OUTDOOR THERMAL COMFORT EFFECTS ON URBAN DESIGN

location
Constanta, Romania

project type
climate engineering research

year
2016

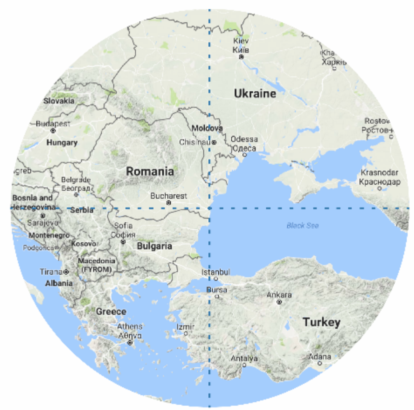
fellow, mentor
Gabriela Barbulescu, Raphael Lafargue

climate
subcontinental

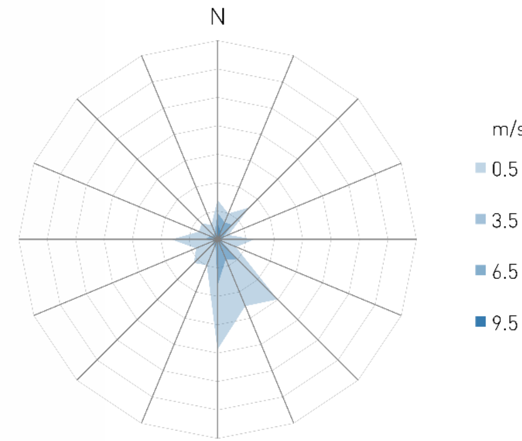
annual average temperature
12.2 °C

humidity above 11.5 g/kg
1901 hrs

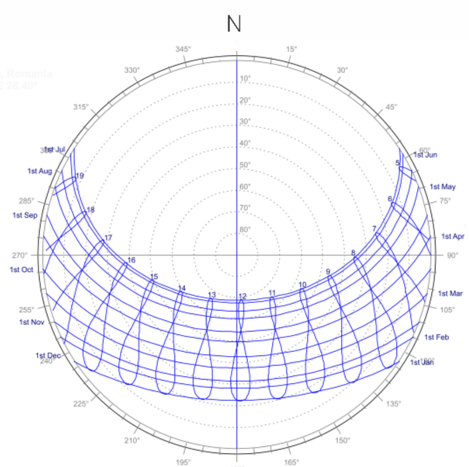
sunshine
2286 hrs



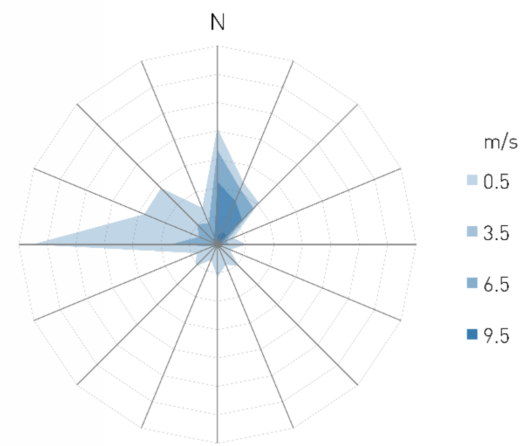
Romania



Summer season



Location: N 44.10°, E 28.40°



Winter and shoulder season

Improving social sustainability through comfortable outdoor spaces

Outdoor Thermal Comfort effects on urban design

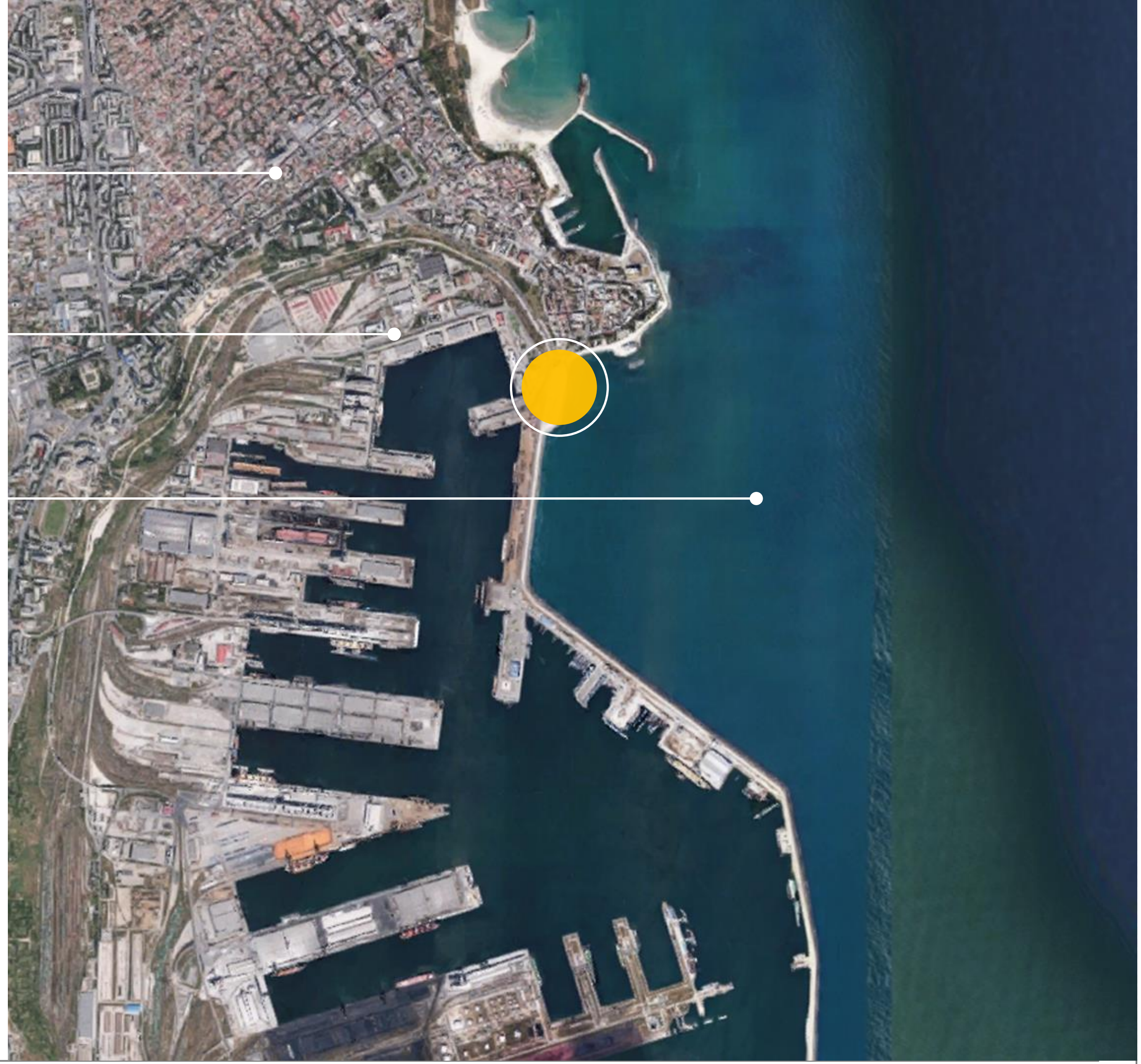
prepared by:
Gabriela Barbulescu

With the help of:
Raphael Lafargue

urban landscape

industrial landscape

natural landscape



THE CASE STUDY OF

IN BETWEEN SPACES

AS NEW OPORTUNITIES

As the second largest city in the country, Constanta grew inland forgetting about its view to the sea meanwhile, the port area expanded south becoming the 4th largest port in Europe.

The process left "lost" areas in between the different landscapes. These spaces are avoided by people but could become new development opportunities that cat rise the quality of living in the city.

3 landscapes

THE NEED OF 1 STORY

PLACE

achieved

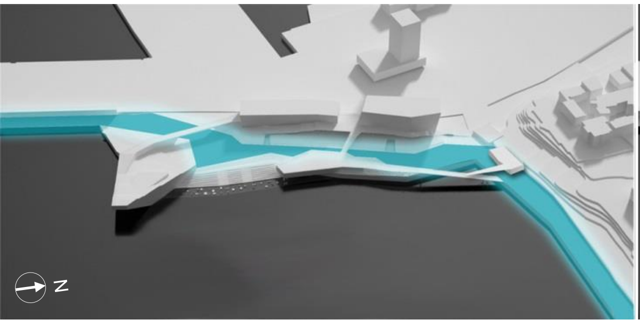
INTEGRATION

Between 3 influencing neighbors: the historic city, the old harbor and the Black Sea, there is an former industry space that I take into study.

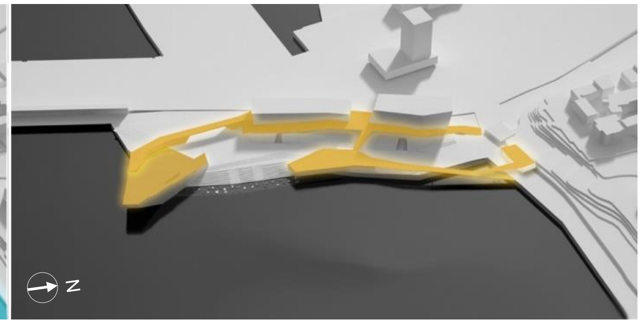
The neighbors present physical and psychological borders towards each other and the challenge is how to we achieve integration?

GOAL | IMPROVE URBAN SOCIAL SUSTAINABILITY

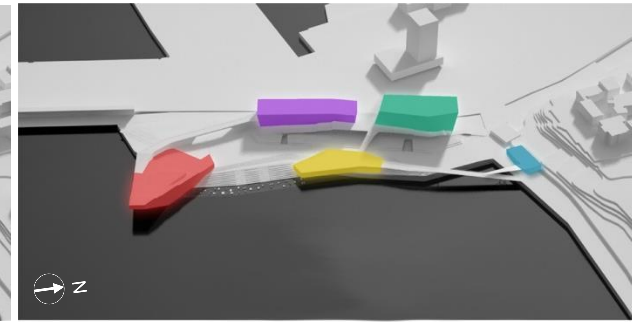
continuous path



observatory layer



functional diversity



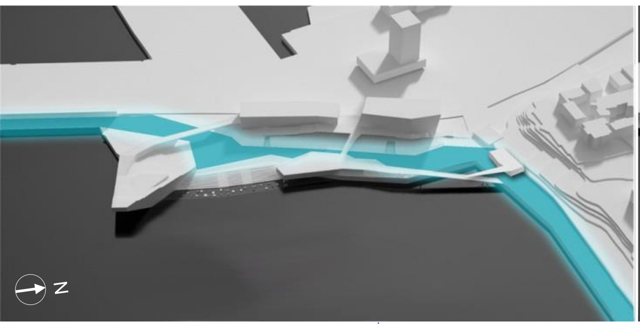
URBAN SOCIAL SUSTAINABILITY

As an architect I proposed an urban development concept that: provides access and linkage between touristic points on the waterfront promotes the presence of the surrounding environments and brings attractiveness through a mix of functions.

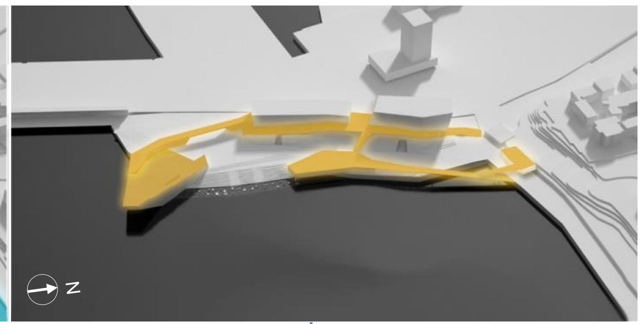
The urban development aims to: promote the image of the city by the water and to achieve urban social sustainability

GOAL | IMPROVE URBAN SOCIAL SUSTAINABILITY

continuous path



observatory layer



functional diversity

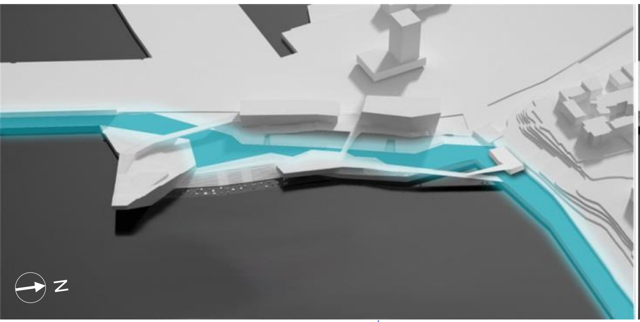
INTENSITY OF OUTDOOR ACTIVITIES → URBAN SOCIAL SUSTAINABILITY

One of the basic parameters which define the urban social sustainability is the intensity of outdoor activities with the number of people and the time they spend outside.

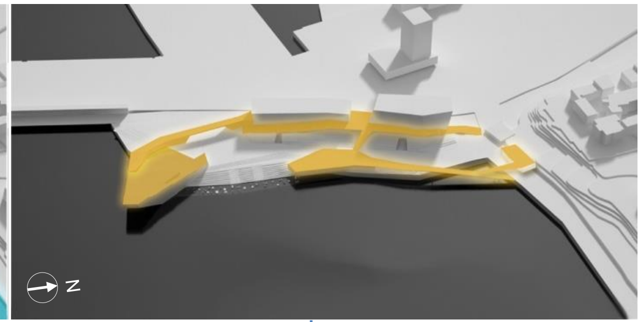
Outdoor activities can be encouraged by functional and aesthetic architecture but the main aspect that brings people outside is providing access to comfortable and protected open spaces in the neighborhood.

GOAL | IMPROVE URBAN SOCIAL SUSTAINABILITY

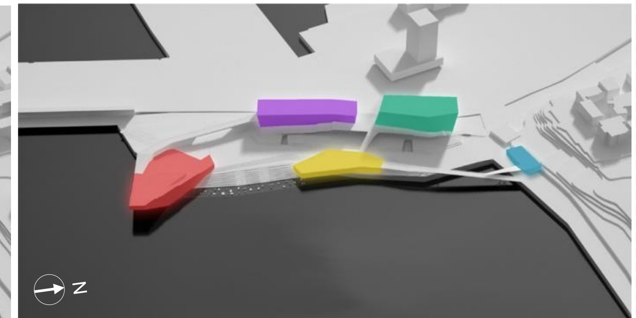
continuous path



observatory layer



functional diversity



COMFORTABLE OPEN SPACES → INTENSITY OF OUTDOOR ACTIVITIES → URBAN SOCIAL SUSTAINABILITY

The focus of my research is on how to achieve outdoor thermal comfort on an open space in order to improve microclimatic conditions for pedestrian use.

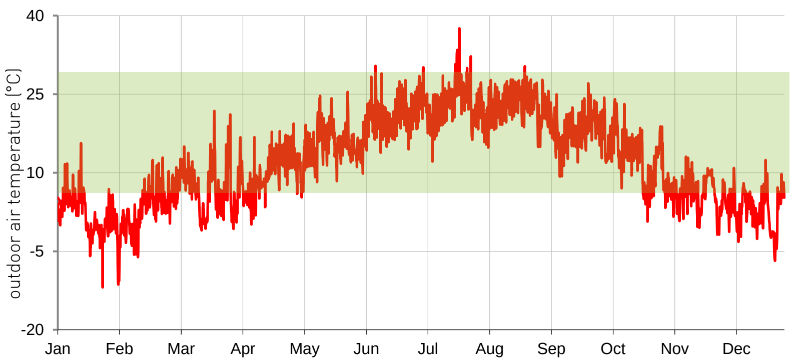
The following presentation complements the architecture project by rethinking the design in consideration of the people's thermal sensation experienced outside of the buildings.

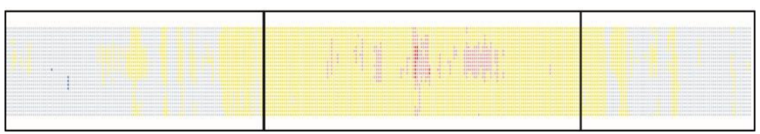
Microclimate improvement strategies are defined for the designed outdoor spaces.

WEATHER | ANALYSIS

Constanta | Romania

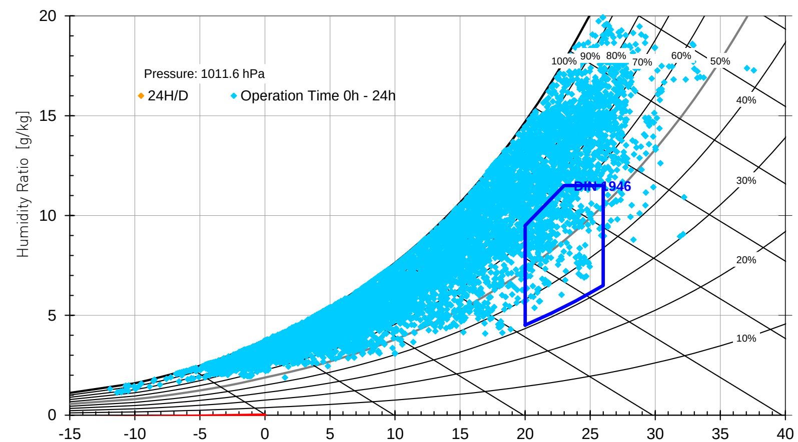
temperature | humidity | wind

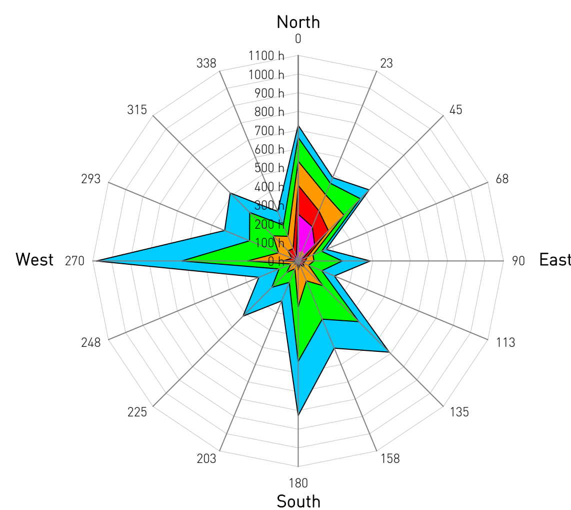




winter & shoulder season: 01 october - 30 april
summer: 01 may - 30 september

data file: IWEC20_constanta_154800





Annual wind directions

Summer wind:
South segment

Winter wind:
North East segment

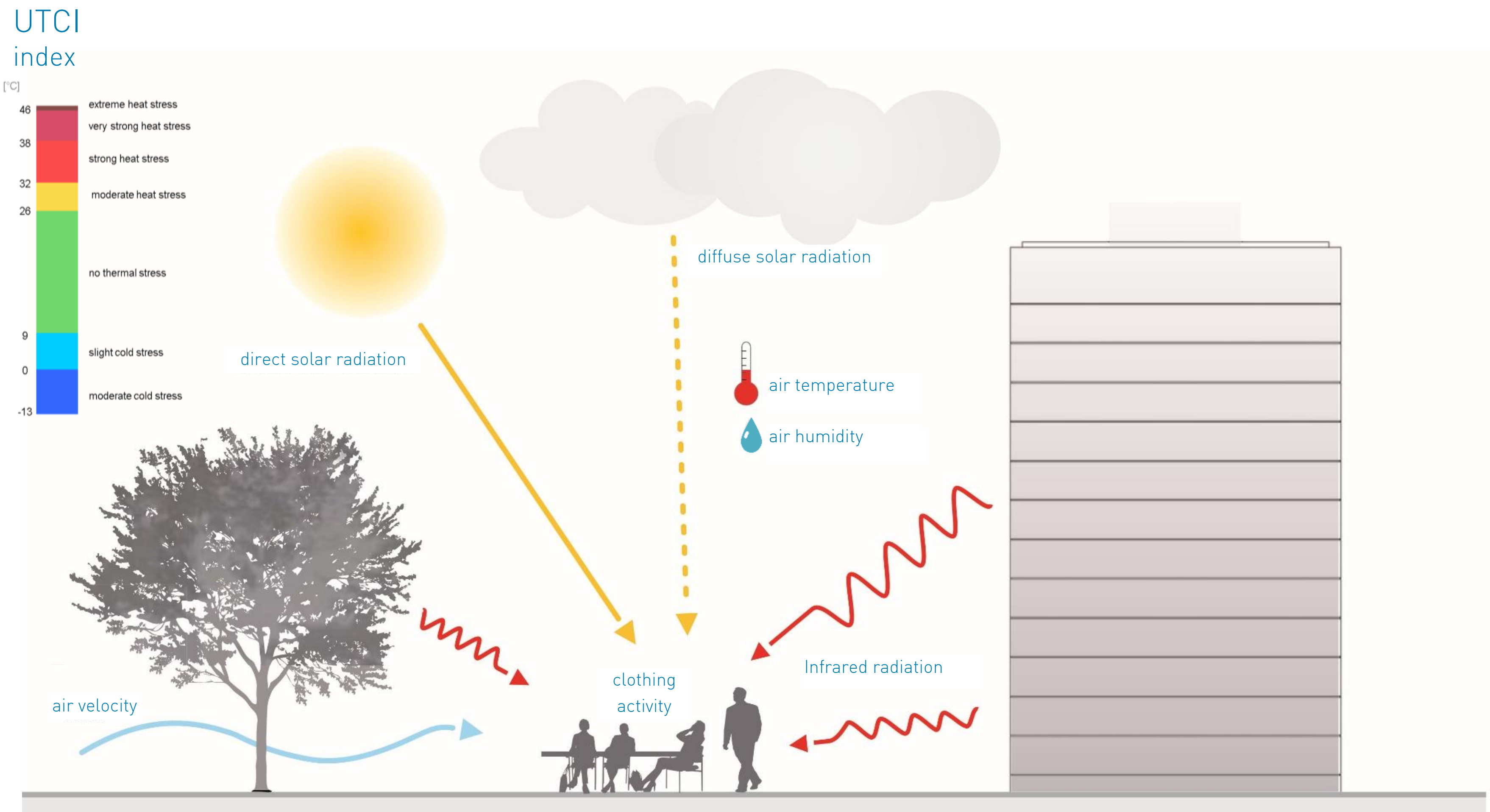
The site i am investigating is located in Romania at the Black Sea coast and therefore has a subcontinental climate. Outdoor temperatures range from -10°C to 30°C with 2 extended analysis periods of the year : cold October - April and hot May - September.

Humidity becomes slightly uncomfortable during the hot period.

Wind is a permanent presence, cold wind from N-E segment and warm breeze from S segment.

OUTDOOR COMFORT

INFLUENCING PARAMETERS



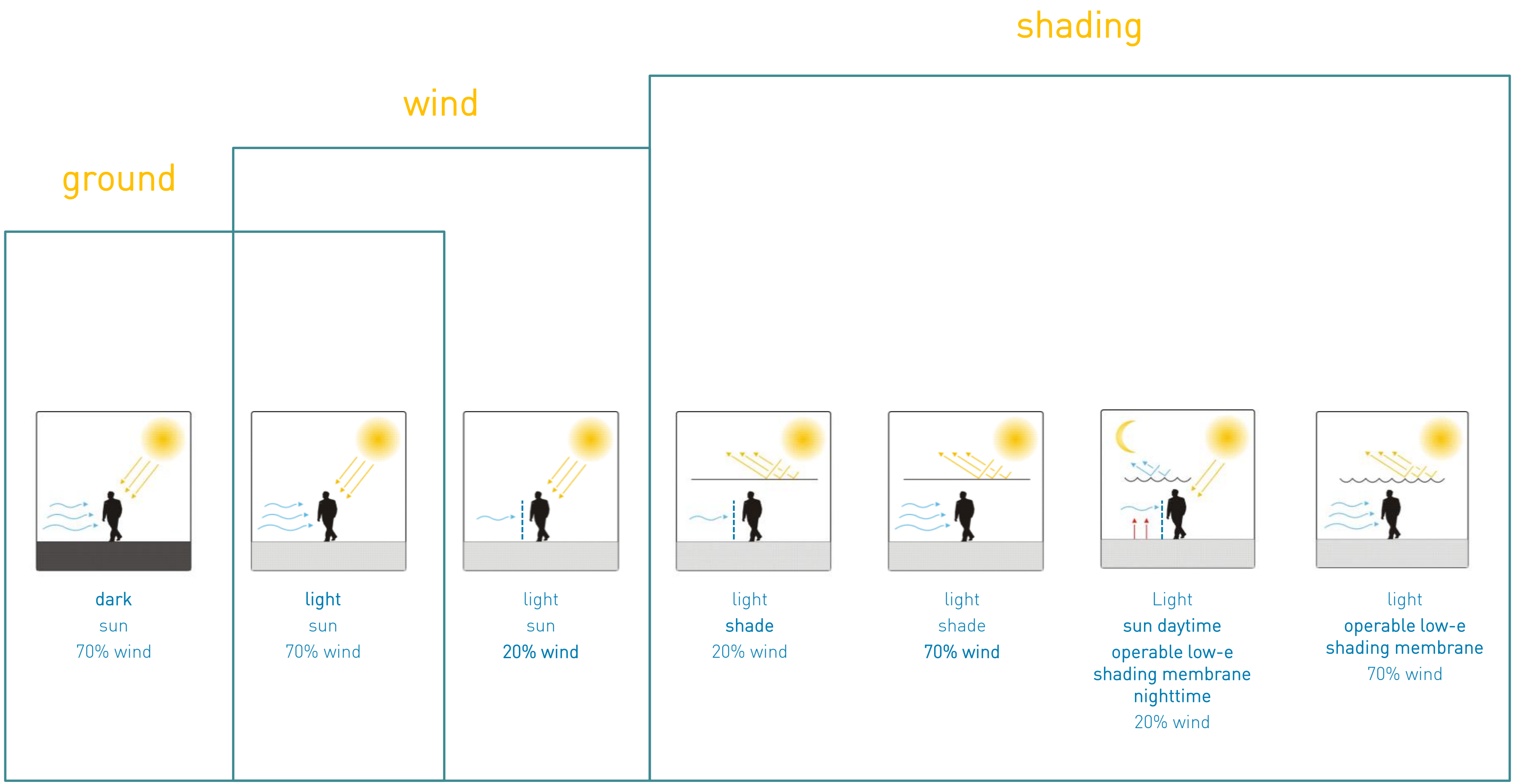
In an outdoor situation, people have more adaptive opportunities to adjust their thermal requirements according to the prevailing weather conditions.

In order to investigate the outdoor comfort we have to analyze the human's bio meteorological comfort index, influenced by :

- ✓ solar radiation
- ✓ infrared radiation
- ✓ air temperature
- ✓ air humidity
- ✓ air velocity
- ✓ clothing factor
- ✓ activity

OUTDOOR COMFORT

THE INFLUENCE OF:



For the case of my city I chose to investigate the influence of different:

- ✓ ground albedo
- ✓ wind exposure
- ✓ shading systems

taking as set parameters:

Standard person: Male, 1.75 m 75 kg, Body surface = 1.78 m .

Emissivity coef of skin & clothing = 0.97.

Solar Absorption coef = 0.7.

Work performance = 172.05 W

Metabolic rate 2.3

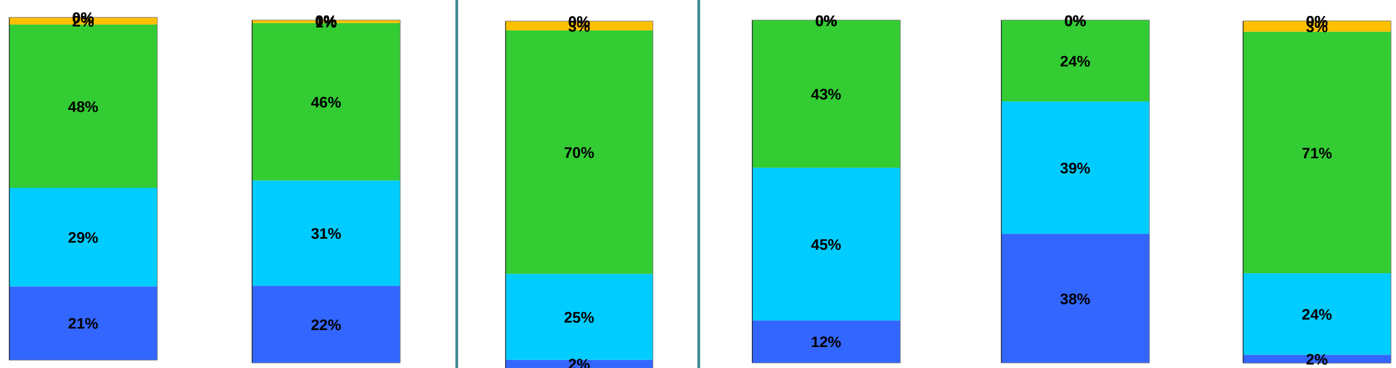
Reference environment: 50% relative humidity

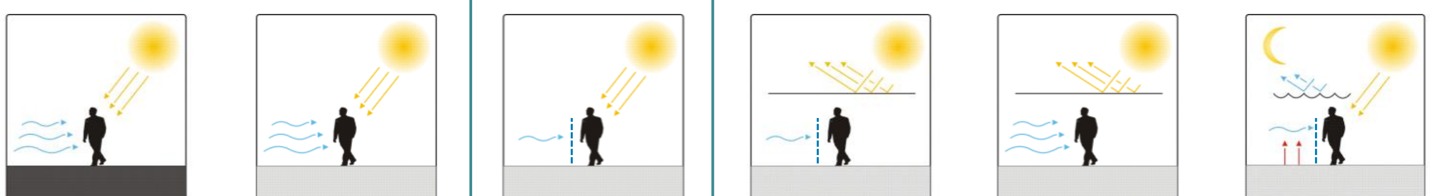
Clothing:summer 0.4 clo

winter 3.0

WINTER & SHOULDER SEASON PERIOD

% of time with 9°C <= UTCI < 26°C   01 october – 30 april   10 am – 04 pm

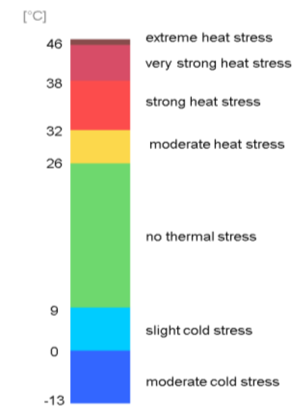




dark	light	light	light	light	Light
sun	sun	sun	shade	shade	sun daytime
70% wind	70% wind	20% wind	20% wind	70% wind	operable low-e shading membrane nighttime
					20% wind
		TARGET			ADD-ON

UTCI

scale



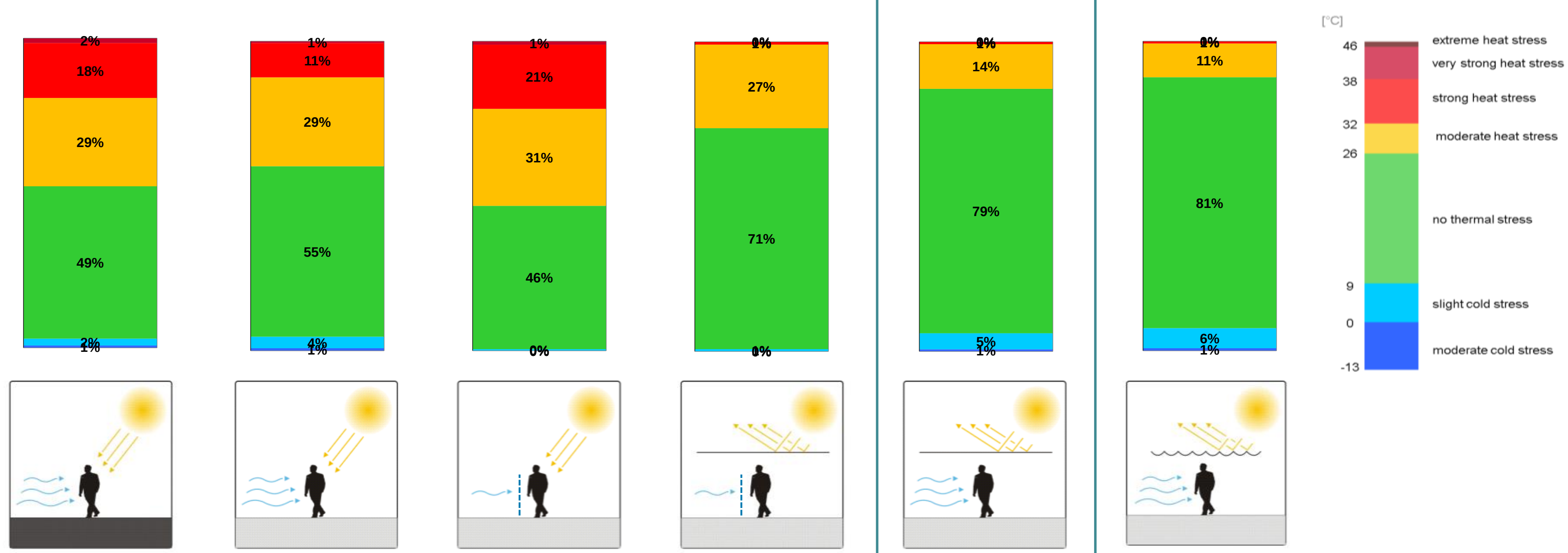
For each period of the year I simulated several Variants to find the best balance between ground wind and sun to understand the best strategy for a proposed urban design.

For the cold period the combination of light ground albedo with full solar exposure and protection from the cold wind is the strategy that achieves the highest comfort.

SUMMER SEASON PERIOD

% of time with 9°C <= UTCI < 26°C — 01 may – 30 september — 10 am – 10 pm

UTCI scale



dark	light	light	light	light	light
sun	sun	sun	shade	shade	operable low-e shading membrane
70% wind	70% wind	20% wind	20% wind	70% wind	70% wind
				TARGET	ADD-ON

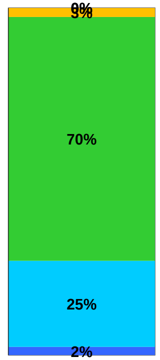
For the summer period, the comfort target is reached by the combination between light ground albedo, wind allowed to flow through the city streets and fixed shading.

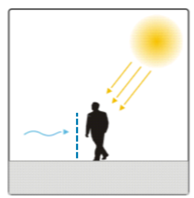
OUTDOOR COMFORT

% of time with 9°C <= UTCI < 26°C

BEST STRATEGIES

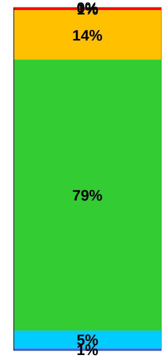
WINTER & SHOULDER SEASON PERIOD

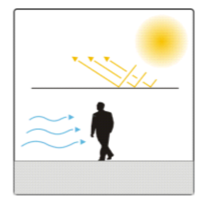




light
sun
20% wind

TARGET





light
shade
70% wind

TARGET

SUMMER PERIOD

With this results I understand:

the general strategies for my city

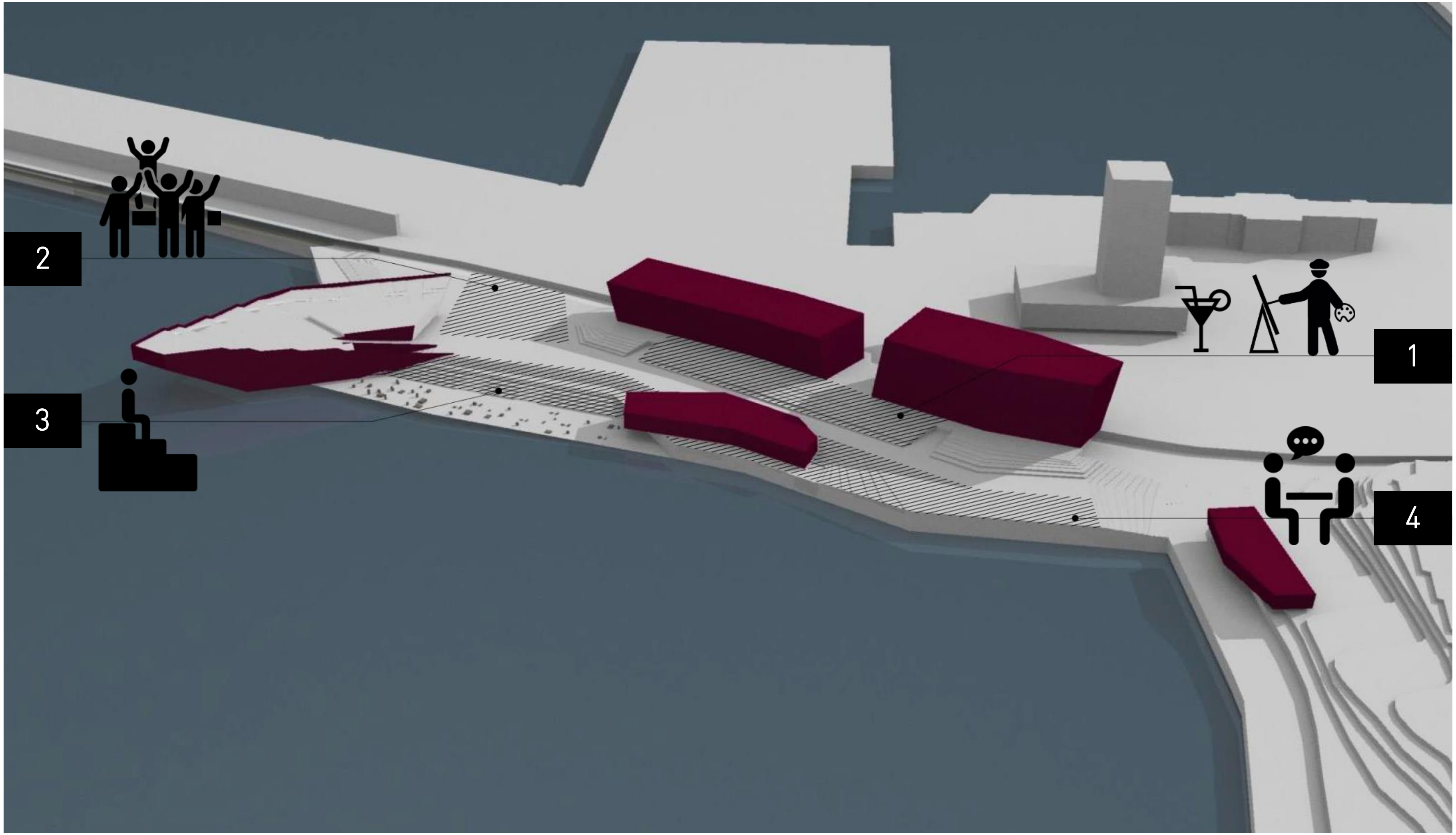
and

I set the comfort targets for each period.

The best strategies for both periods represent the comfort targets that are further compared with the UTCI results reached at local scale.

ORIGINAL DESIGN

test with KLIMA ENGINEERING



The original urban design featured 4 main outdoor areas

Each area represents a different outdoor space typology.

building entrance | exhibitions

an event plaza

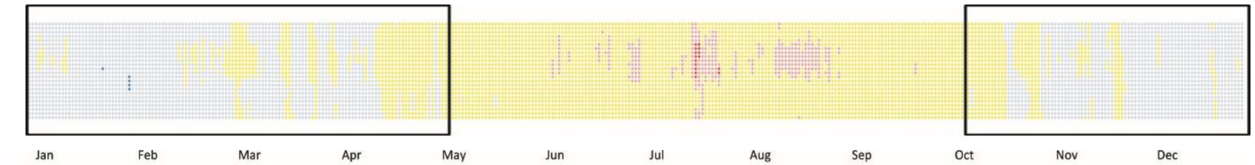
an open-air amphitheater

and a restaurant esplanade.

Having the cluster buildings set and the outdoor areas influenced by the layout I can start investigating the comfort on my master plan.

SOLAR EXPOSURE

winter & shoulder period

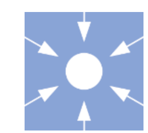


In order to assess the UTCI present on the given urban layout, each outdoor area is analysed for solar and wind exposure for the two periods of the year.

Therefore, in regards of solar exposure in the cold season, the outdoor areas receive a significant amount of radiation and the spots can be rated as well solar exposed.

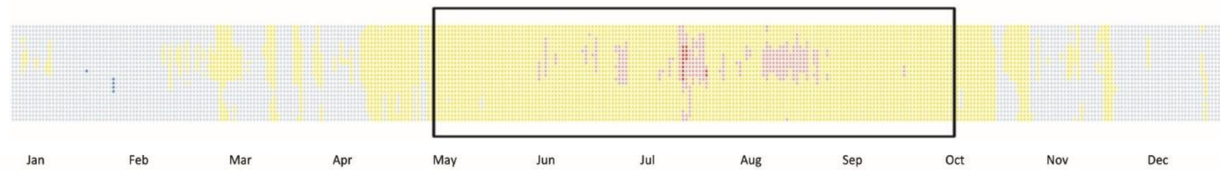
assessment:

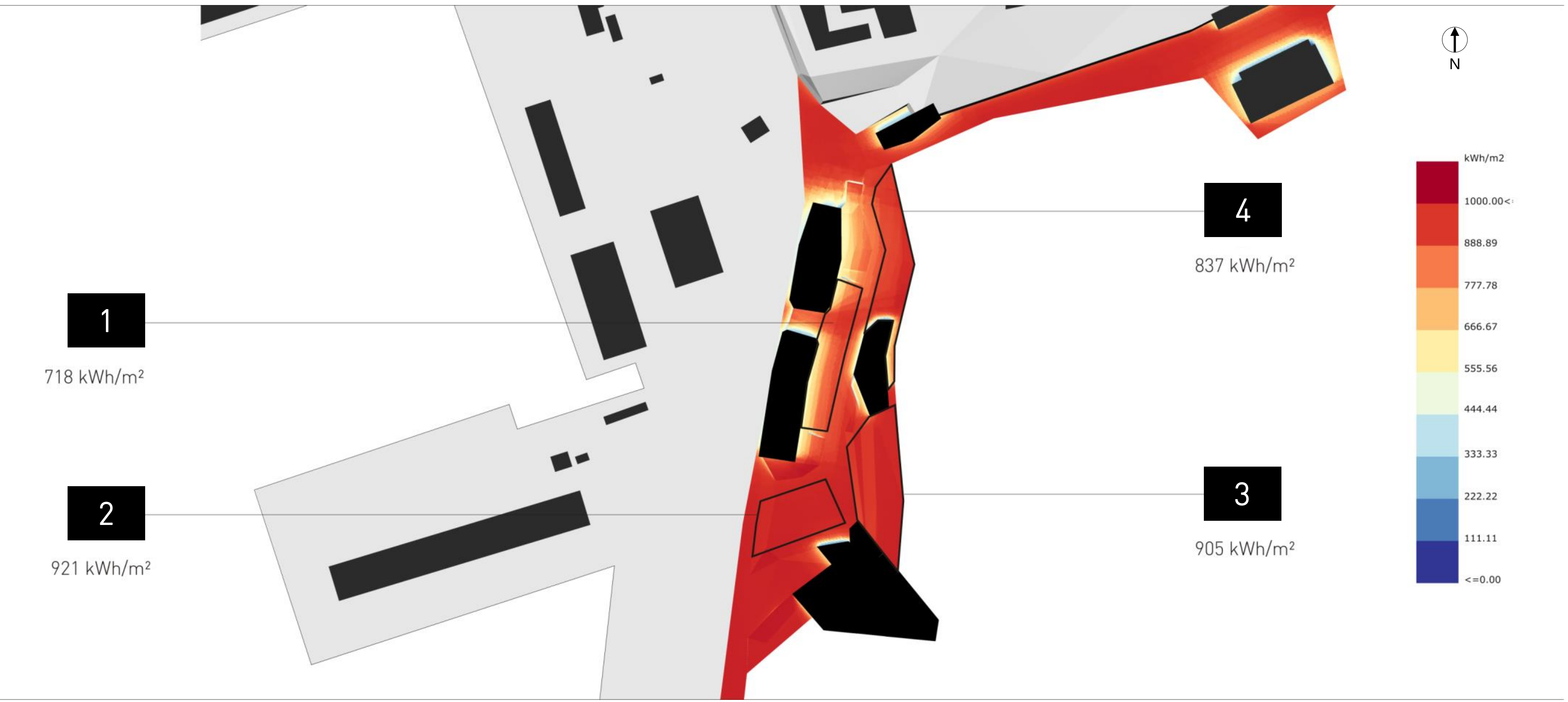
Positive
Solar exposure



SOLAR EXPOSURE

summer period



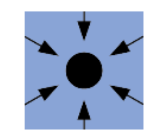


In the summer period the areas are under full solar exposure which is a negative effect present on the site, long exposure: can be highly dangerous to the user's health.

Shading mitigations are needed, either locally or by adapting the master plan.

assessment:

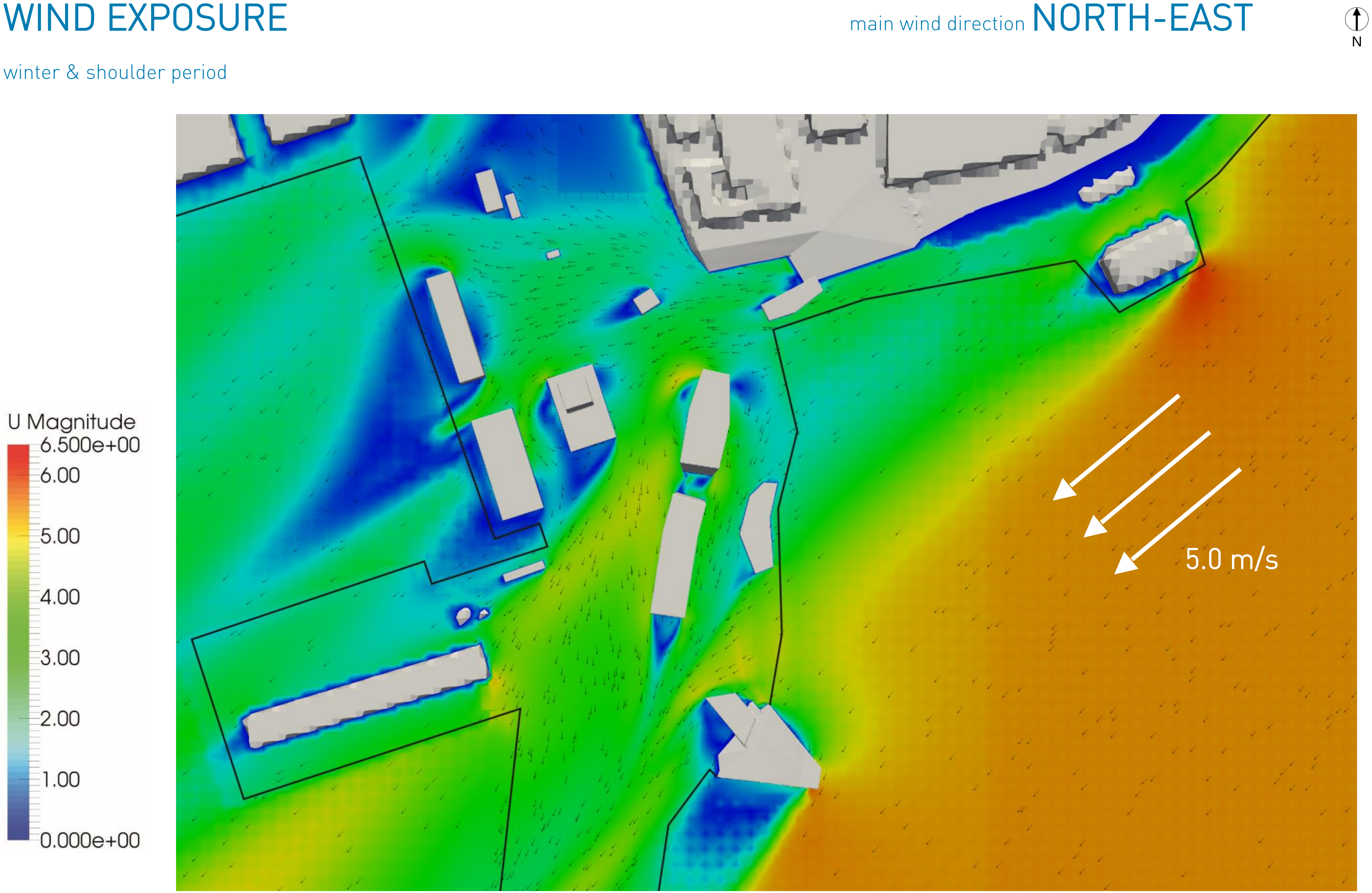
Negative Solar exposure



WIND EXPOSURE

main wind direction NORTH-EAST

winter & shoulder period



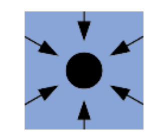
Next, looking at the wind situation. In the cold period the dominant wind is coming from the NE segment, at an average wind speed of 5 m/s.

The clip was made at 10 m above sea level, equivalent with the elevation at which a person is walking on the promenade.

assessment:

Negative

Wind exposure

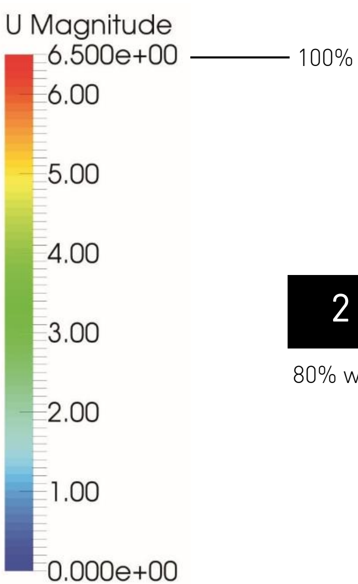


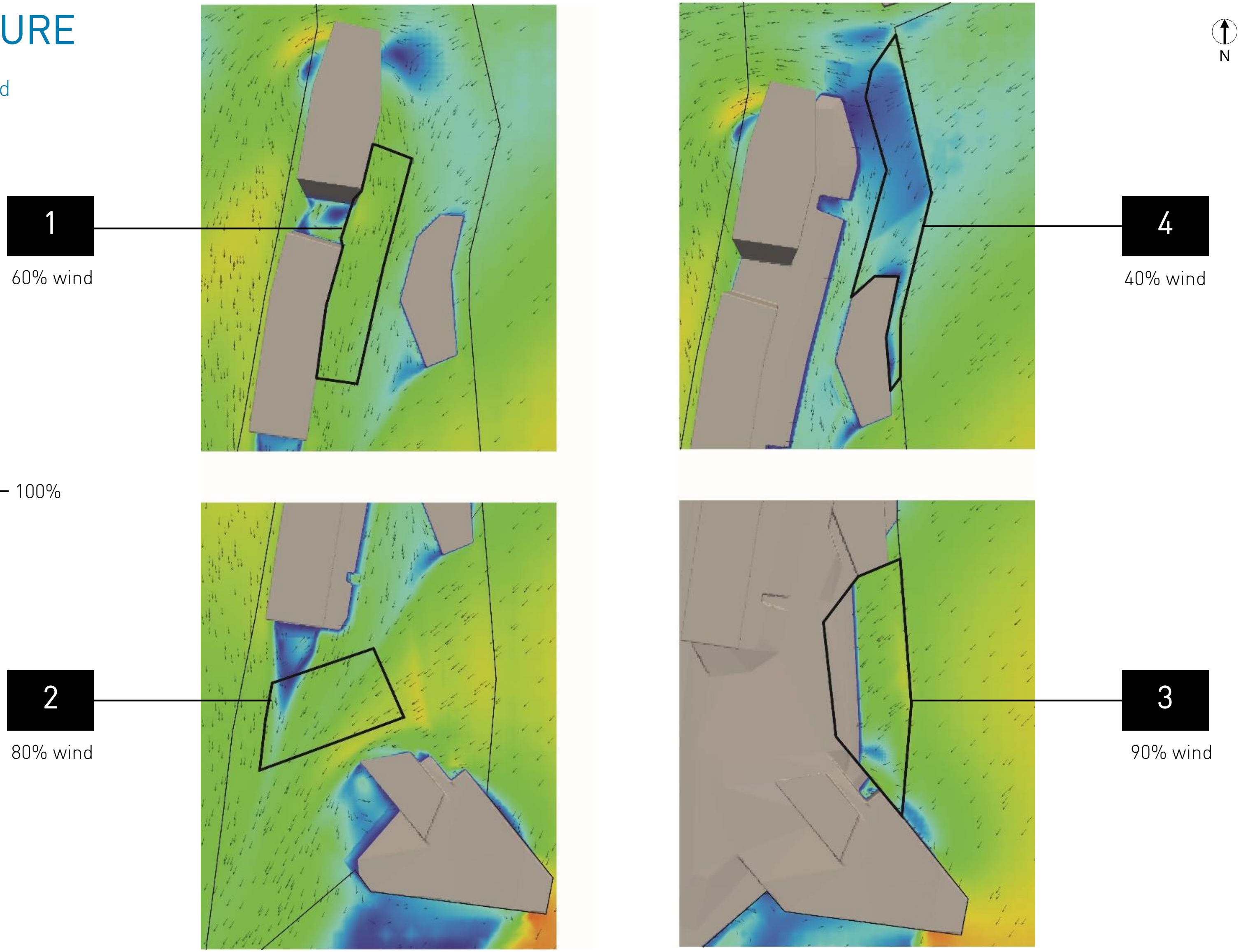
WIND EXPOSURE

winter & shoulder period

main wind direction

NORTH-EAST





I analyzed each area at the pedestrian height to assess the wind speed and the wind distribution through the urban layout.

With the UTCI comfort target strategy in mind, in the cold period to block the wind, I can identify areas that are critical as nr. 3 with 90% wind coming through.

assessment:

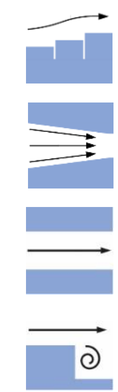
Wind effects present on the site

stepping effect

funnel effect

channelling effect

turbulent corner effect

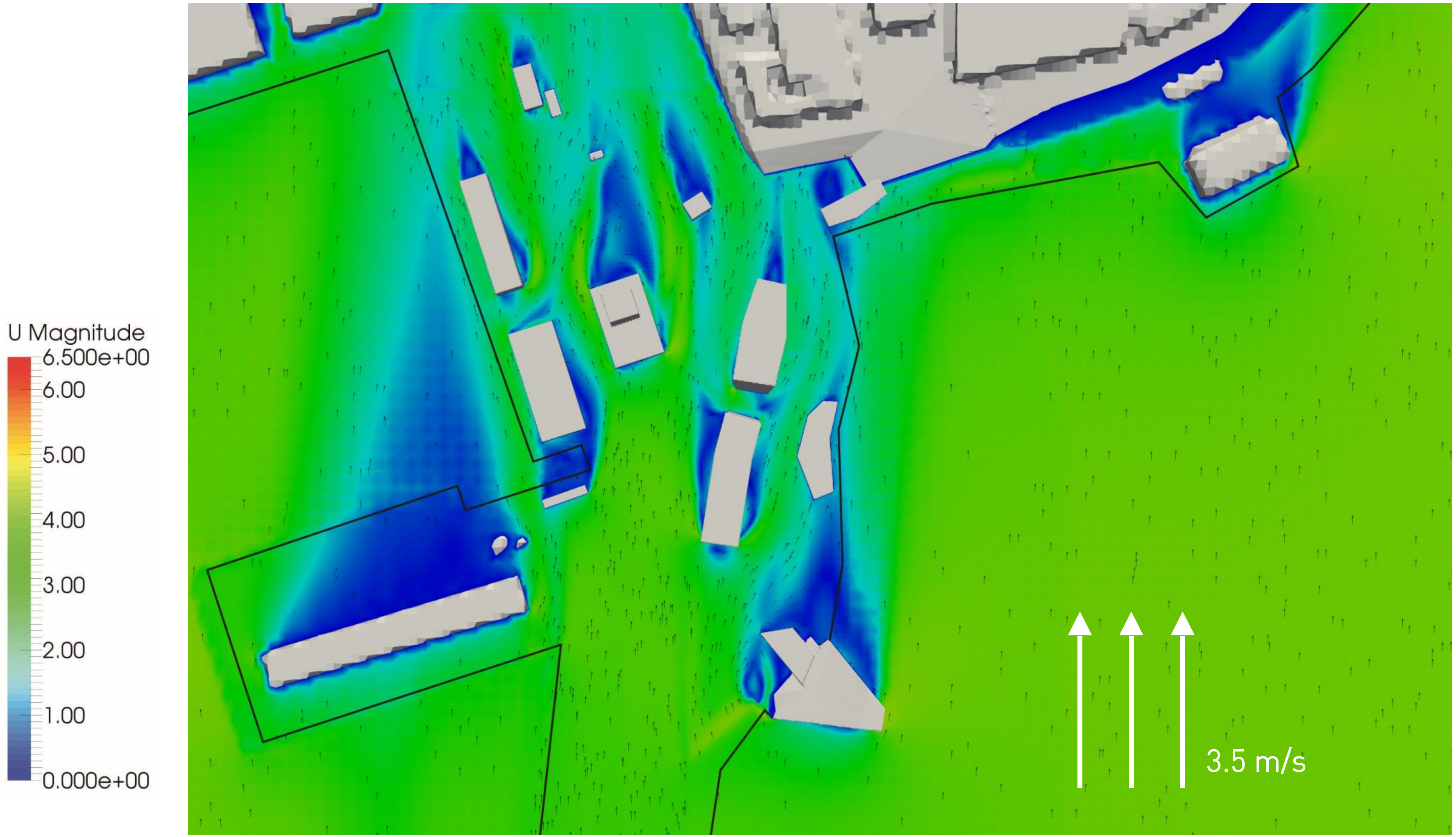


WIND EXPOSURE

summer period

main wind direction **SOUTH**

N



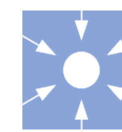
In summer the wind direction changes to the South segment and flows with an average wind speed of 3.5 m/s. The outdoor areas are ventilated, wind is in our advantage.

This clip was made at the same 10 m avove sea level height relevent for a person walking on the promenade..

assessment:

Positive

Wind exposure

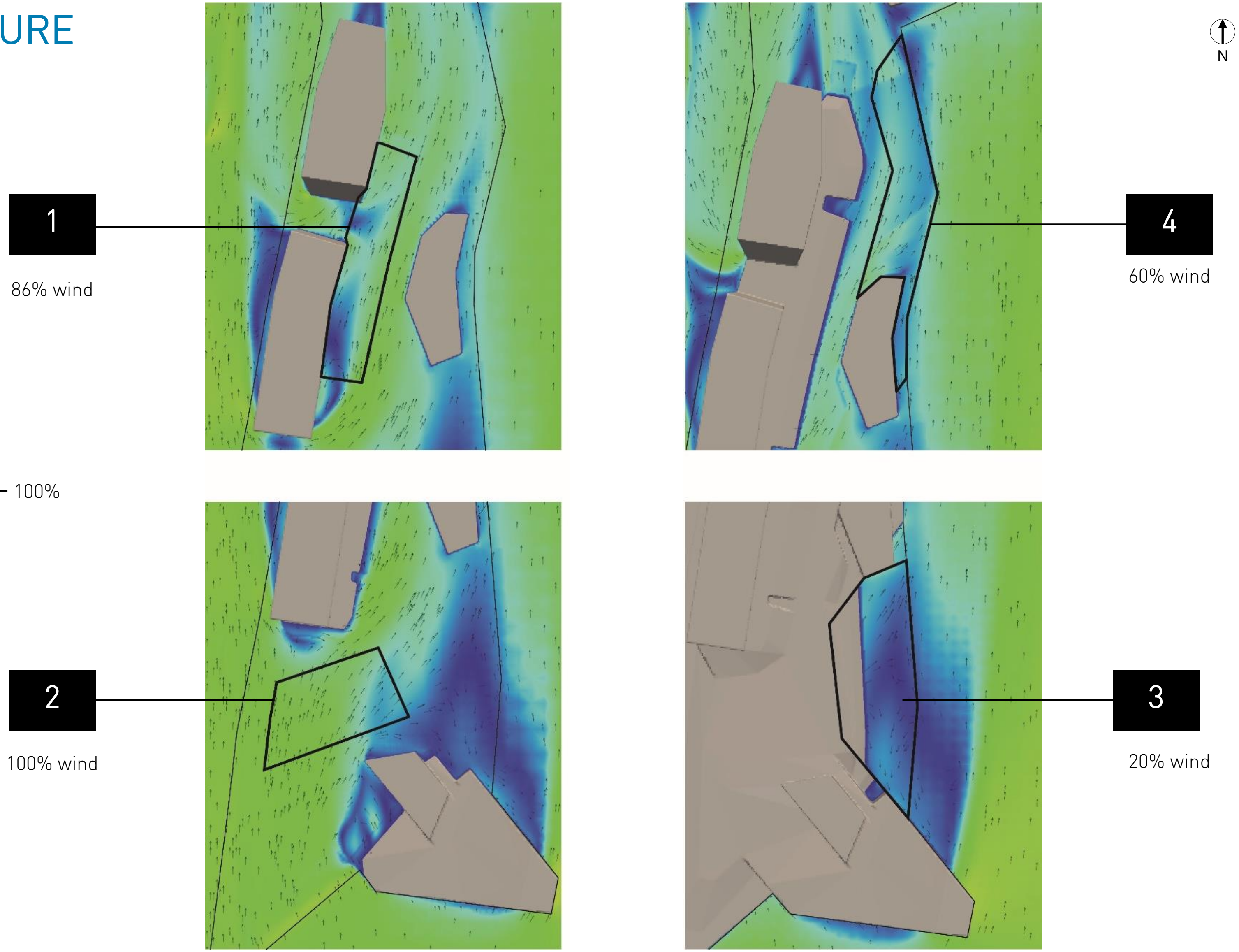


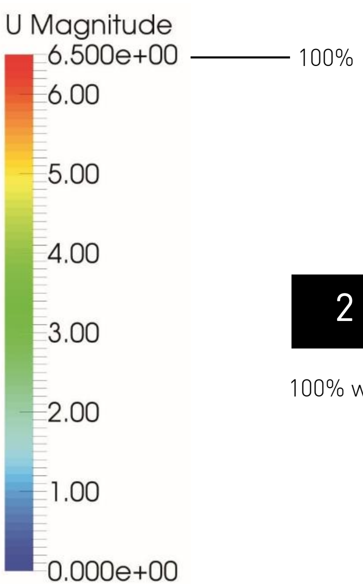
WIND EXPOSURE

summer period

main wind direction

SOUTH



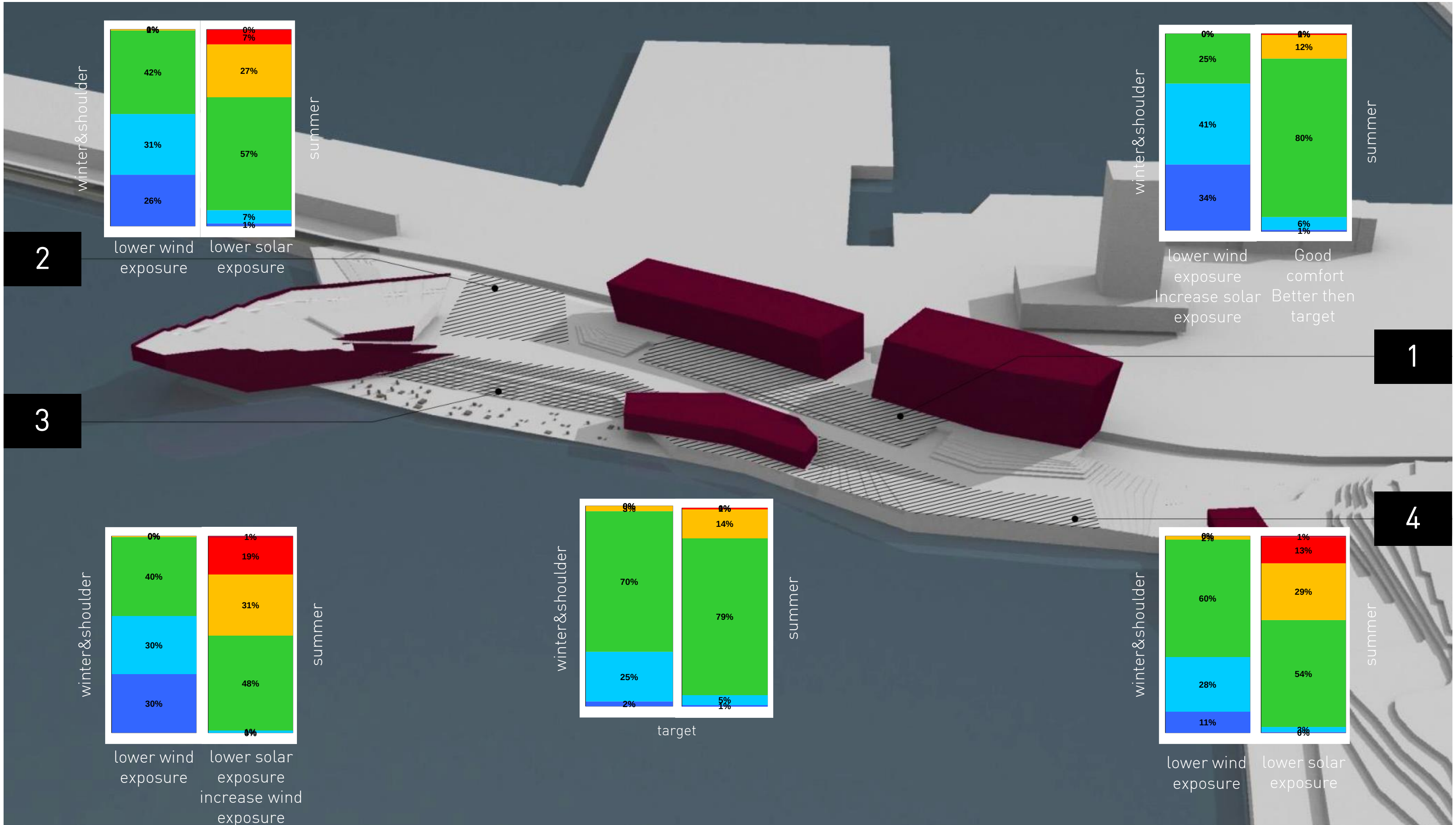


The same approach for each spot; in this period the situation looks pleasant with the sea breeze ventilating the urban layout but still area nr3 is not ventilated enough.

For a comfortable situation according to the target parameters for the summer period, the wind should be allowed at least 70%.

ORIGINAL DESIGN

OUTDOOR COMFORT RESULTS



Out of the previous solar and wind simulations I re-assess the comfort for the original design and compare it with the targets.

The results for area nr.1 show for cold season a demand for blocking the wind and. expose more to sun while in summer the increased wind velocity and the shade from the building brings a great comfort.

For area nr.2, cold season demands lowering the wind exposure while summer lowering the solar exposure.

ORIGINAL DESIGN READAPTED

INTERATIVE PROCESS

geometry test 1

geometry test 2

geometry test 3

MASSING
ORIENTATION
SHAPE

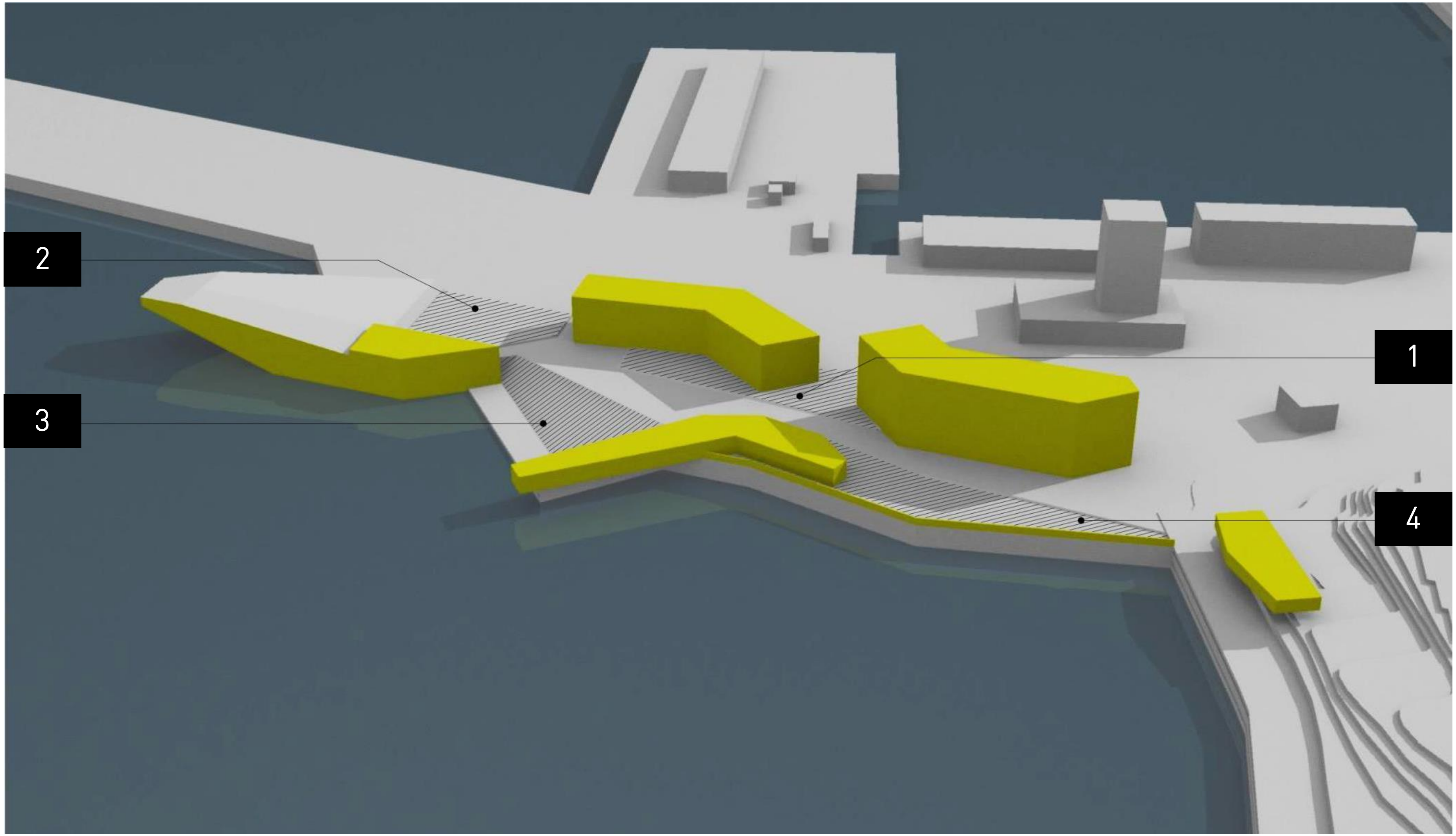
SOLAR WIND
UTCI
SIMULATIONS

OPTIMIZED
DESIGN

After this results I identified the weaknesses of the original urban design and I start readapting it to mitigate the comfort requirements.

A series of test geometries were put through the same iterative process of simulations and an optimized layout was identified.

OPTIMIZED DESIGN



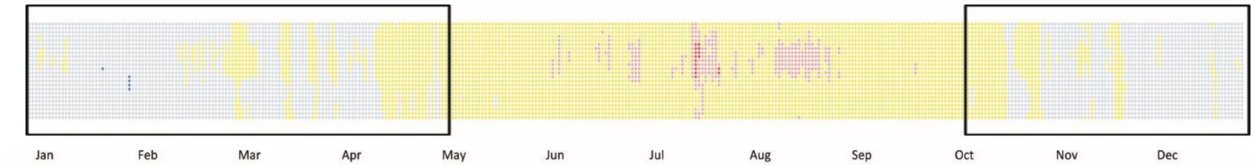
Design criteria are applied to the urban site and optimization decisions have been made.

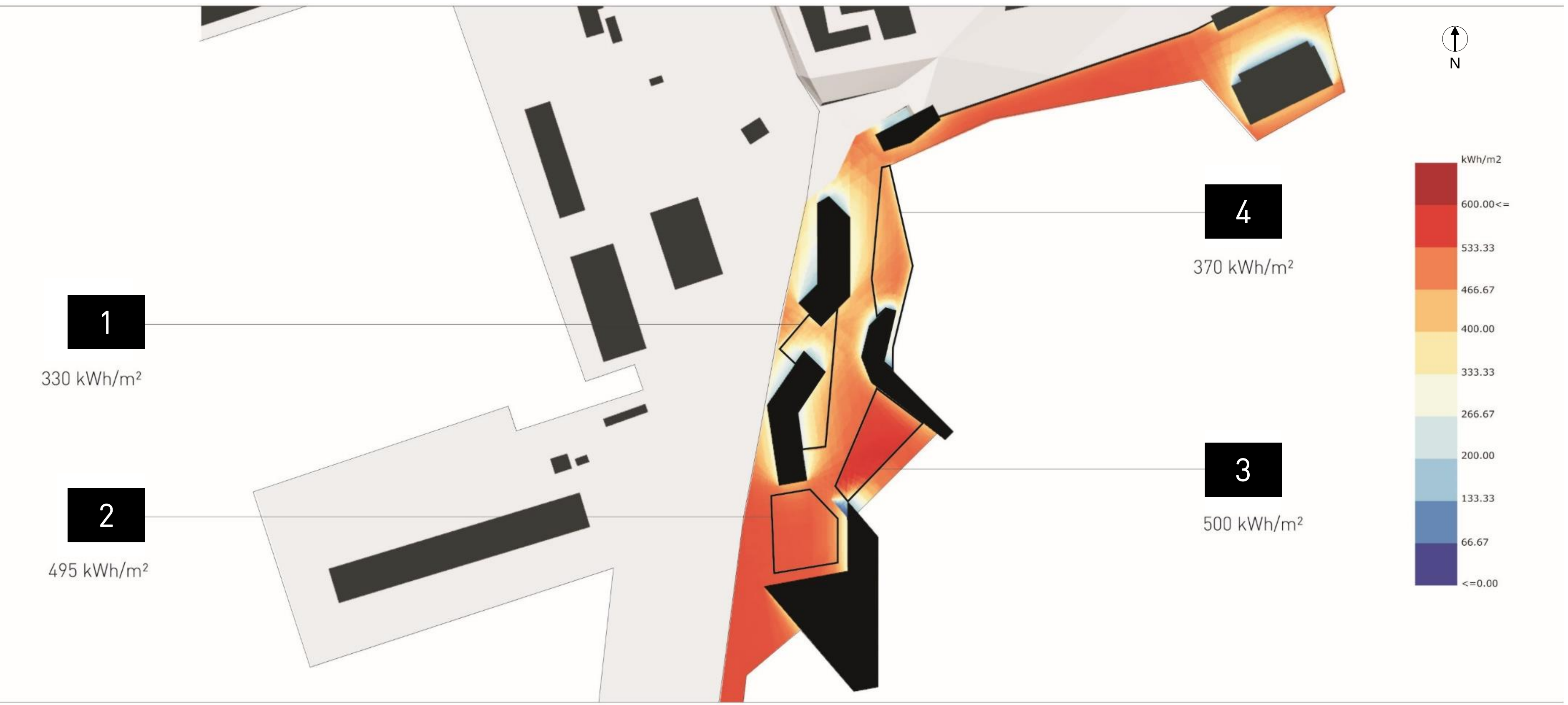
While the solar aspect can be solved with local removable systems, the wind aspect can be more efficiently tackled with a change in the orientation and shape of the geometry.

The readapted, optimized design keeps roughly the square meters of the buildings and the 4 areas still suited for their usage.

SOLAR EXPOSURE

winter & shoulder period





The new design passes through the same iterative process of investigating the solar exposure for each period.

In the cold period by changing the massing I was able to keep the solar exposure of the areas. Sun is in the advantage of the open spaces for this season.

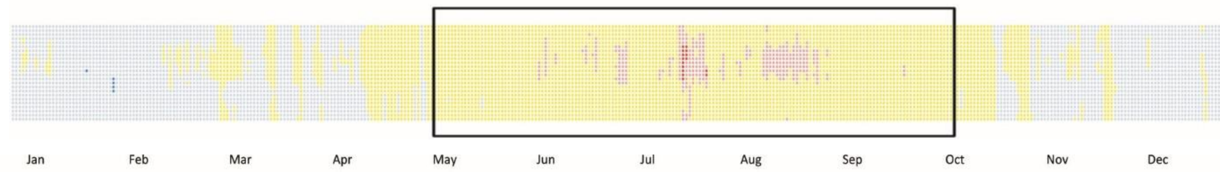
assessment:

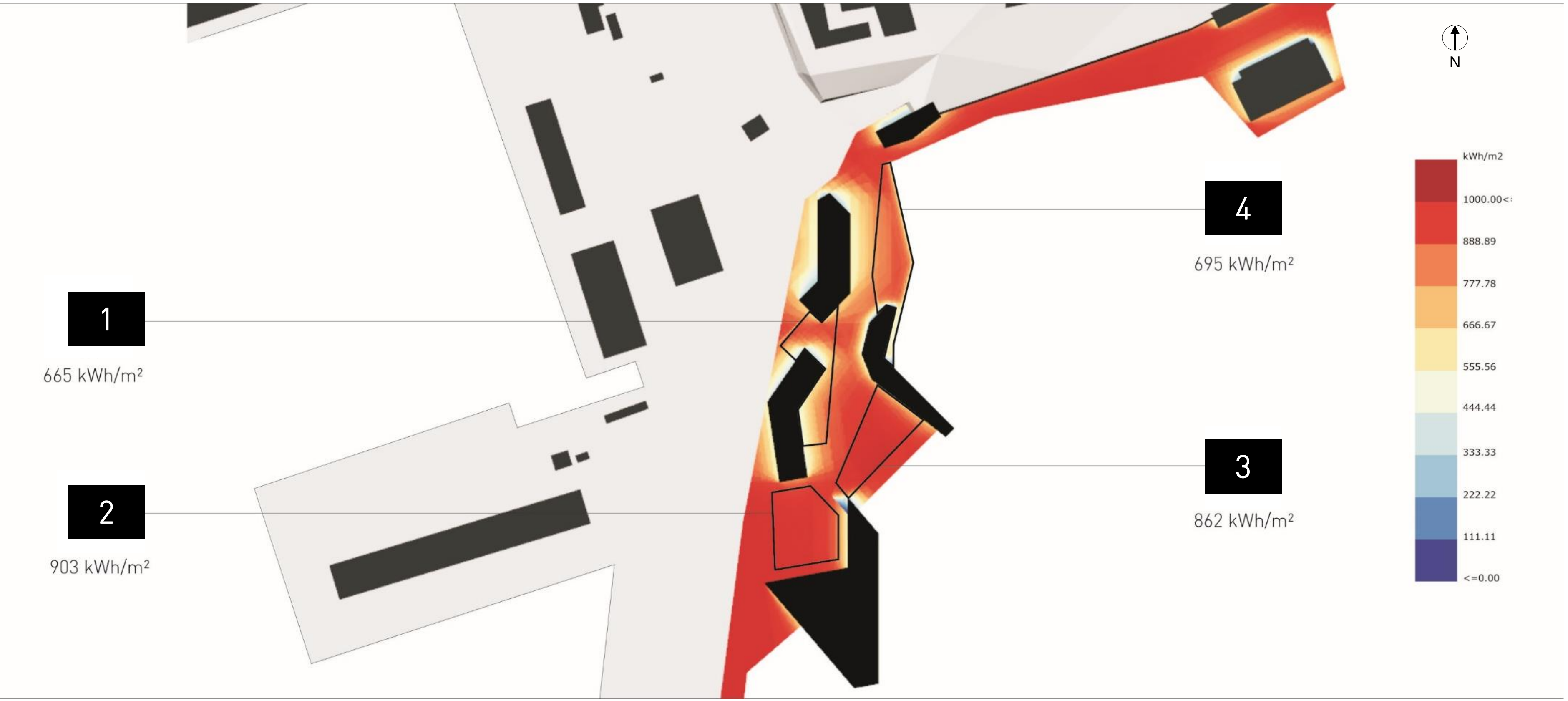
Positive

Solar exposure

SOLAR EXPOSURE

summer period





While in the summer period the spots 2 and 3 are still fully exposed, the spots 1 and 4 are improved.

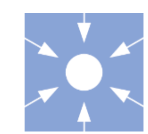
As local mitingation, operable sun shading systems are proposed to lower the solar exposure.

ex Nenufar sunshades by Samoa

assessment:

Positive

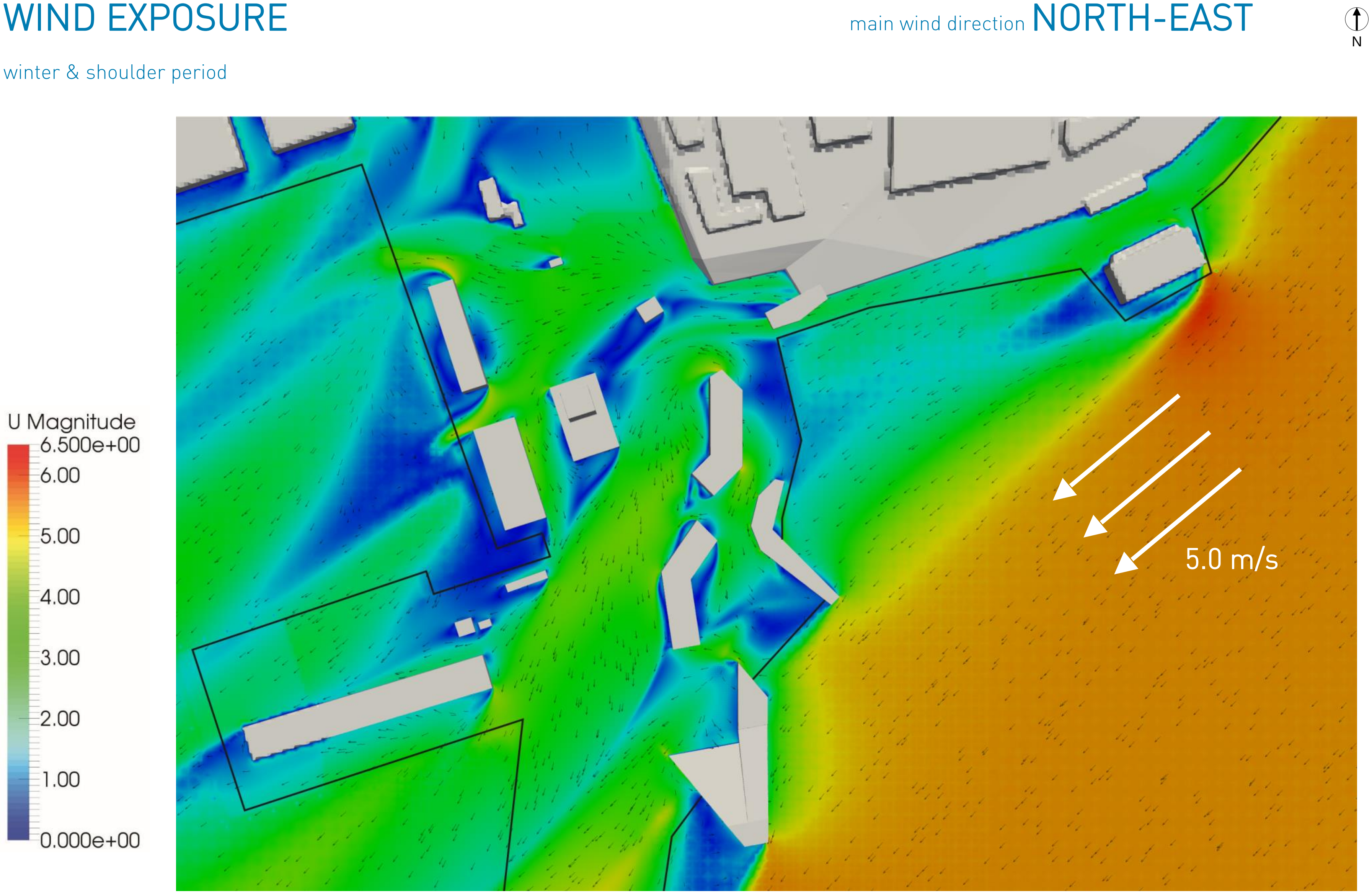
Solar exposure



WIND EXPOSURE

winter & shoulder period

main wind direction NORTH-EAST



The wind situation for the optimized design in the cold season looks better. The massing is actually protecting the outdoor spaces from the cold NE wind.

assessment:

Positive

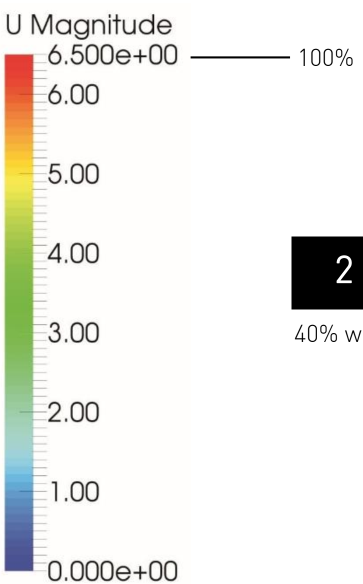
Wins protection

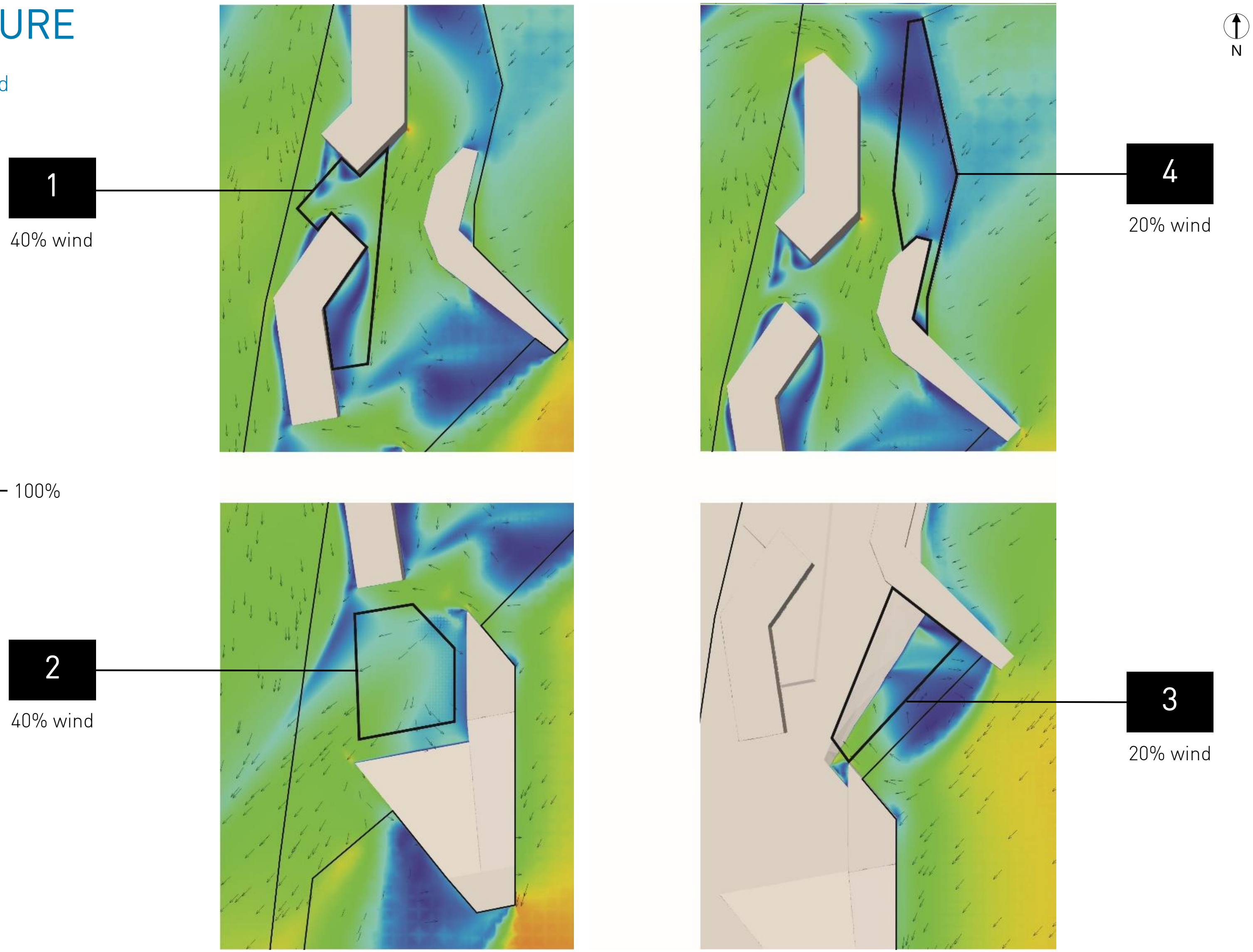
WIND EXPOSURE

winter & shoulder period

main wind direction

NORTH-EAST





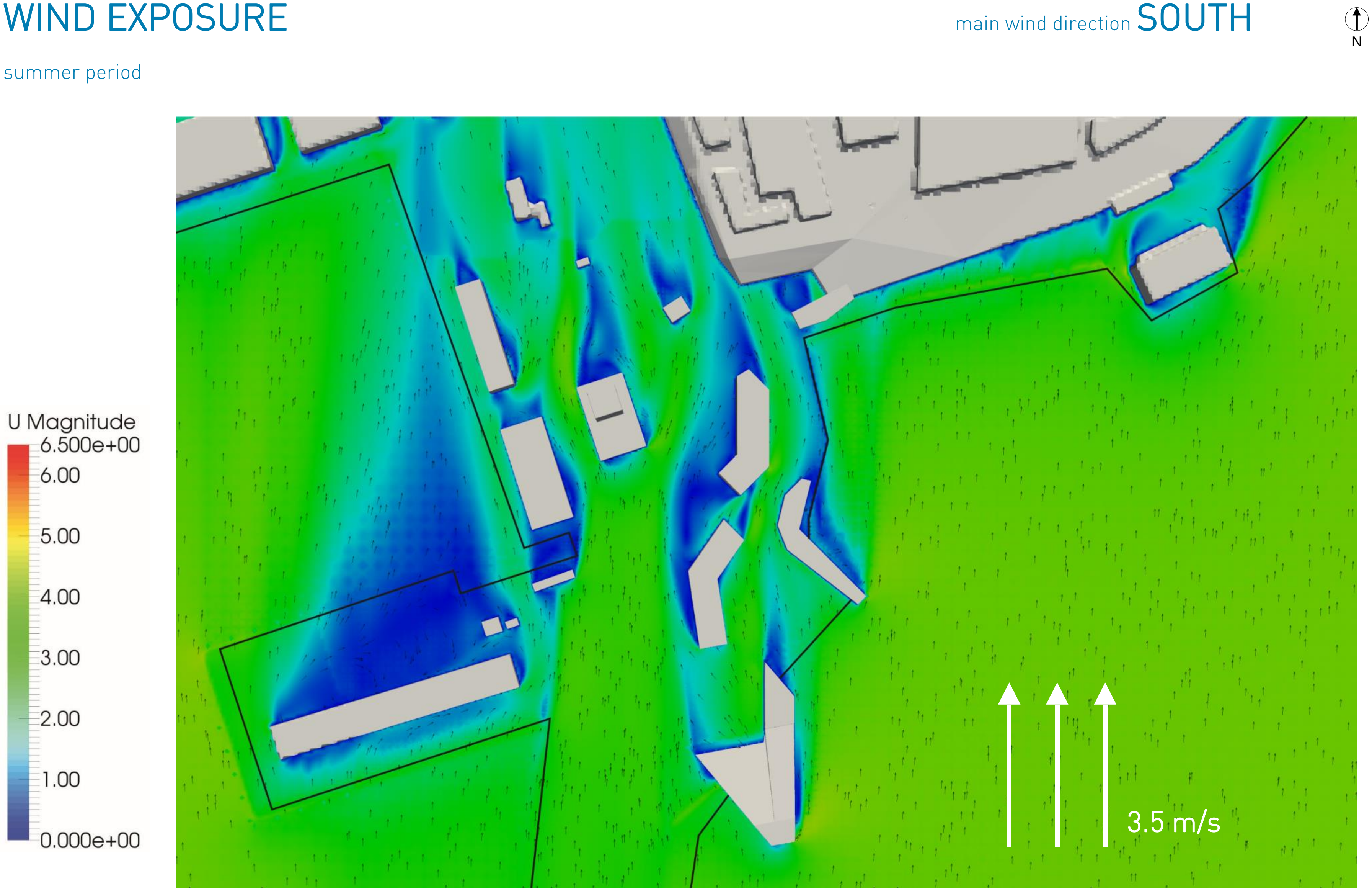
Besides changing the shape and orientation of the buildings, I added and simulated a glass wall as local measure to protect even more area nr.4; the restaurant esplanade.

For area nr. 3 the new orientation of the slope with the tow buildings parallel blocking the wind, the effects of stepping and funnel are avoided and the comfort of this area increases significantly.

WIND EXPOSURE

summer period

main wind direction SOUTH



The wind situation for the optimized design in the summer season is also good. The new shape and orientation of the massing is allowing the South wind to flow through without creating discomfort.

The areas are well ventilated and suited for the outdoor activities required by the design.

assessment:

Positive

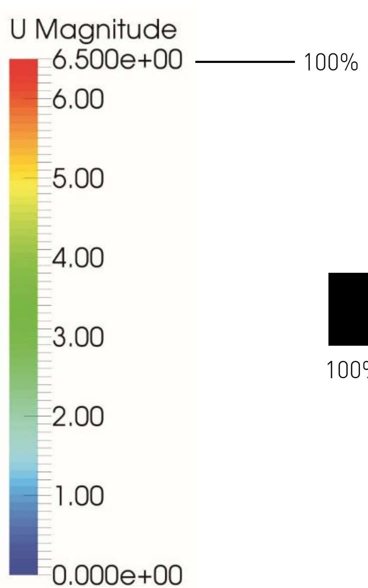
Wins exposure

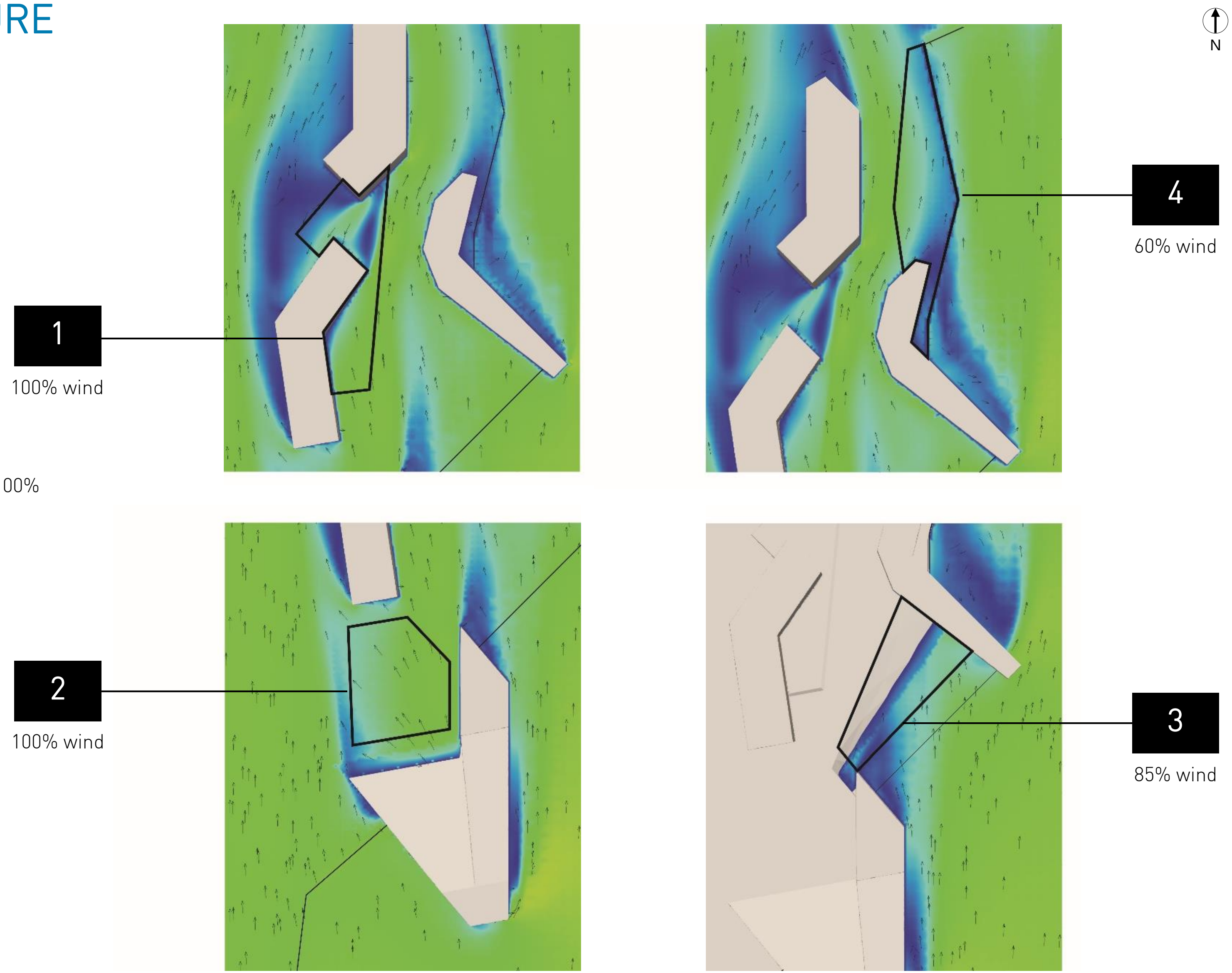
WIND EXPOSURE

summer period

main wind direction

SOUTH



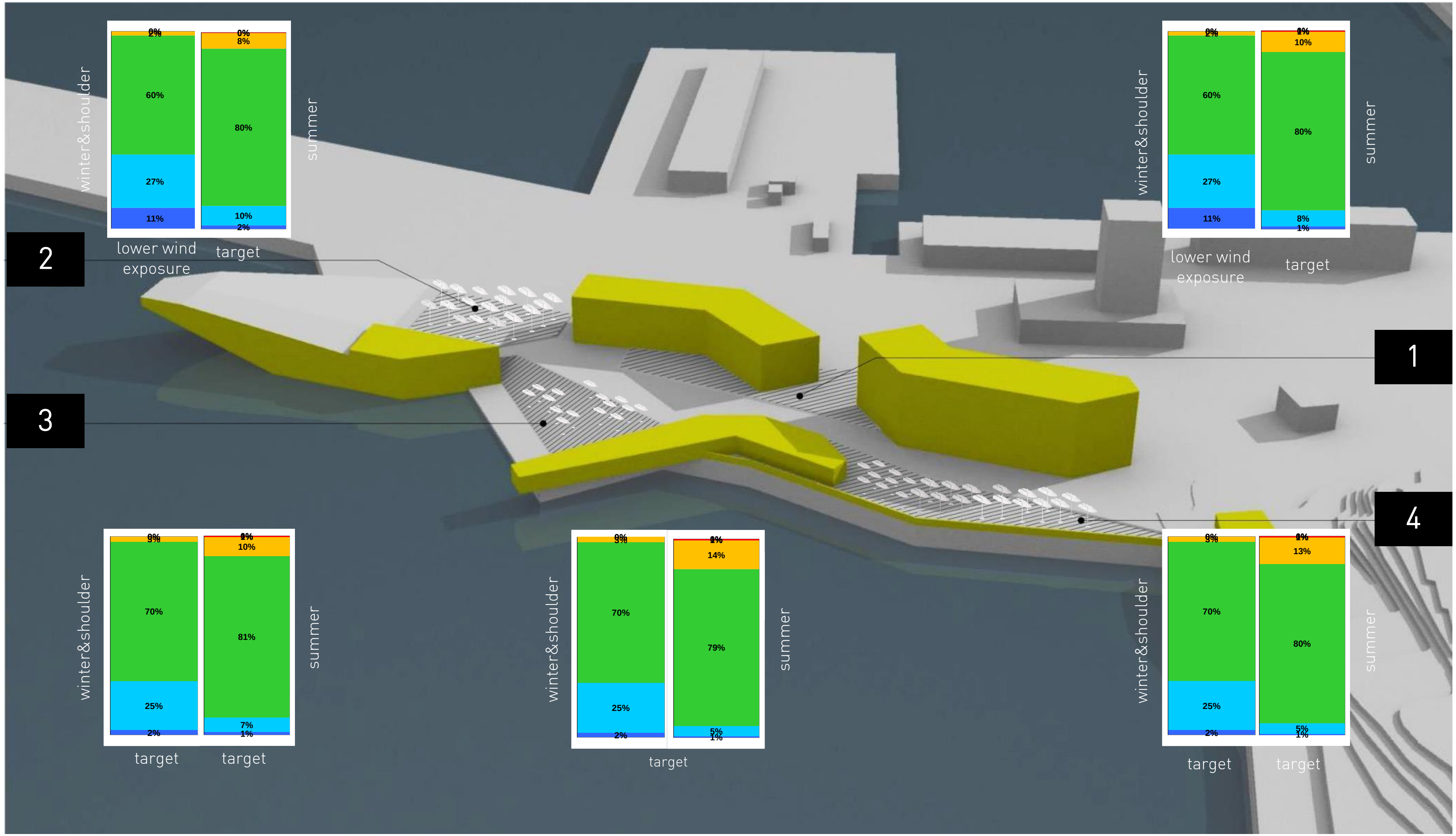


Acording to the target parameter related to wind exposure, almost all the areas recieve a good exposure to wind (higher then 70%) .

Area nr. 4 shows a 60% exposure due to the presence of the wind blocker wall on the edge of the platform. This wall can be proposed as removable according to season.

OPTIMIZED DESIGN

OUTDOOR COMFORT RESULTS

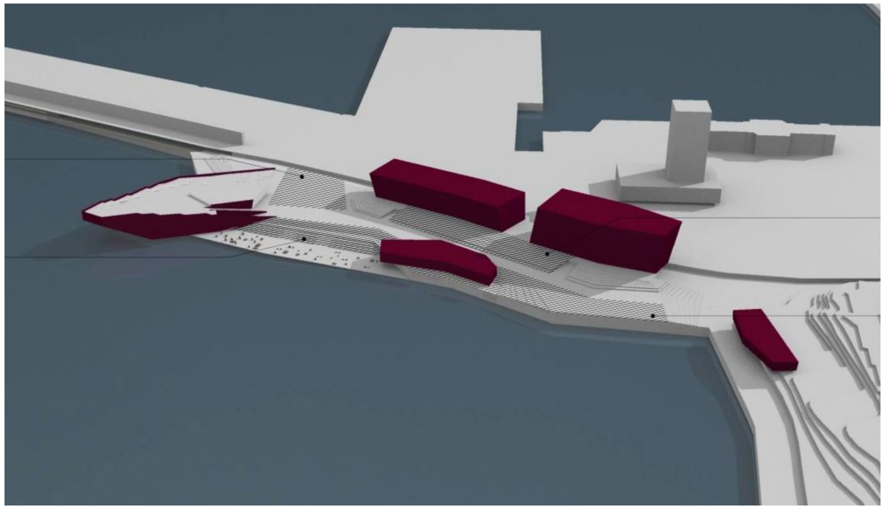


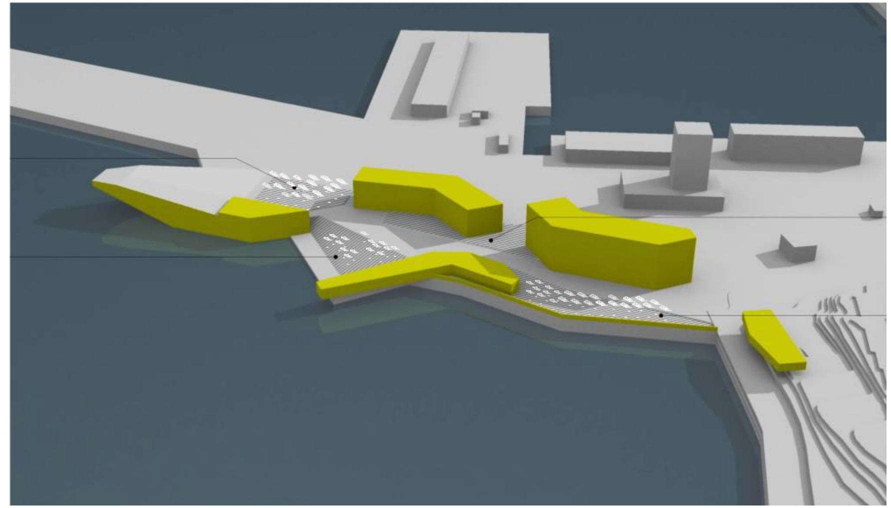
Outdoor comfort simulation results show for both of the periods the comfort target being reached even exceeded in the summer case due to the wind access of 85% on the area nr 3.

The same methodology has been applied for the other 3 outdoor areas and the results for both periods of the year reaches the target and the comfort threshold for the climate and activities in case.

ORIGINAL DESIGN

OPTIMIZED DESIGN





"Good public spaces enhance community cohesion and promote health, happiness, and well-being for all citizens as well as fostering investment, economic development and environmental sustainability."

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THANK YOU !

The research aims to provide a guidelines of improving social sustainability through testing and designing thermally comfortable outdoor spaces based on climate comfort strategies.

In conclusion, the comfort of outdoor environments can be significantly improved not only through local measures that upgrade the urban plan but even more by playing with the massing at its concept stage.

One highlighted conclusion is that each outdoor space requires site-specific and customized comfort strategies that consider geographical location as well as the unique built and climatic context.