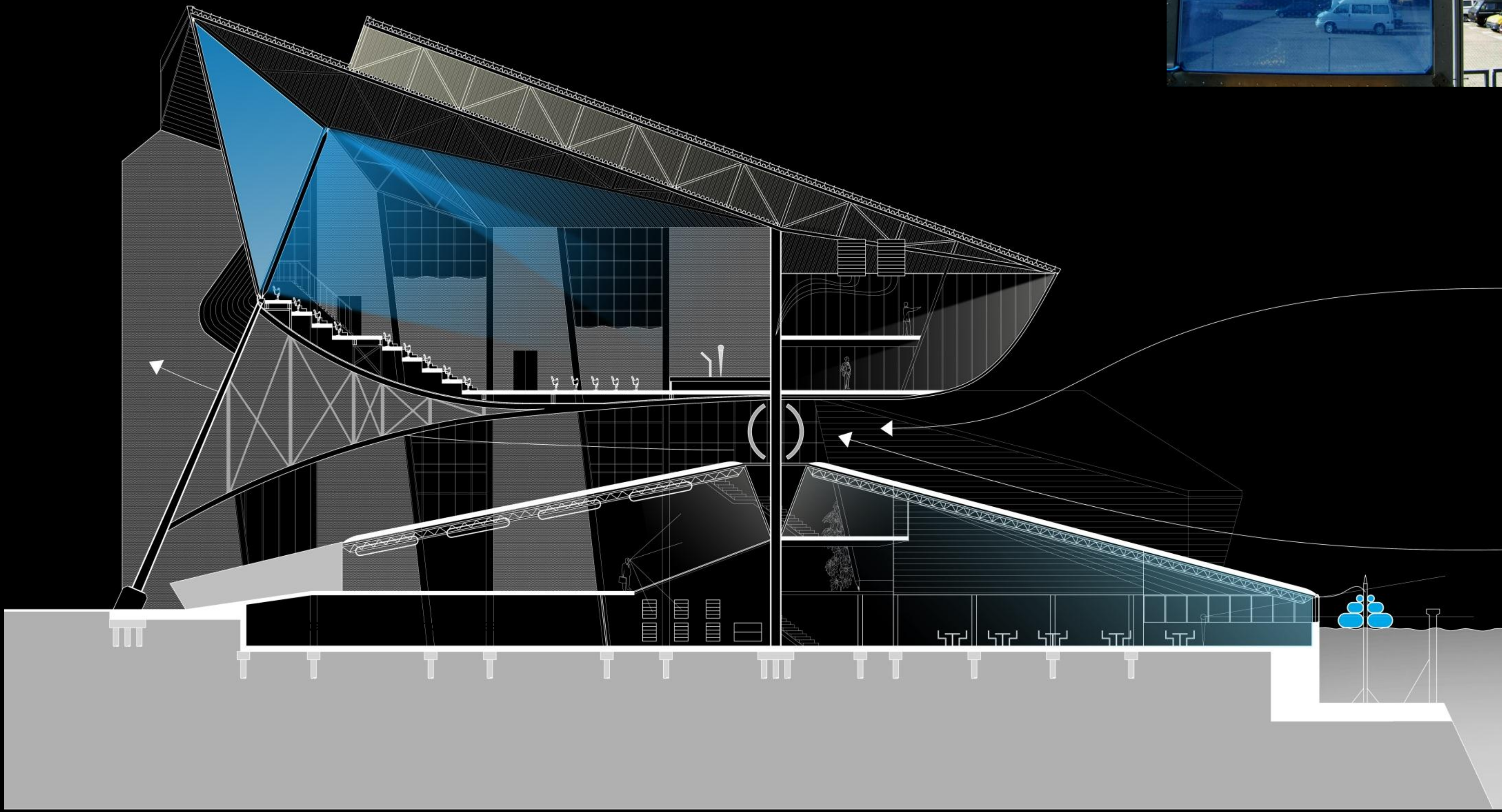

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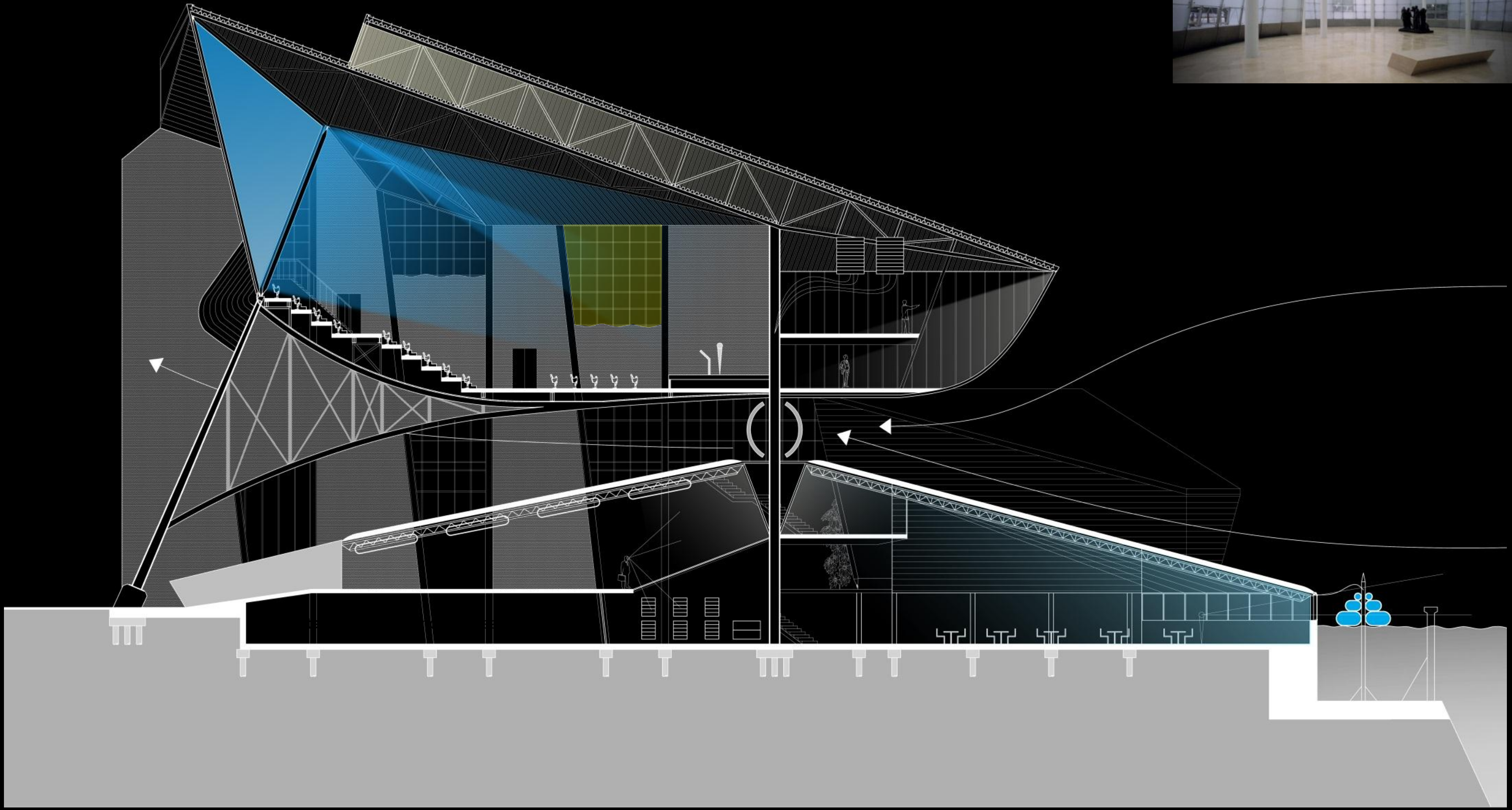

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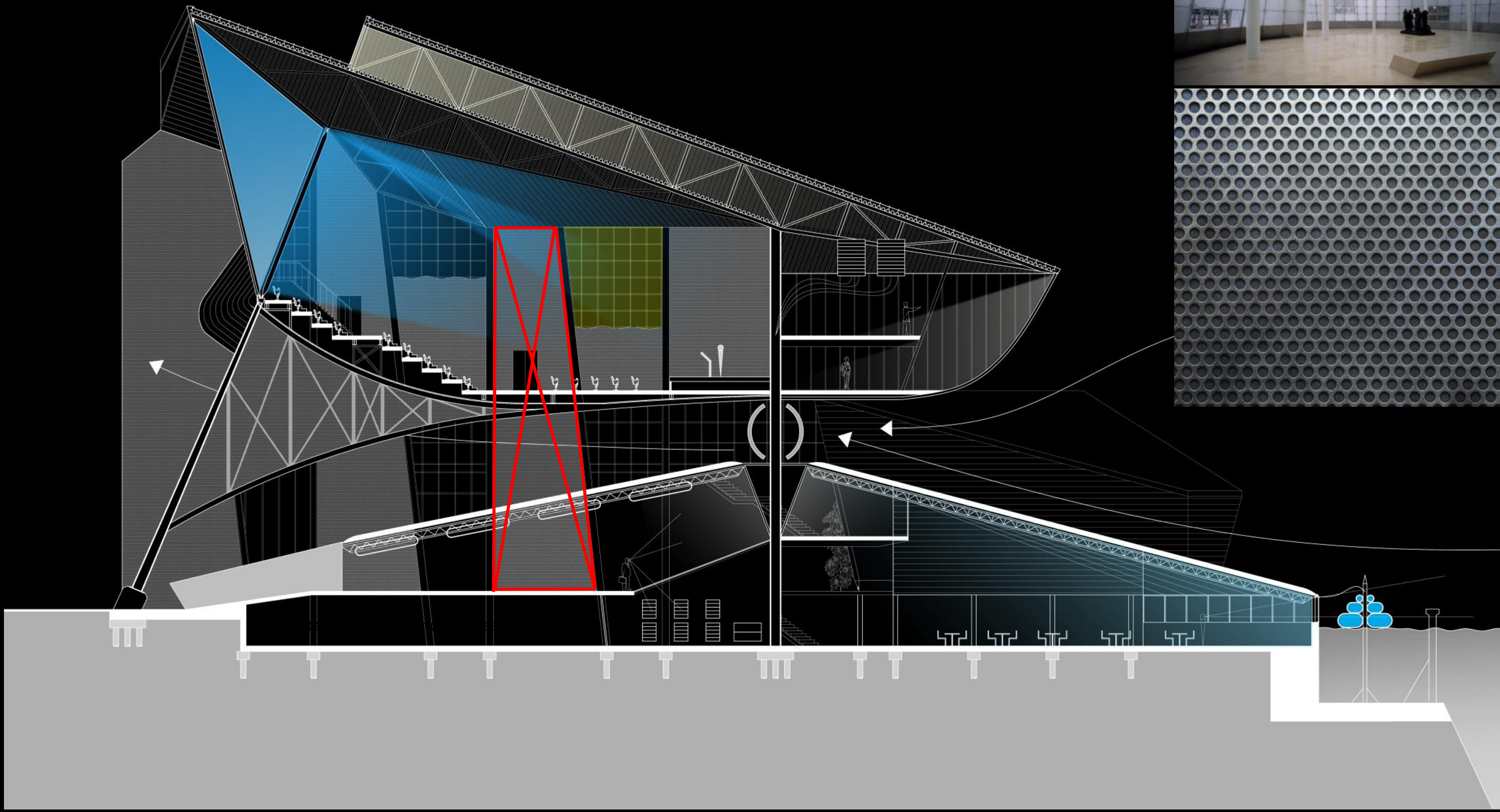
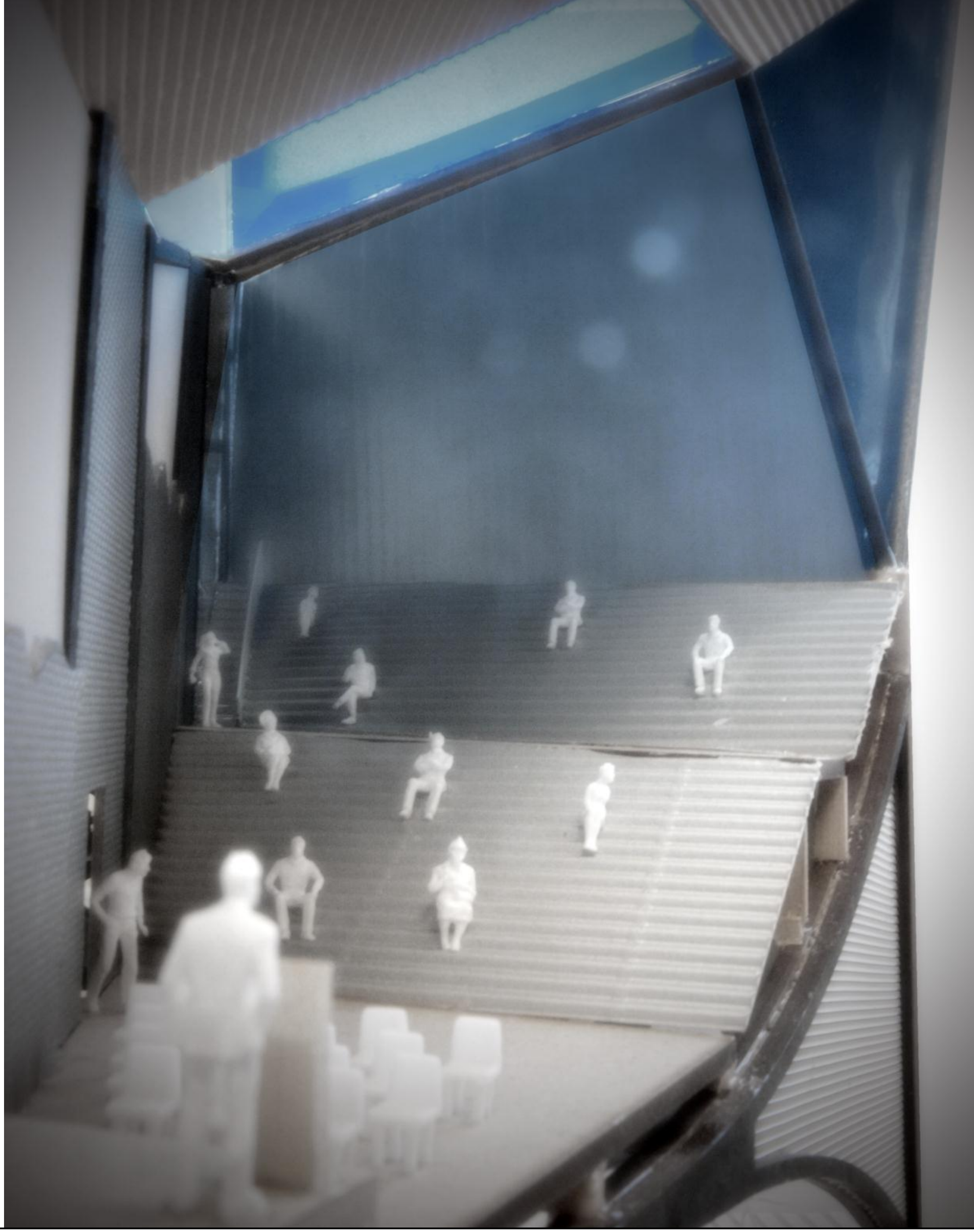


Model impressions

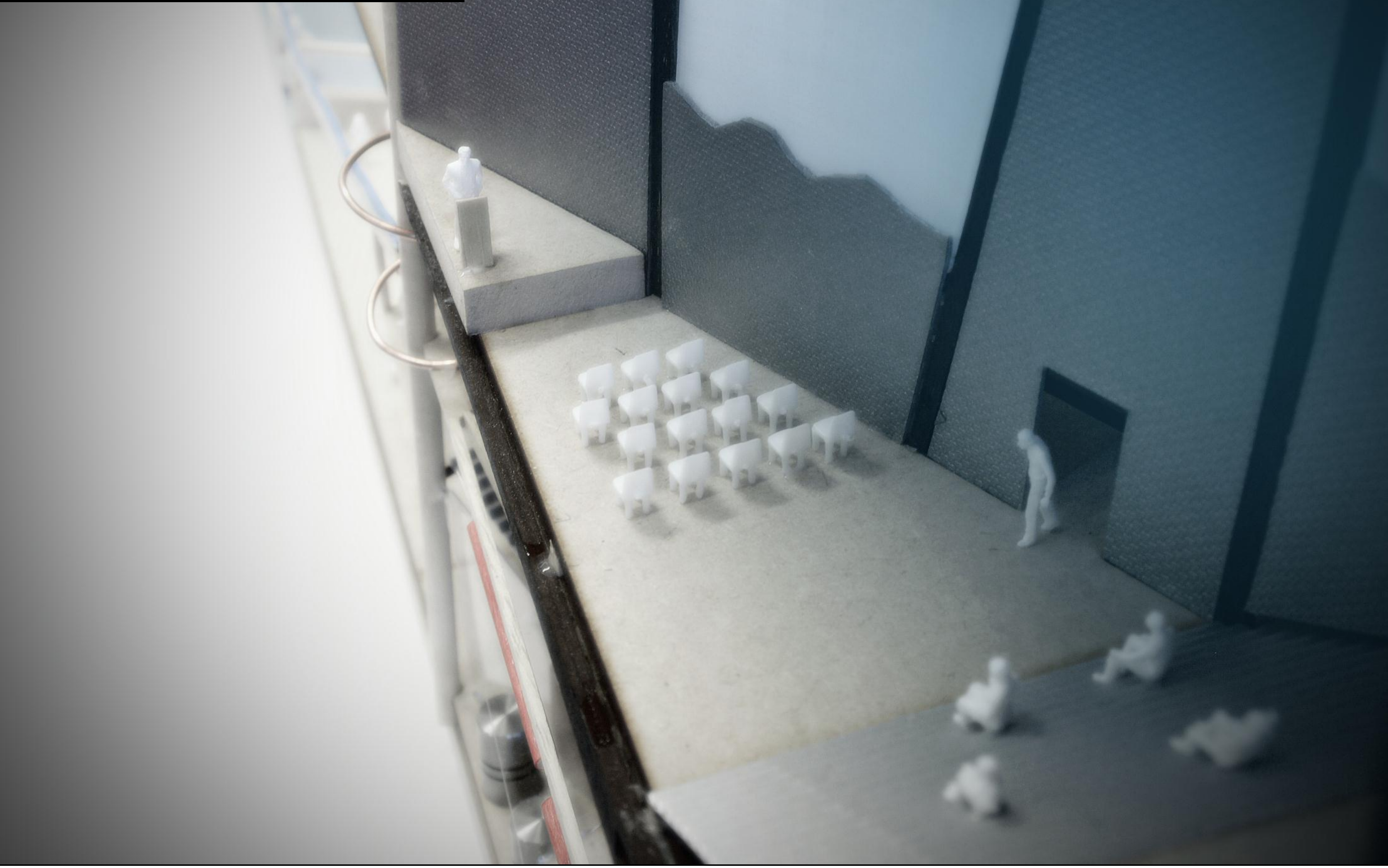
Auditorium

Model impressions

Auditorium

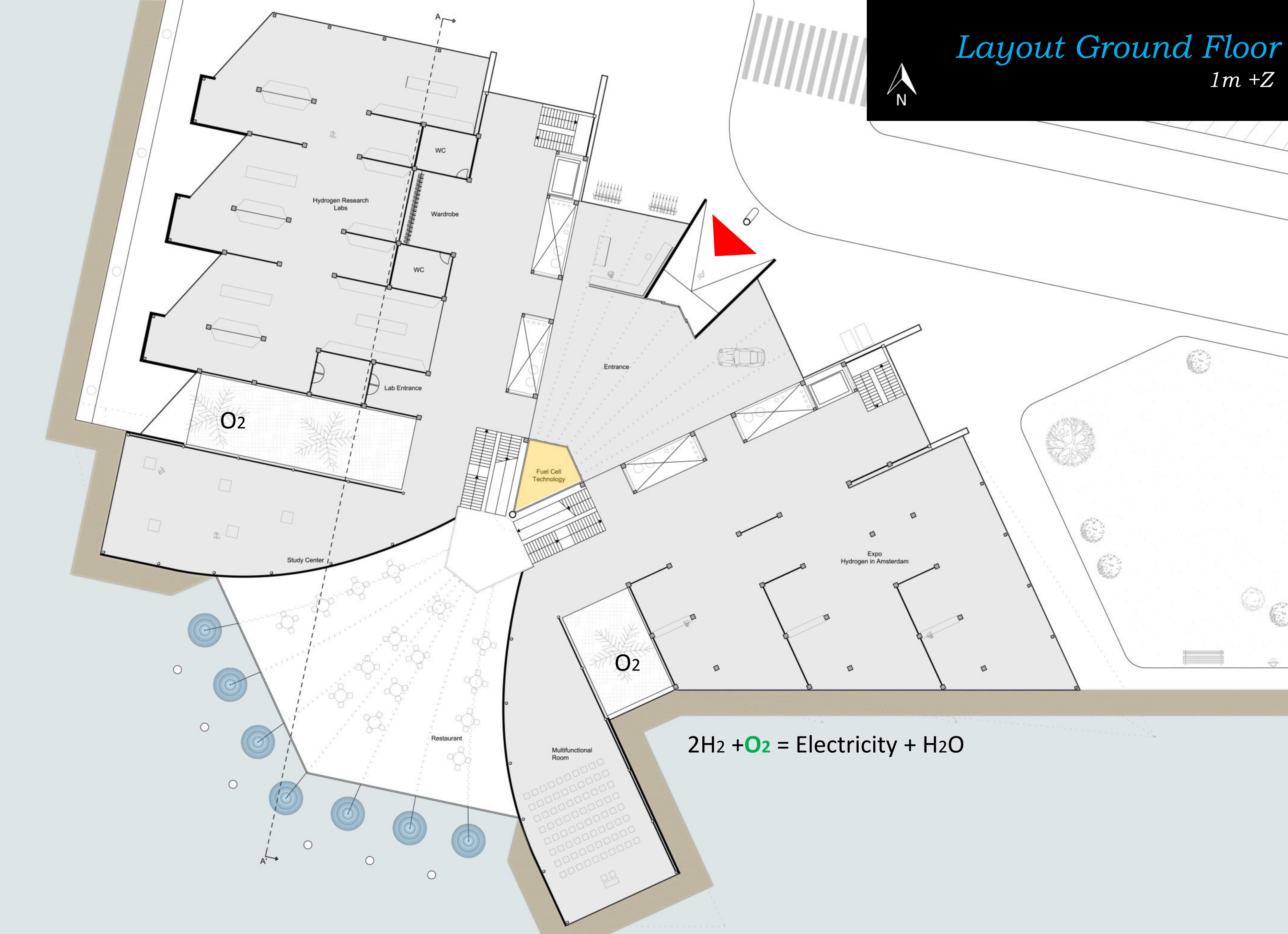


Model impressions
Auditorium



Layout Ground Floor

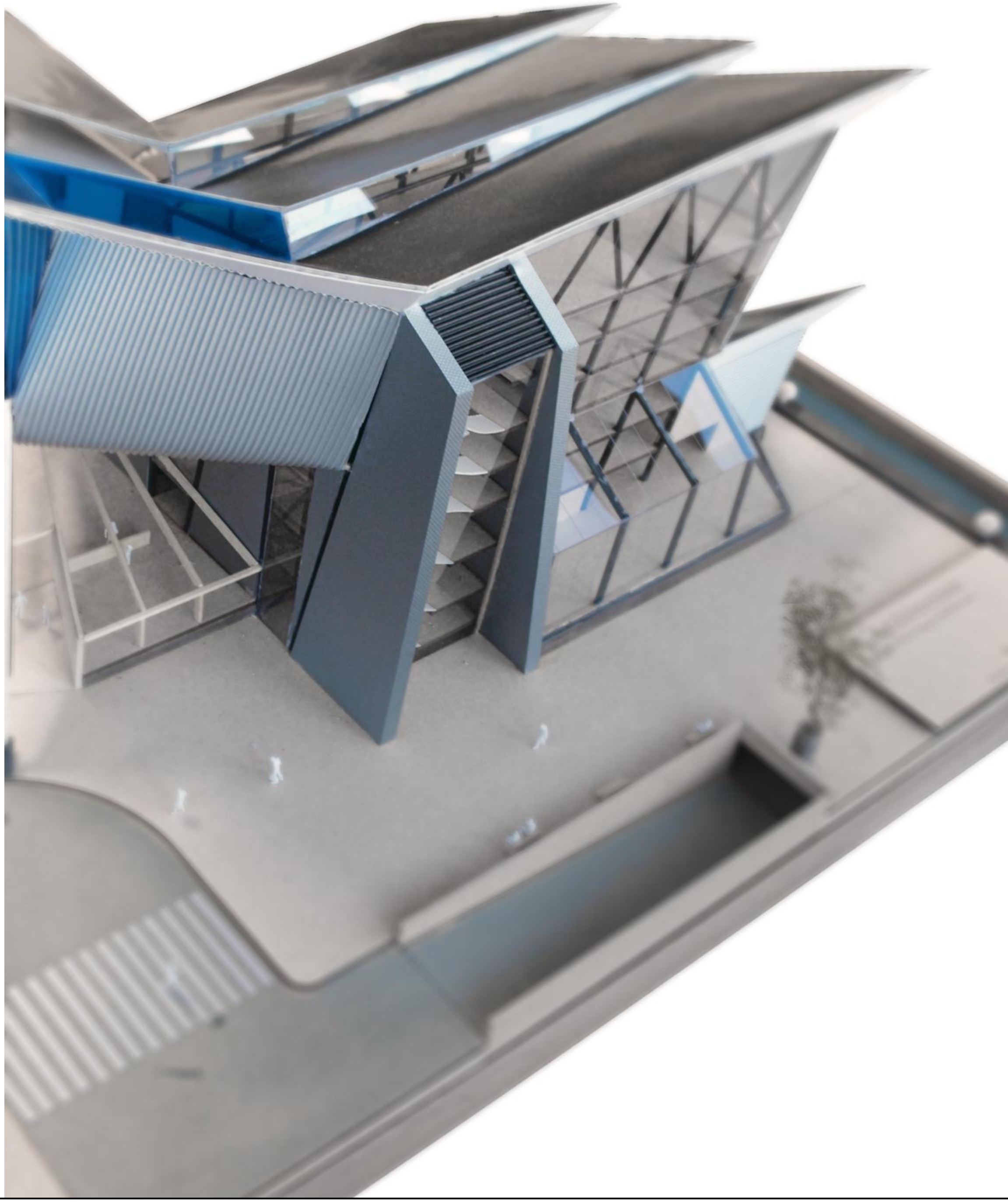
1m +Z



$2H_2 + O_2$ = Electricity + H_2O

Model impressions

Entering the building



Model impressions
Entering the building

Model impressions

Entering the building

Model impressions
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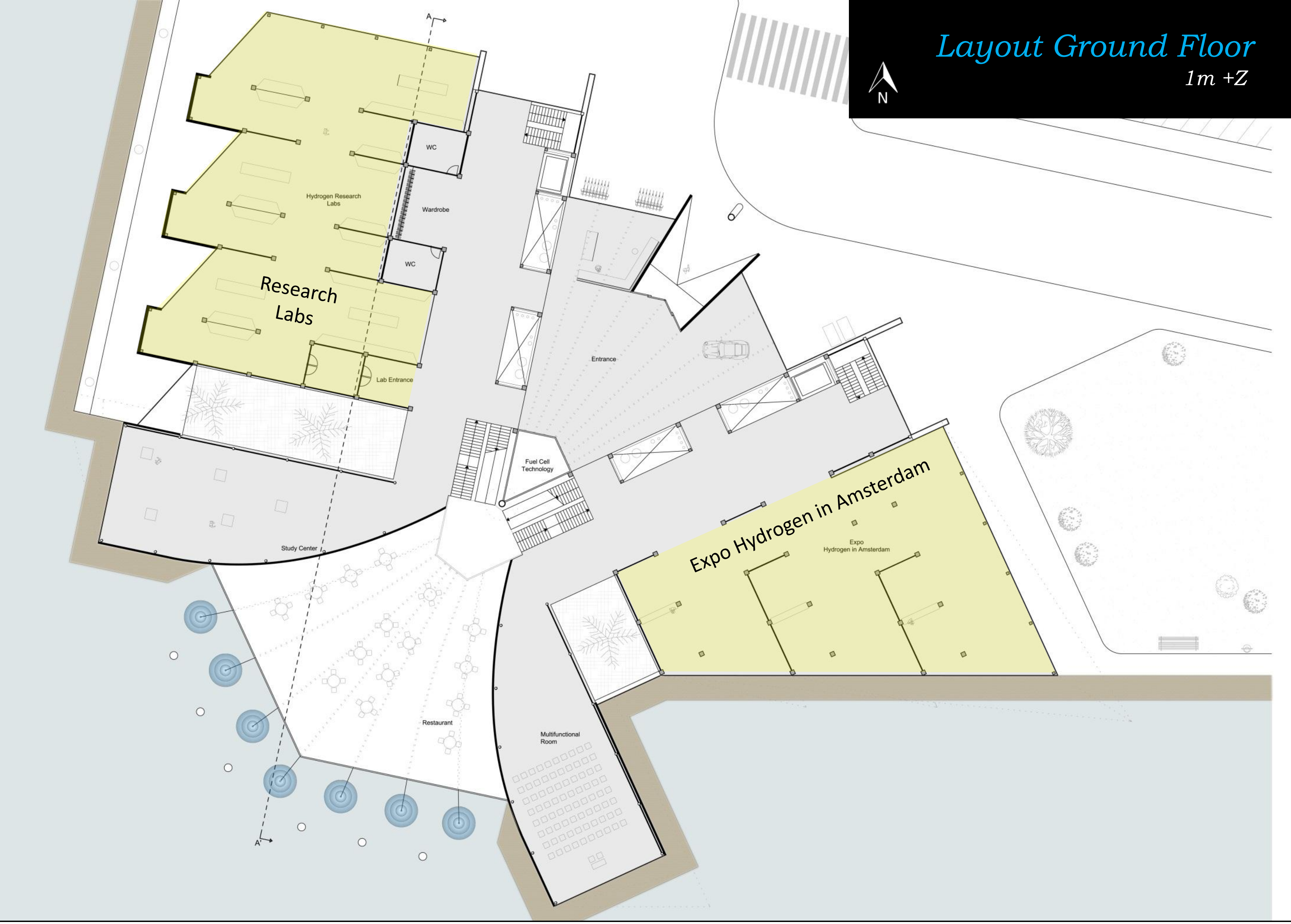
Model impressions
Entering the building

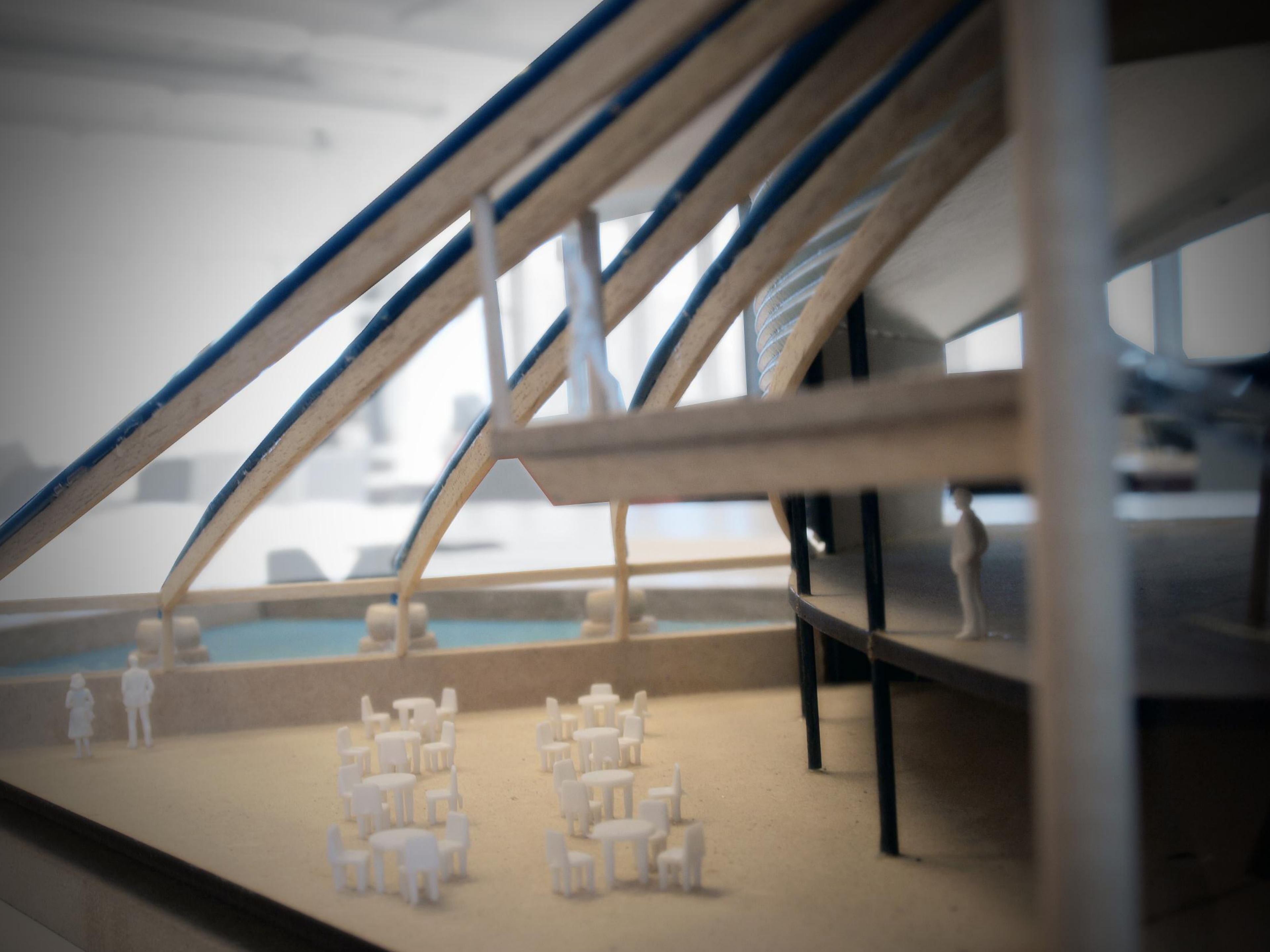
Layout Ground Floor

1m +Z



Impression

Arriving by boat, around the building



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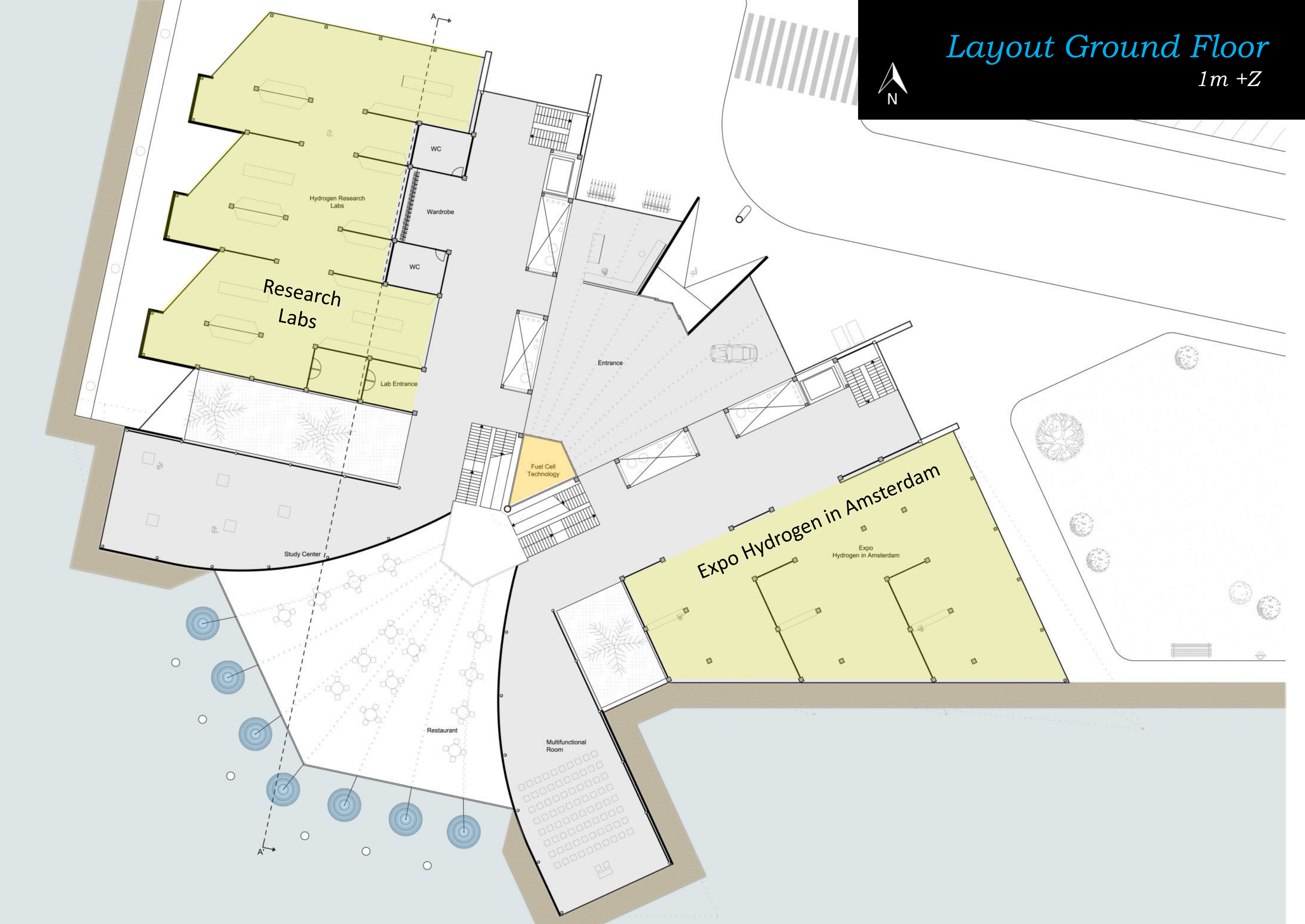

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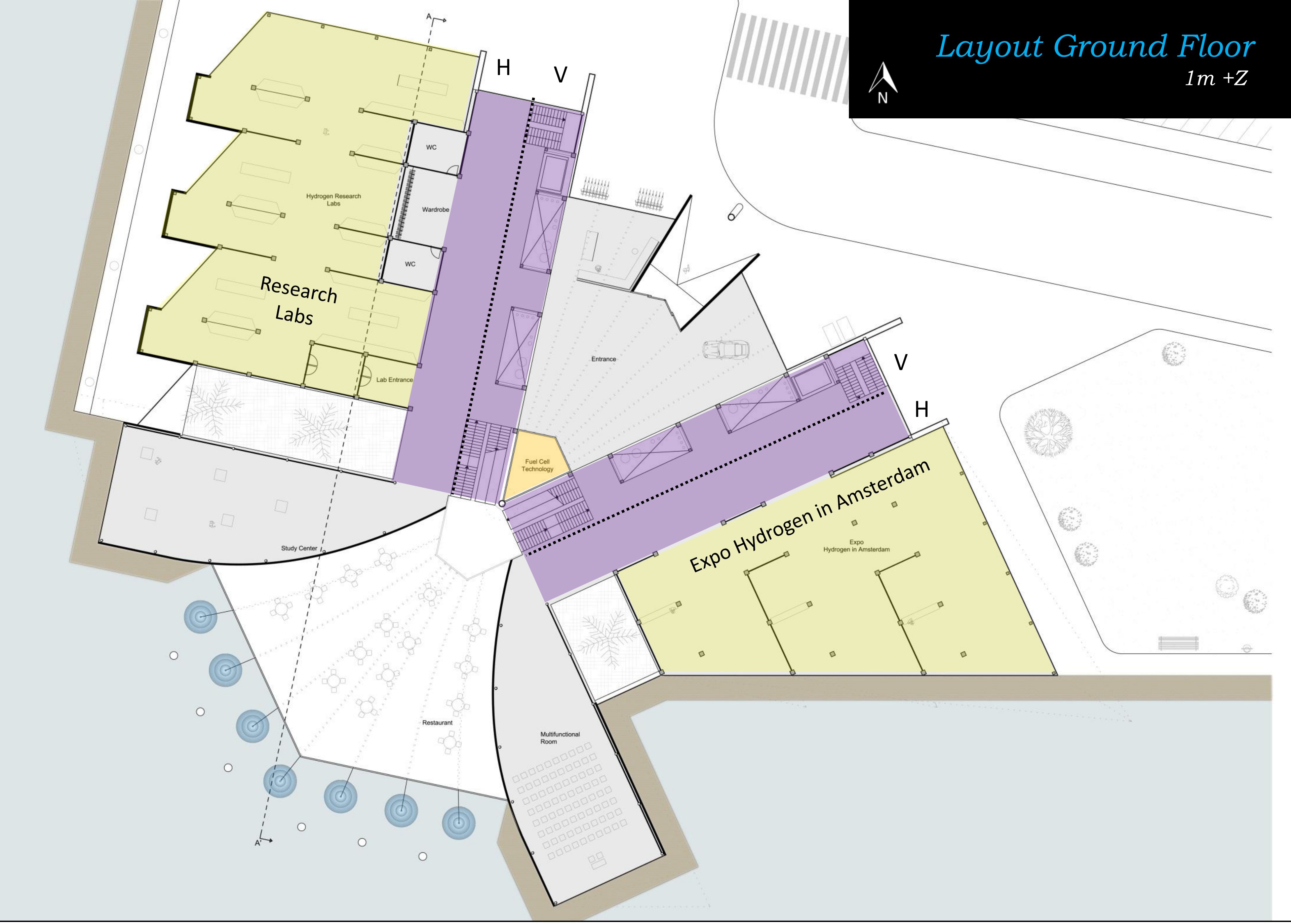

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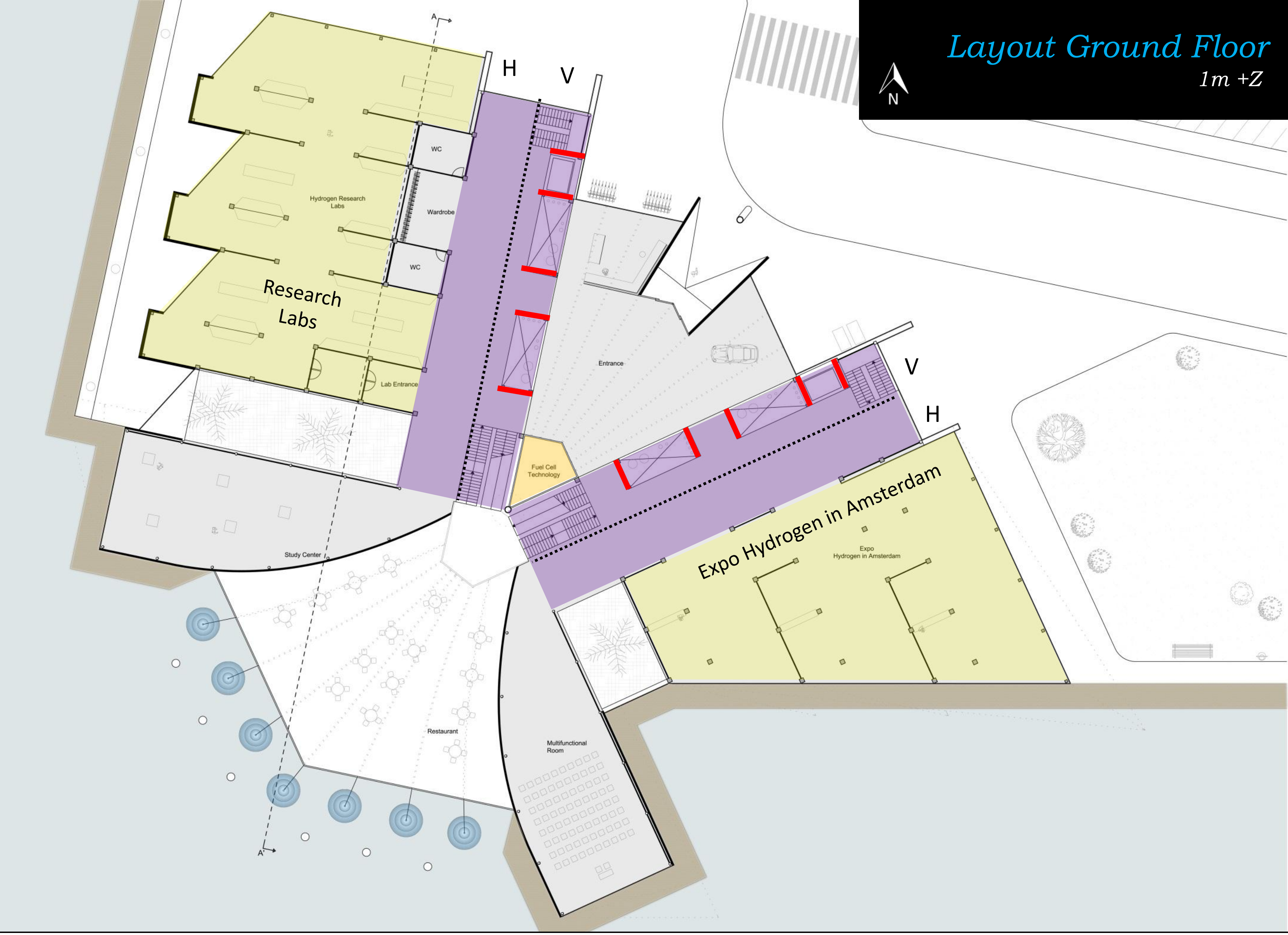

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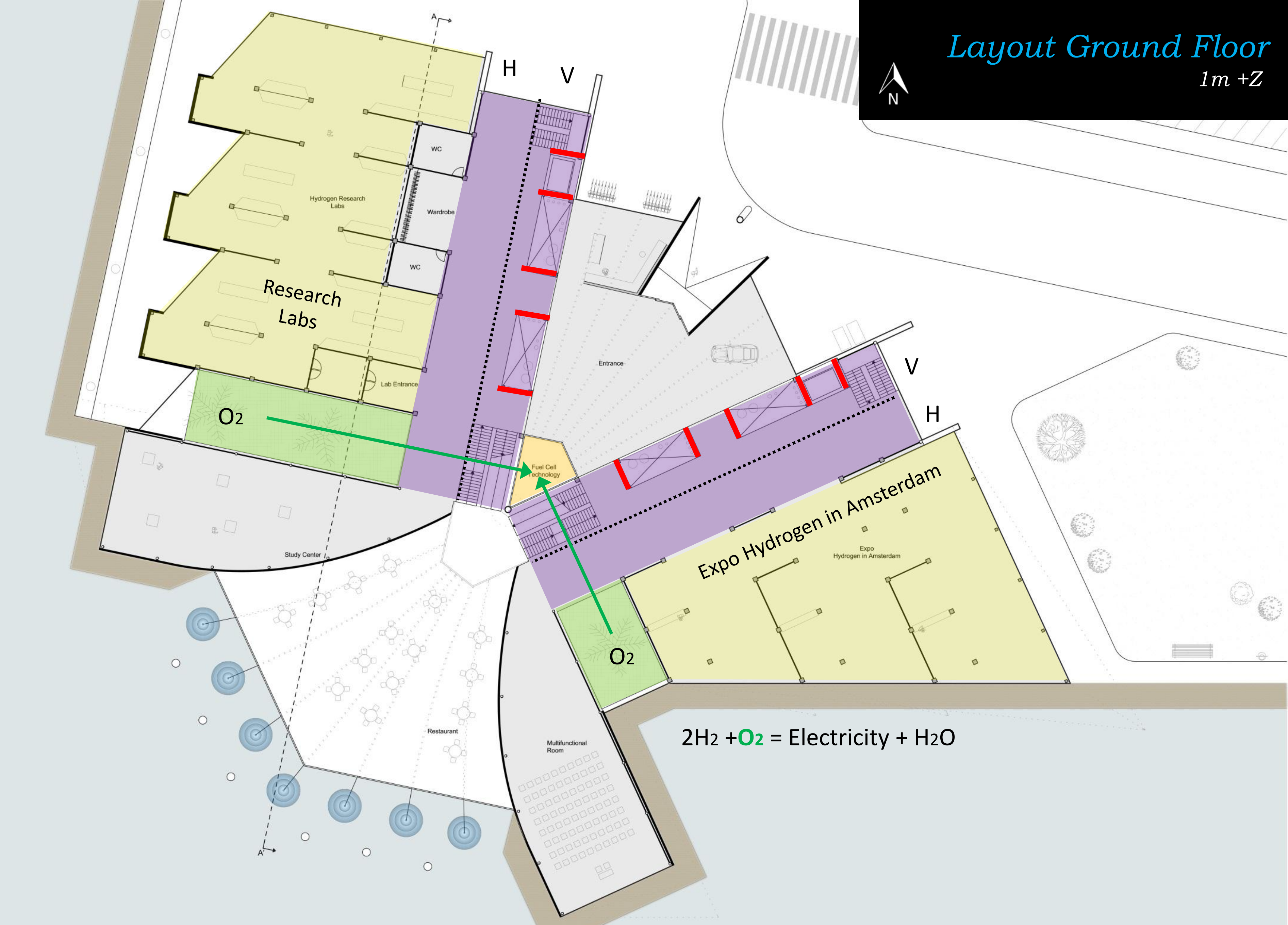

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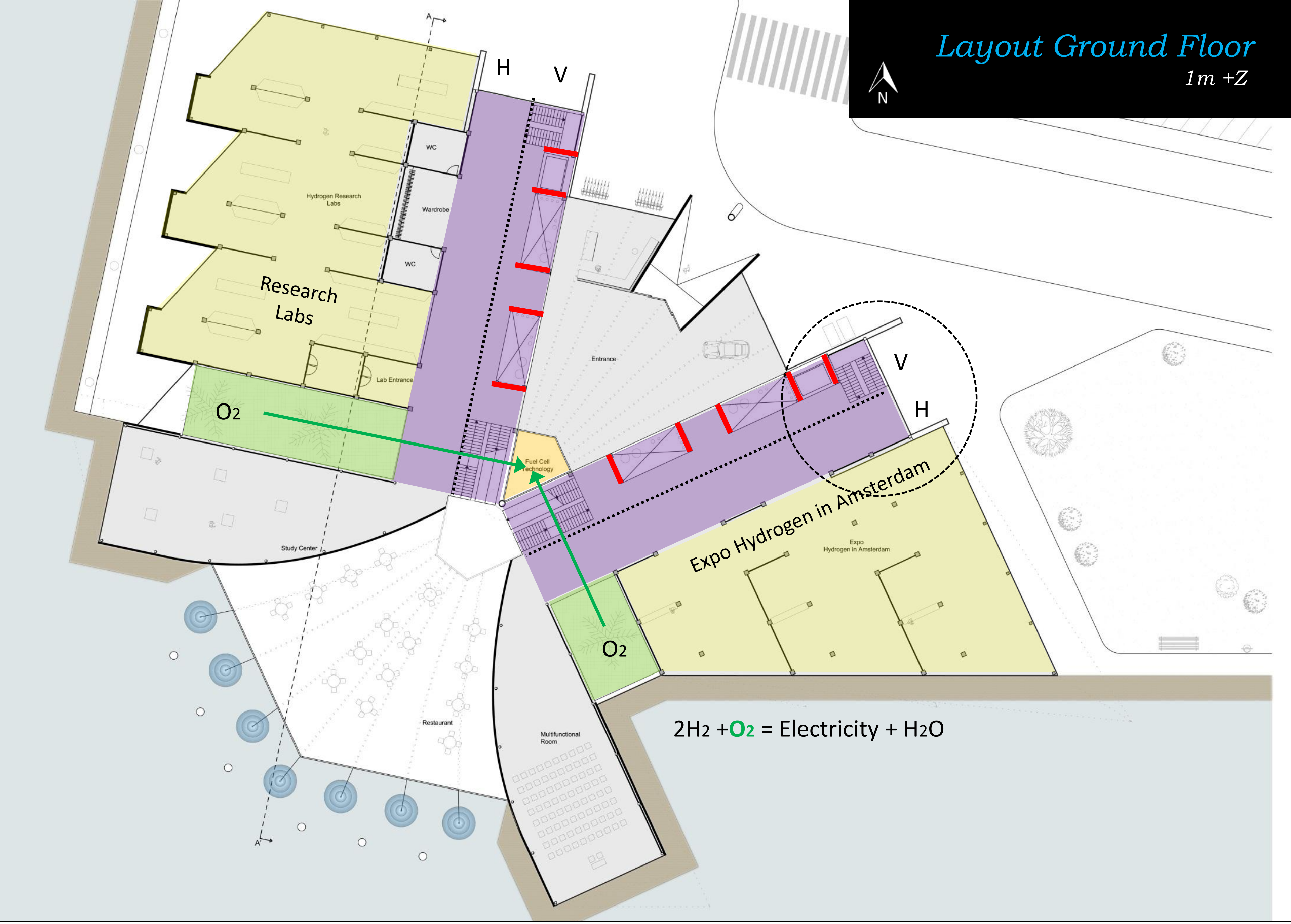
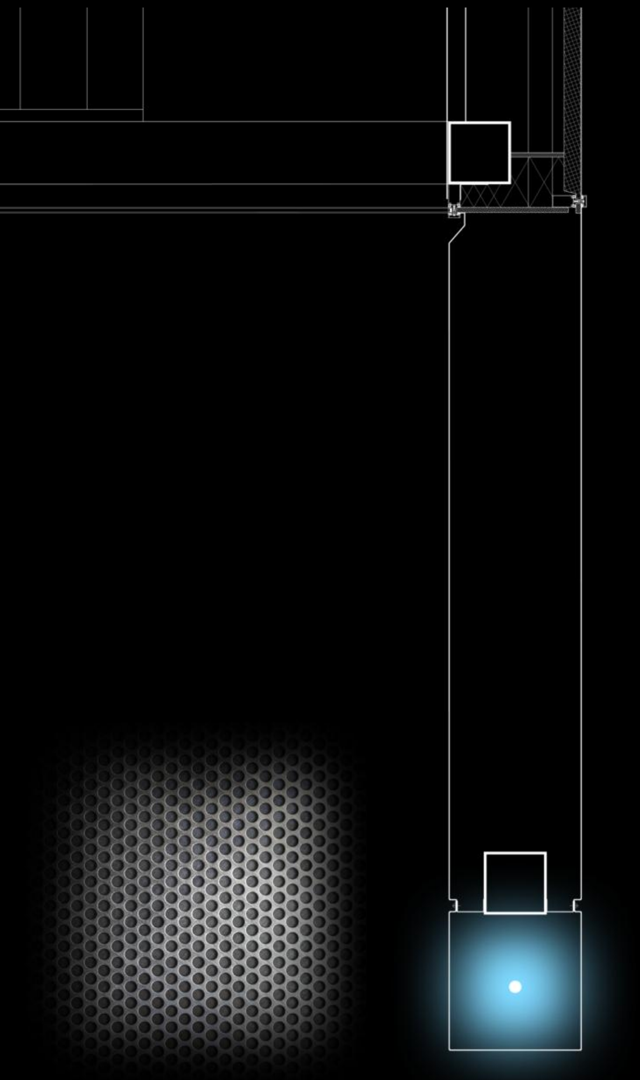
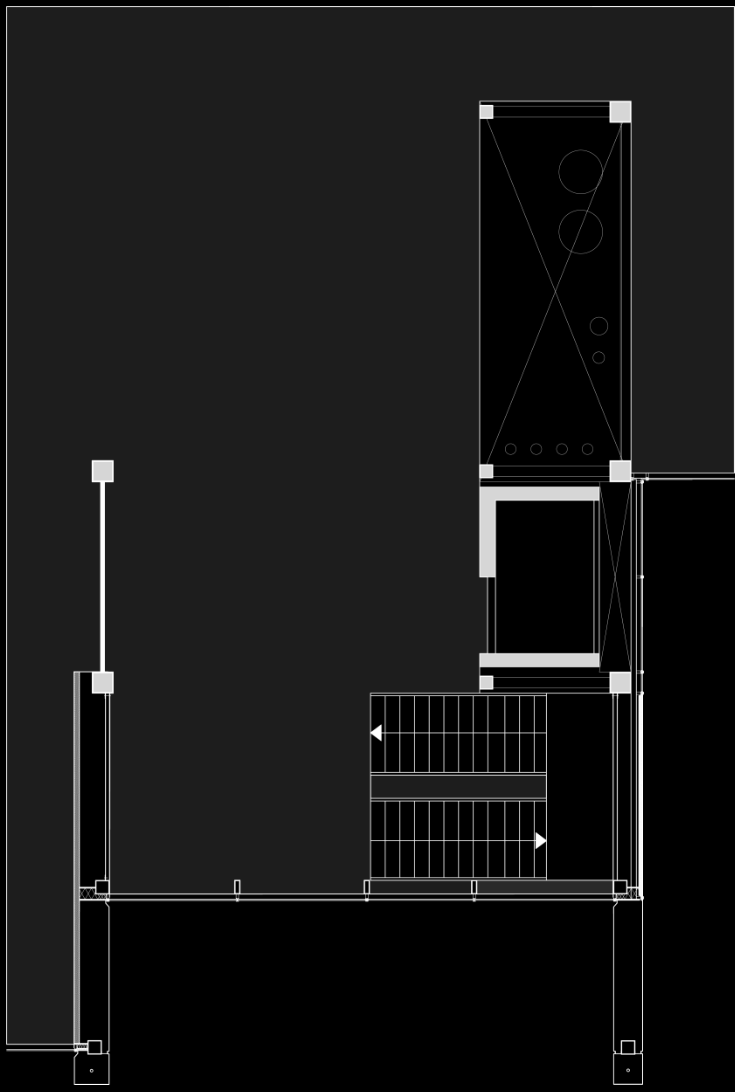


$2H_2 + O_2$ = Electricity + H_2O

Detail Building Shaft

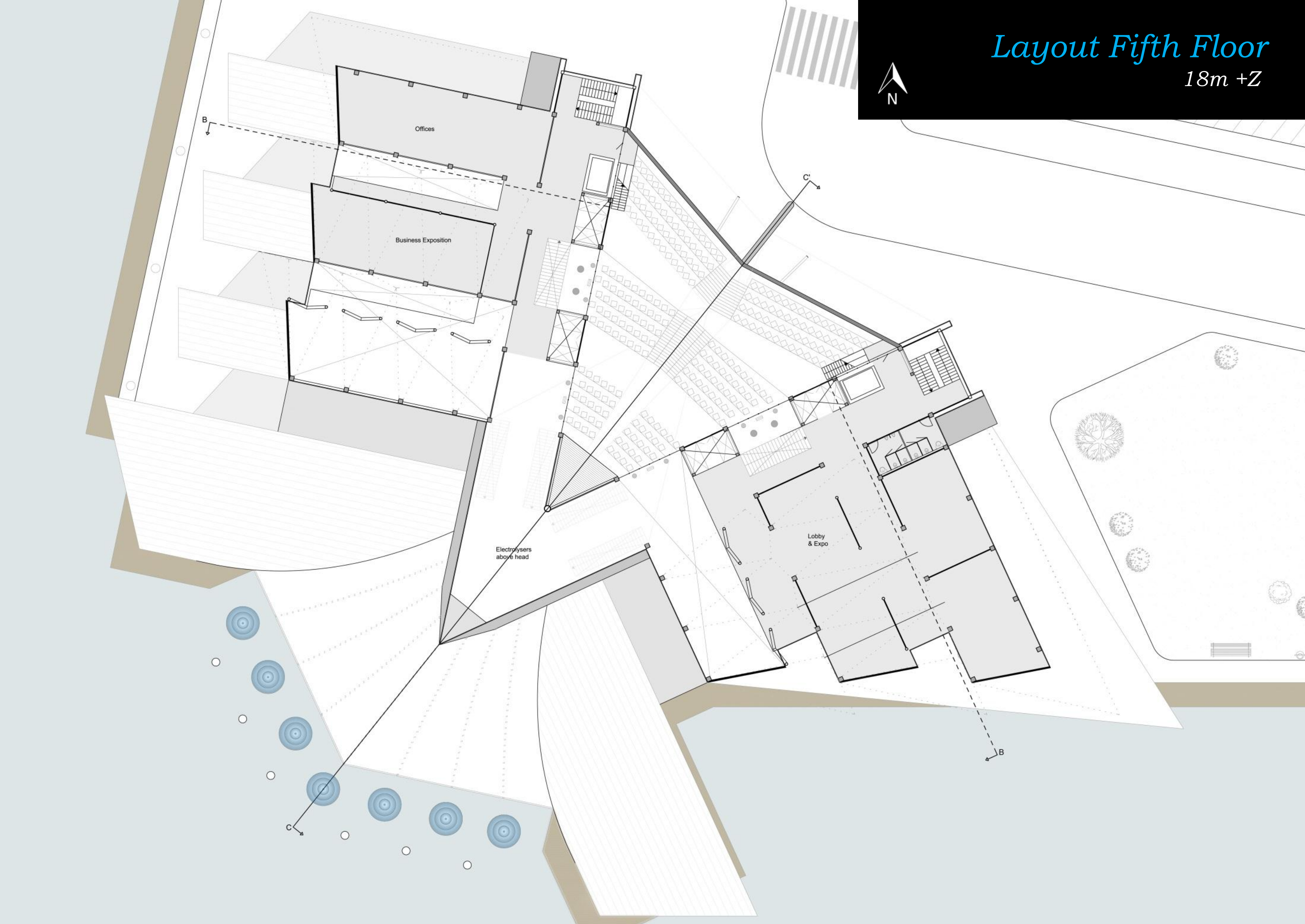
Indoor/ Outdoor - Material





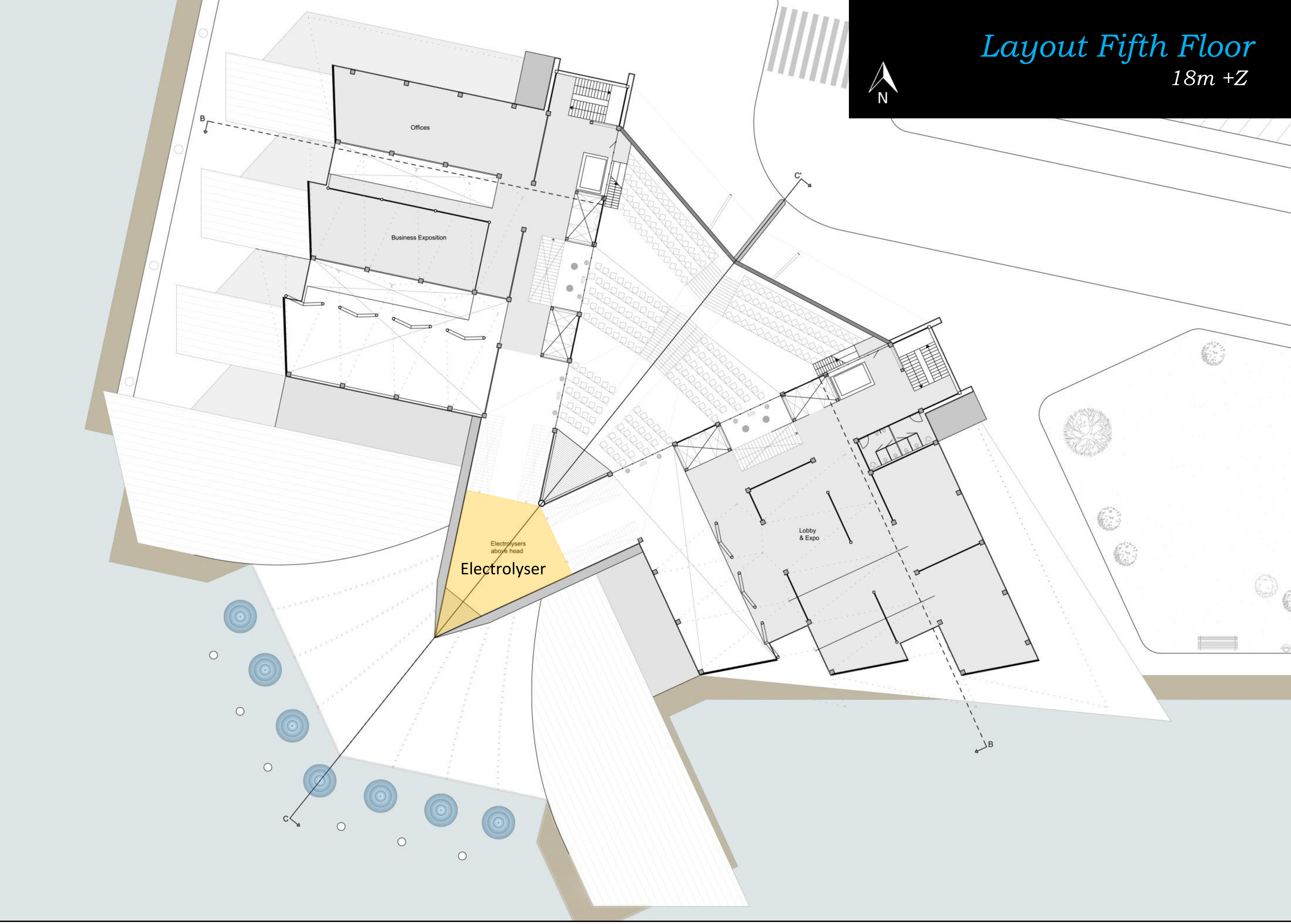
Layout Fifth Floor

18m +Z



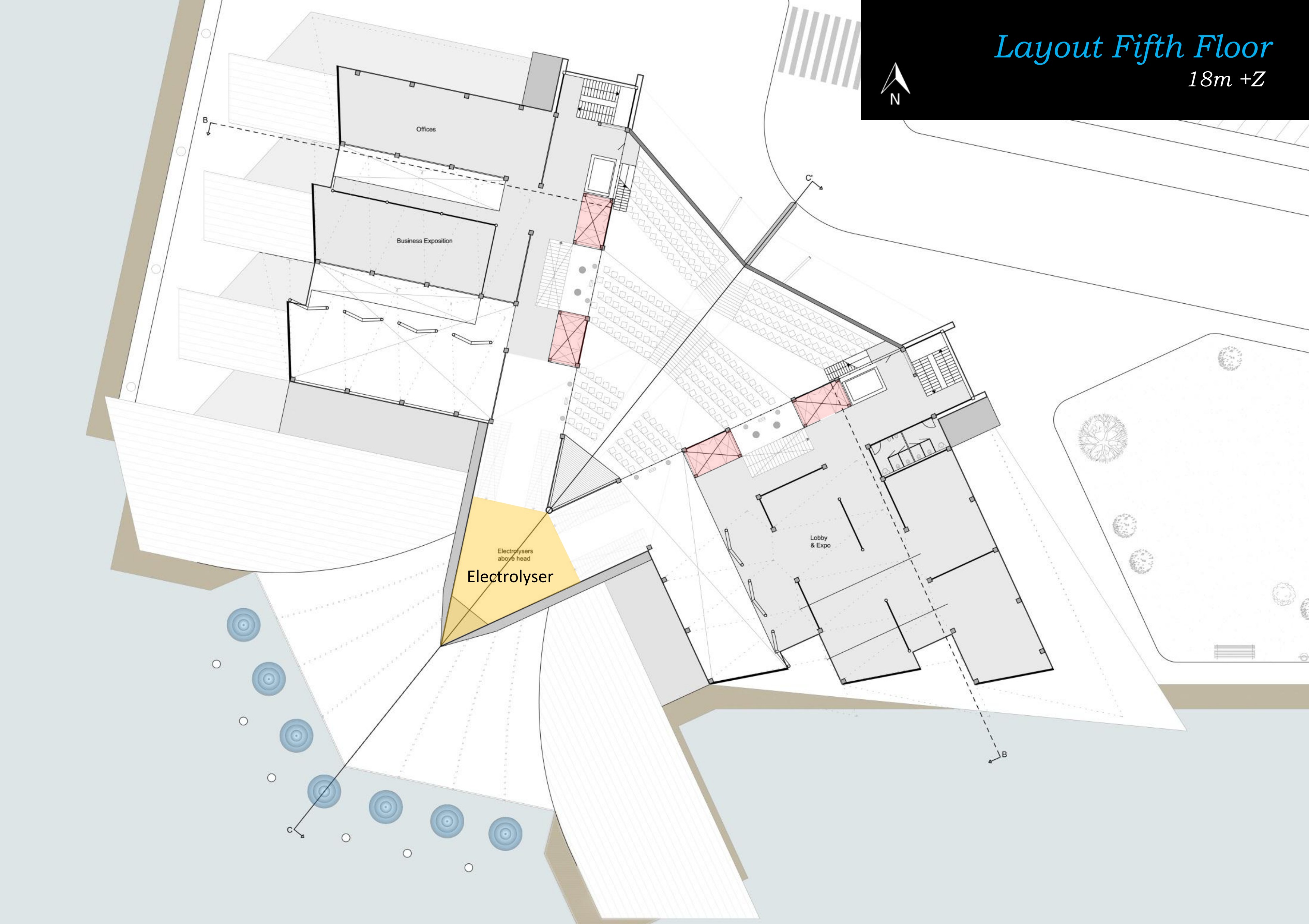
Layout Fifth Floor

18m +Z



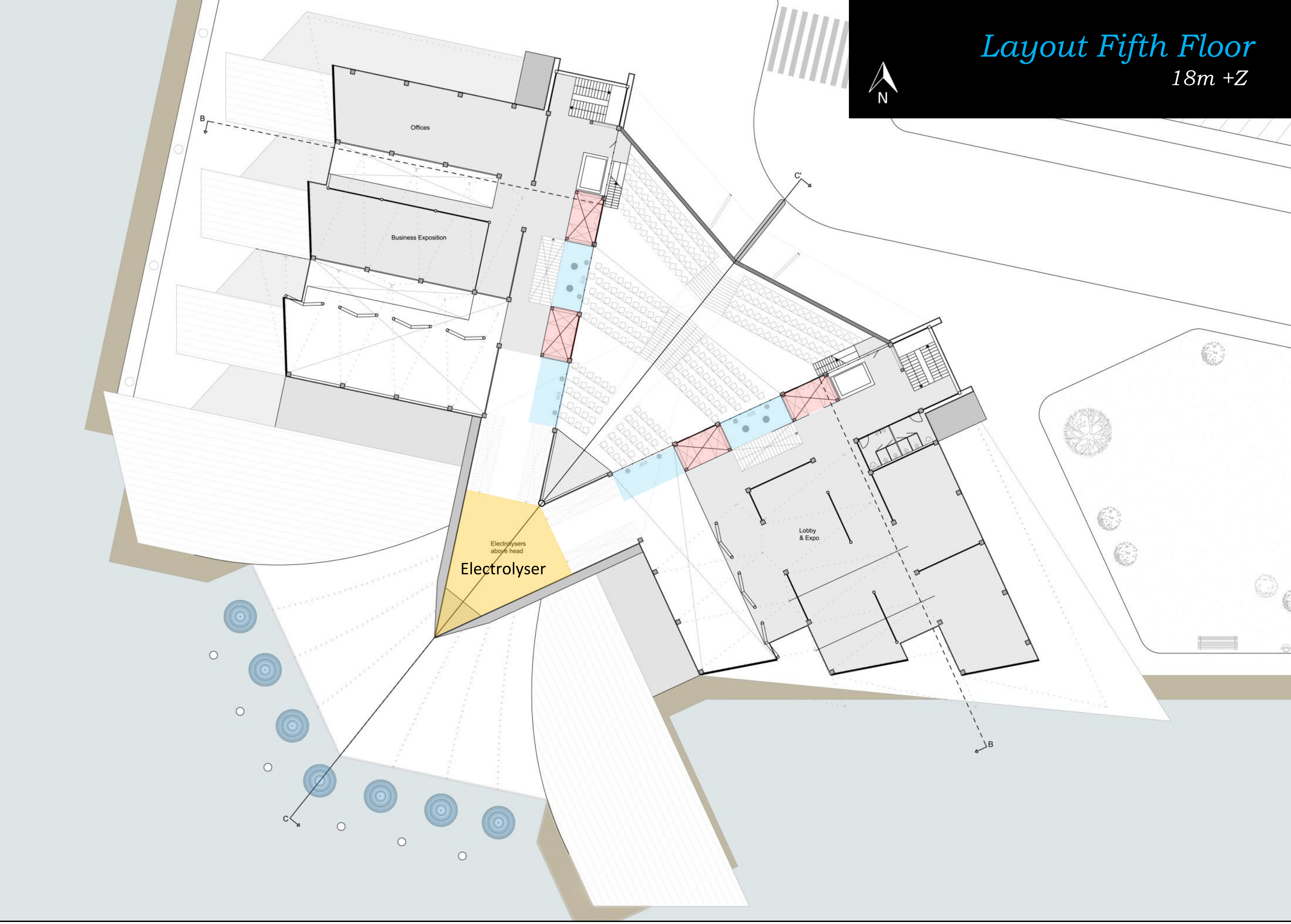
Layout Fifth Floor

18m +Z



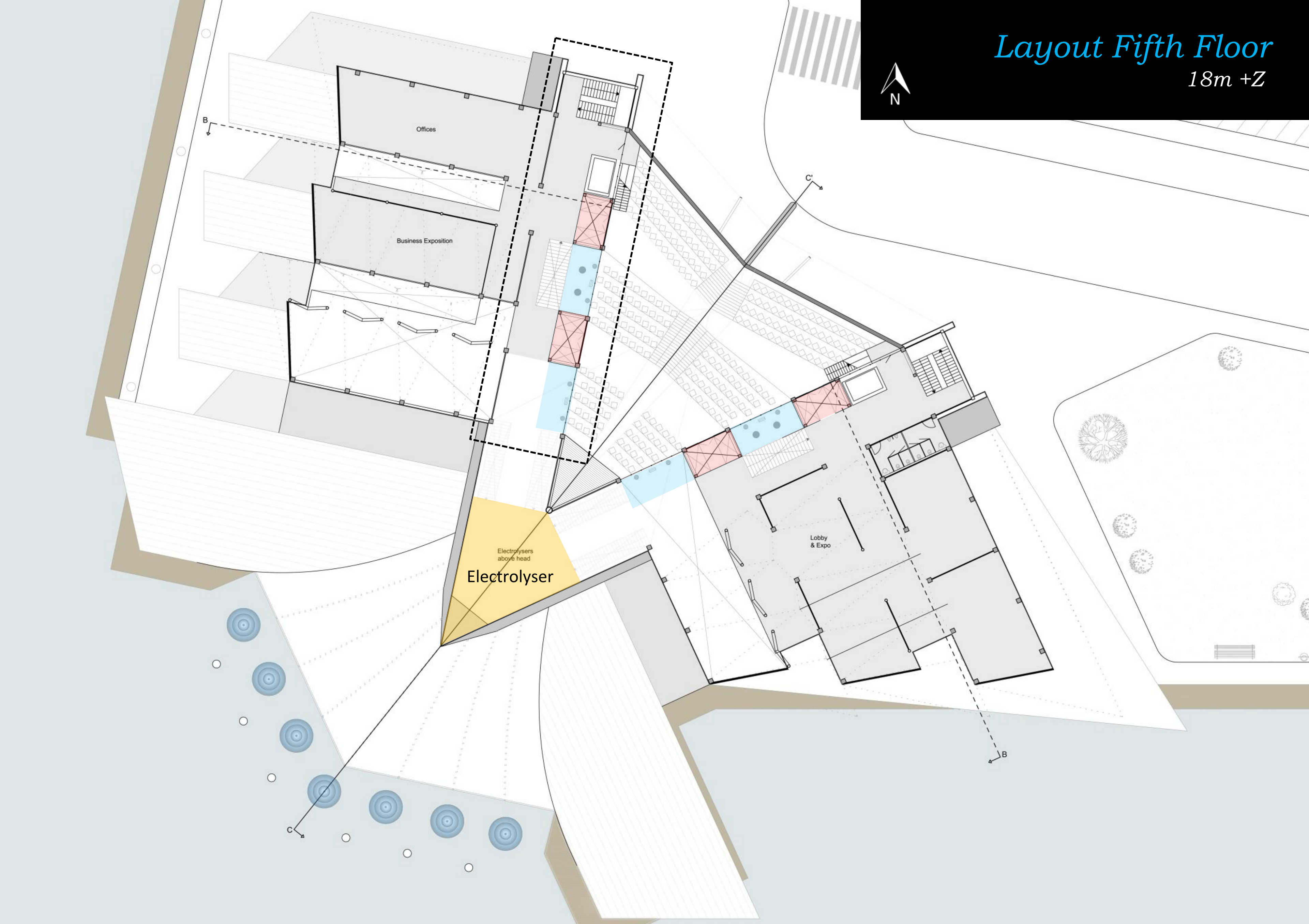
Layout Fifth Floor

18m +Z



Layout Fifth Floor

18m +Z

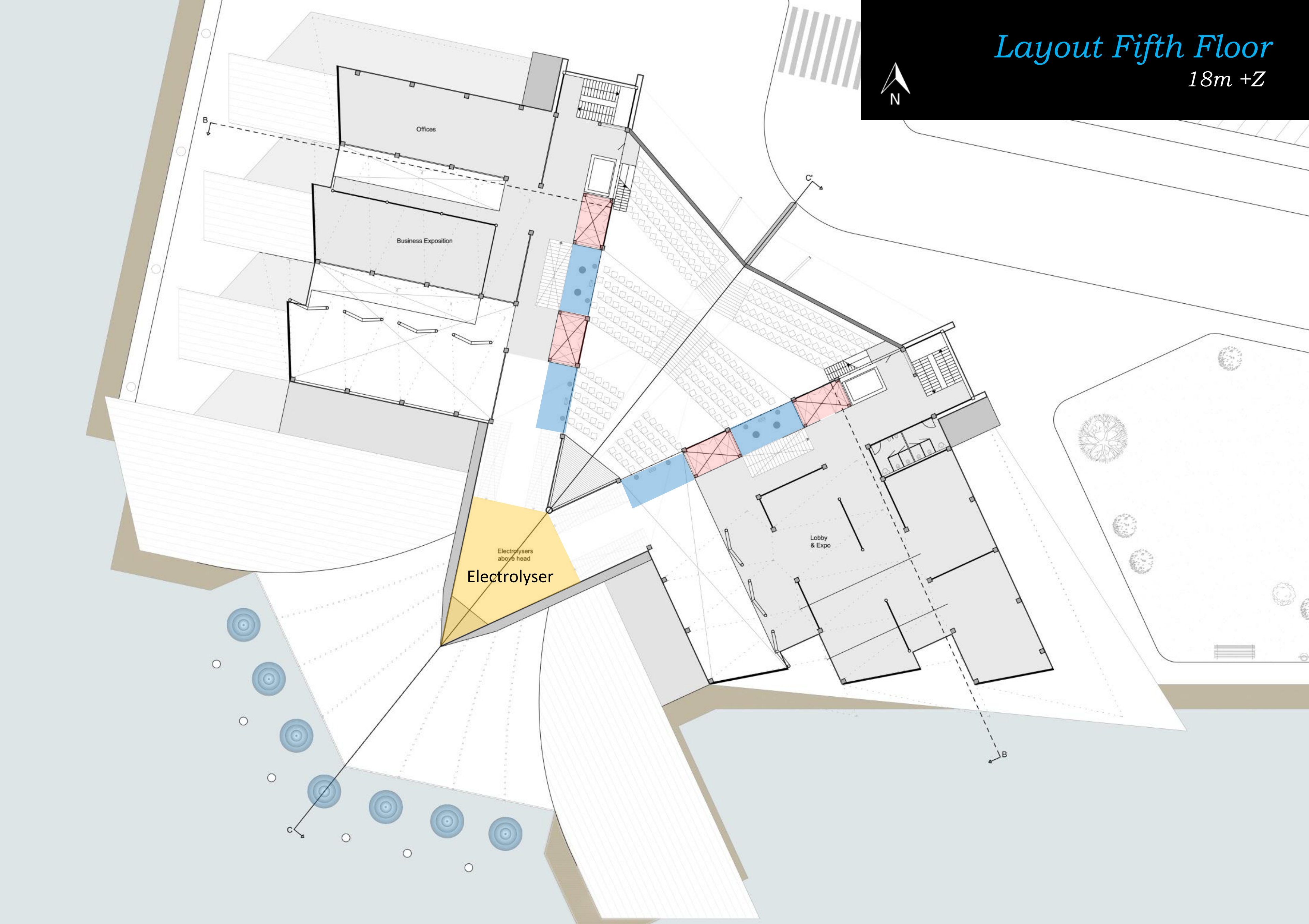


Corridor Impression

Routing/ lighting/ ducting/ materials

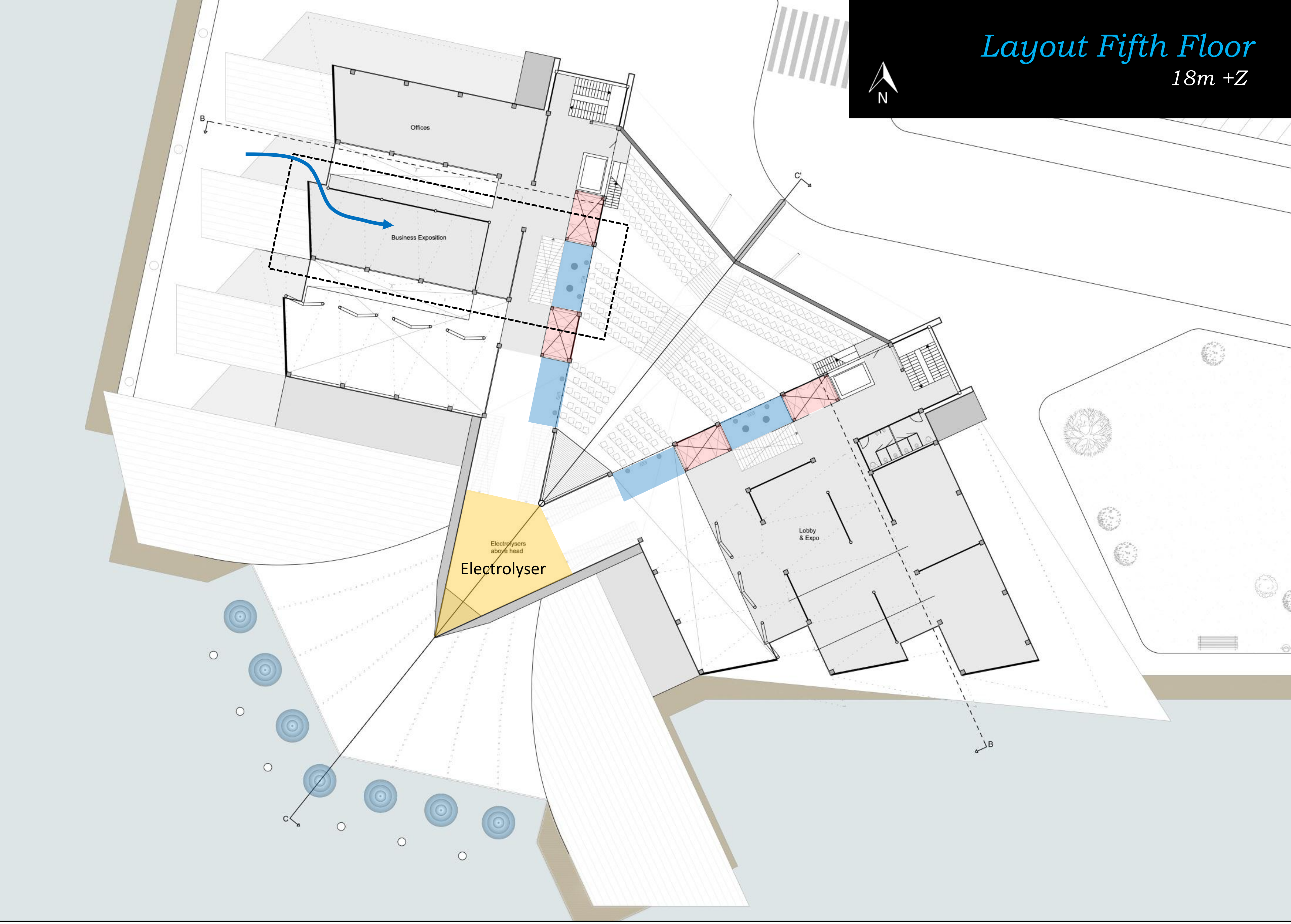
Layout Fifth Floor

18m +Z



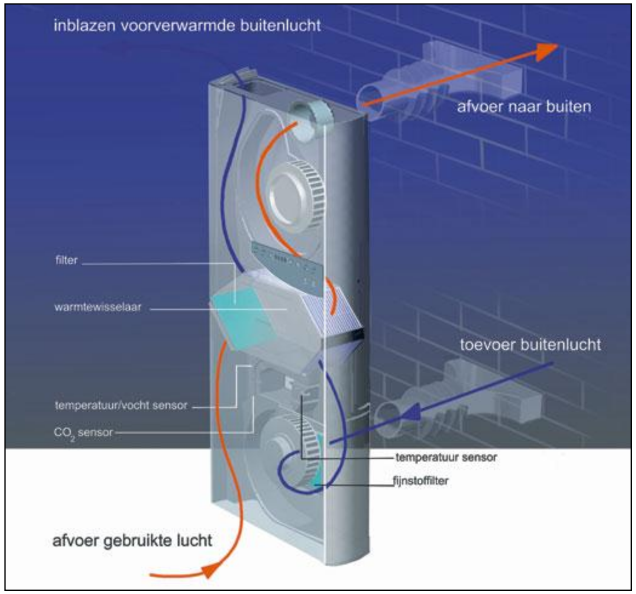
Layout Fifth Floor

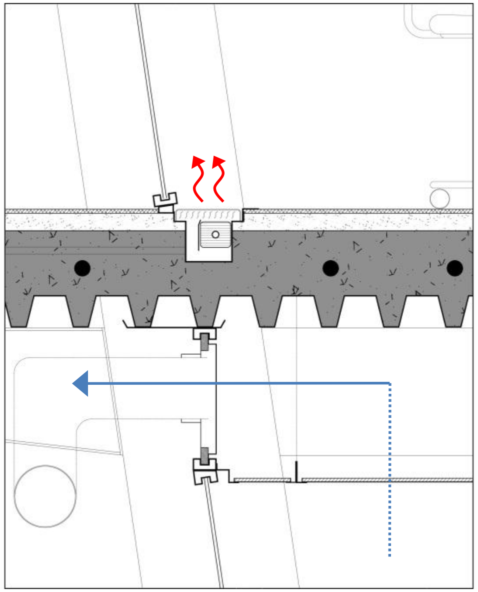
18m +Z

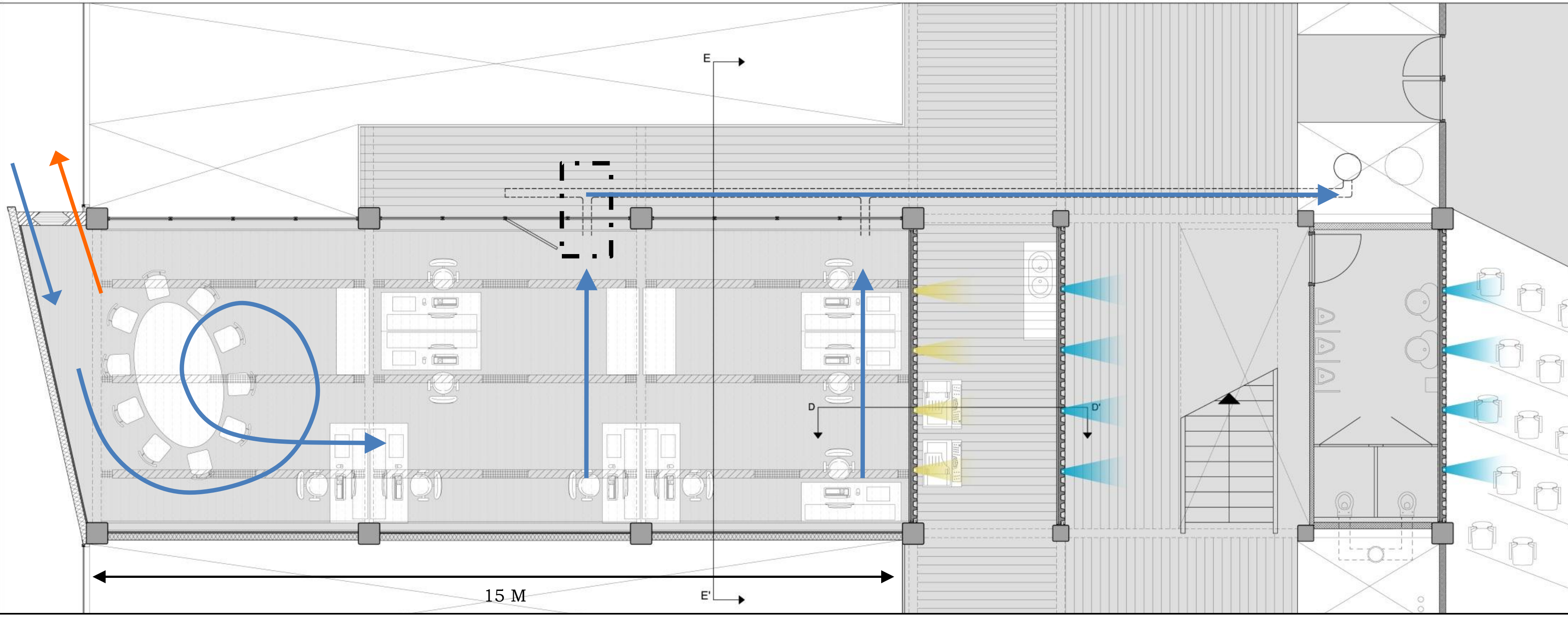


Office Layout
Quality & Installations

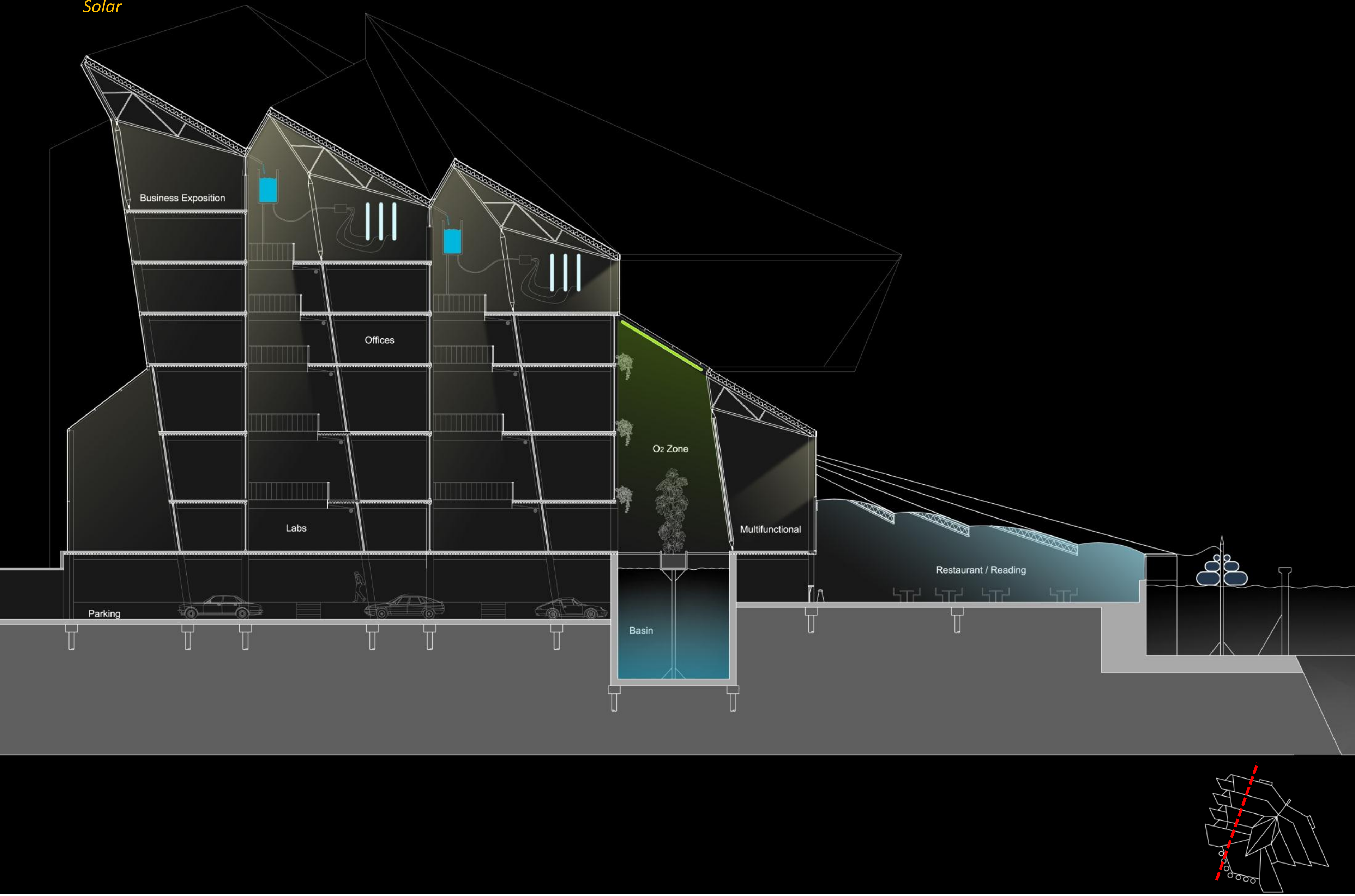
- Lighting corridor, auditorium
- Decentralized office ventilation
- Slow extraction of air
- Fast trench heating
- Constant concrete floor activation



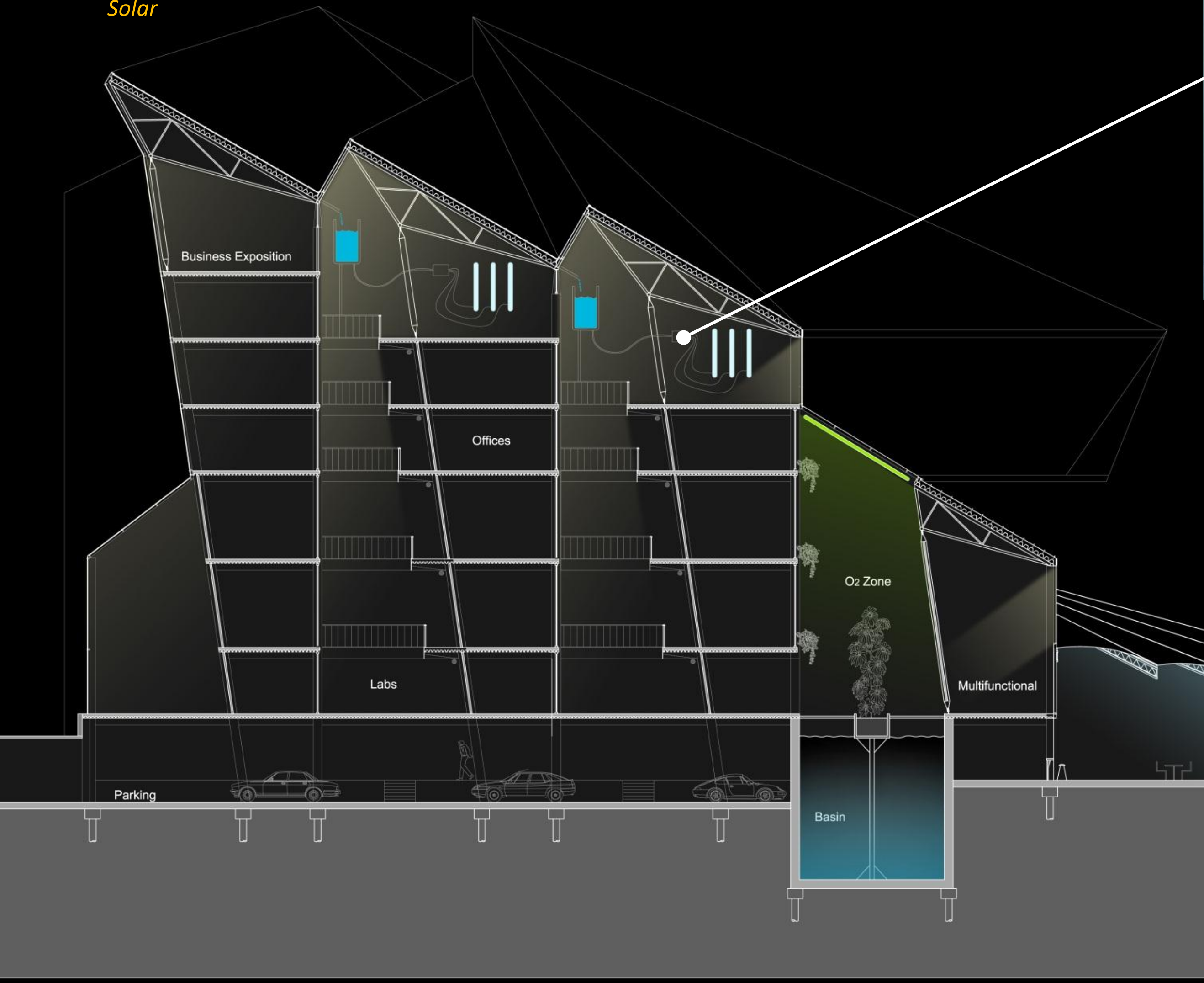




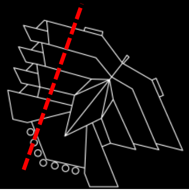
30 Degrees - south
Solar



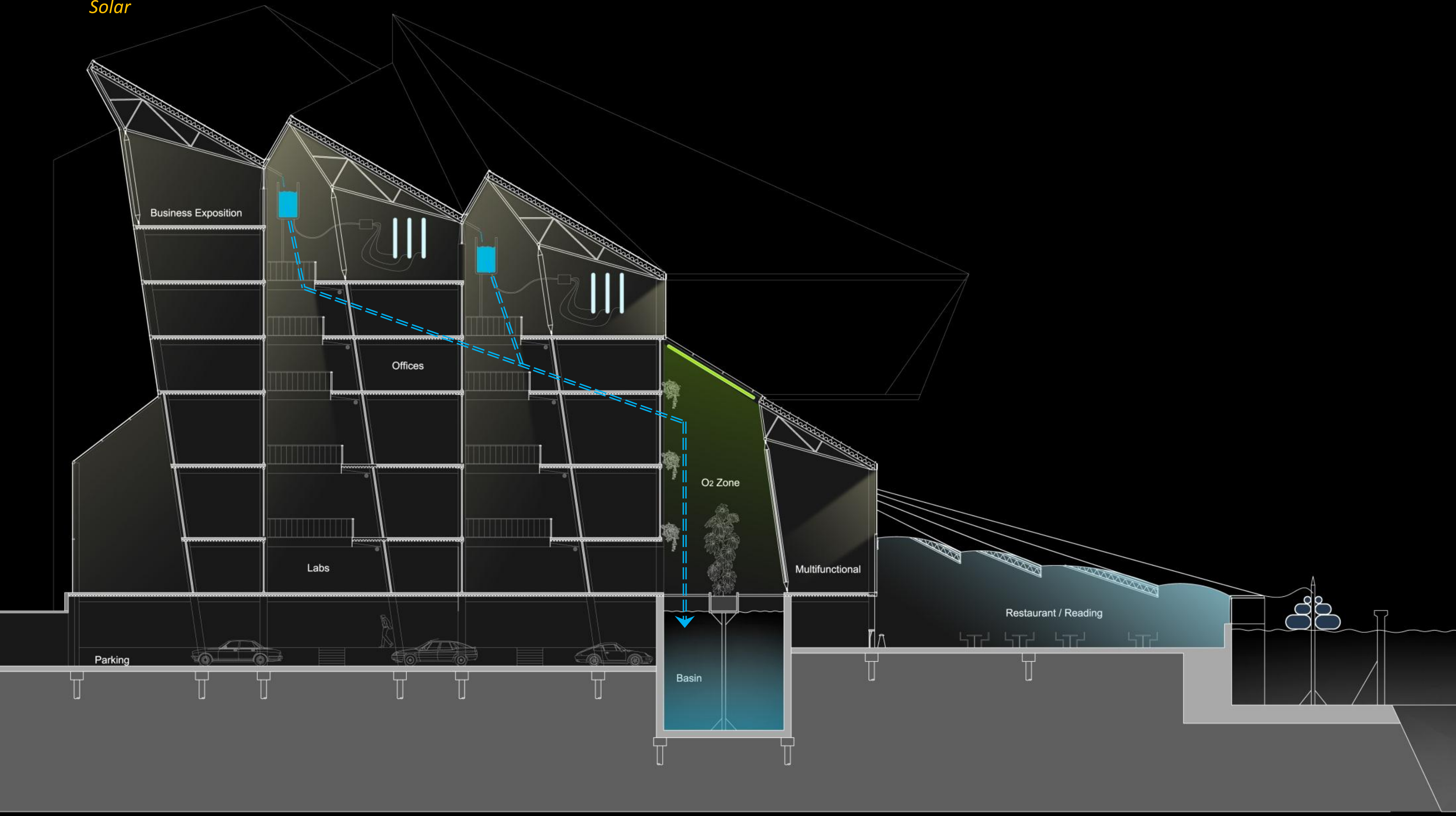
30 Degrees - south
Solar

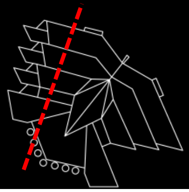


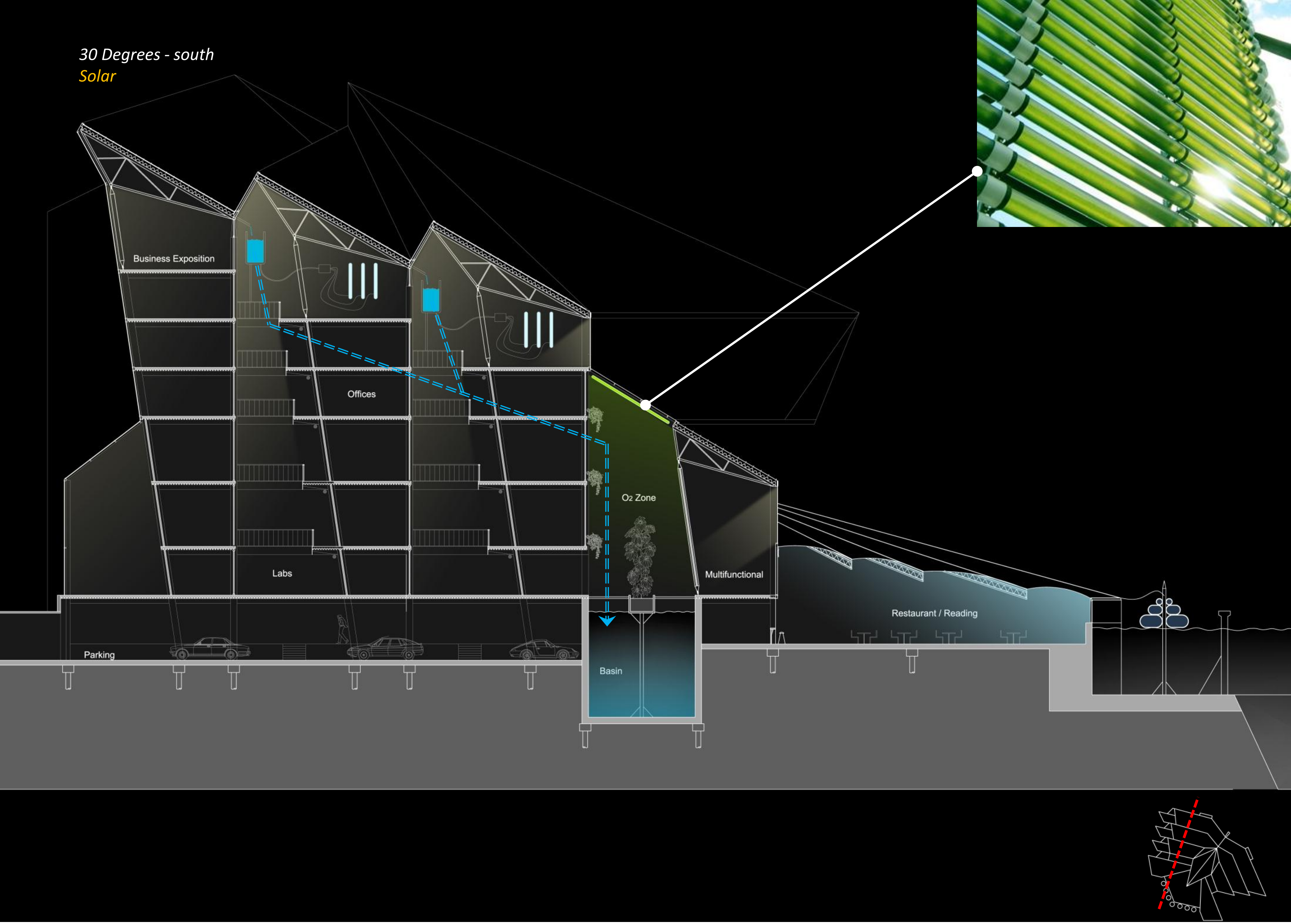
Albert France-Lanord - Stockholm - Bahnhof Pionen



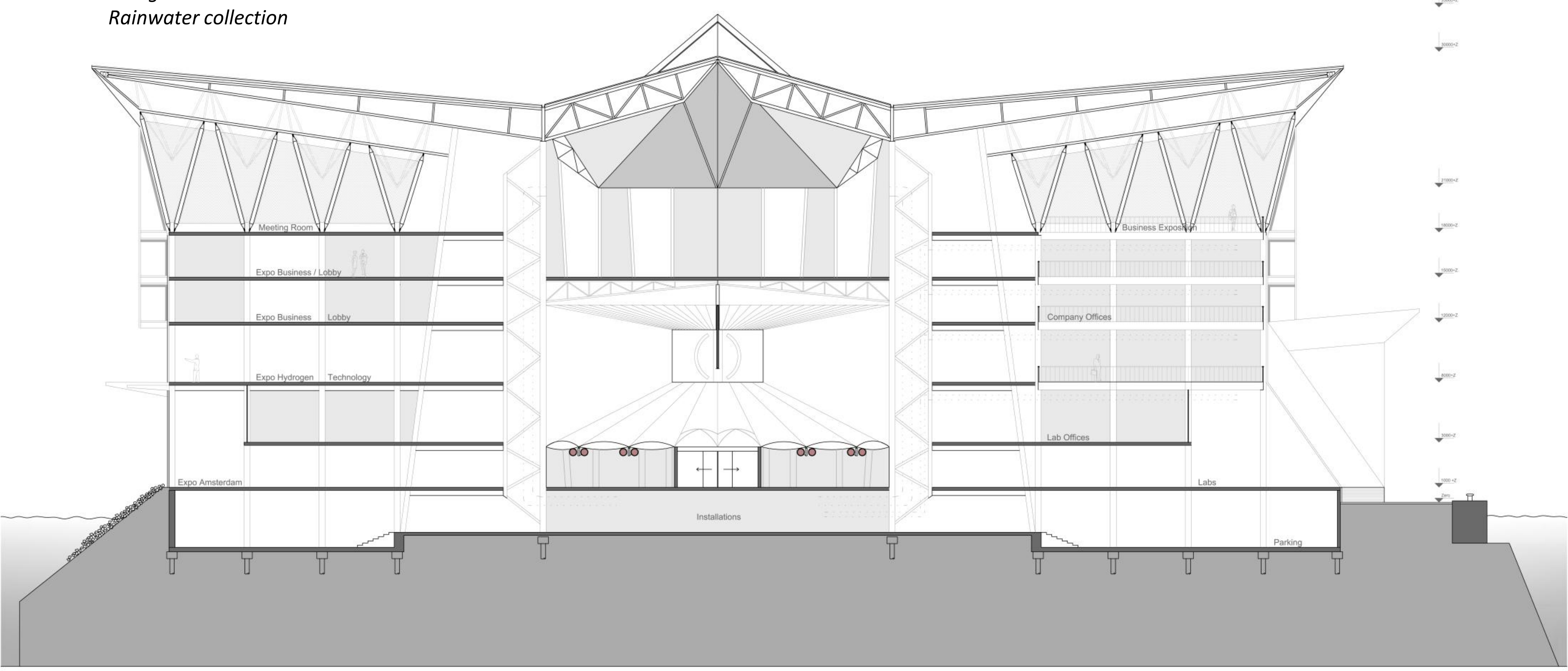
30 Degrees - south
Solar

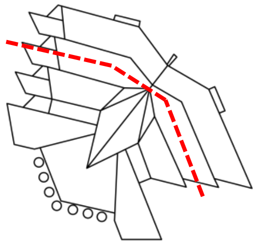




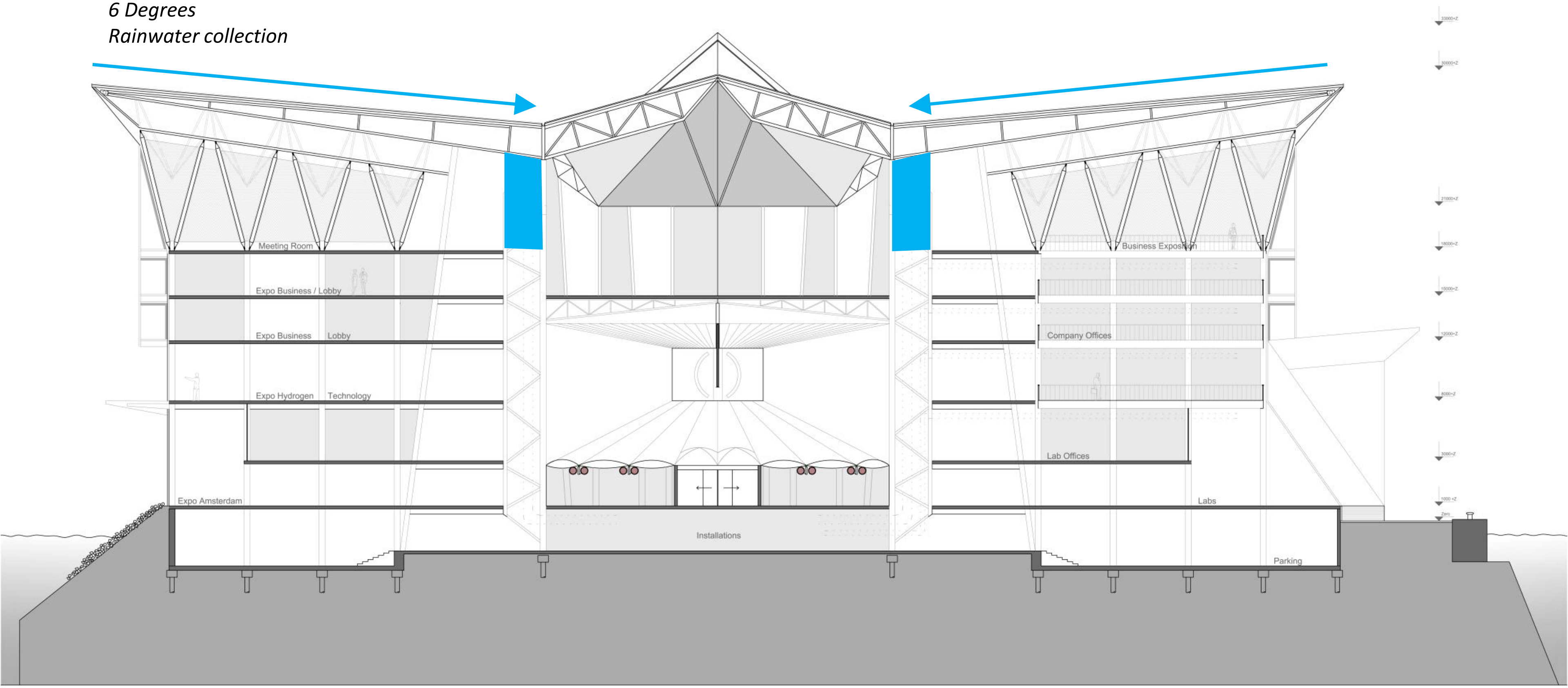

30 Degrees - south
Solar
Business Exposition
Offices
Labs
Parking
O2 Zone
Multifunctional
Restaurant / Reading
Basin

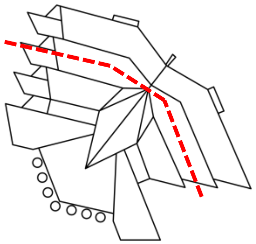
6 Degrees
Rainwater collection

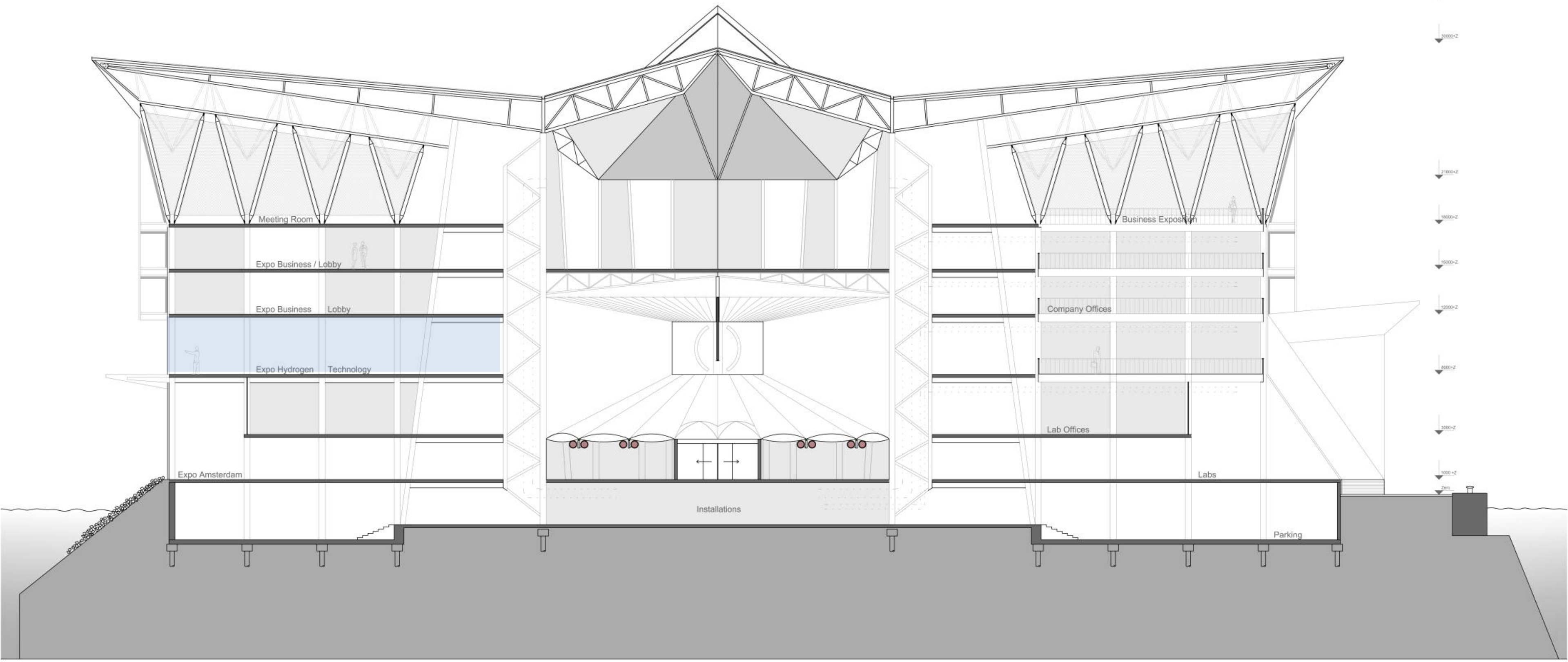


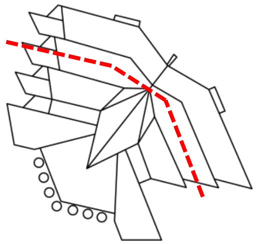


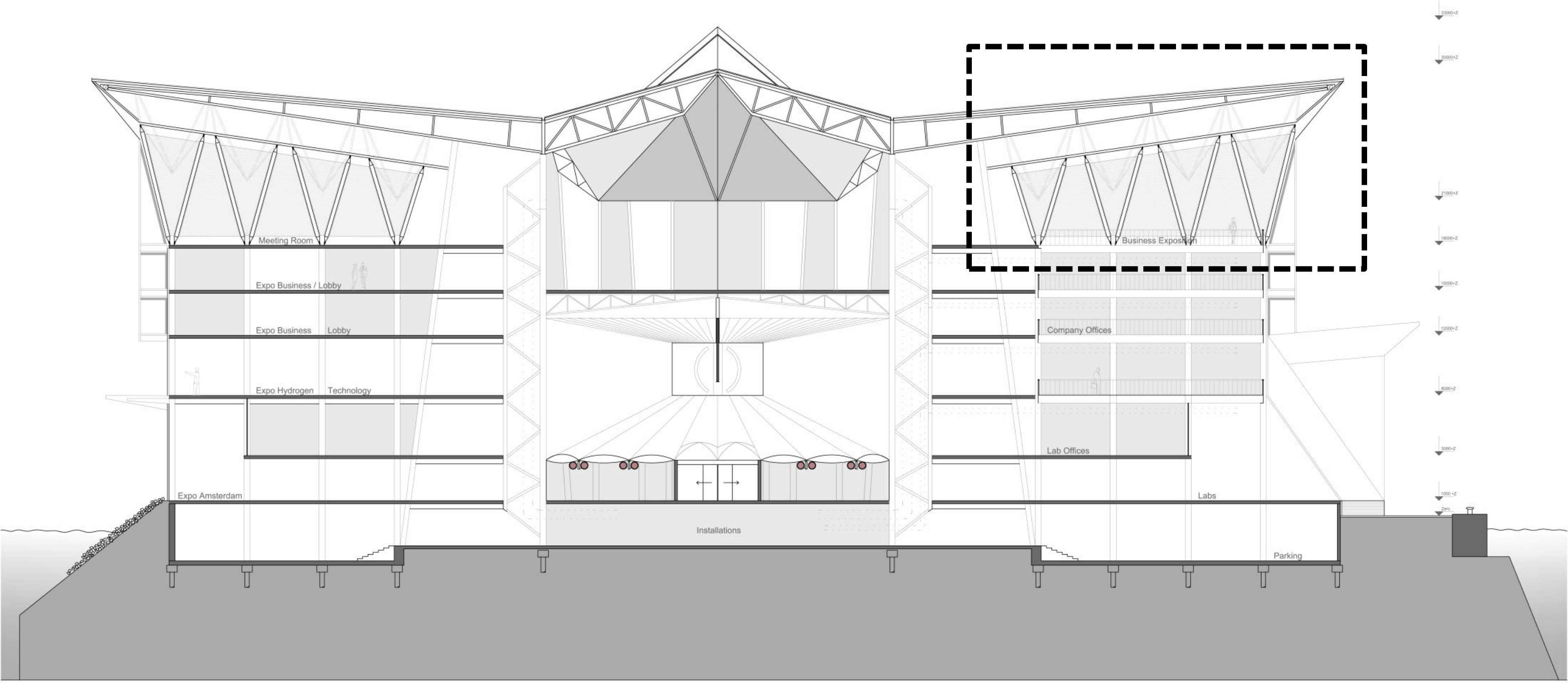
6 Degrees
Rainwater collection

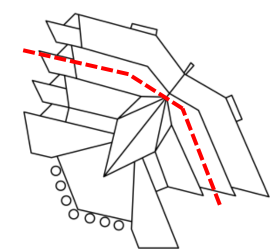


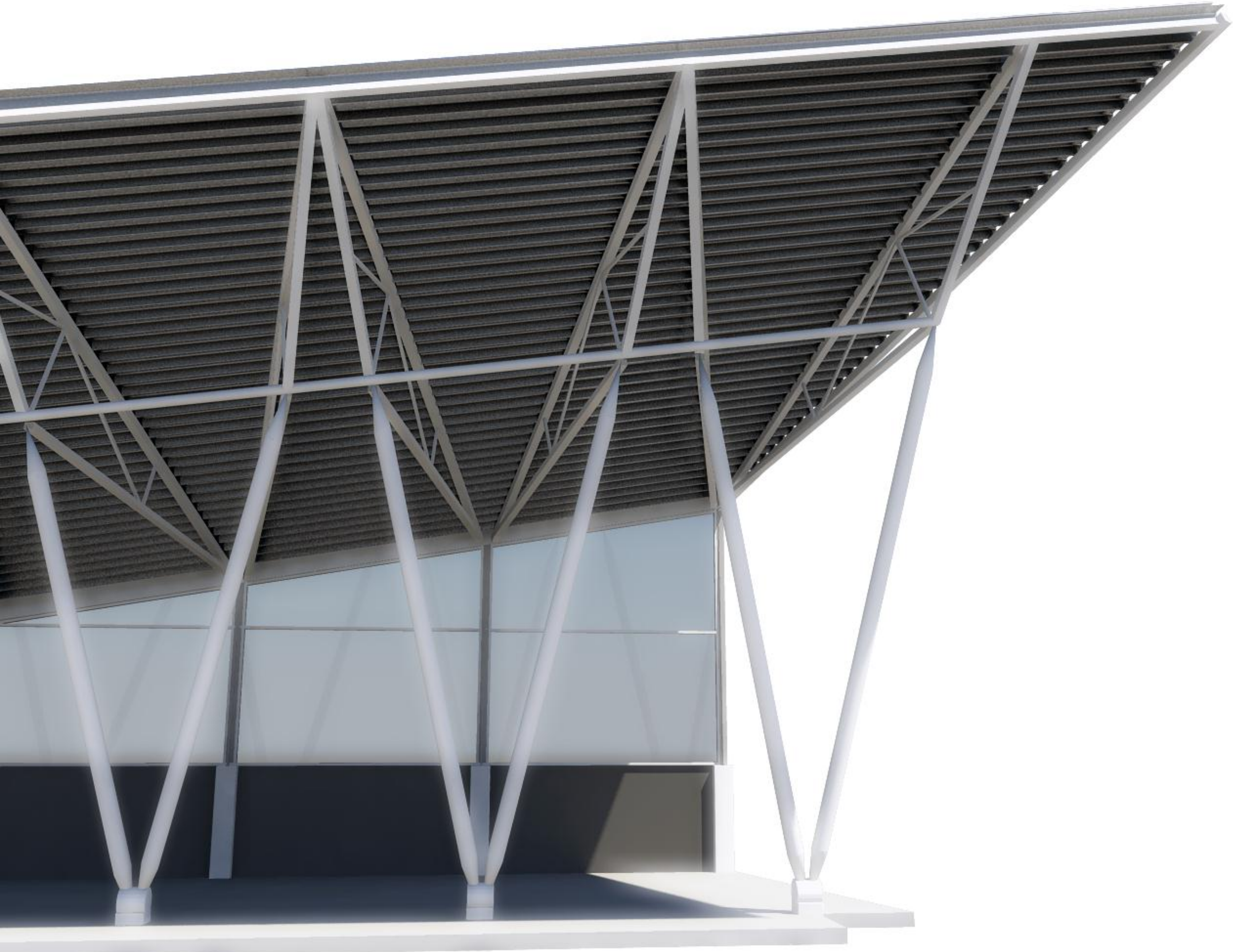


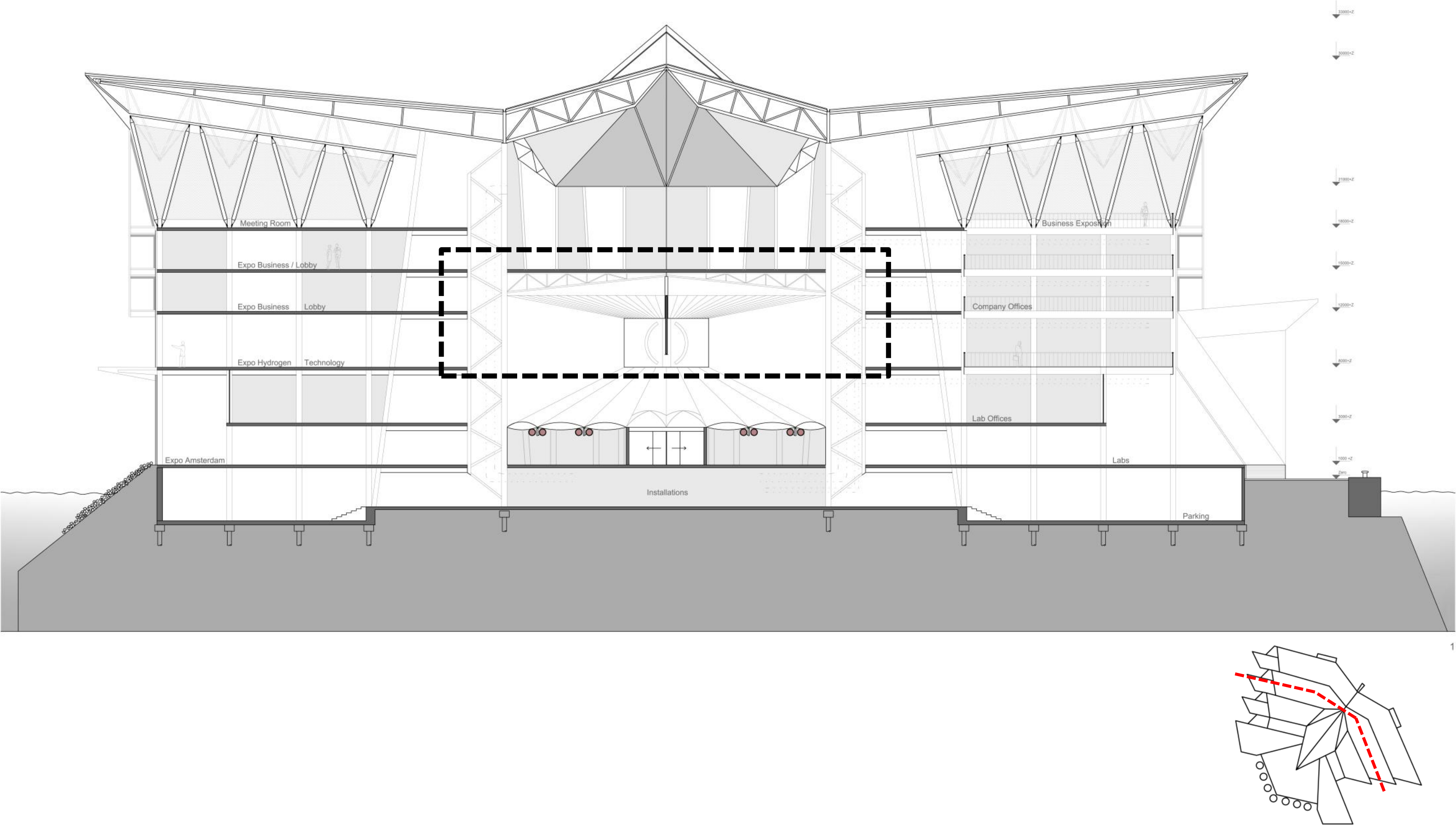

Meeting Room
Expo Business / Lobby
Expo Business Lobby
Expo Hydrogen Technology
Expo Amsterdam
Installations
Business Exposition
Company Offices
Lab Offices
Labs
Parking

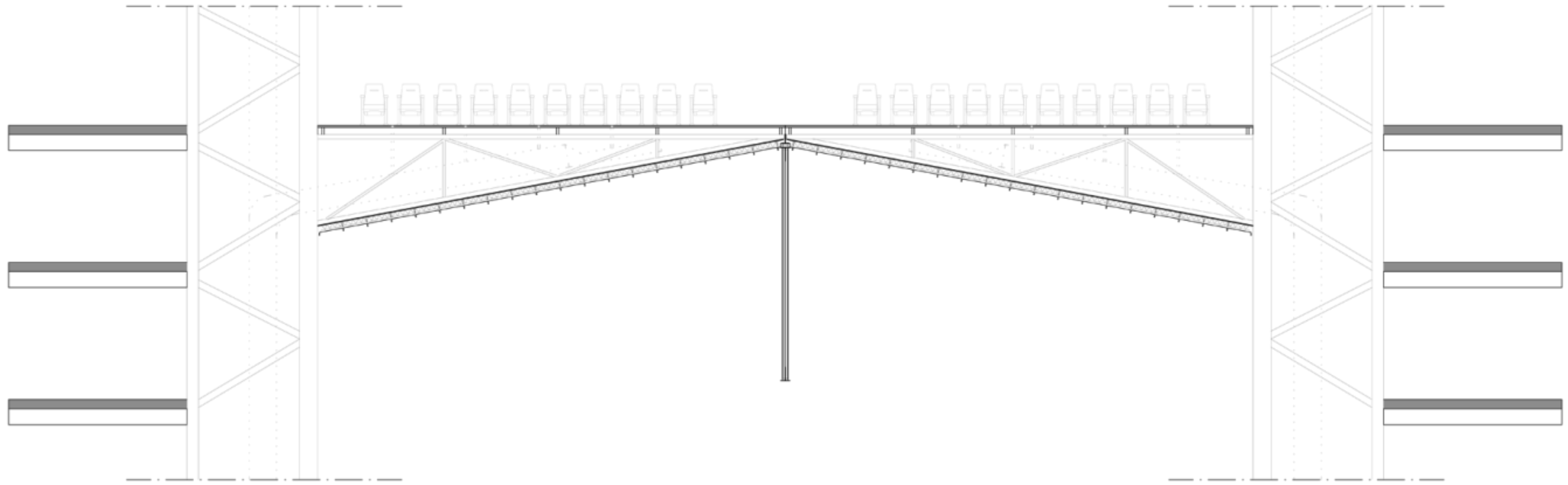



Meeting Room
Expo Business / Lobby
Expo Business
Lobby
Expo Hydrogen
Technology
Expo Amsterdam
Installations
Business Expos
Company Offices
Lab Offices
Labs
Parking

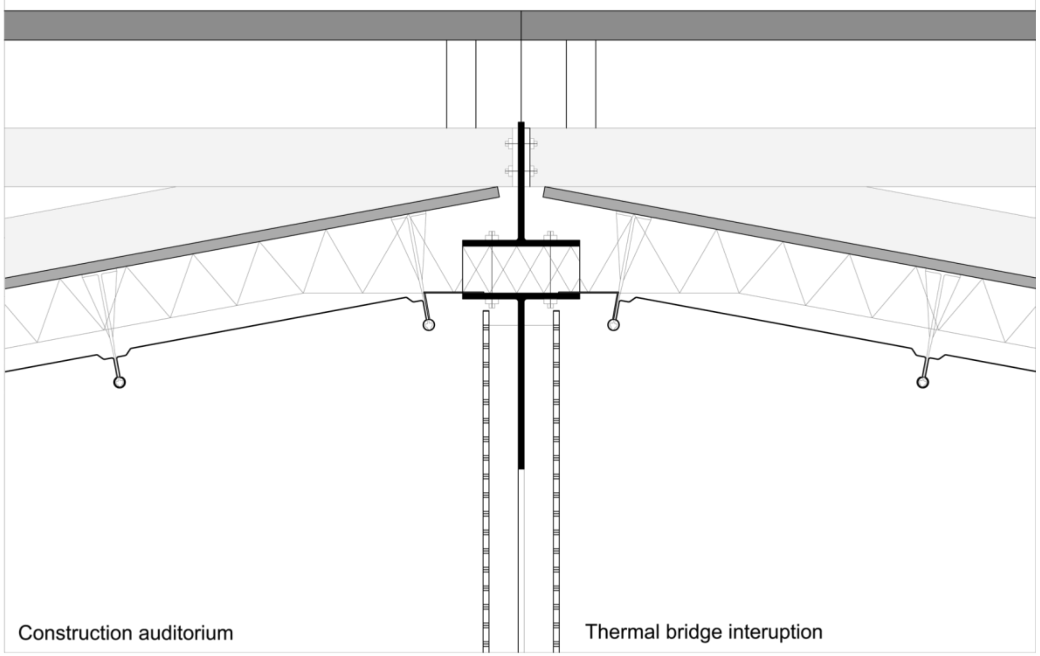





Meeting Room
Expo Business / Lobby
Expo Business Lobby
Expo Hydrogen Technology
Expo Amsterdam
Installations
Company Offices
Lab Offices
Labs
Parking
1



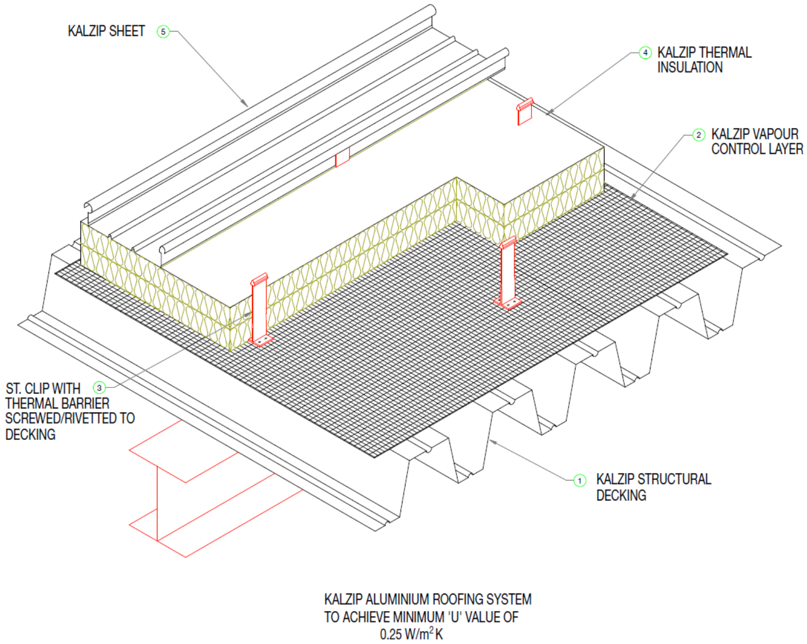
Construction auditorium



Construction auditorium

Thermal bridge interuption

Arcam building, Amsterdam



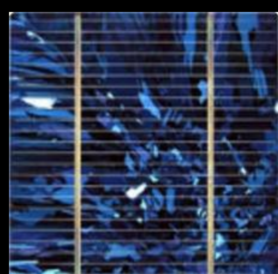
+

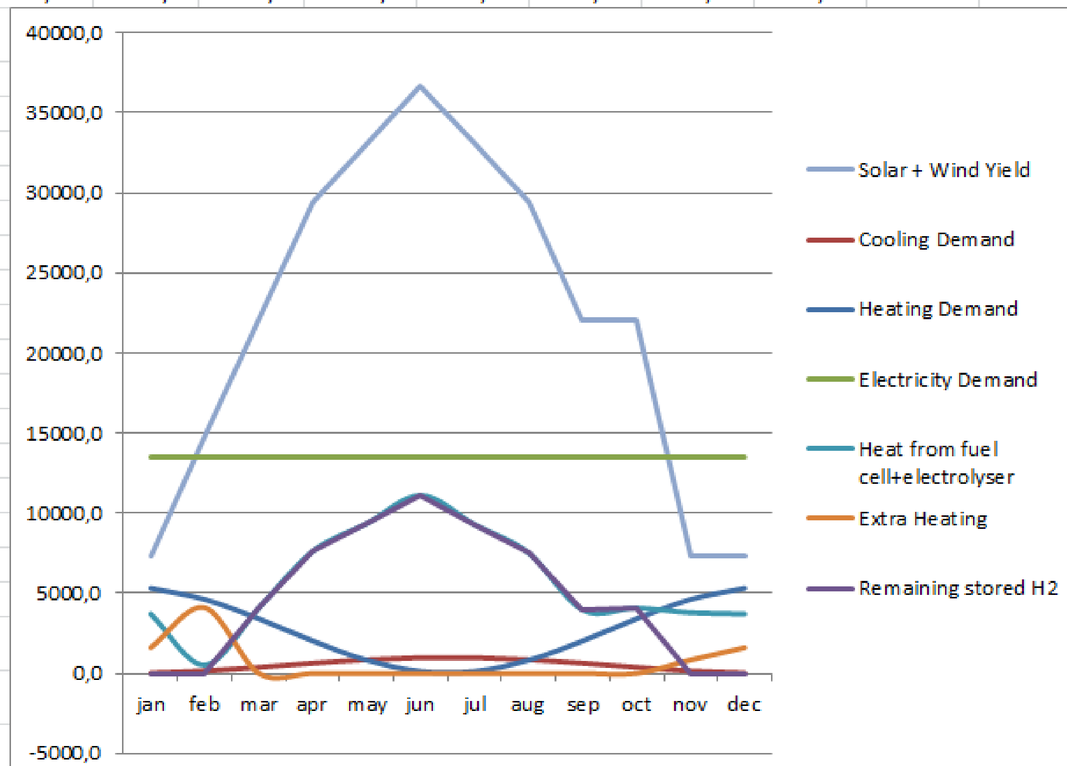
Kalzip Aluminium

Uni-solar amorphous solar cells

	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
Heating Demand kWh	5315,0	4619,3	3414,4	2023,1	818,2	122,5	122,5	818,2	2023,1	3414,4	4619,3	5315,0
Cooling kWh (electrical)	22,5	150,5	372,1	627,9	849,5	977,5	977,5	849,5	627,9	372,1	150,5	22,5
Electricity kWh	13500,0	13500,0	13500,0	13500,0	13500,0	13500,0	13500,0	13500,0	13500,0	13500,0	13500,0	13500,0
Wind Kwh	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Full solar hours per day	1,0	2,0	3,0	4,0	4,5	5,0	4,5	4,0	3,0	3,0	1,0	1,0
Yield 80% verlies (accu) kWh	7344,0	14688,0	22032,0	29376,0	33048,0	36720,0	33048,0	29376,0	22032,0	22032,0	7344,0	7344,0
Electr: Surplus/shortage energy kWh?	-6178,5	1037,5	8159,9	15248,1	18698,5	22242,5	18570,5	15026,5	7904,1	8159,9	-6306,5	-6178,5
TRANSFORMED into hydrogen kWh	0,0	518,8	4080,0	7624,0	9349,2	11121,3	9285,3	7513,2	3952,0	4080,0	0,0	0,0
Electrolyser kW needed	0,0	1,4	11,3	21,2	26,0	**30,9**	25,8	20,9	11,0	11,3	0,0	0,0
USED FROM STORAGE by Fuel Cell kWh	15446,3	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	15766,2	15446,3
Heat released kWh	3707,1	518,8	4080,0	7624,0	9349,2	11121,3	9285,3	7513,2	3952,0	4080,0	3783,9	3707,1
Shortage/surplus **Heat?** kWh	-1607,8	-4100,5	665,6	5600,9	8531,0	10998,7	9162,7	6695,0	1928,9	665,6	-835,4	-1607,8
Additional Heating (**USED FROM STORAGE**) kWh	1607,8	4100,5	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	835,4	1607,8
Fuel cell kW needed	17,2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	17,5	**17,2**
Remaining stored H2 Kwh	0	0	4079,968	7624,03	9349,24	11121,27	9285,268	7513,236	3952,032	4079,968	0	0

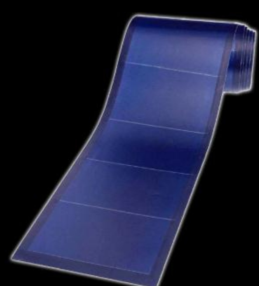
Floorarea M2	**9000**
Heating/m2a	29
Cooling/m2a	8
Electricity /m2a	18
Efficiency Solar Panels	0,12
Burning hydrogen efficiency	1
Fuel Cell efficiency	0,4
Electrolyser efficiency	0,5
Building operating hours	12
Heat pump system? 1= yes, 0=no	1
COP Heating	8
COP Cooling	12
M2 solar panels	**2550**
M2 wind turbines	**0**
Feasible?	**Feasible!**

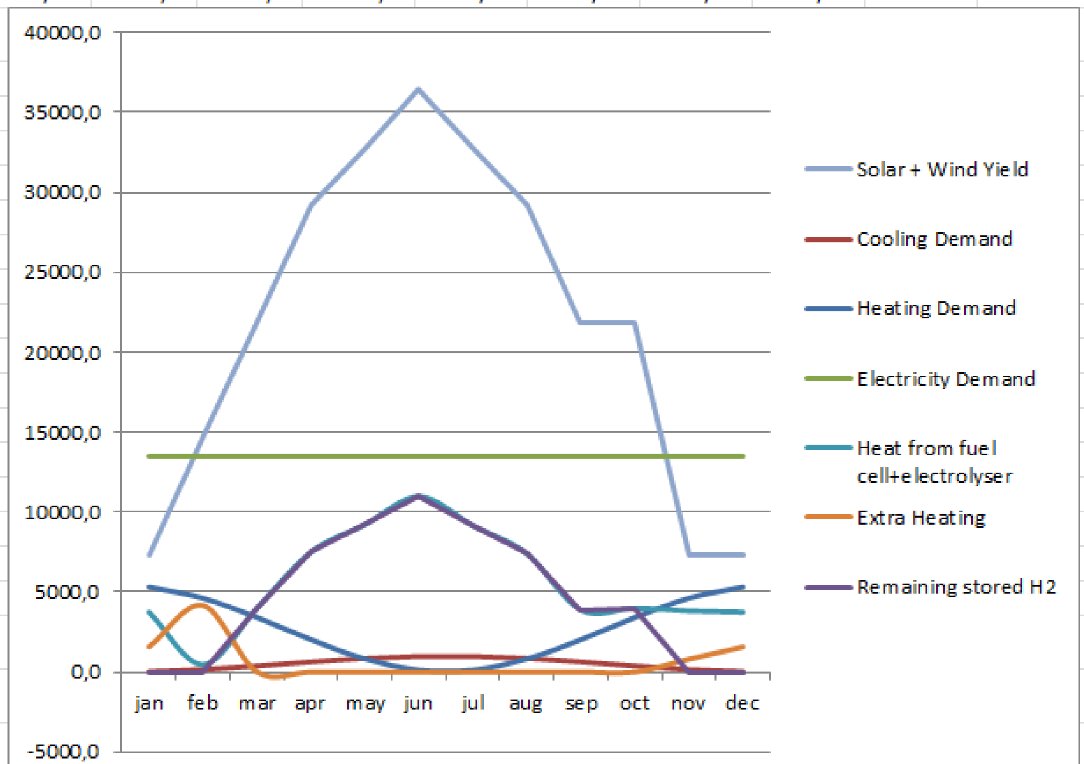




	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
Heating Demand kWh	5315,0	4619,3	3414,4	2023,1	818,2	122,5	122,5	818,2	2023,1	3414,4	4619,3	5315,0
Cooling kWh (electrical)	22,5	150,5	372,1	627,9	849,5	977,5	977,5	849,5	627,9	372,1	150,5	22,5
Electricity kWh	13500,0	13500,0	13500,0	13500,0	13500,0	13500,0	13500,0	13500,0	13500,0	13500,0	13500,0	13500,0
Wind Kwh	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Full solar hours per day	1,0	2,0	3,0	4,0	4,5	5,0	4,5	4,0	3,0	3,0	1,0	1,0
Yield 80% verlies (accu) kWh	7286,4	14572,8	21859,2	29145,6	32788,8	36432,0	32788,8	29145,6	21859,2	21859,2	7286,4	7286,4
Electr: Surplus/shortage energy kWh?	-6236,1	922,3	7987,1	15017,7	18439,3	21954,5	18311,3	14796,1	7731,3	7987,1	-6364,1	-6236,1
TRANSFORMED into hydrogen kWh	0,0	461,2	3993,6	7508,8	9219,6	10977,3	9155,7	7398,0	3865,6	3993,6	0,0	0,0
Electrolyser kW needed	0,0	1,3	11,1	20,9	25,6	**30,5**	25,4	20,6	10,7	11,1	0,0	0,0
USED FROM STORAGE by Fuel Cell kWh	15590,3	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	15910,2	15590,3
Heat released kWh	3741,7	461,2	3993,6	7508,8	9219,6	10977,3	9155,7	7398,0	3865,6	3993,6	3818,4	3741,7
Shortage/surplus **Heat?** kWh	-1573,3	-4158,1	579,2	5485,7	8401,4	10854,7	9033,1	6579,8	1842,5	579,2	-800,9	-1573,3
Additional Heating (**USED FROM STORAGE**) kWh	1573,3	4158,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	800,9	1573,3
Fuel cell kW needed	17,3	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	17,7	**17,3**
Remaining stored H2 Kwh	0	0	3993,568	7508,83	9219,64	10977,27	9155,668	7398,036	3865,632	3993,568	0	0

Floorarea M2	**9000**
Heating/m2a	29
Cooling/m2a	8
Electricity /m2a	18
Efficiency Solar Panels	0,069
Burning hydrogen efficiency	1
Fuel Cell efficiency	0,4
Electrolyser efficiency	0,5
Building operating hours	12
Heat pump system? 1= yes, 0=no	1
COP Heating	8
COP Cooling	12
M2 solar panels	**4400**
M2 wind turbines	**0**
Feasible?	**Feasible!**

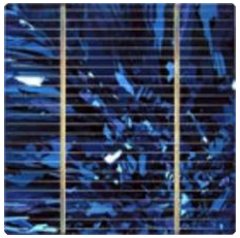


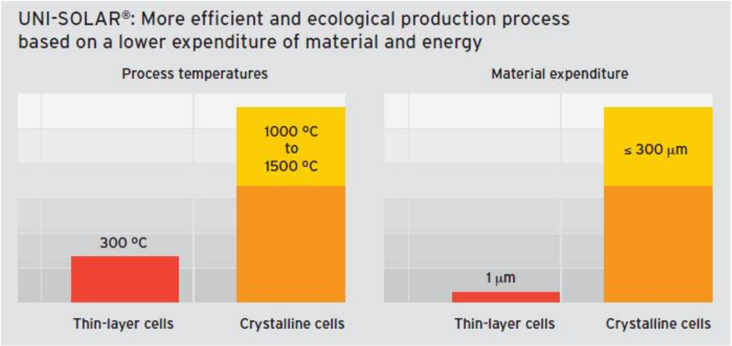


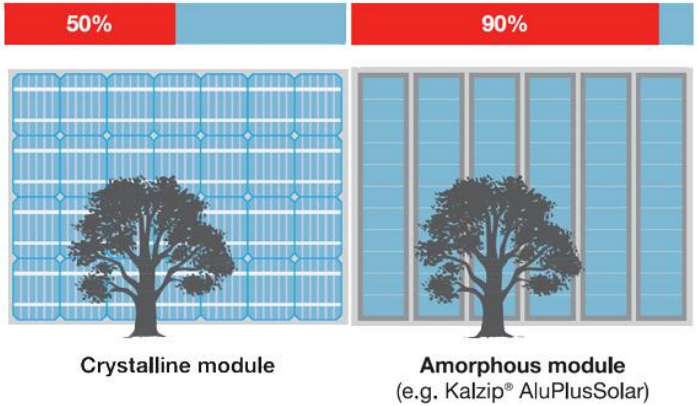
Solar panels

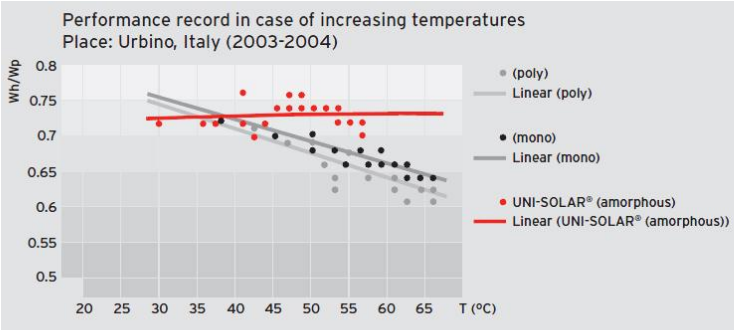
Sustainable Choice Amorphous PV

	Multicrystalline	**Amorphous**
Efficiency:	15-18%	5-8% (12-20% in 2020)
Needed roof surface:	2550 m2	4400 m2









Amorphous silicon cells have a lower annual yield per m2, but they have a better annual yield in kWh/kWp. This means that the crystalline cells are less efficient per installed kWp. The reason of this is that amorphous cells can handle high temperatures, low light levels, and shading better. So crystalline solar cells are better in laboratory conditions, but the amorphous solar cells are more efficient (25%) per kWp in outdoor conditions.

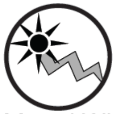

Flexible

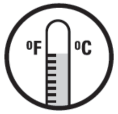

Lightweight


Durable


No-Glass


Shadow Tolerant

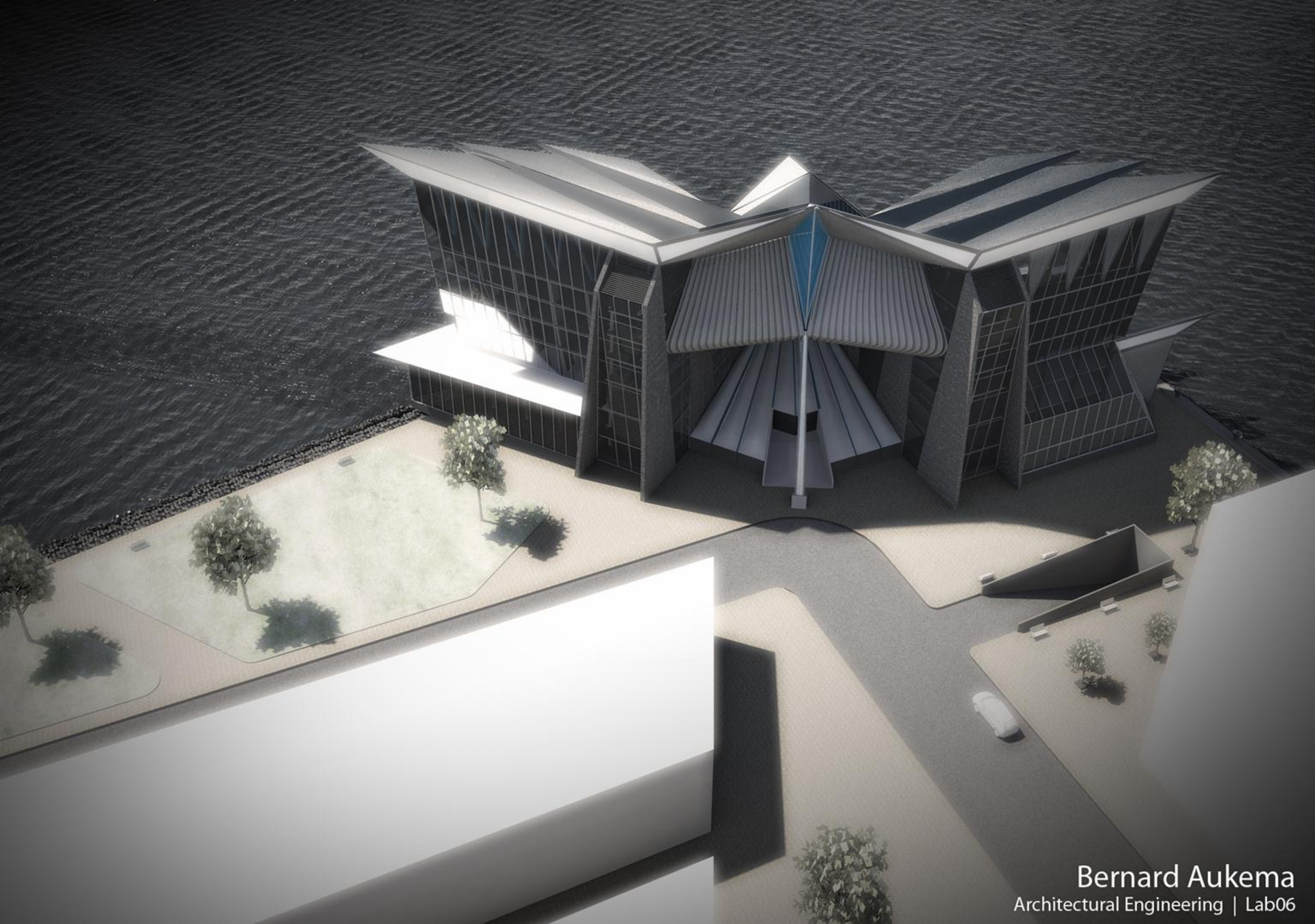

More kWh



High Temp Performance


Low Light Performance

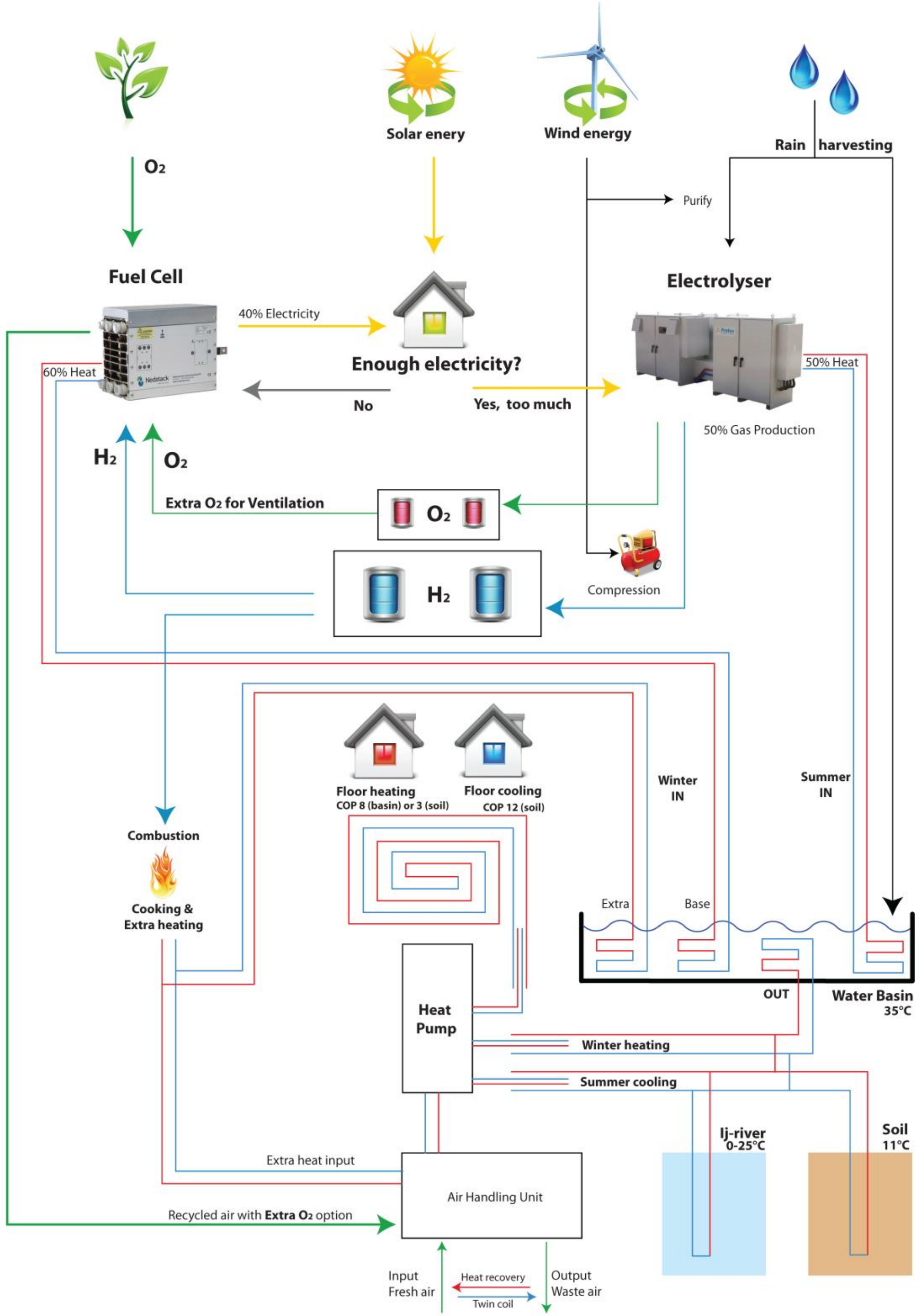
Thank you for your attention



Bernard Aukema
Architectural Engineering | Lab06

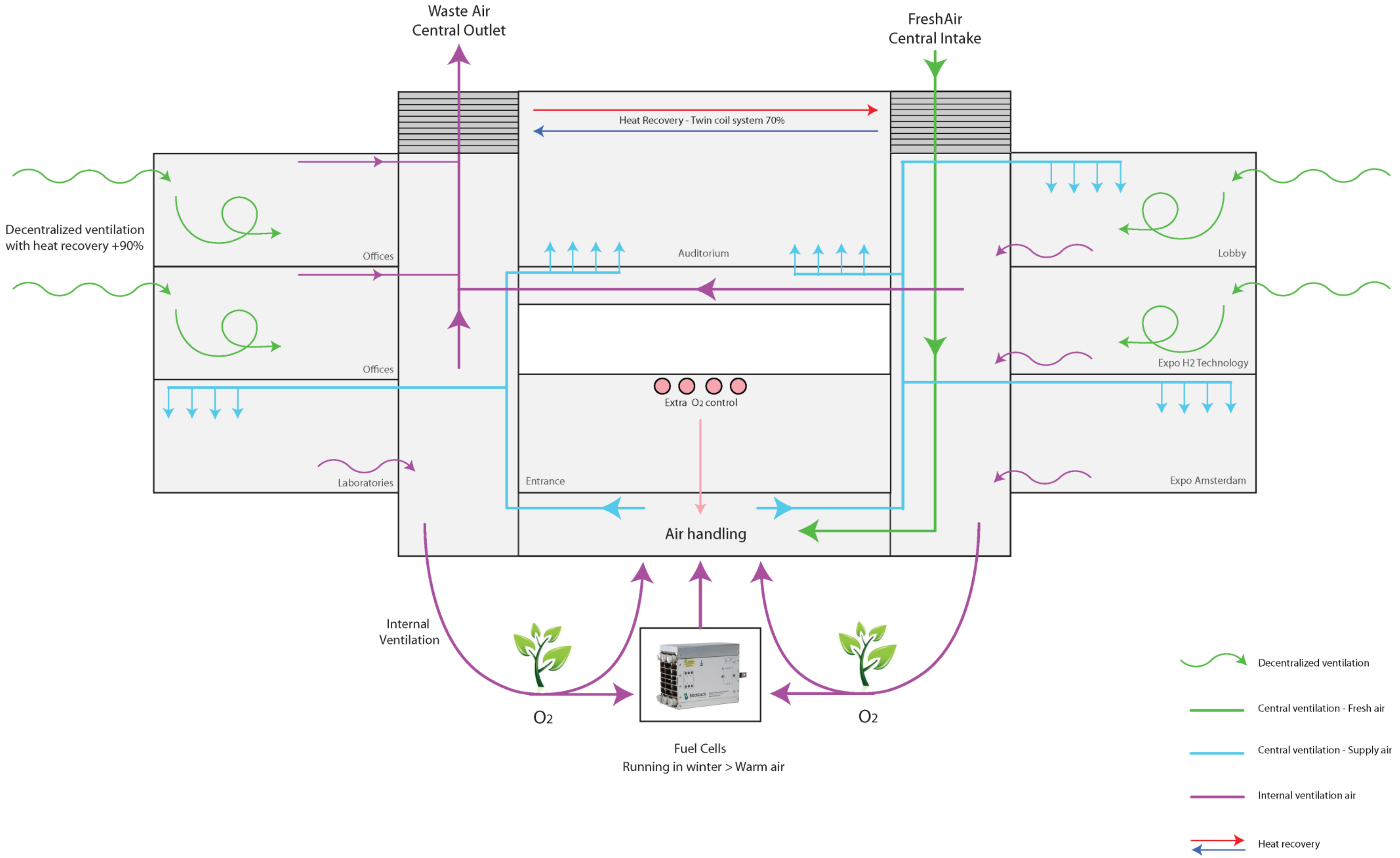
Additional Sheet

Building installation scheme



Additional Sheet

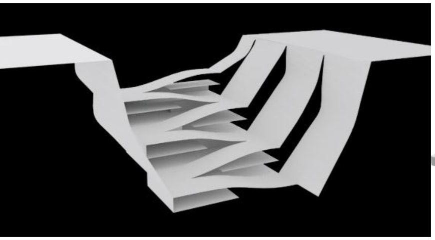
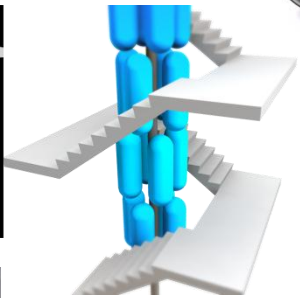
Building ventilation scheme

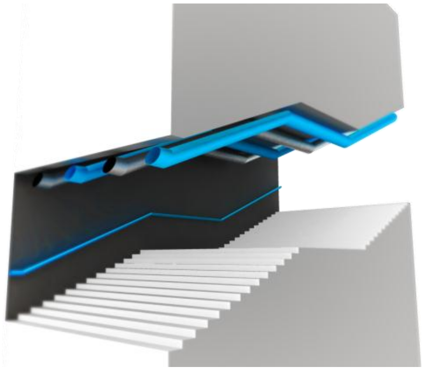
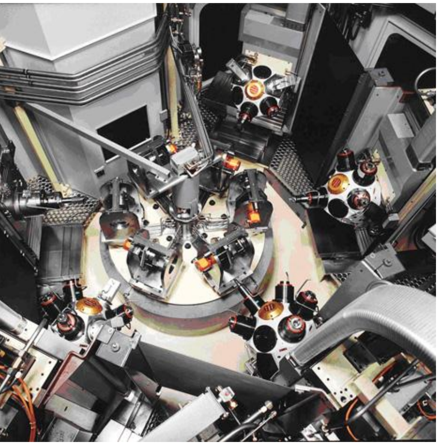
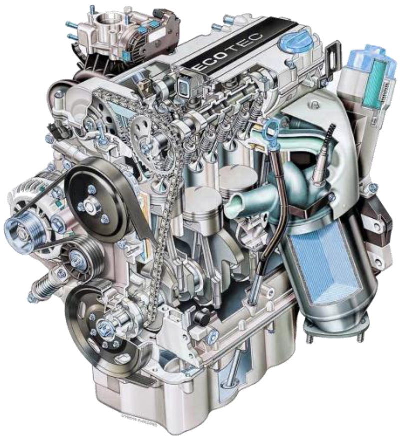


Additional Sheet

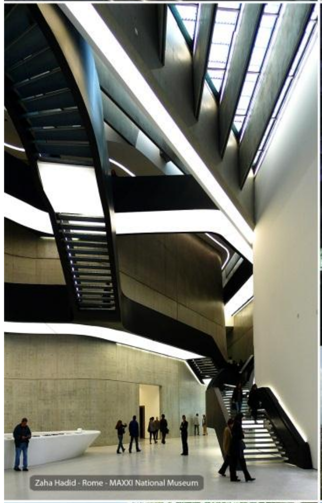
P3 (october 2011) - Entrance

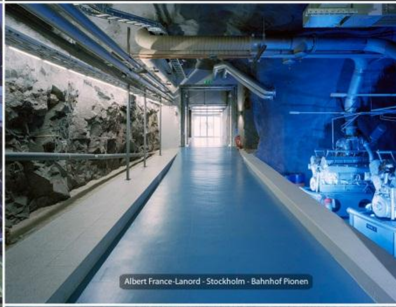
Additional Sheet
Inspirations

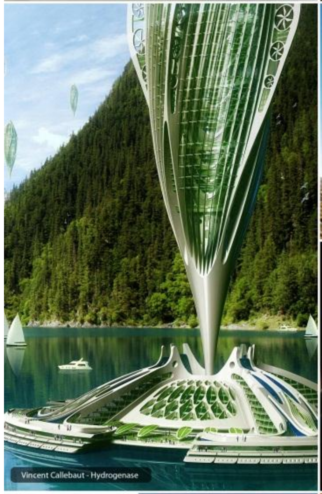




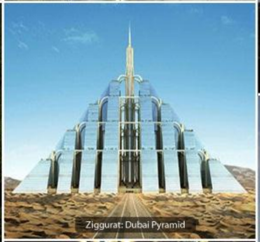





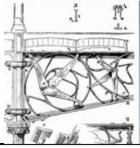






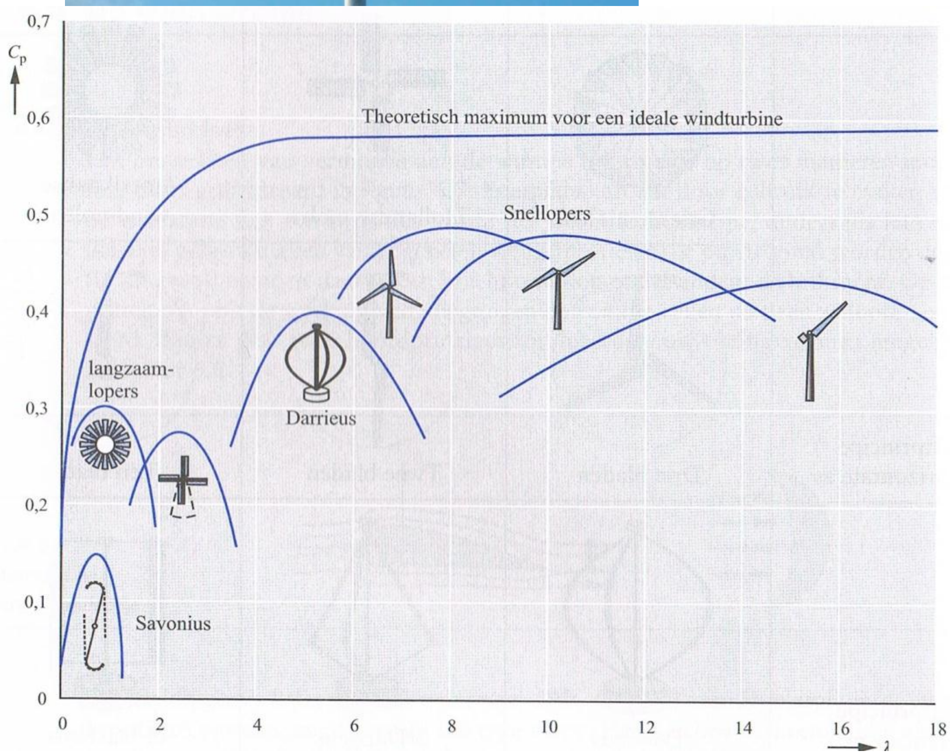


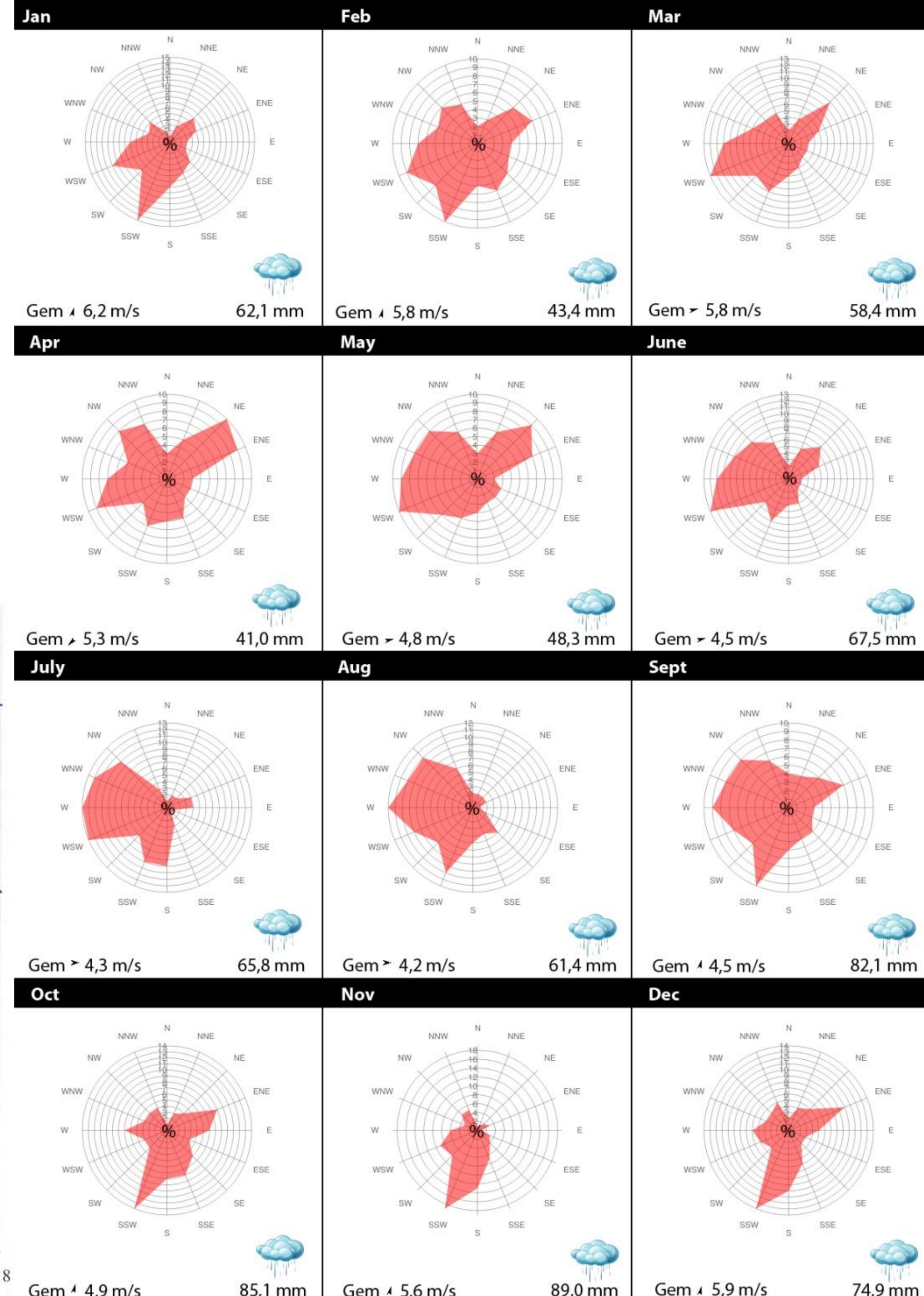



Additional Sheet

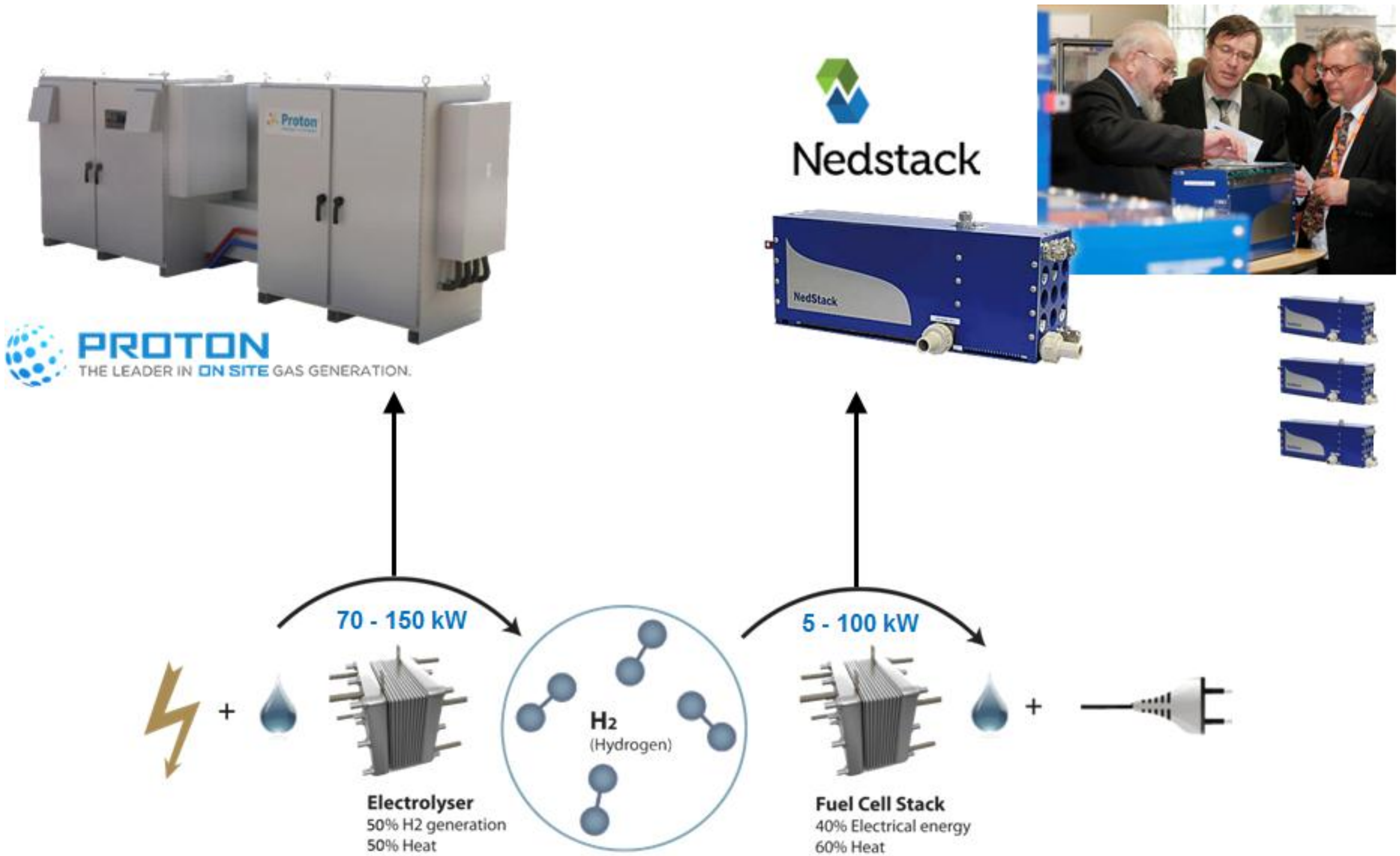
Wind & turbines





Additional Sheet

Market investigation



Additional Sheet

Kunst & Energieroute NDSM-east

BOLON