



**QUEEN'S
UNIVERSITY
BELFAST**

CityZEN Strategy Plan #3 Gruz, Dubrovnik

Keeffe, G. (Designer), van den Dobblessteen, A. (Designer), & Pulselli, R. (Designer). (2016). CityZEN Strategy Plan #3 Gruz, Dubrovnik. Design

Document Version:
Other version

Queen's University Belfast - Research Portal:
[Link to publication record in Queen's University Belfast Research Portal](#)

General rights

Copyright for the publications made accessible via the Queen's University Belfast Research Portal is retained by the author(s) and / or other copyright owners and it is a condition of accessing these publications that users recognise and abide by the legal requirements associated with these rights.

Take down policy

The Research Portal is Queen's institutional repository that provides access to Queen's research output. Every effort has been made to ensure that content in the Research Portal does not infringe any person's rights, or applicable UK laws. If you discover content in the Research Portal that you believe breaches copyright or violates any law, please contact openaccess@qub.ac.uk.



Dubrovnik (Gruž) Roadshow'

THE CITY VISION

Monday 31st Oct to Friday 4th Nov 2016

Hosted by DURA – The City of Dubrovnik Development Agency

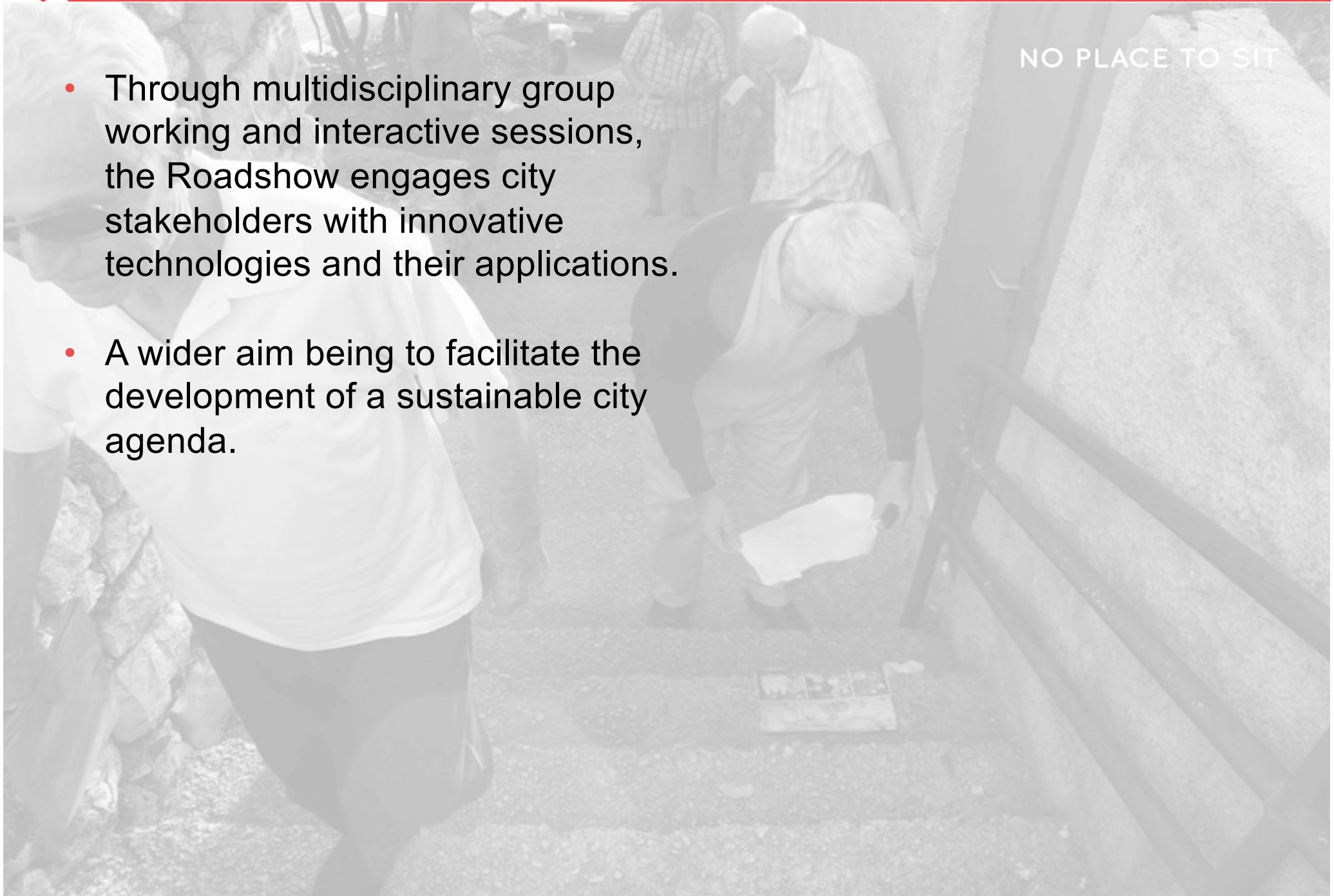




AIMS & AMBITION

- Through multidisciplinary group working and interactive sessions, the Roadshow engages city stakeholders with innovative technologies and their applications.
- A wider aim being to facilitate the development of a sustainable city agenda.

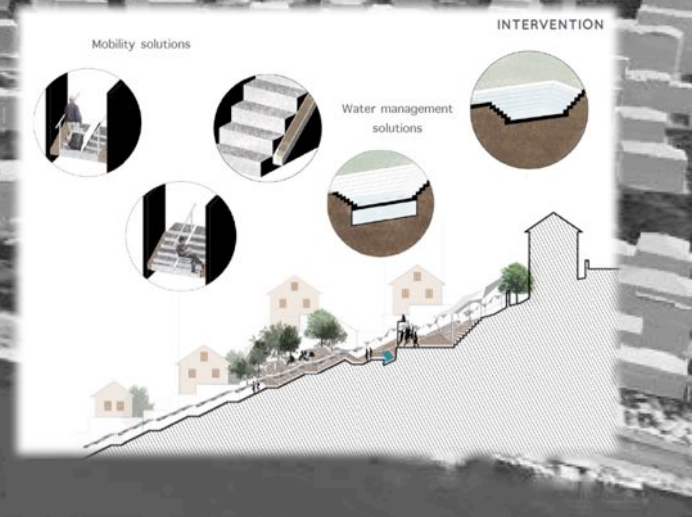
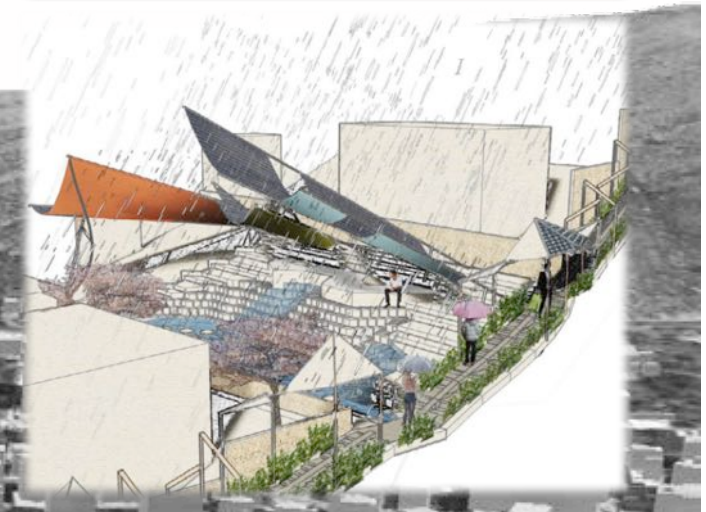
NO PLACE TO SIT





SWAT STUDIO

- A 2-Week Intensive Student Sustainable Urban Intervention workshop, will visit each hosting city within 2 months before the start of each Roadshow.





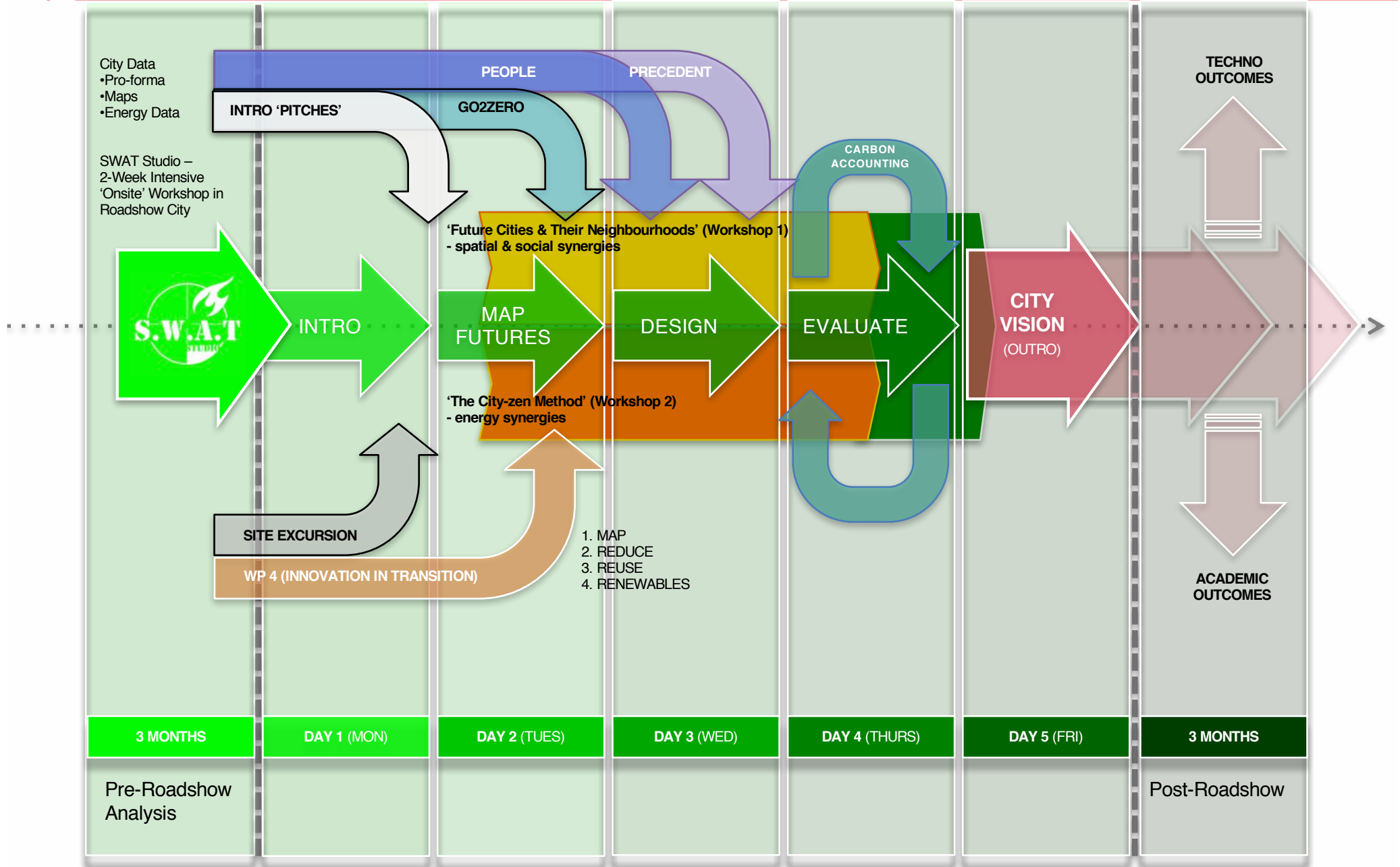
DAILY ACTIVITIES

Activities & events that have taken place so far over the 5 Day programme include:

- Energy Potential Mapping
- Design workshops
- Serious Gaming
- Mini-Masterclasses (Social & Technical)
- Future Innovation Technology lecture/seminar
- Carbon Accounting



DAILY ACTIVITIES (5-DAY SCHEMATIC)



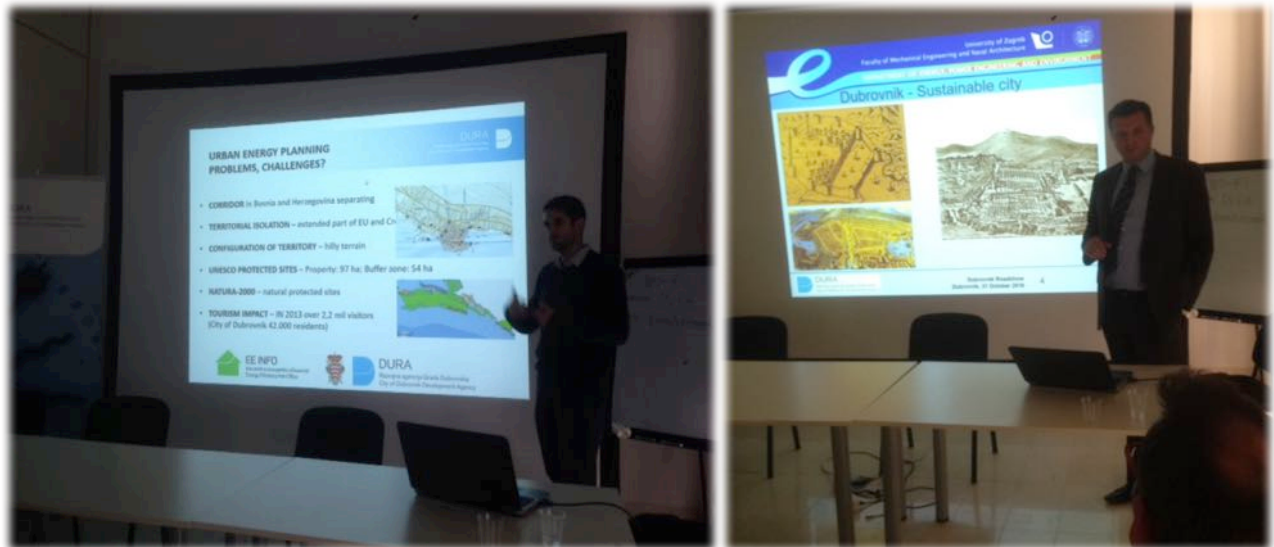
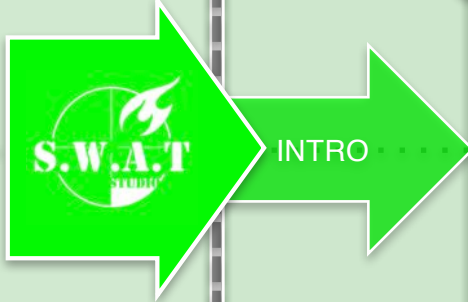


DAY 1 - 'PITCHES' BY ROADIES & THE CITY

- City Data
- Pro-forma
 - Maps
 - Energy Data

INTRO 'PITCHES'

SWAT Studio –
2-Week Intensive
'Onsite' Workshop in
Roadshow City



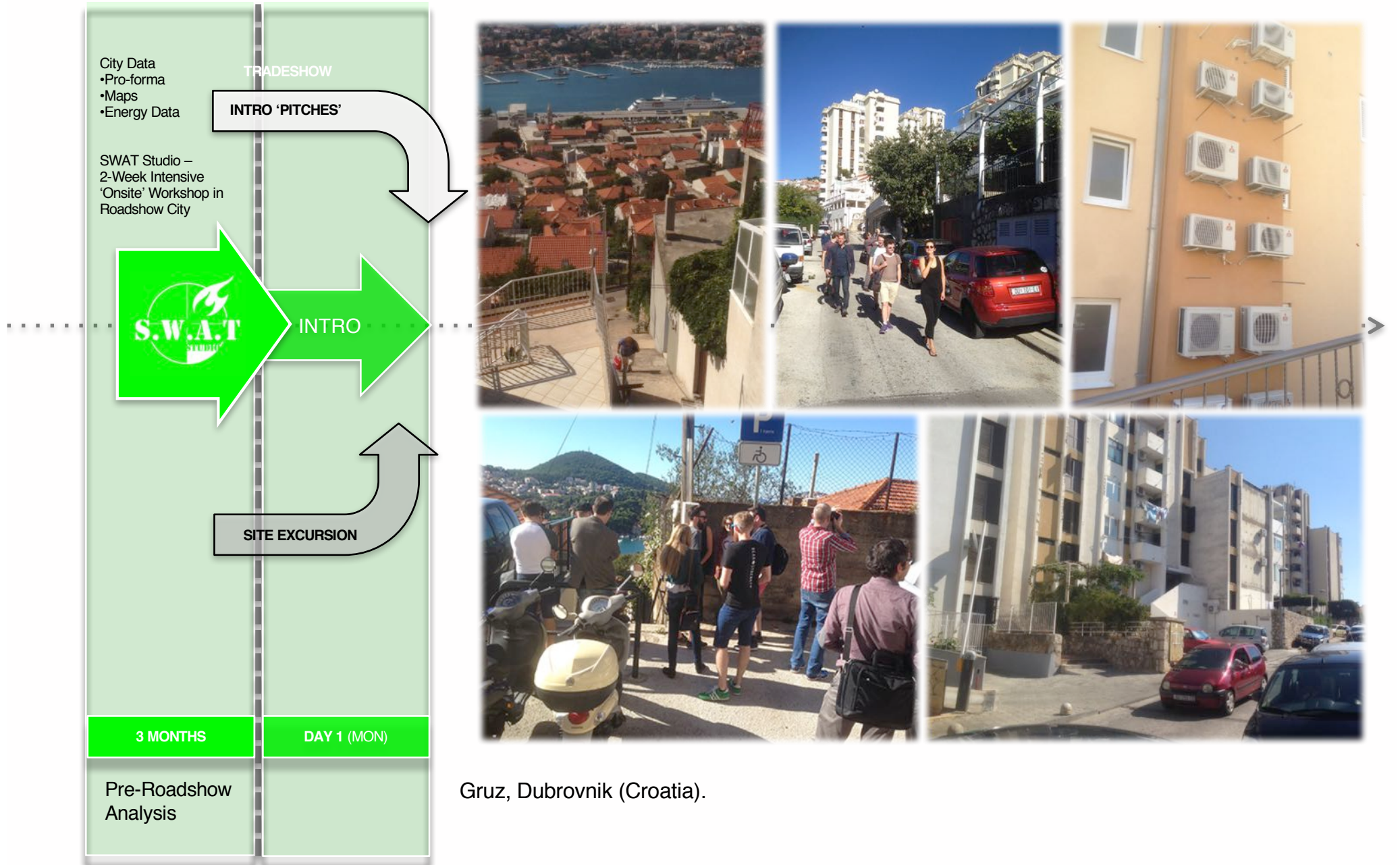
3 MONTHS

DAY 1 (MON)

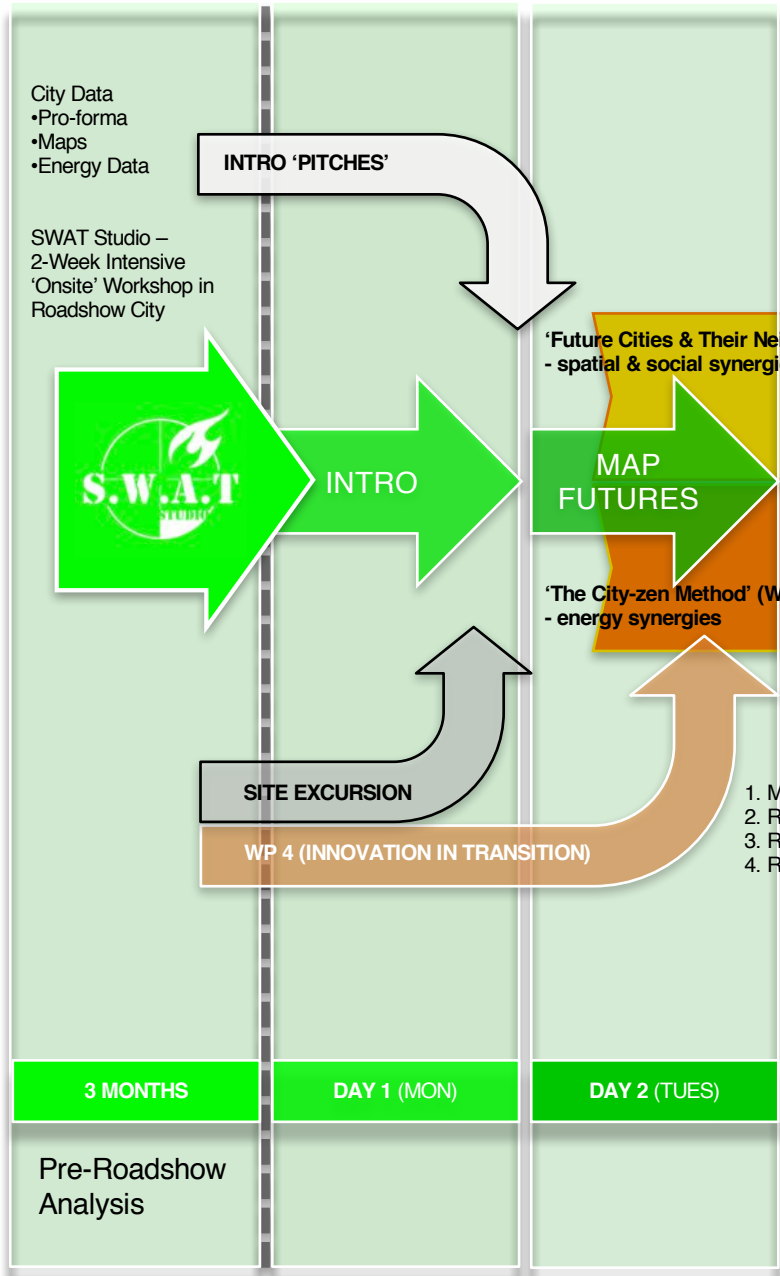
Pre-Roadshow
Analysis



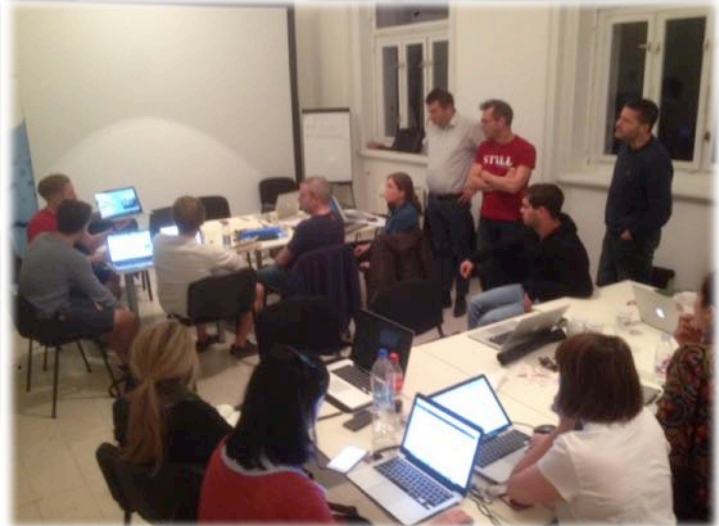
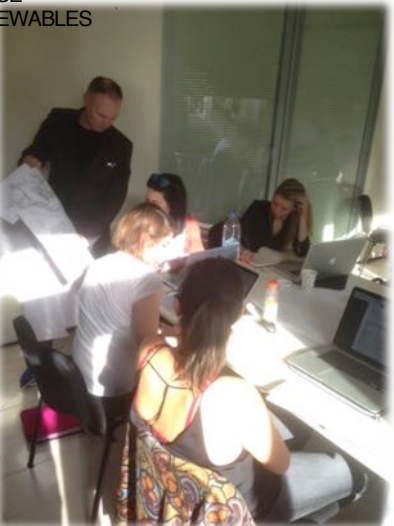
DAY 1 - SITE EXCURSION



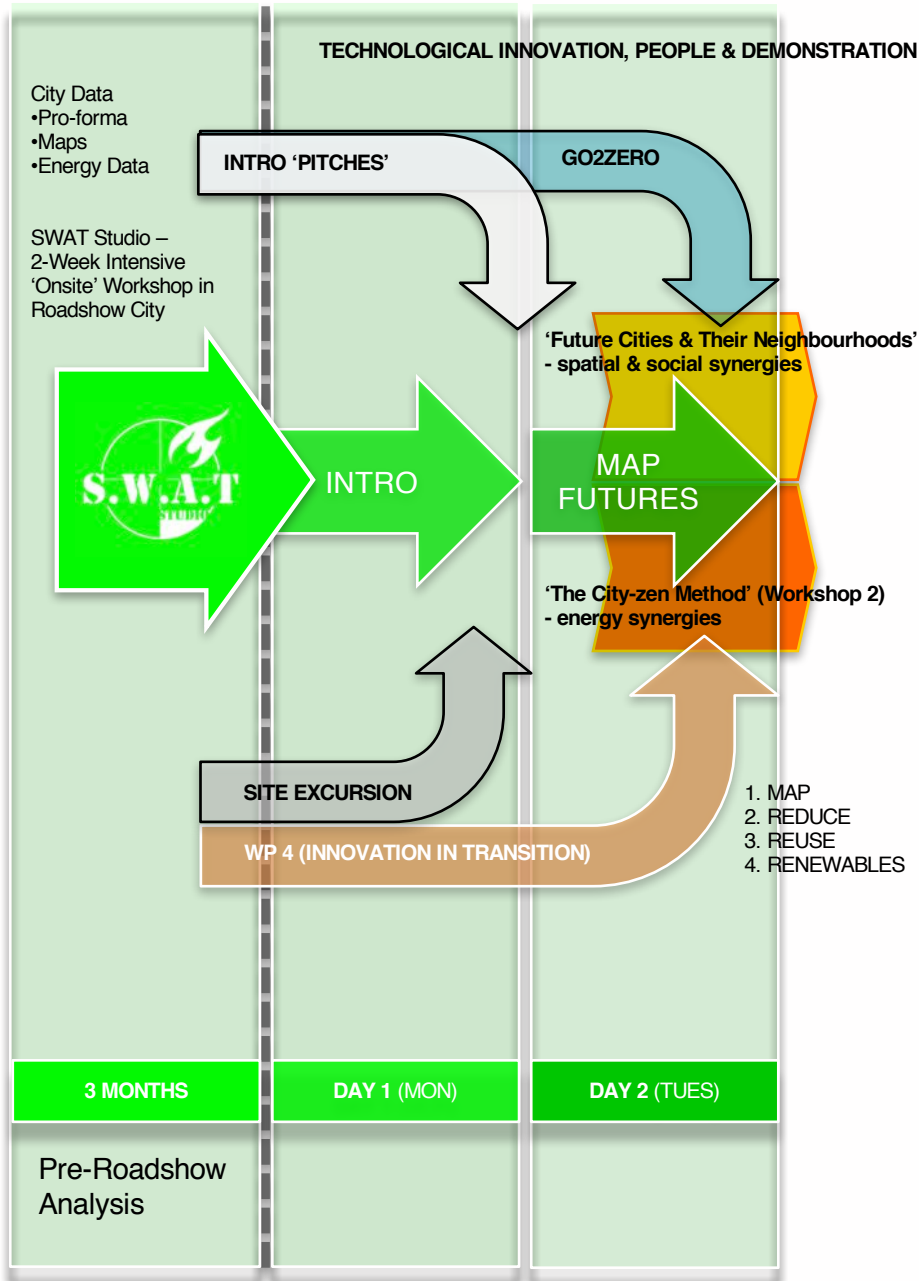
DAY 2 - WORKSHOP BEGINS



1. MAP
2. REDU
3. REUSE
4. RENEWABLES

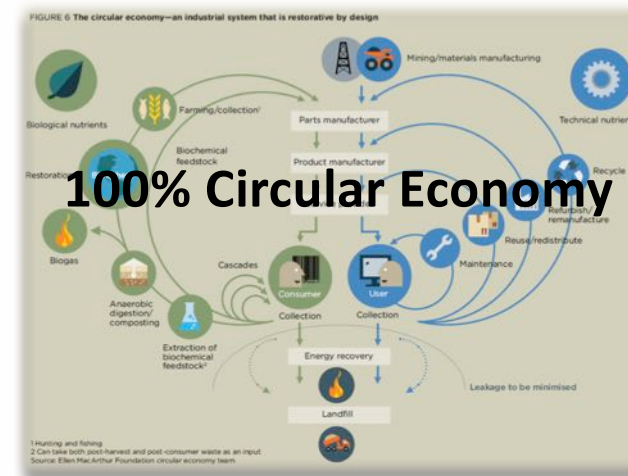
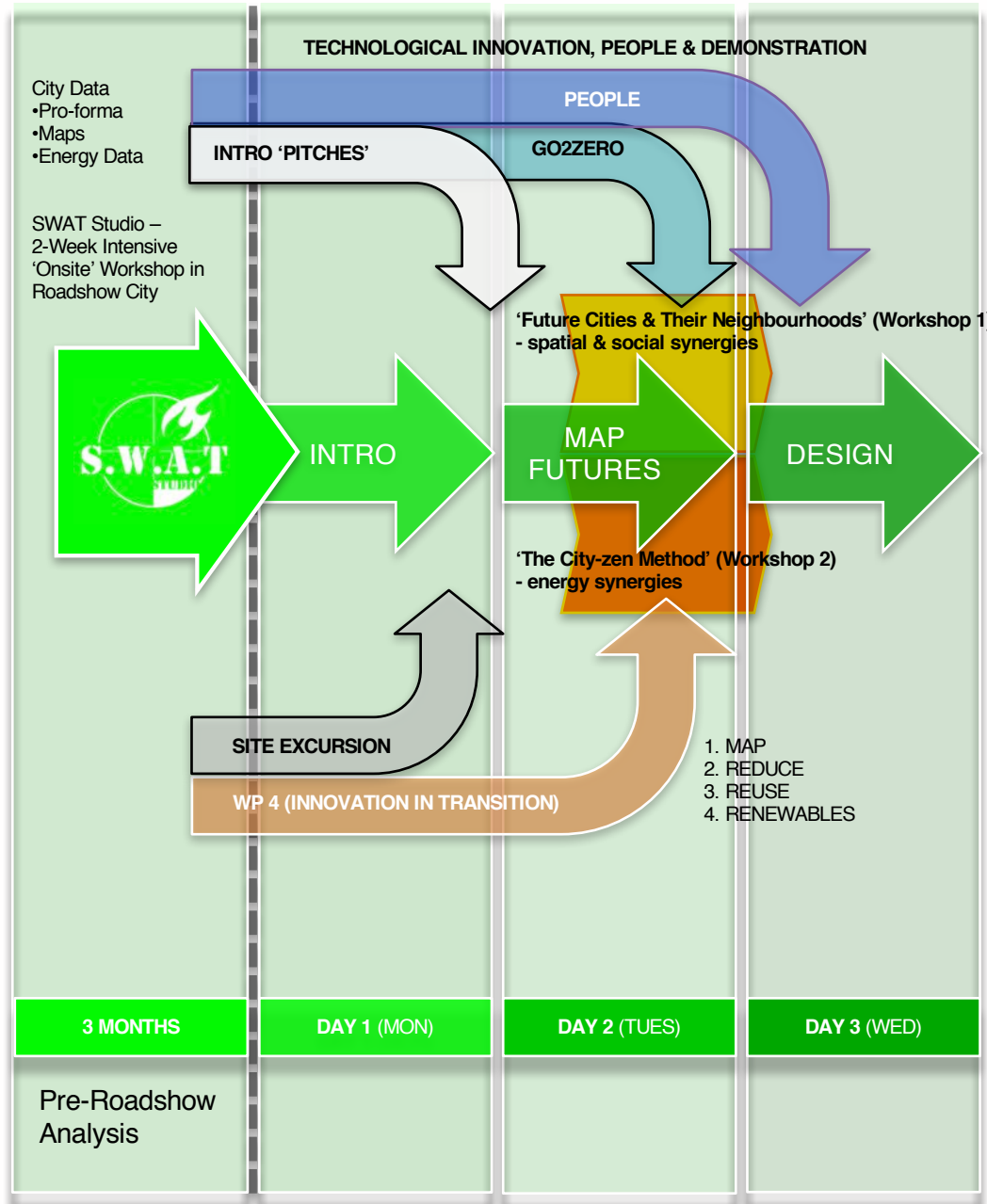


DAY 2 - GO2ZERO (SERIOUS GAME)



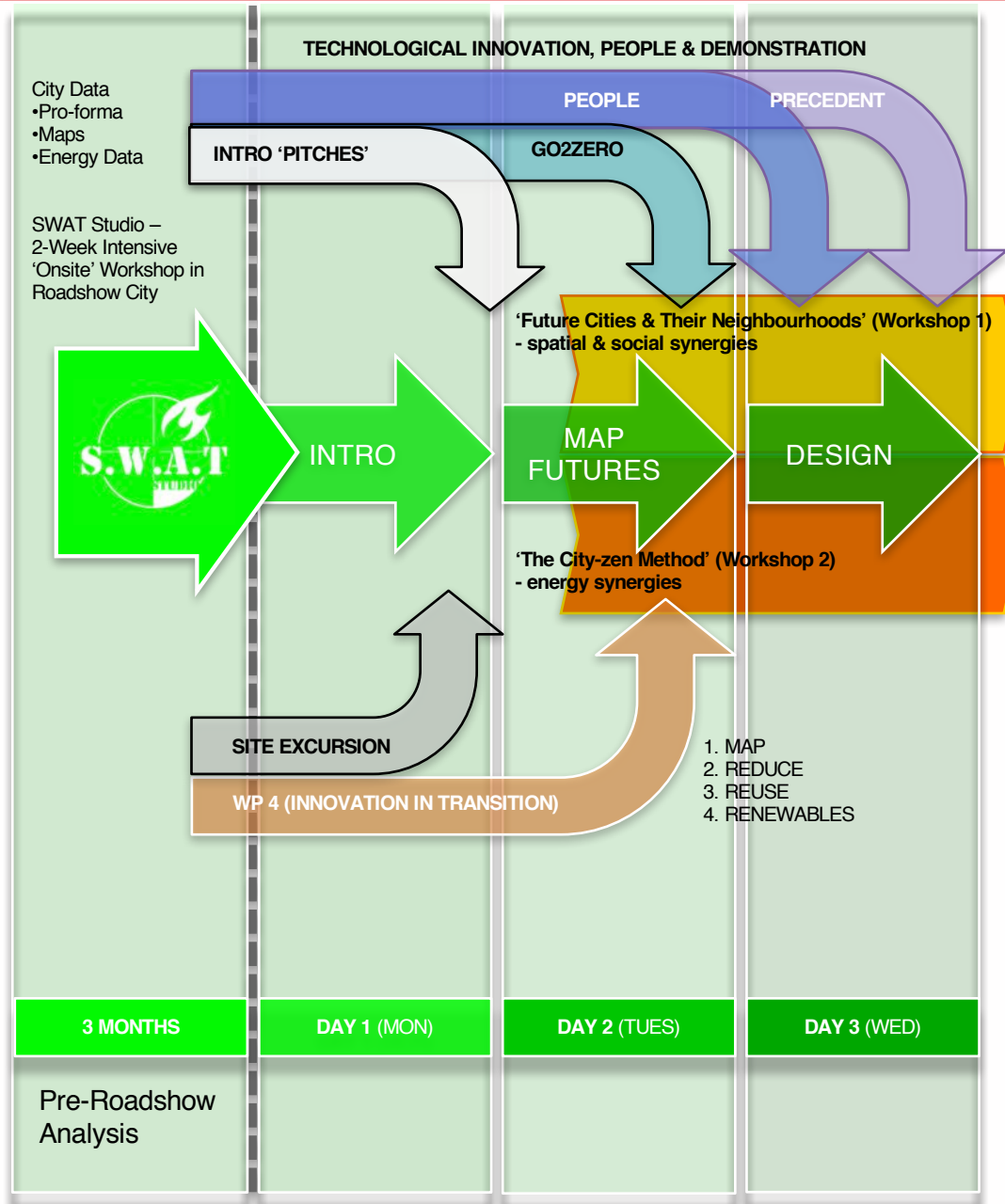


DAY 3 - MINI-MASTERCLASS 1 (PEOPLE & TECHNOLOGY)





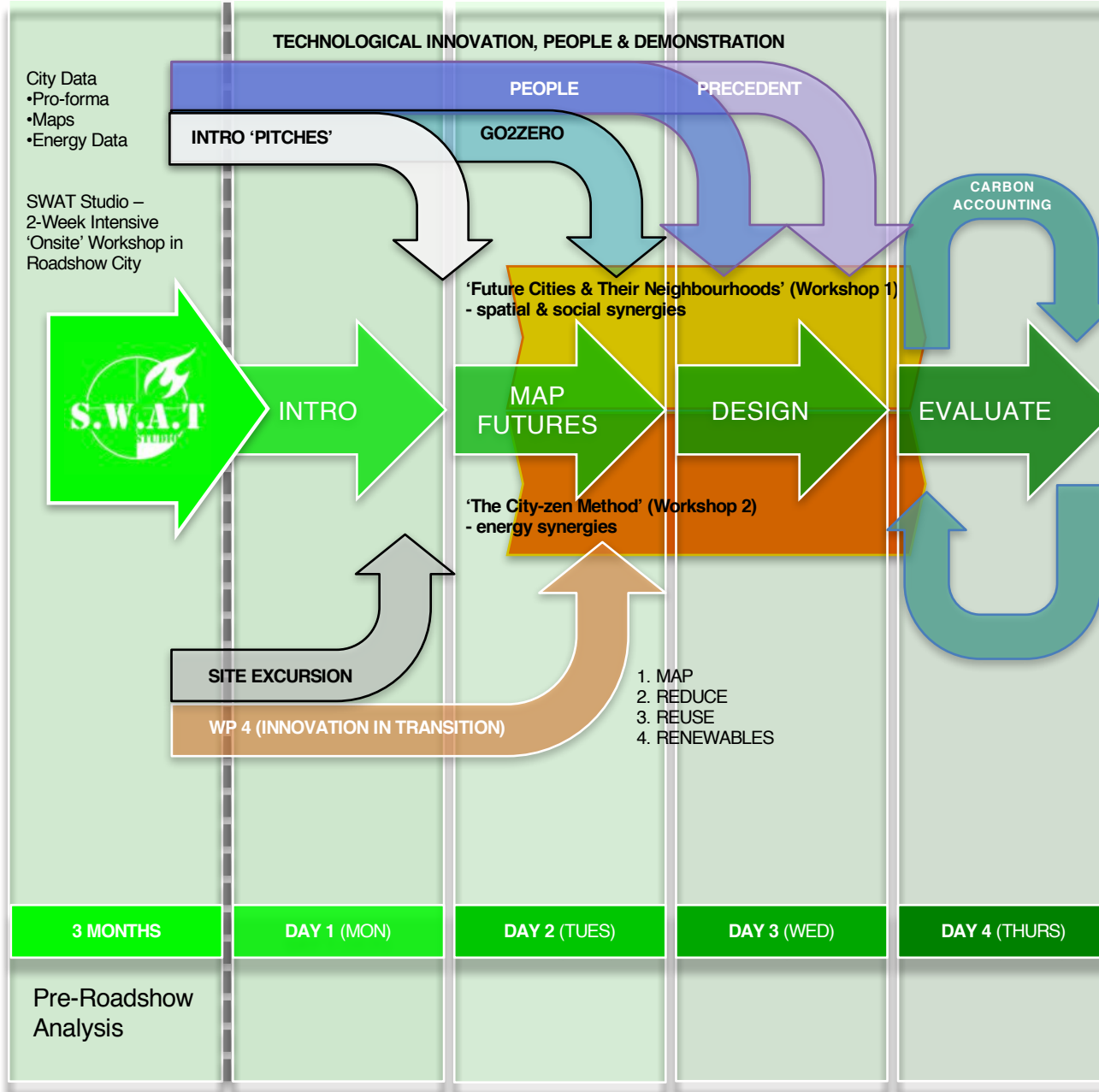
DAY 3 - FUTURE TECHNOLOGIES (SMART CITIES)



At the Dubrovnik Roadshow **Ceco Gakovic** (CityOS) gave a seminar on Smart Cities and technologies in Dubrovnik, Sarajevo & Croatia generally.

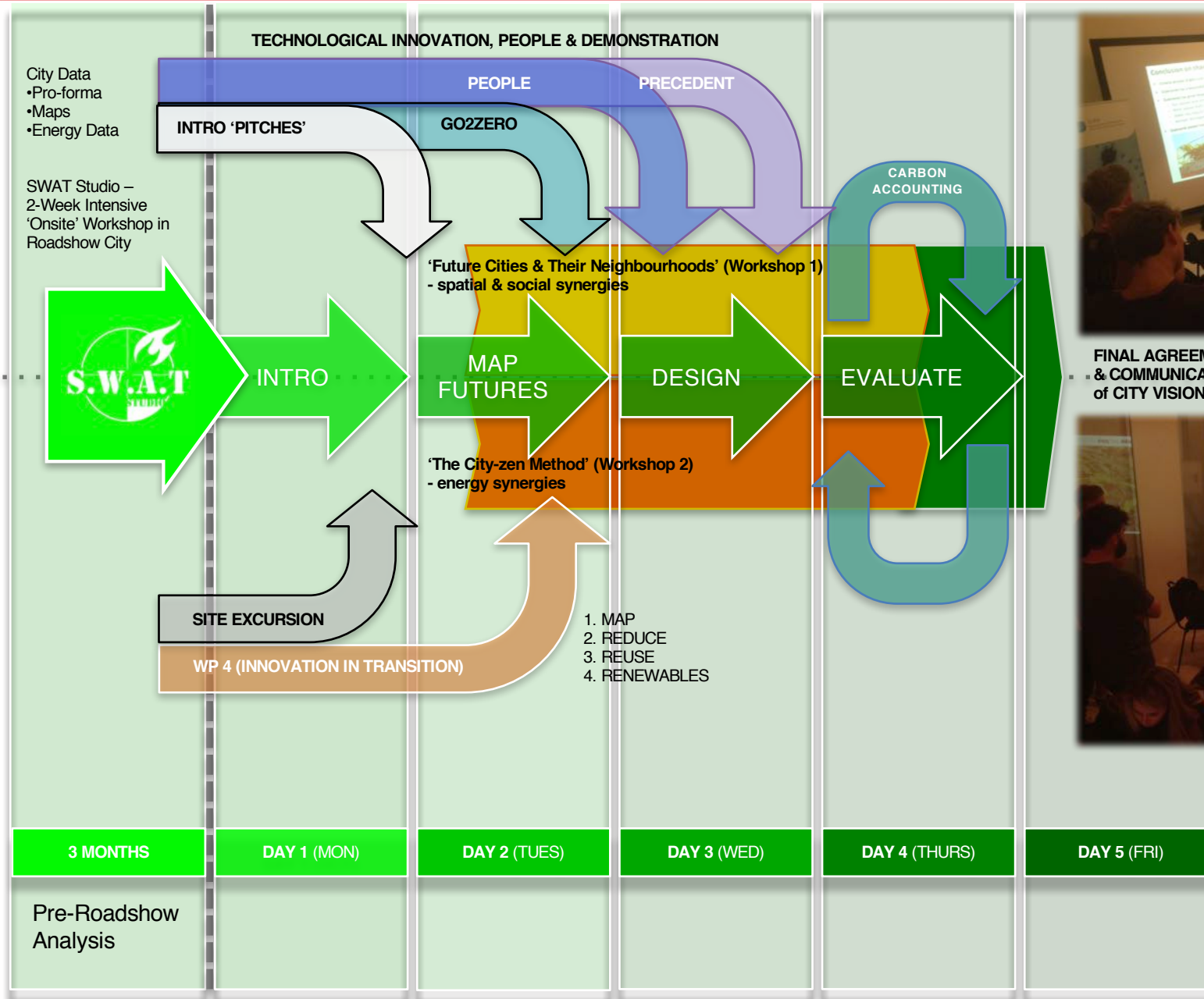


DAY 4 - MINI-MASTERCLASS 2 (CARBON ACCOUNTING)





DAY 4 - FINAL AGREEMENT & COMMUNICATION

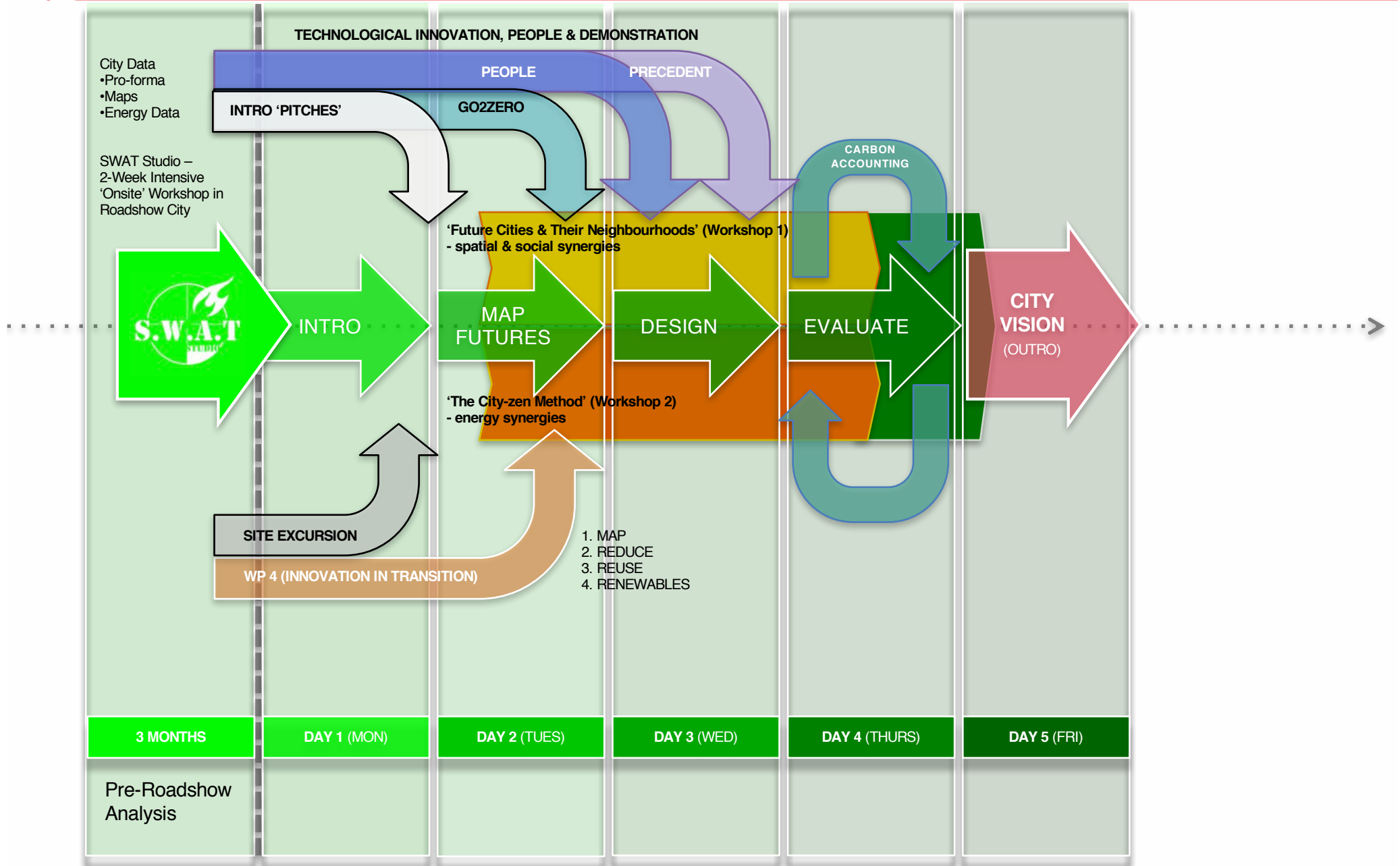


FINAL AGREEMENT & COMMUNICATION of CITY VISION





DAY 5 - 'THE CITY VISION'



Gruž energy transition plan

Final presentation – DURA, Dubrovnik, 4 November 2016



University of Zagreb



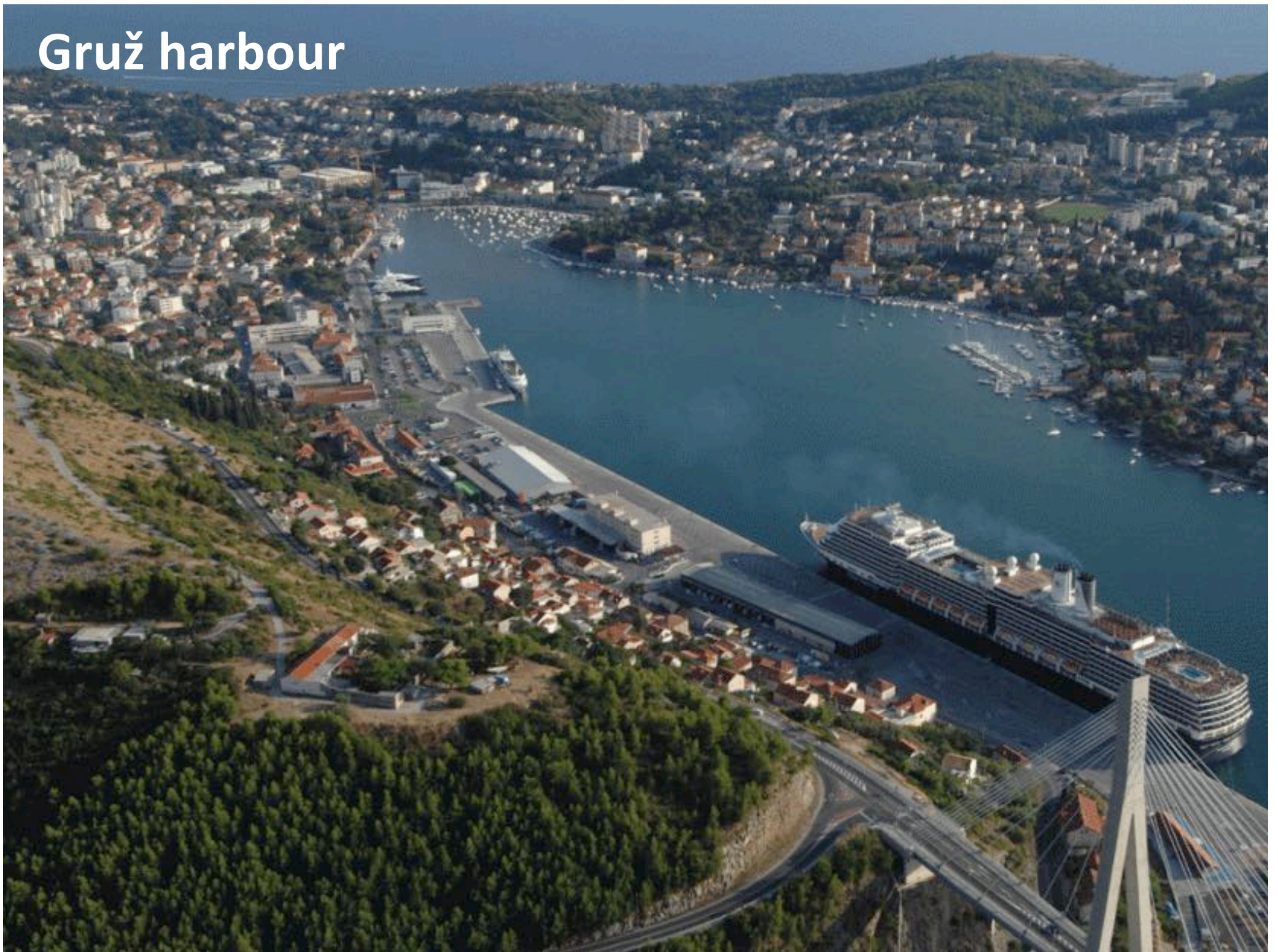


Local typology, climate, geography



The site

Gruž harbour



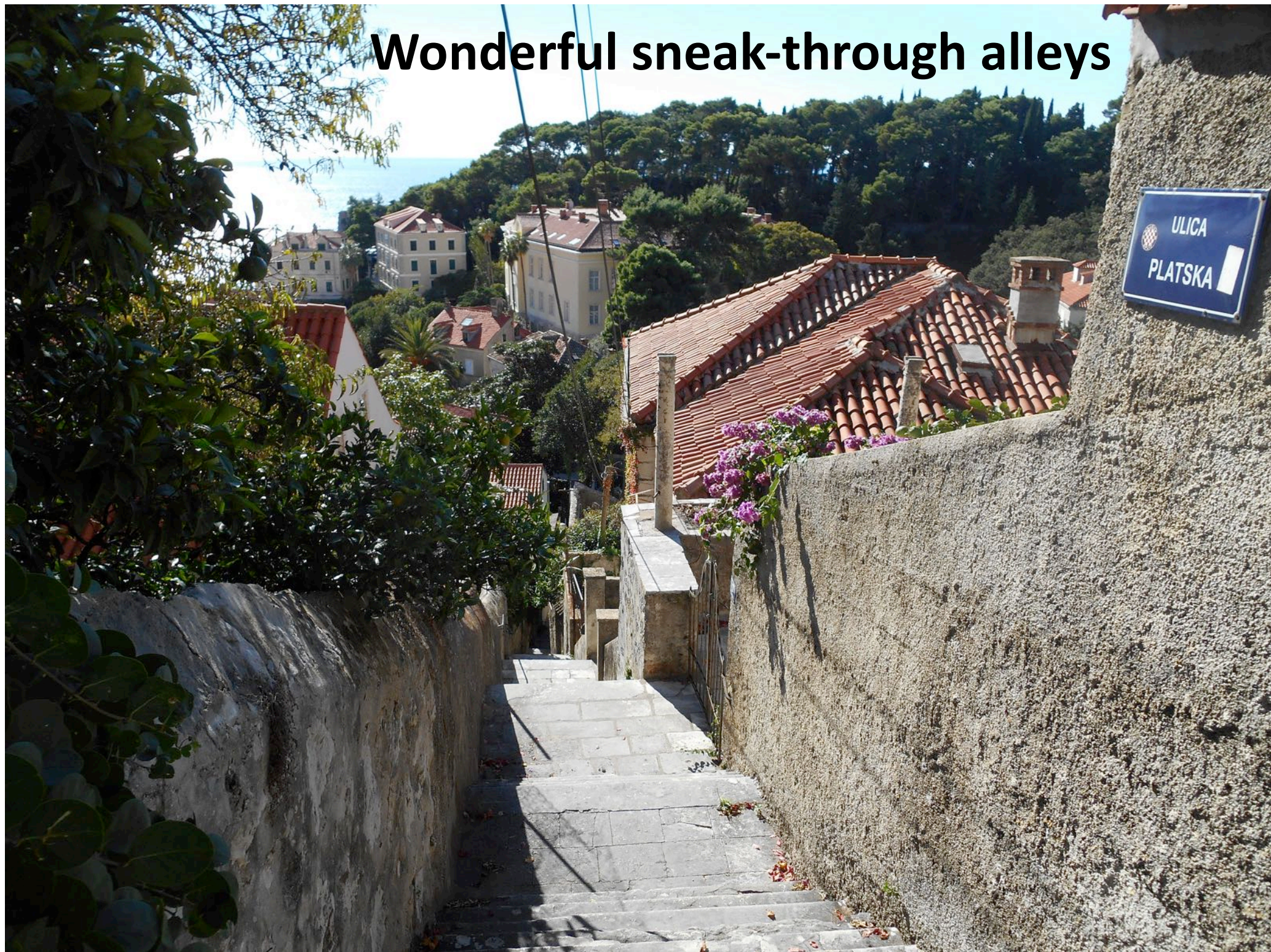
Gruž houses and apartment blocks



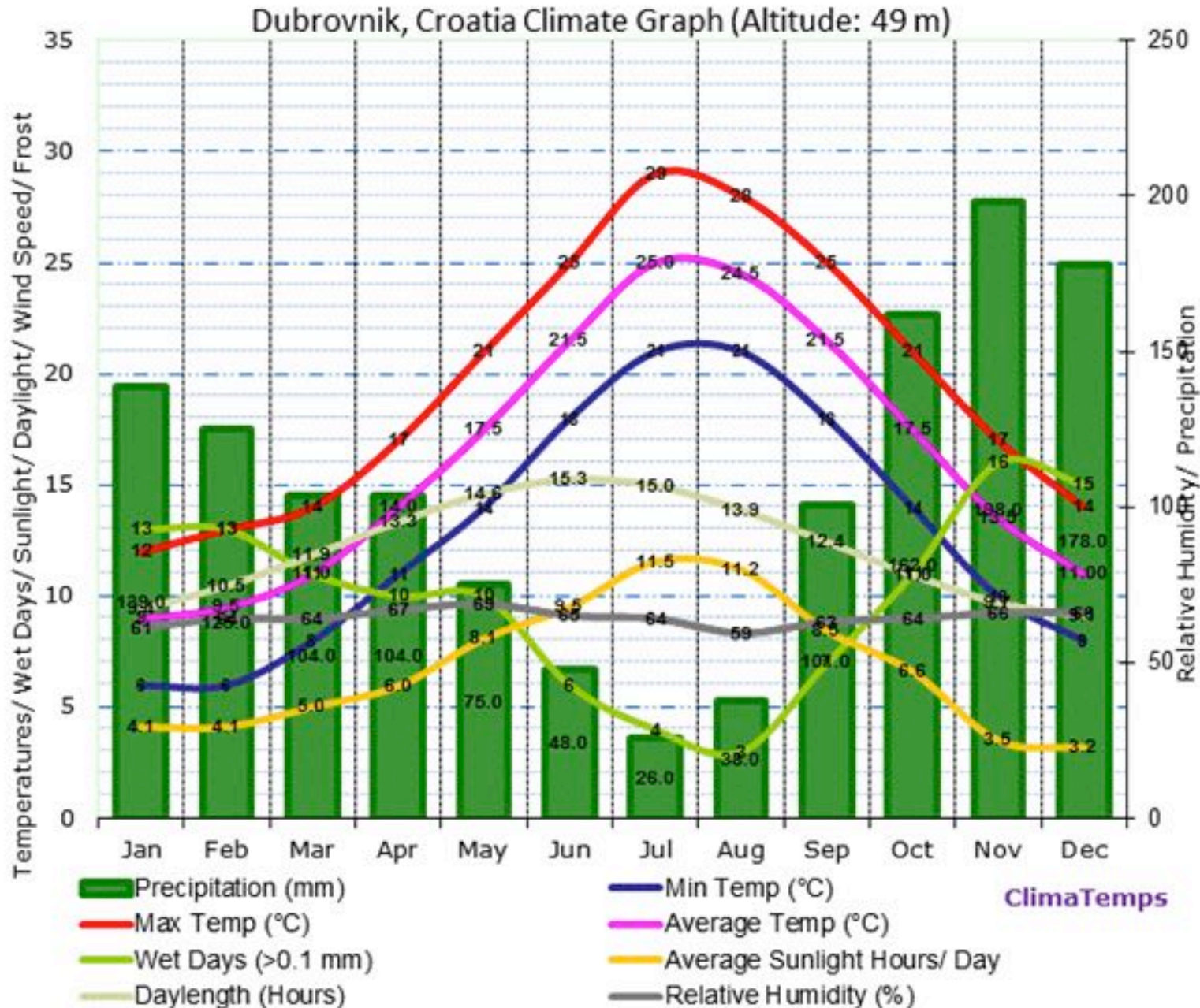
Beautiful palaces, some poorly maintained



Wonderful sneak-through alleys



Climate chart Dubrovnik



Mean temperature: 16.4°C

Temperature of soil and deep open water is nearly stable around this value.

→ Close to perfect for pre-heating and for pre-cooling buildings

Annual rainfall: 1304 mm

= nearly 1 mln m³/yr for Gruž, excl. run-off from mountains.

There are 2900 households in Gruž.

These households use 280 m³/yr

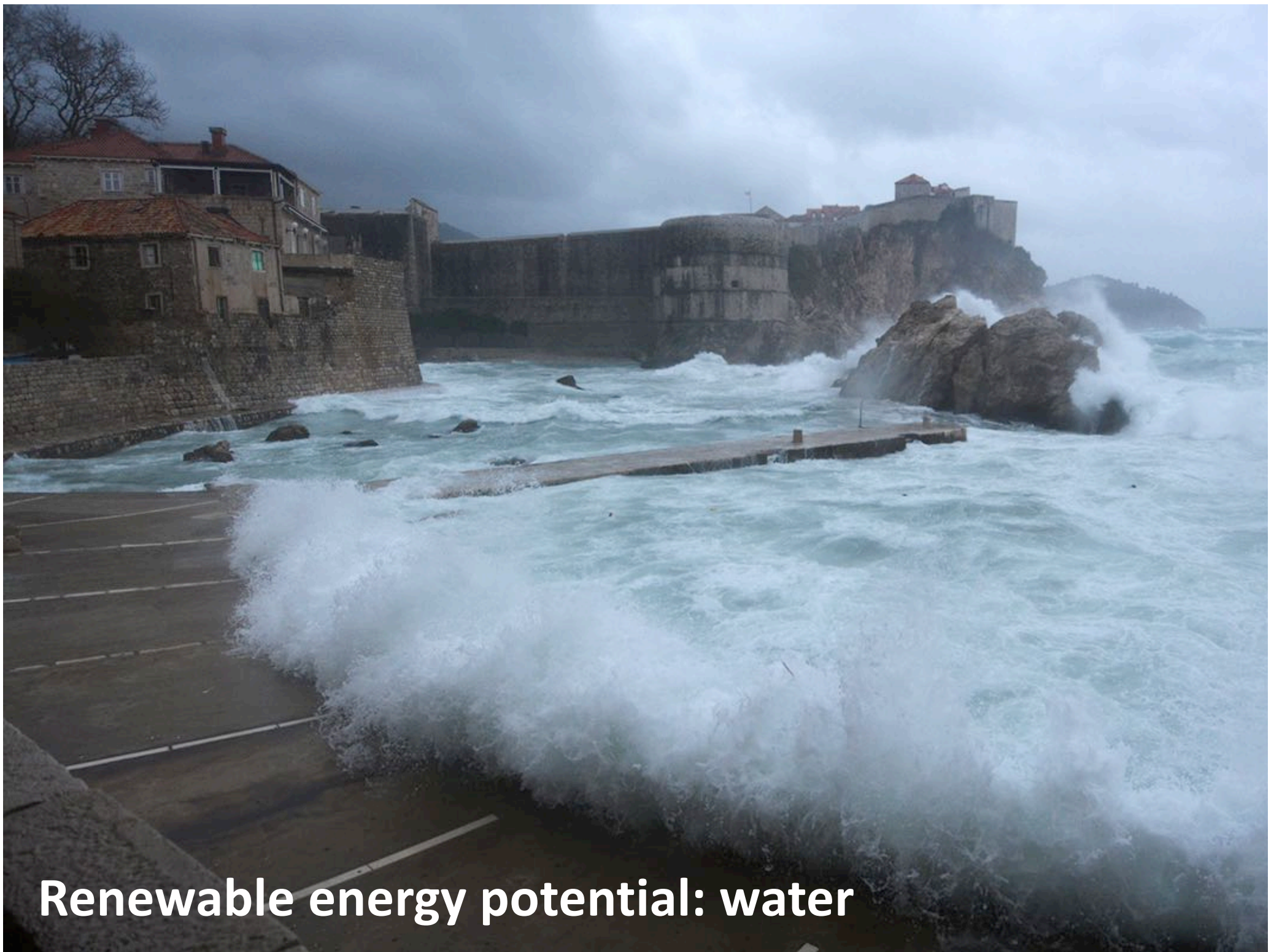
→ There is more than enough rain for domestic water use

Renewable energy potential: sun



Renewable energy potential: wind & reforestation





Renewable energy potential: water

In short,

WELCOME TO
HEAVEN!



But also this





...and this

...and this

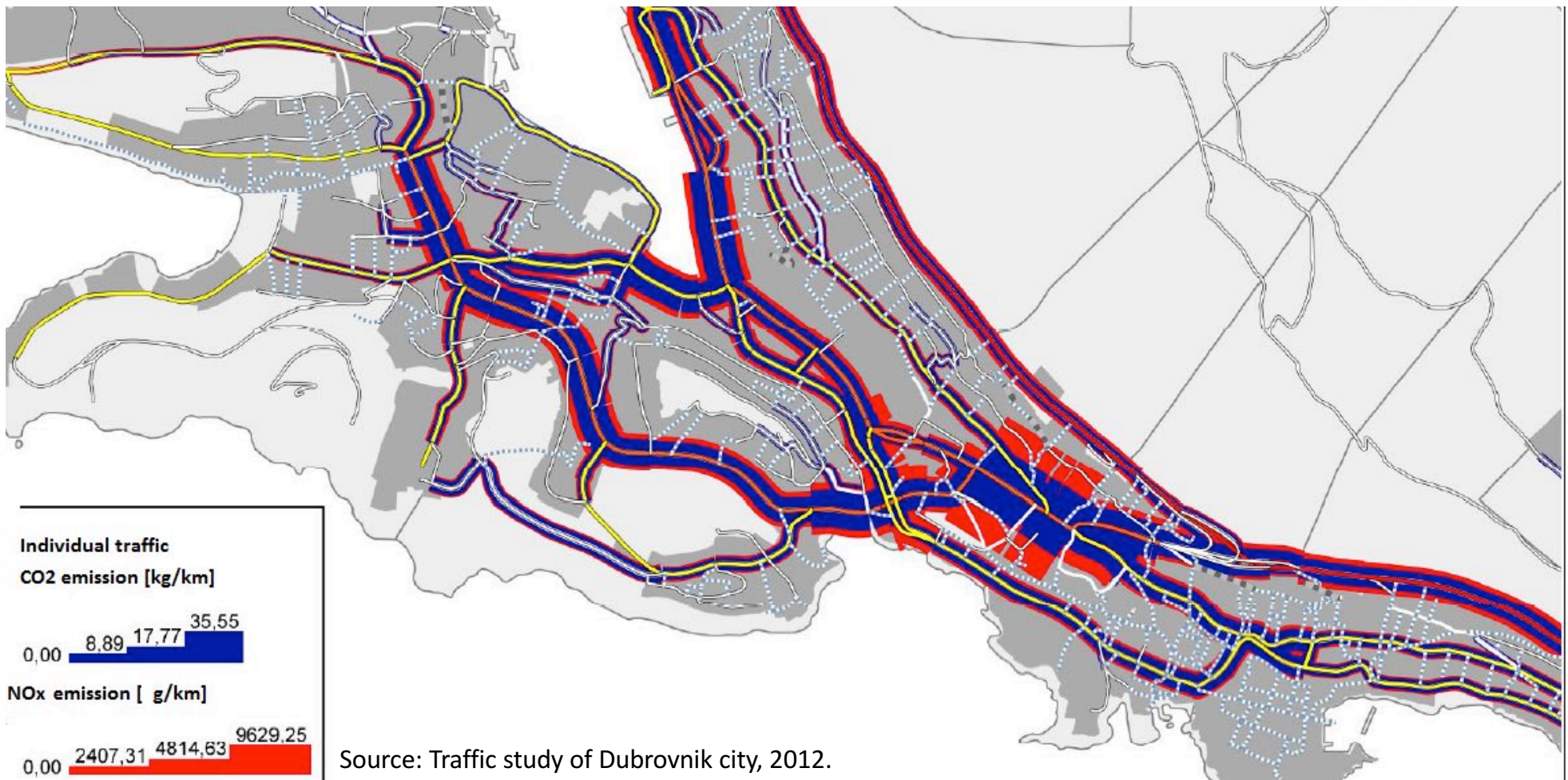




... and this.

CO₂ and NO_x emission of urban traffic

- Not enough parking space
- Bicycle transportation difficult
- Public transportation system in need of improvement
- Pedestrian traffic problem during touristic season



Conclusion on characteristics

- Croatia already largely runs on renewables (57%), Dubrovnik less so
- Dubrovnik has a favourable climate for energy efficiency
- Dubrovnik has great renewable energy potential
 - Sun: passive solar energy, solar thermal, photovoltaic, PVT
 - Wind: passive drafts up and down the hills, wind power
 - Water: sea mass for heat exchange, hydro-electric from run-off water, blue energy
 - Biomass: bio-organic waste, material from forest maintenance
- Dubrovnik people have adaptive capacity



Challenges

- **Tourism** → great numbers of people in summer
→ energy consumption of boats, pollution
→ secondary traffic → see traffic...
- **Traffic** → fuel consumption of cars & buses, pollution, traffic jams, safety issues
- **Energy**
 - Reliance on fossil fuels
 - Unused renewable potential
 - Unused potential from waste (water)



Opportunities

- Saving energy in existing neighbourhoods
- (Micro) Grids for smart use of heat, cold and electricity
- Use of local renewables
- Making better use of cruise ship tourism
 - Increase tax on cruise tourists
 - Waste water to bio-energy
 - Become a green fuel port

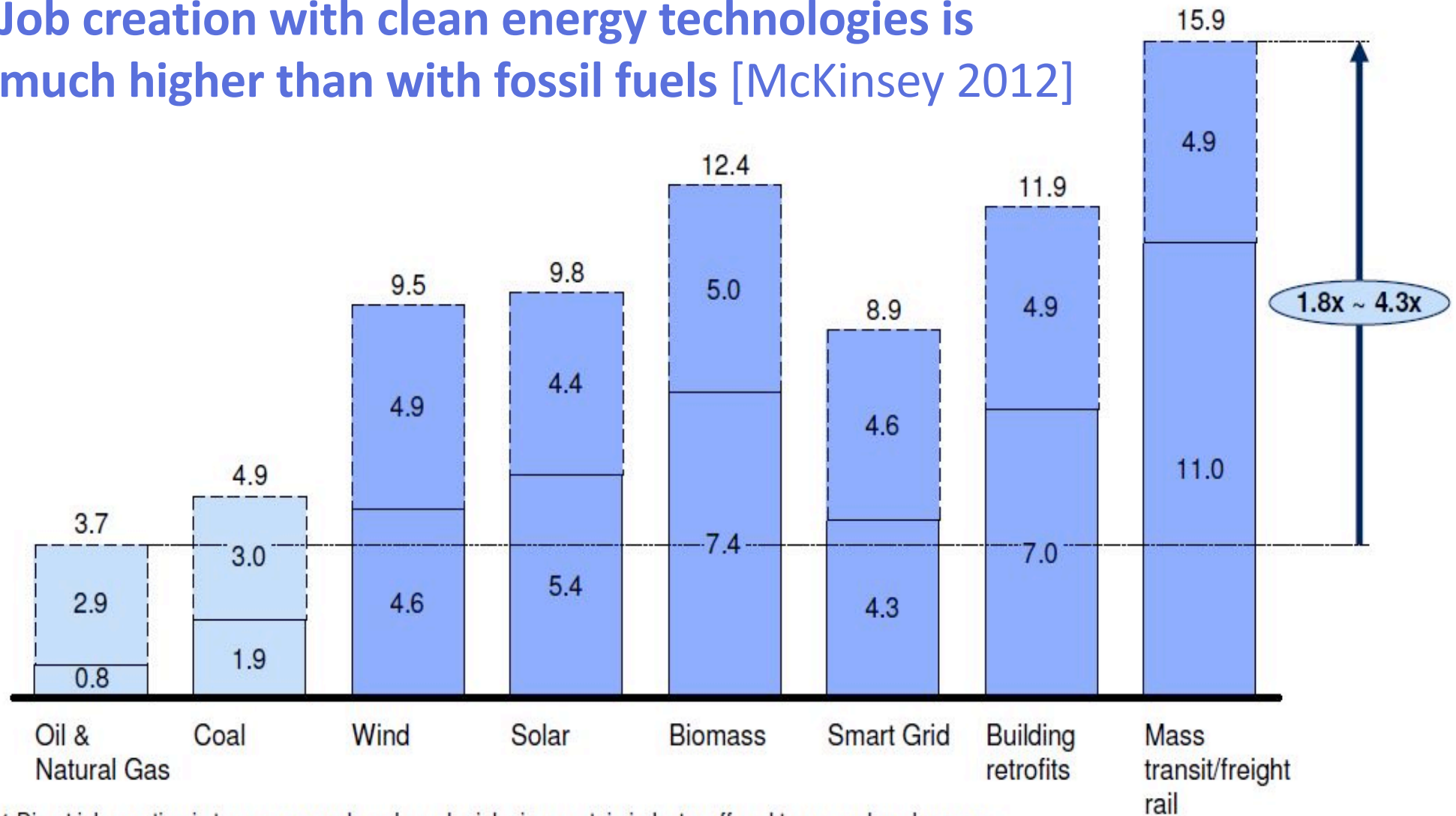


Bornholm: 'We want to be part of the future, not of the past'

Employment impacts by energy source
 Number of job creation per \$1 million of investment

■ Fossil-based jobs □ Direct job creation¹
■ Green jobs □ Indirect job creation²

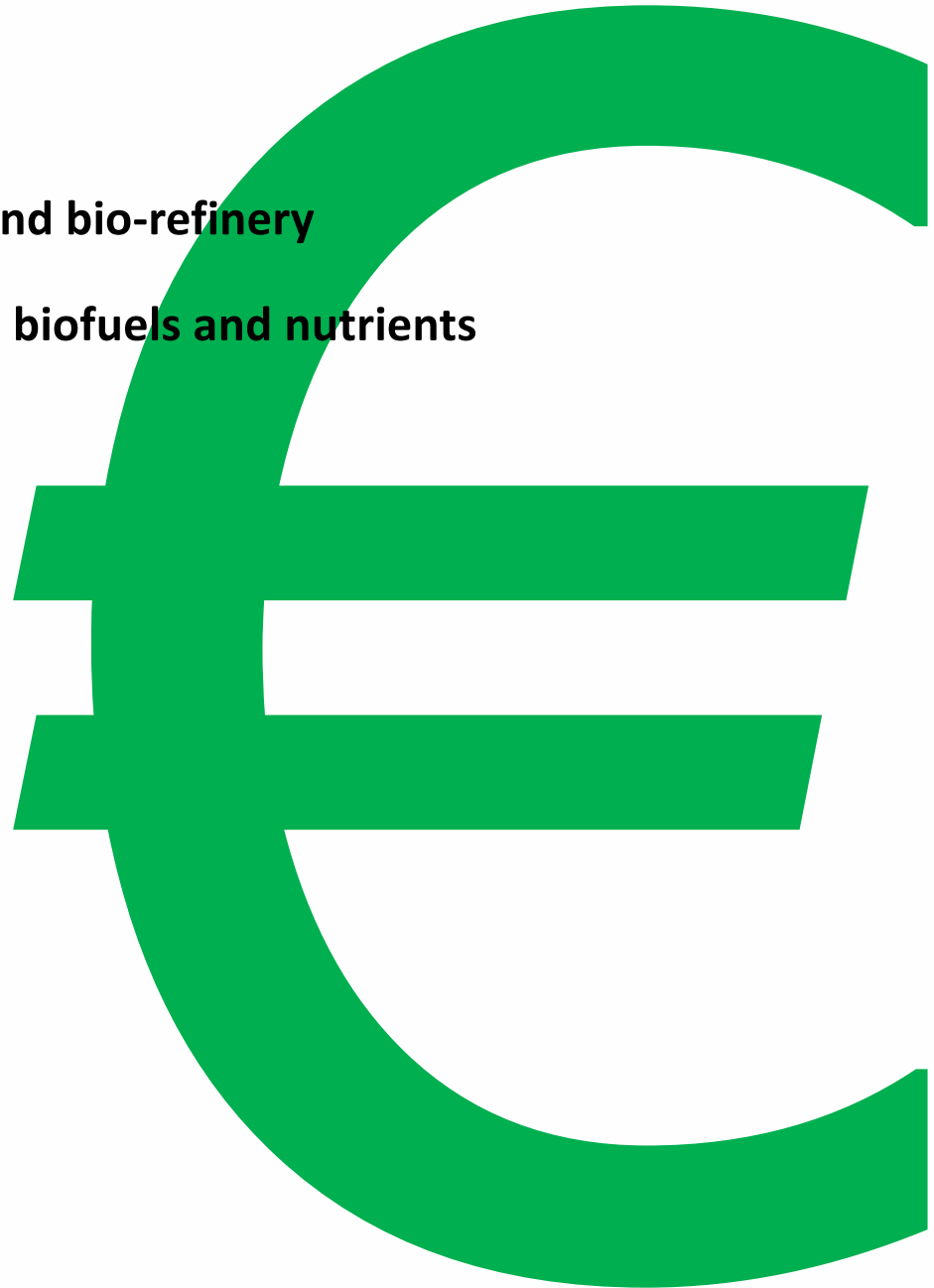
Job creation with clean energy technologies is much higher than with fossil fuels [McKinsey 2012]



1 Direct job creation is temporary work and regular jobs in a certain industry offered to unemployed persons
 2 Indirect job creation is temporary work and regular jobs outside a certain industry offered to unemployed persons

Triple win objective

- Increase taxes on cruise ship tourism
- Invest in green bio-digester, algae farm and bio-refinery
- Process waste water from cruise ships to biofuels and nutrients
- Create employment for Gruž
- Sell back biofuel and food
- Create a cleaner city





Can your city be sustainable, without a sustainable economy?



Four heated swimming pools, etc



The cruise ship is a city – that moves!

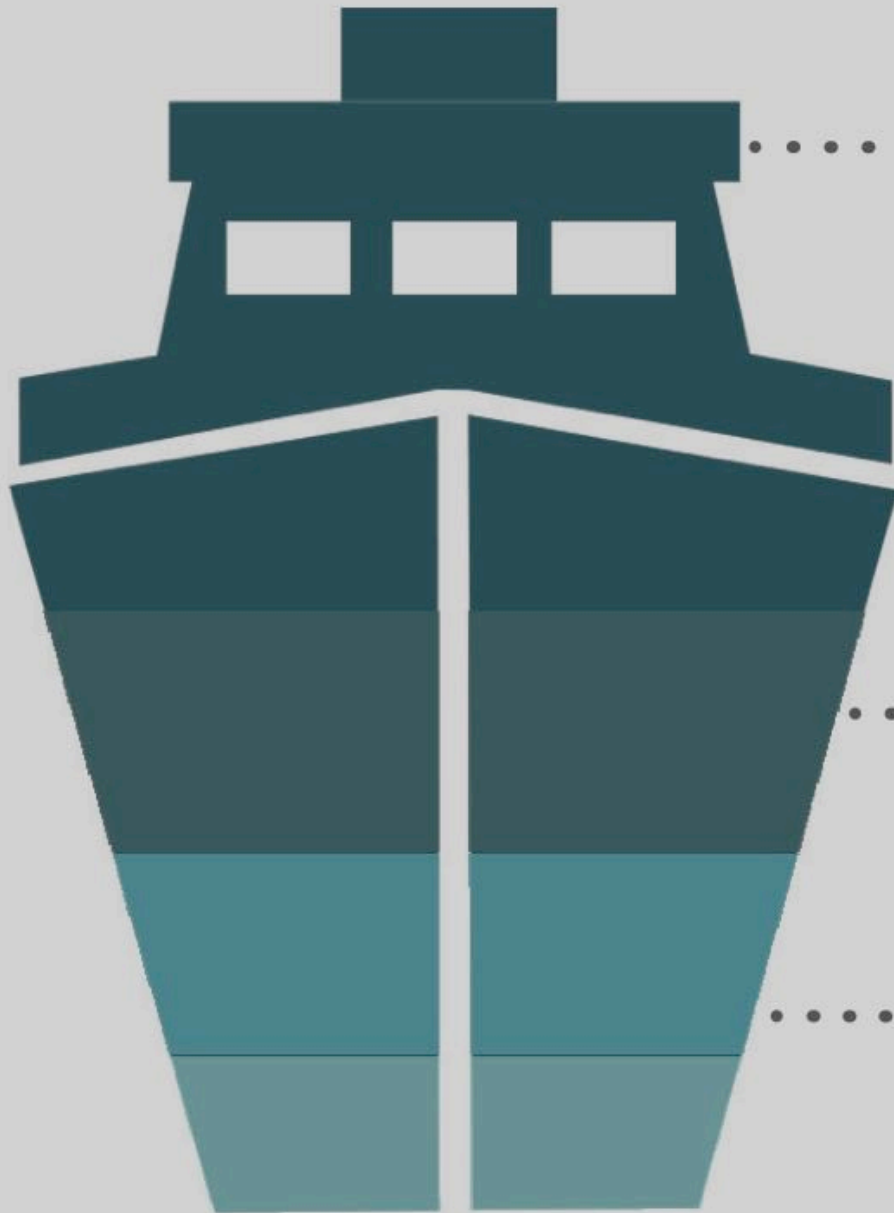


Fully air-conditioned American lifestyle has 4 x the impact of a typical European



Density = 5,000 people per hectare Gruz= 60 people per hectare

TYPICAL CRUISE SHIP



• Passengers 2500
• Crew 900
• Length 292m
• Sea 32m

• Fuel for travel to Split:
-5 hours at 5000 Litres/hour
-25,000 Litres/day

• Raw sewage- 80,000 Litres/day
• Grey Water- 600,000 Litres/day
• Bilge- 60,000 Litres/day

• Algae production: 150m³/yr/Ha
In summer: 11m³/day/Ha
= 25 Ha/Boat

8260 cups
of coffee



5000 eggs
for breakfast



2000
steaks



1000
baked



1150 pounds
of bananas



Food and drink consumed daily on cruise ships (Based on Disney Cruise Line statistics)



Impact on town per year 1100 hectares of forest

Impact of boat 11,900 hectares p/y

9000 army tanks heavy

Generates the same amount of sulphur dioxide fumes as 13.1 Million cars on a daily basis

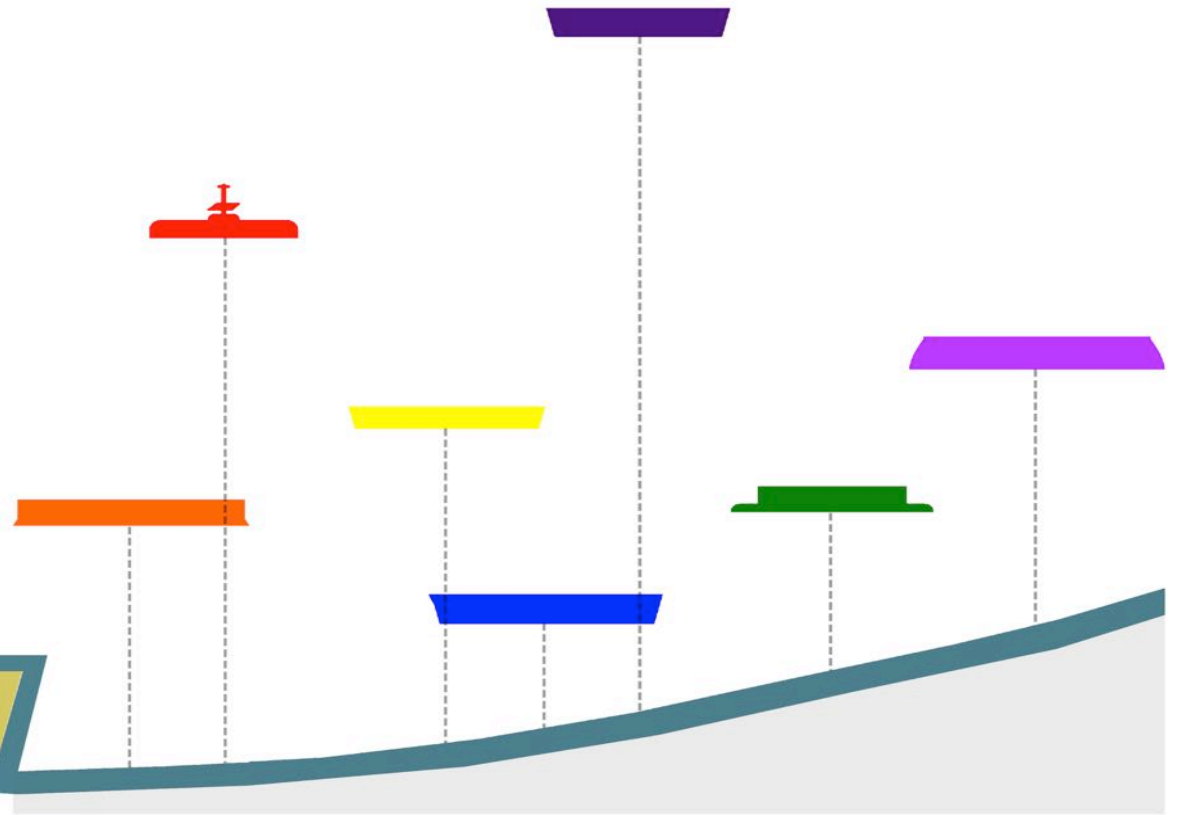
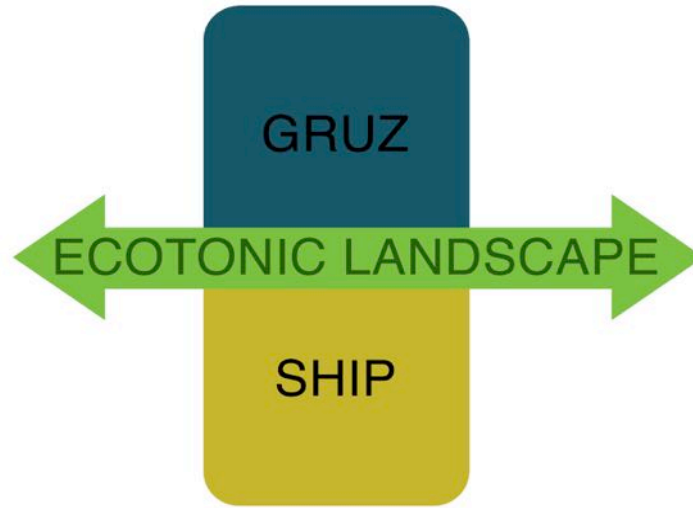
140,000 to 210,000 gallons of sewage per week

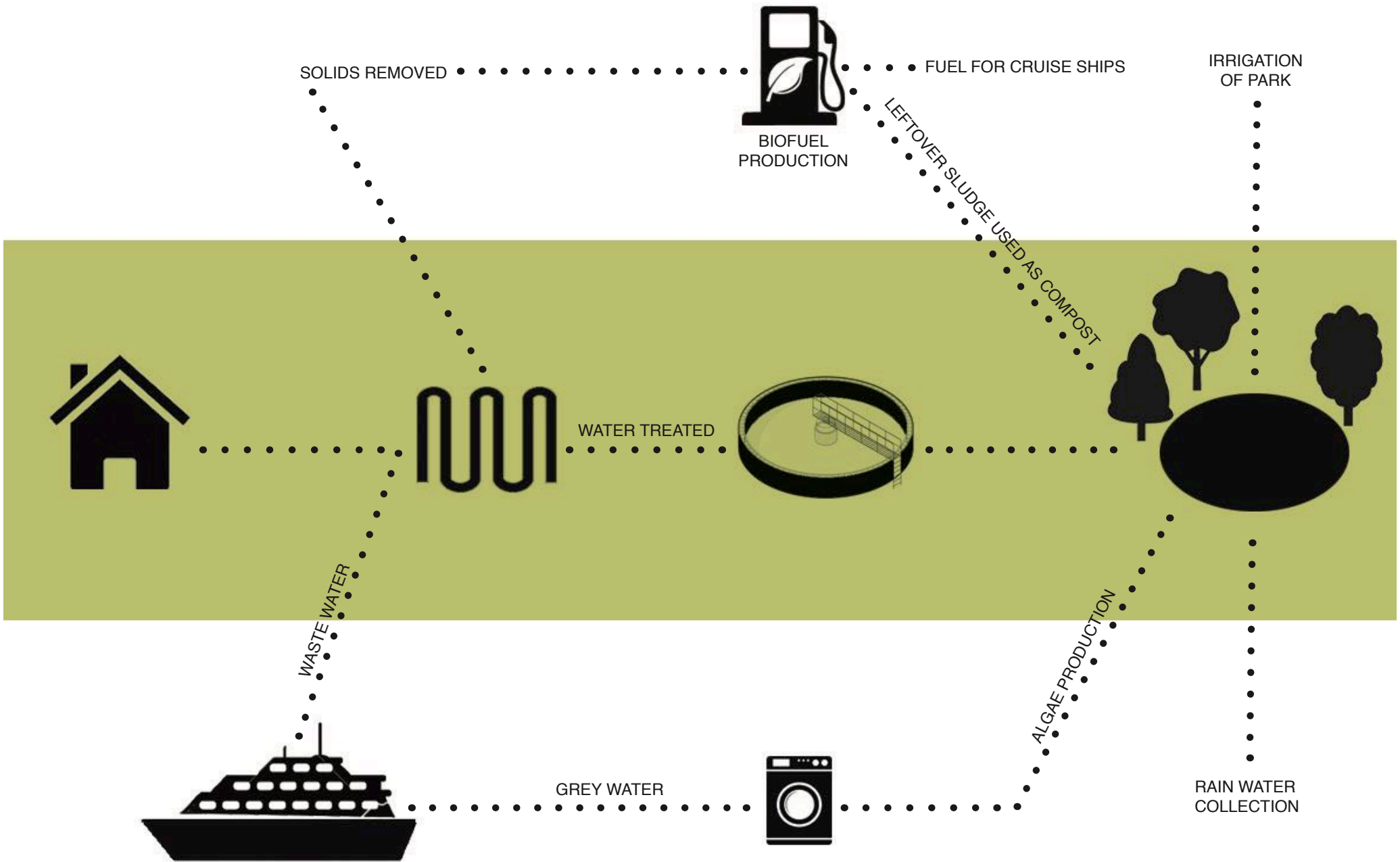
1,165,000 to 1,235,000 gallons of toxic water released per week

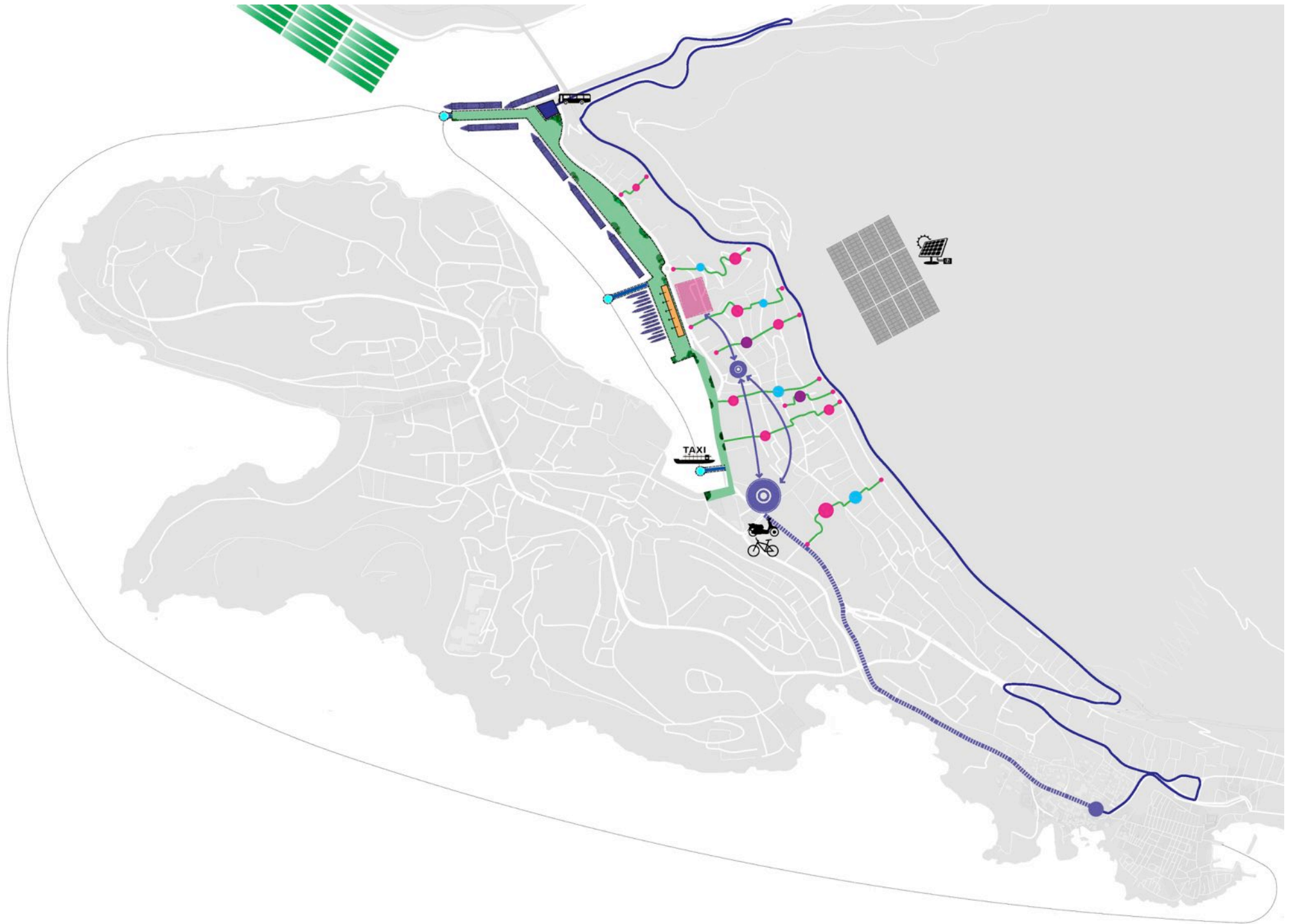


CARBON FOOTPRINT OF CRUISESHIPS									Tourist Season x 8
item	value	unit	EF	unit	CF: t CO2eq/day	note	1 day ha forest/day	Season ha/yr	x8 ships
people	3400	n							
passengers	2500	n							
crew	900	n							
fuel oil	25000	L/day	3.14	kg CO2eq/kg	78.40		5.81	1,045.29	8,362.31
mooring	5000	L/5hrs	3.14	kg CO2eq/kg	15.68	Period of mooring	1.16	209.06	1,672.46
solid waste	1200	kg/day	1.16	kg CO2eq/kg	1.39		0.10	18.56	148.48
water supply & grey water manag	600	m3/day	0.585	kg CO2eq/m3	0.35	assumed 200L/day per capita	0.03	4.68	37.45
sewage	80000	L/day	0.115	kg CO2eq/L	9.20		0.68	122.64	981.12
bilge	60000	L/day	0.115	kg CO2eq/L	6.90		0.51	91.98	735.84
TOTAL GHG EMISSION					112	TOTAL IMPACT OF N1 CRUISESHIP /day	8.29	1,492.21	11,937.66
						Total Impact of Gruz neighbourhood			1,100.00

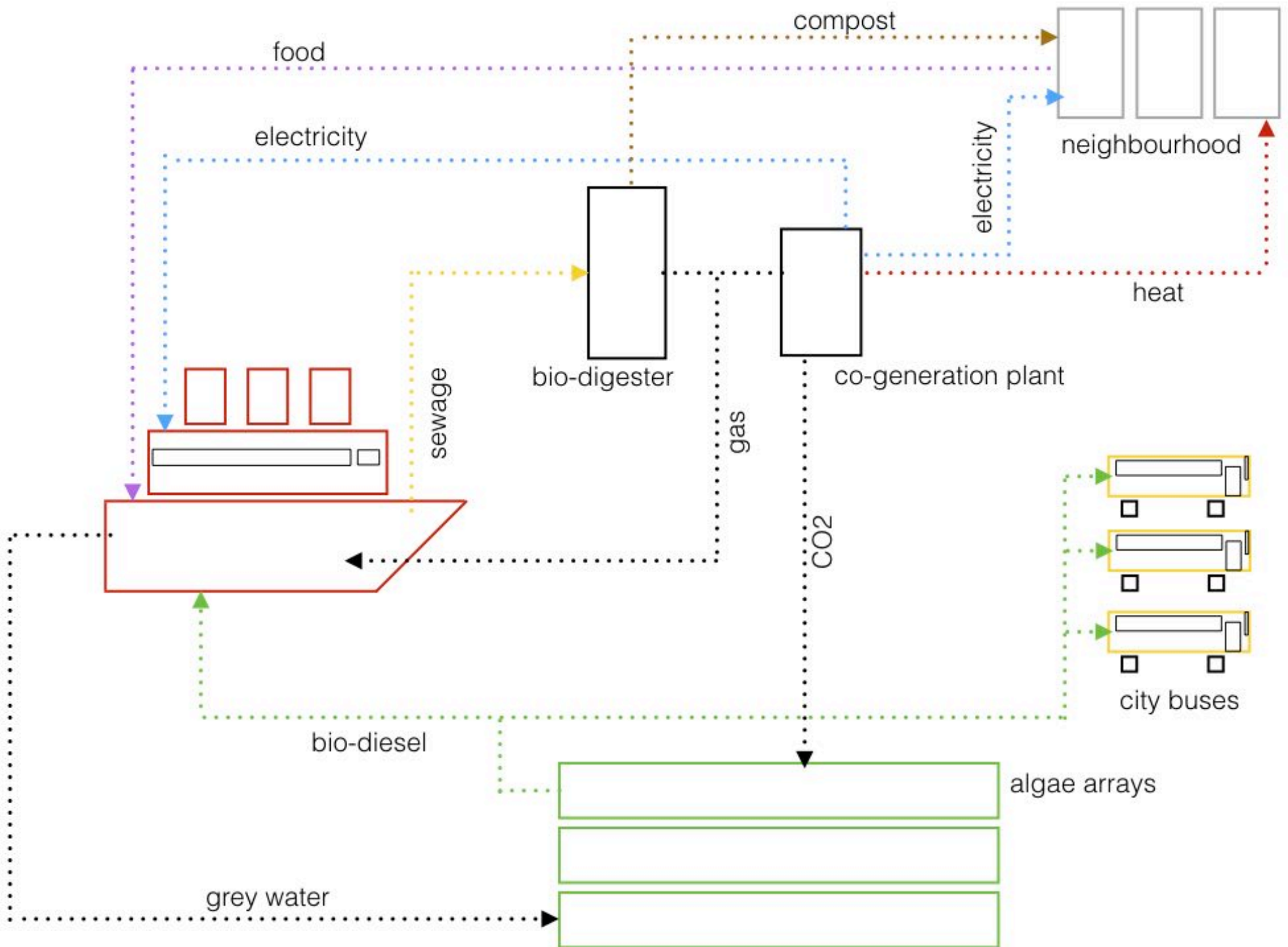
AVOIDED CARBON EMISSION										Possible income
item	value	unit	EF	unit	CF: t CO2eq/day	note	eq. ha forest over season			
BIOGAS production from sewage	3200	m3	1.31	kg CO2eq/m3	4.19	potential biogas production assumed to replace an equivalent quantity of natural gas (EF natural gas to assess avoided emission)	55.89			
BIOFUEL production from algae 50ha array	200000	kg	3.24	kg CO2eq/kg	648.00	potential biofuel production assumed to replace an equivalent quantity of diesel (EF diesel to assess avoided emission)	8,640.00	Fuel value /annum =		€ 38,000,000.00
HEAT production from sewage	200	kWh	0.136	kg CO2eq/kWh	0.03	potential heat production assumed to replace an equivalent quantity of heat from natural gas combustion (EF natural gas to assess avoided emission)	0.36			
Electricity for mooring from renewable source	32	MWh/day							cost	€ 518,400.00
TOTAL AVOIDED EMISSION					652.22		8,705.74			



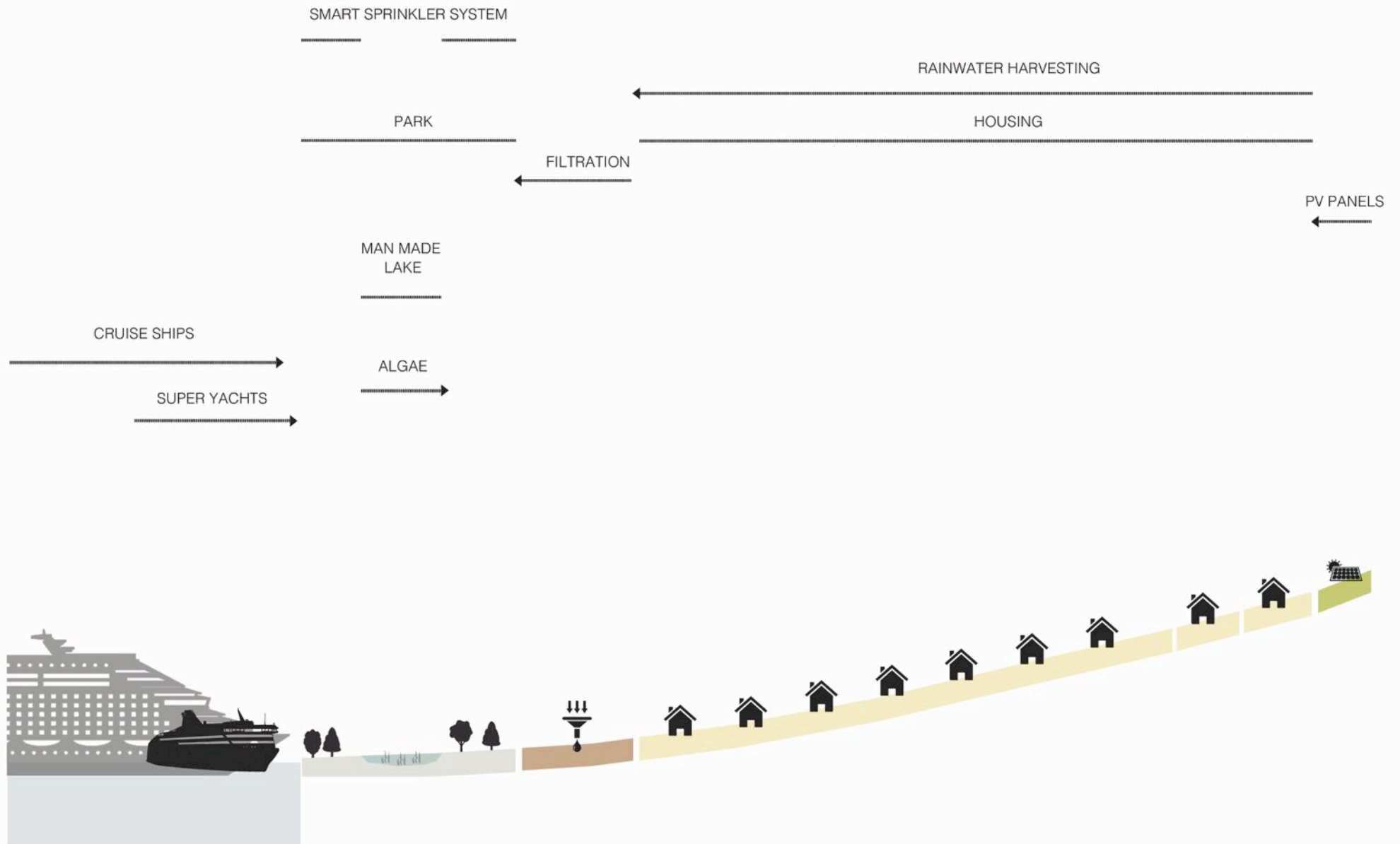




Attenuated tourist experience

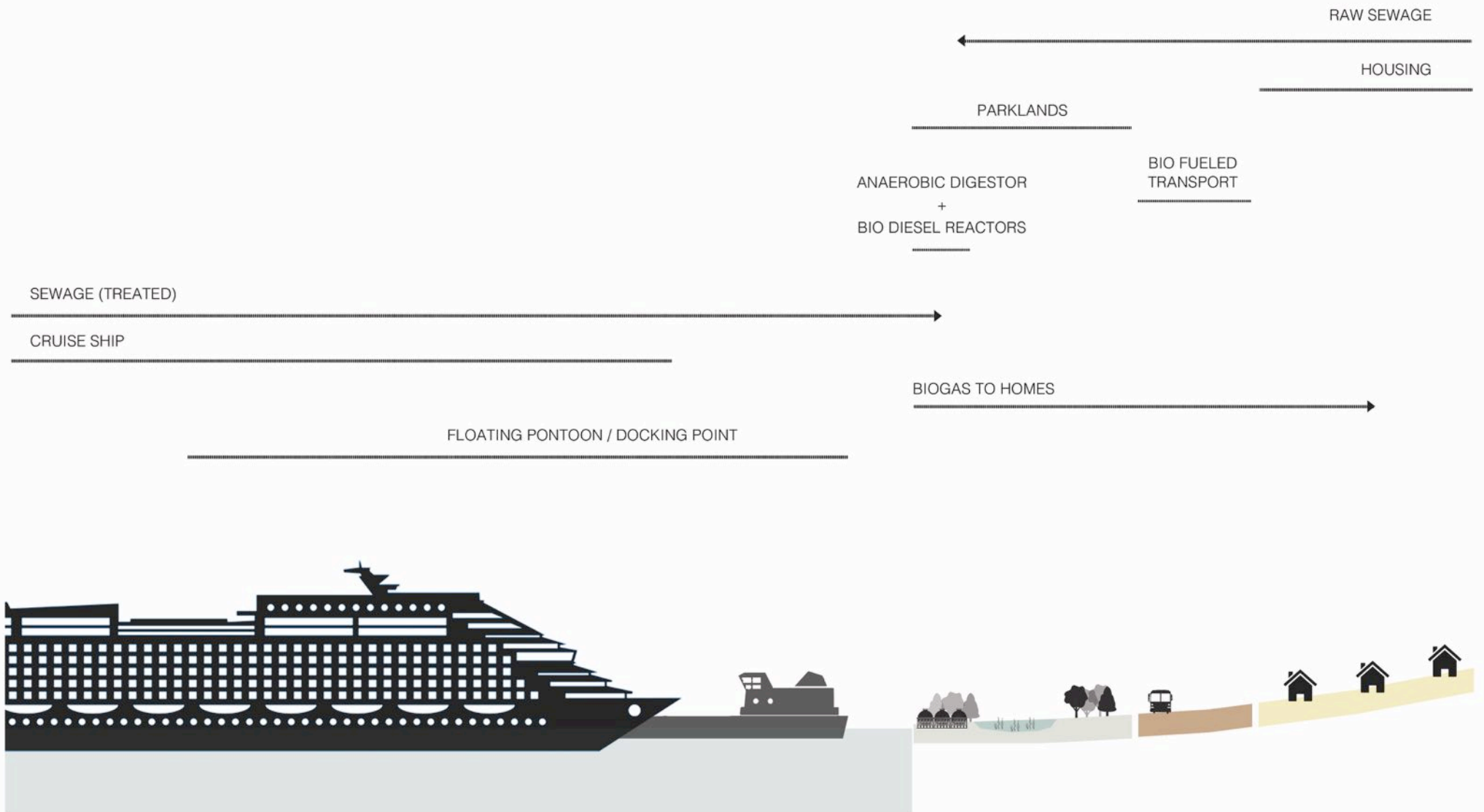


RELATIONAL INFRASTRUCTURES

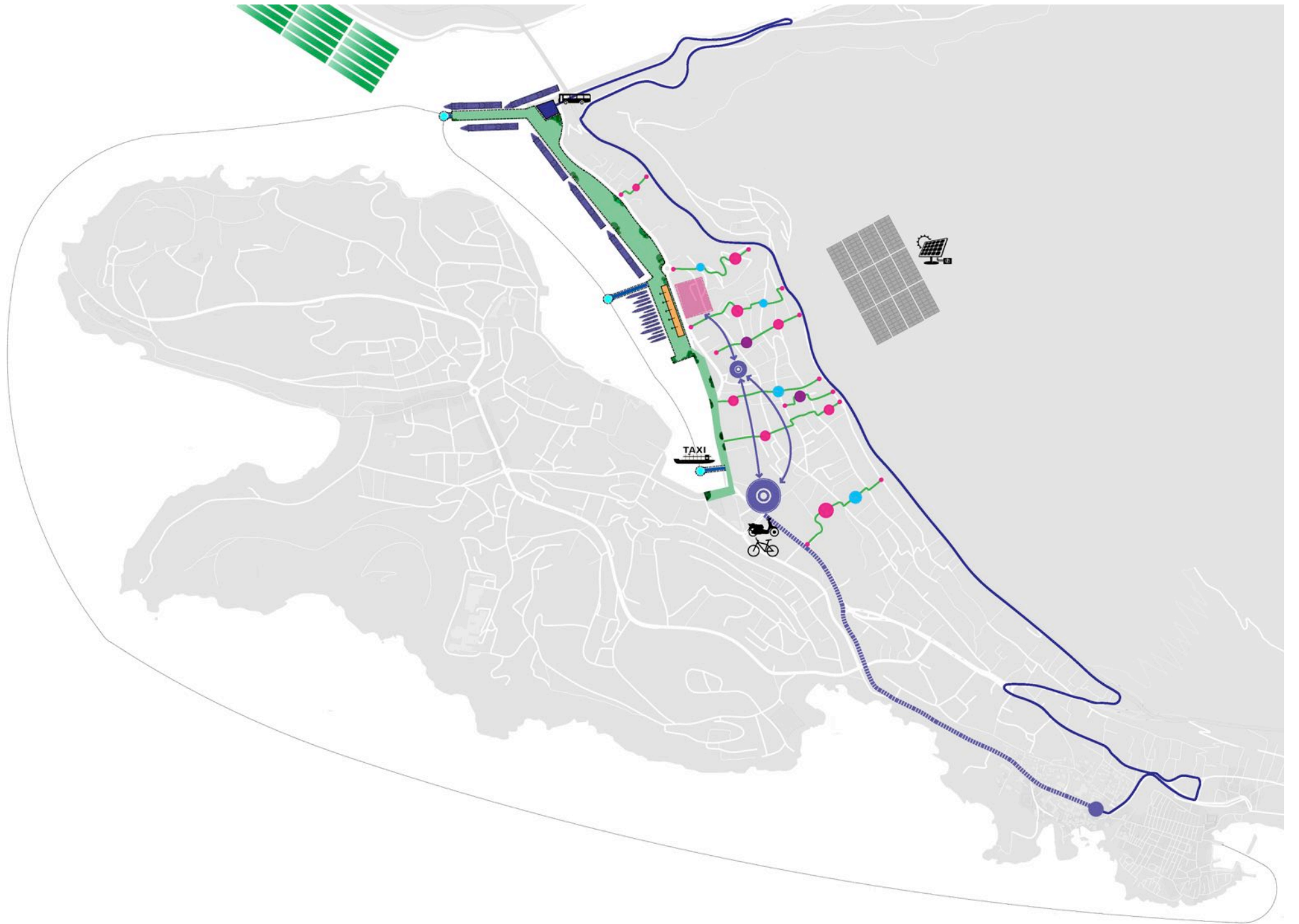


Attenuated landscape

RELATIONAL INFRASTRUCTURES



Attenuated landscape



Attenuated Landscape

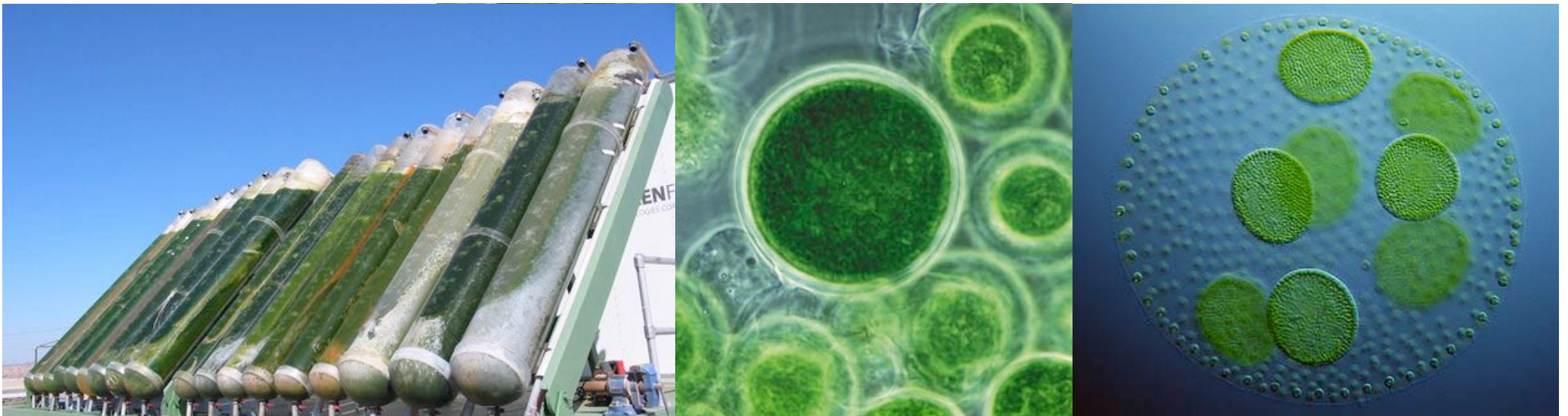
Algaculture

Most productive strains are Spirulina and Botryococcus Braunii

Natural oil content 45 % dry weight – low in sulphur – biodegradable – in fact edible!

Grown in bio-reactors – translucent cultivation tanks

Can utilise waste Carbon Dioxide from power plants



Algae - biofuel

100,000 strains

Exceptionally rich in natural hydrocarbons.

100x yield of rape

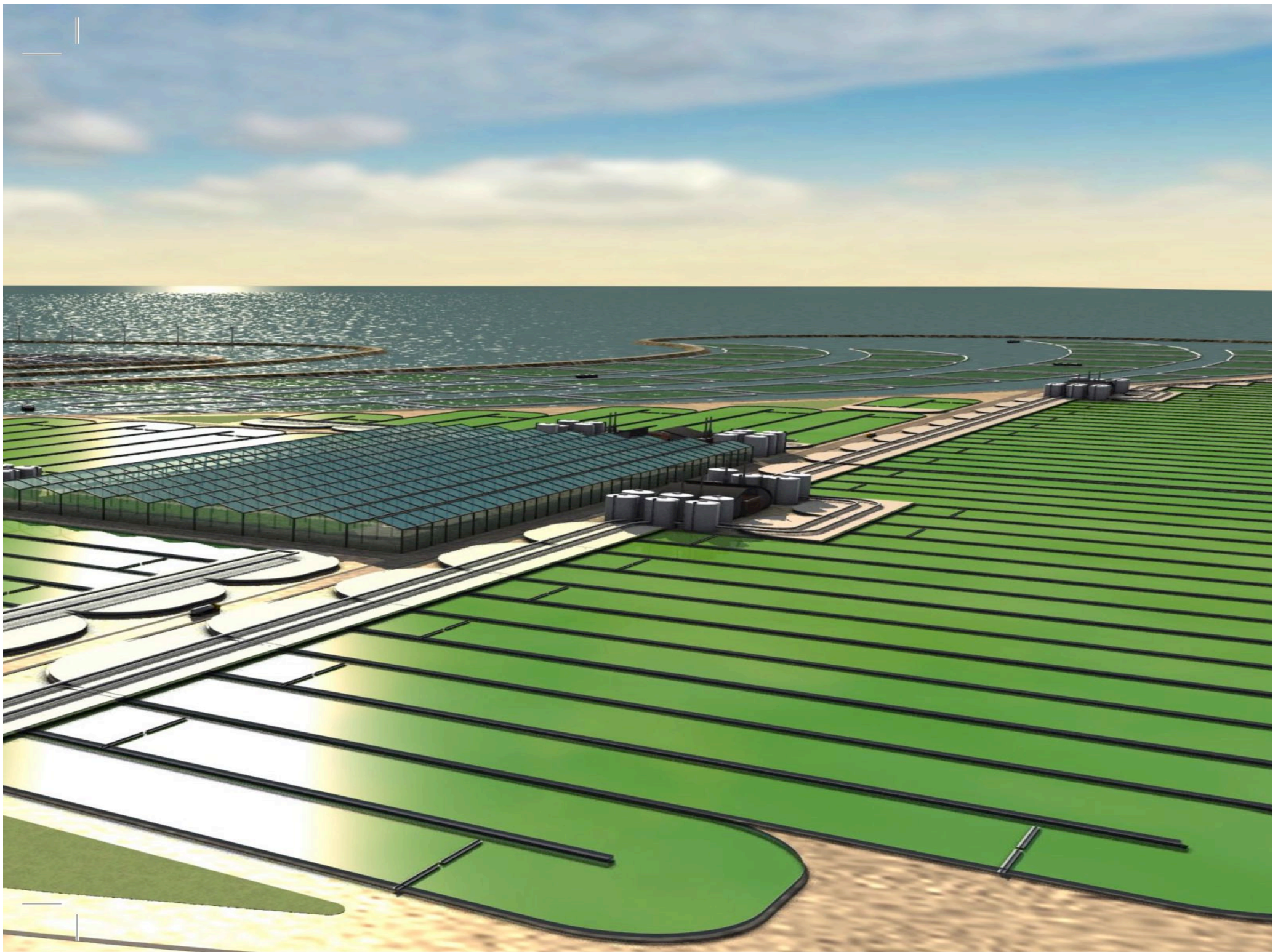
Produce up to 150,000 litres of bio-diesel per hectare/yr

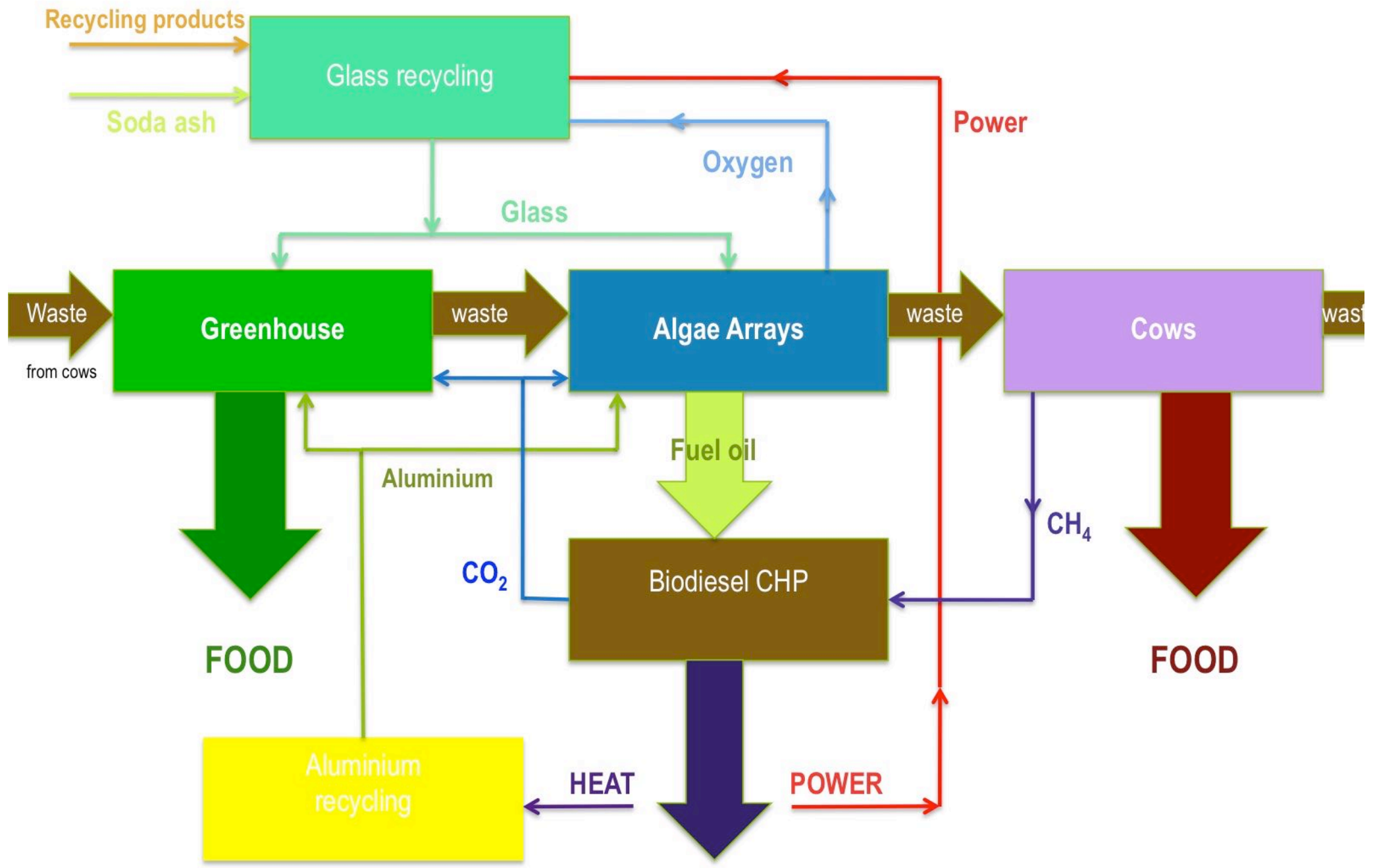
New technologies could increase this to 3,000,000 l/ha
Using lit technology.

Continuous production cycle, unlike land crops

Carbon neutral

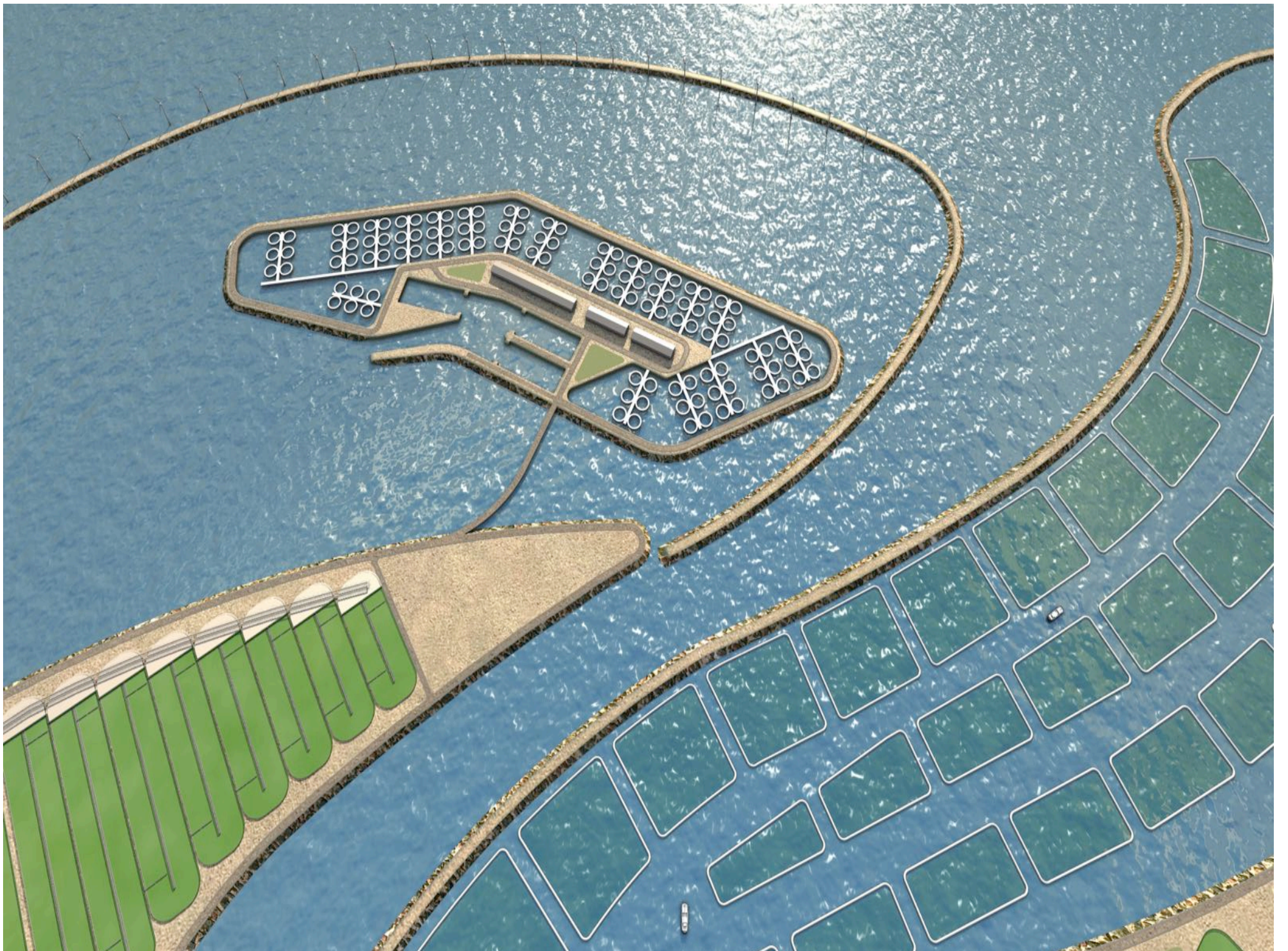


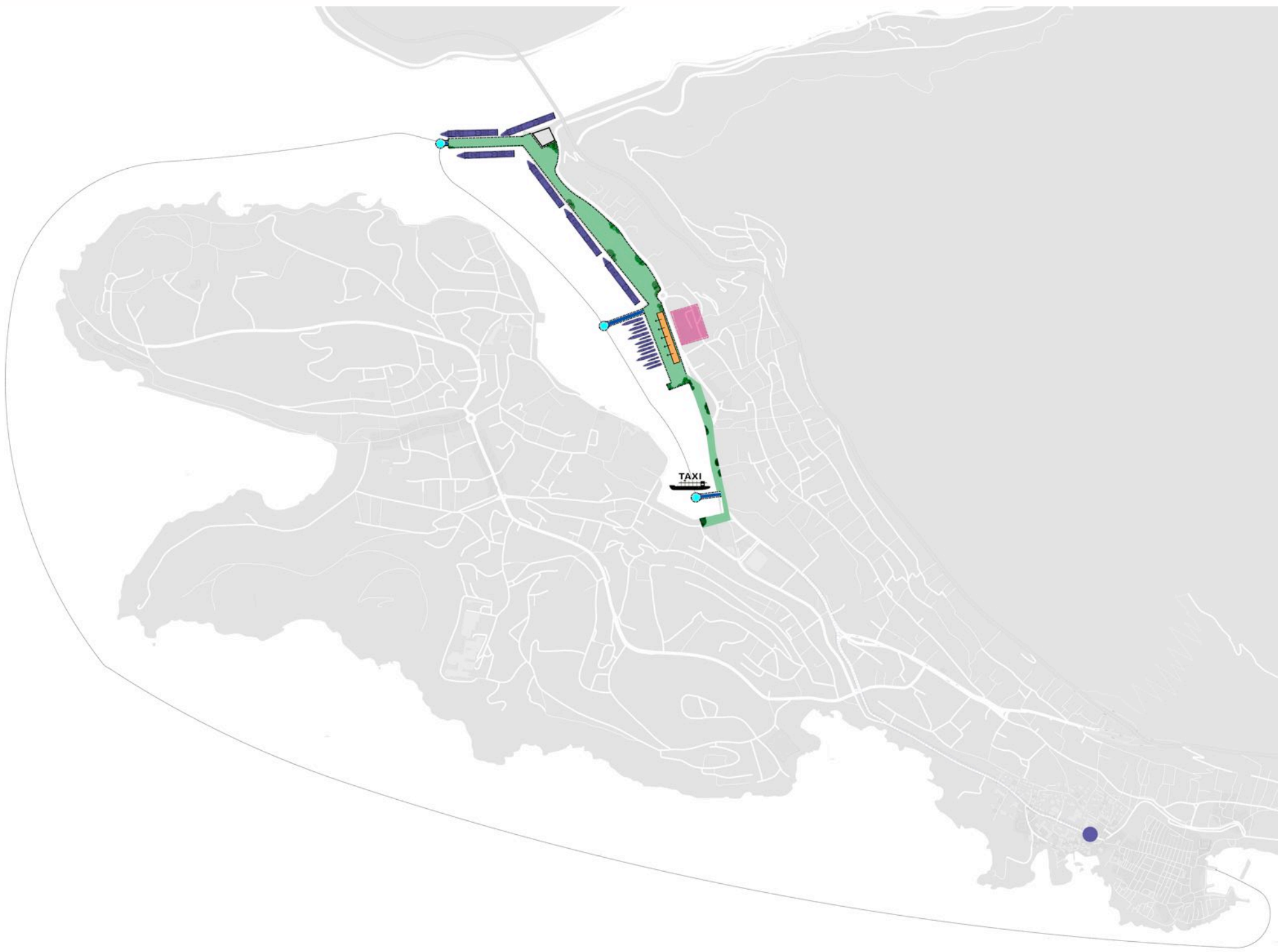




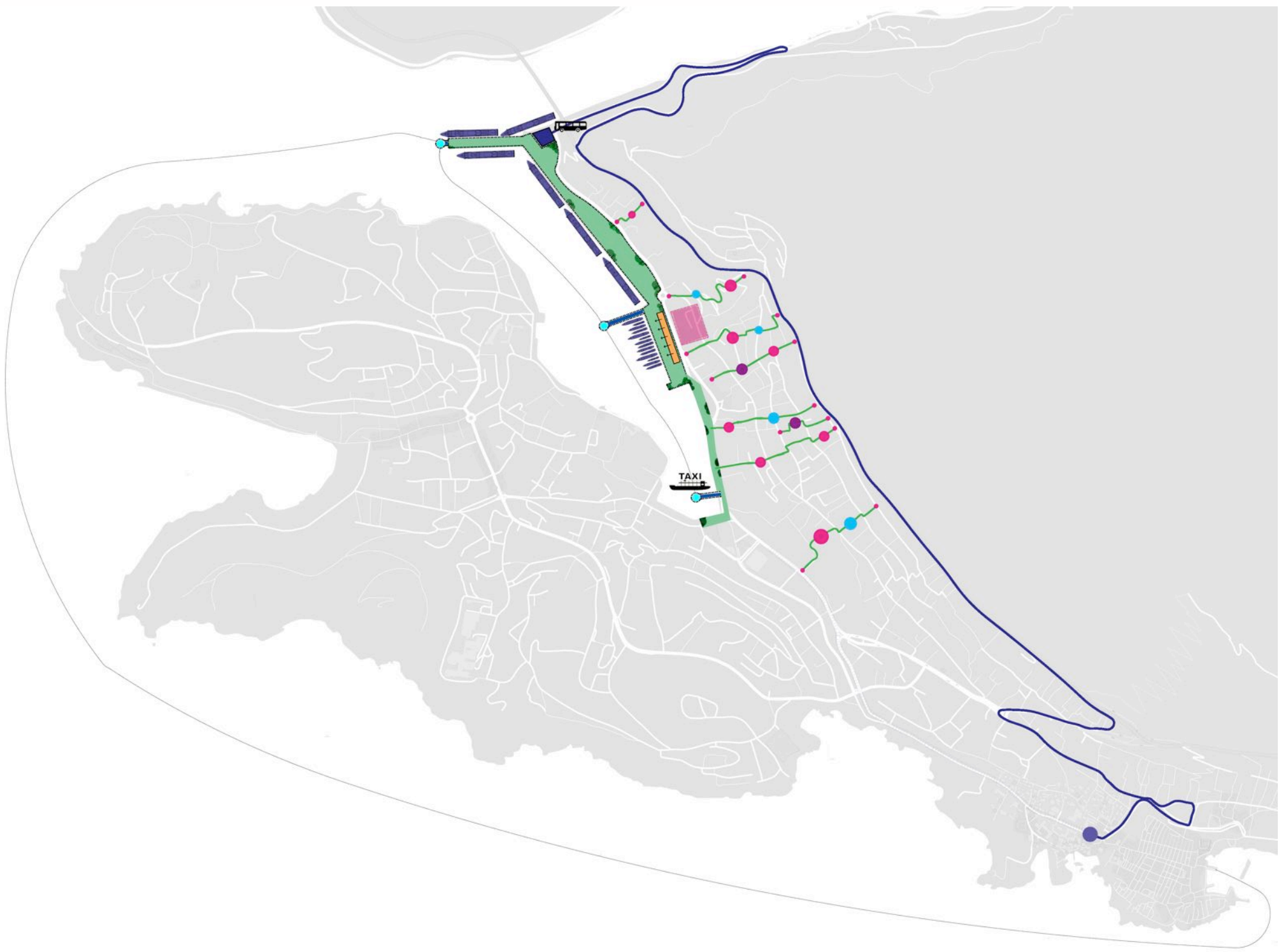


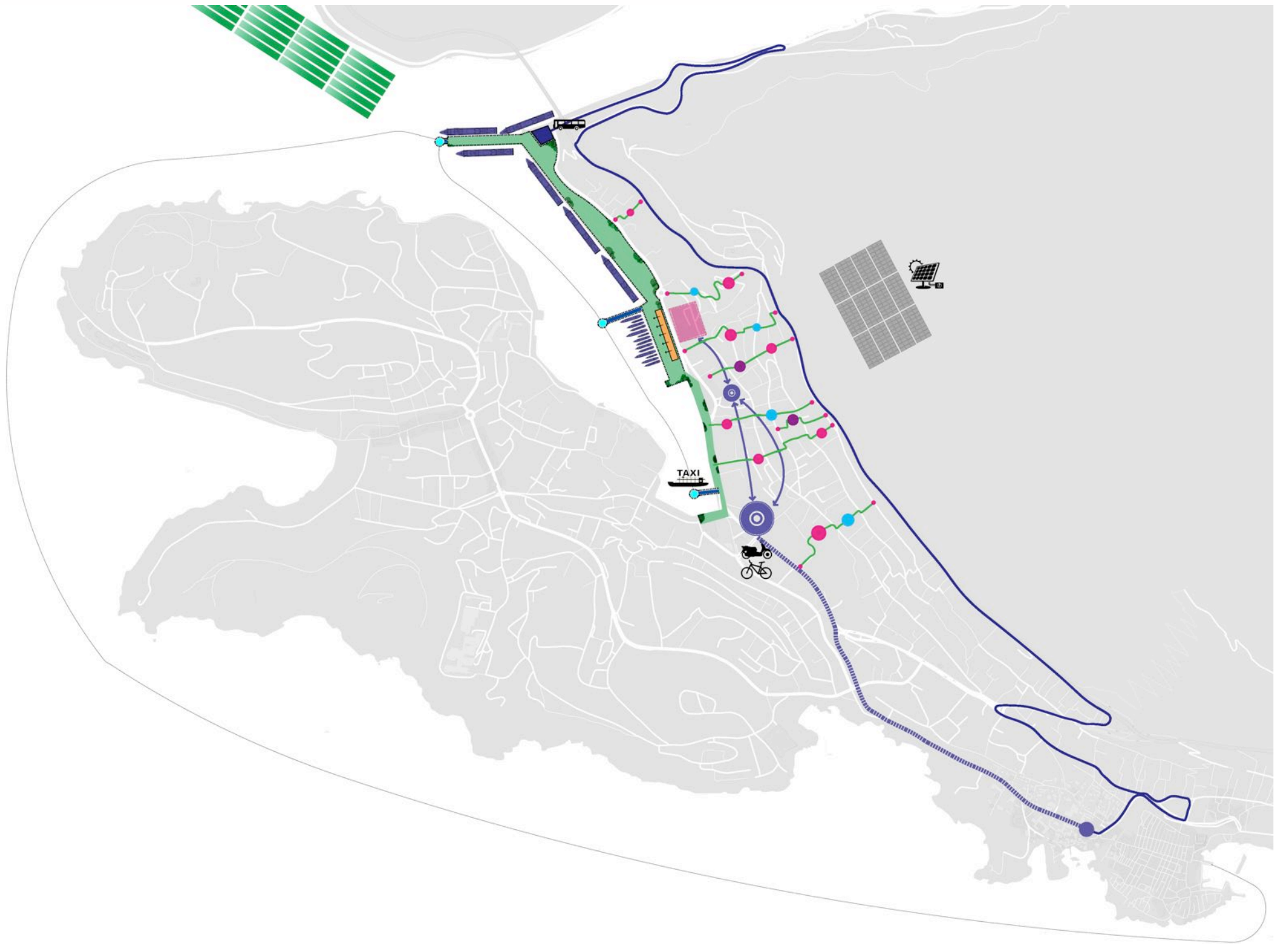
Generate €38,000,000 fuel oil in tourist season and bio-diesel for transport

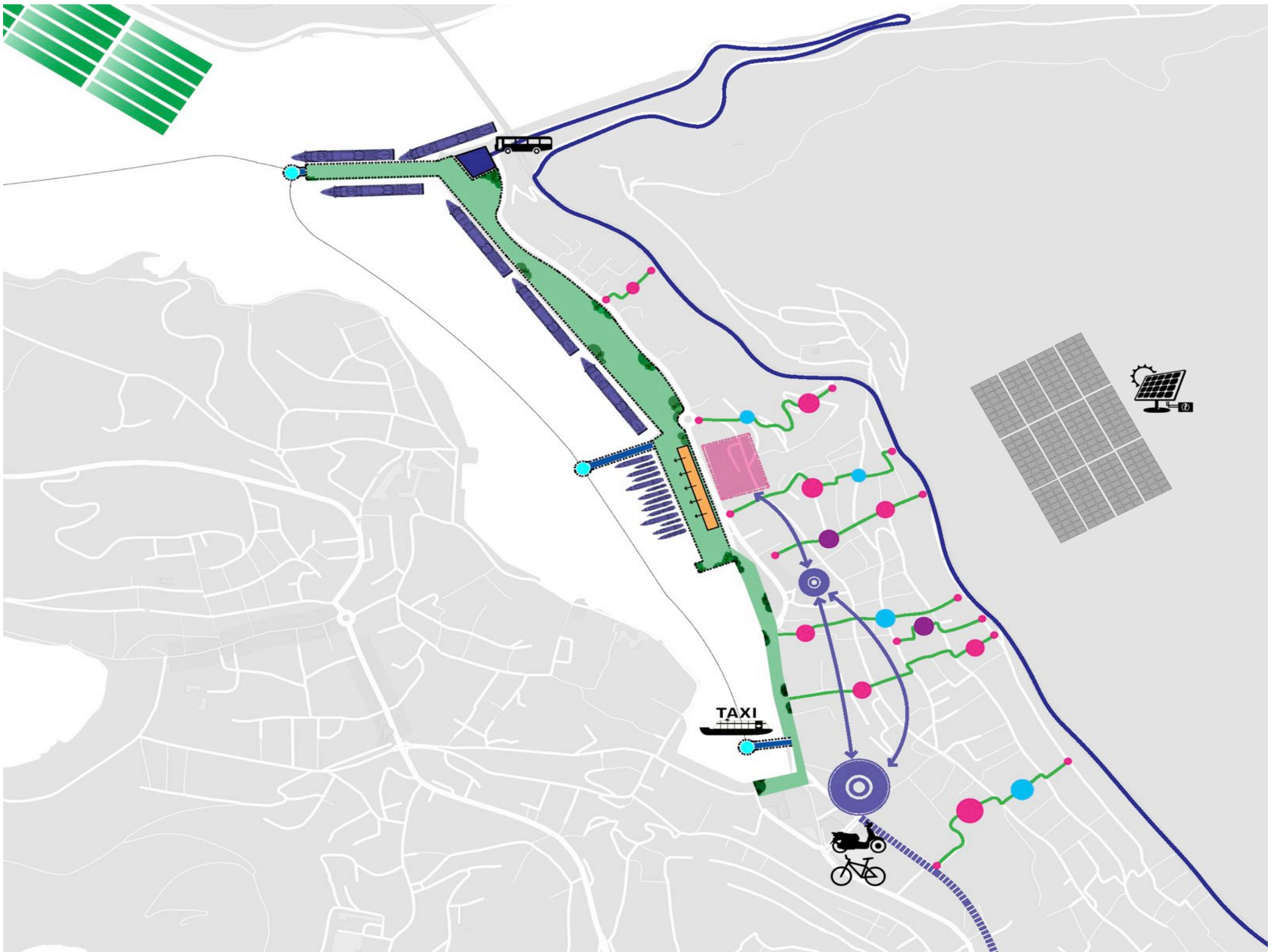


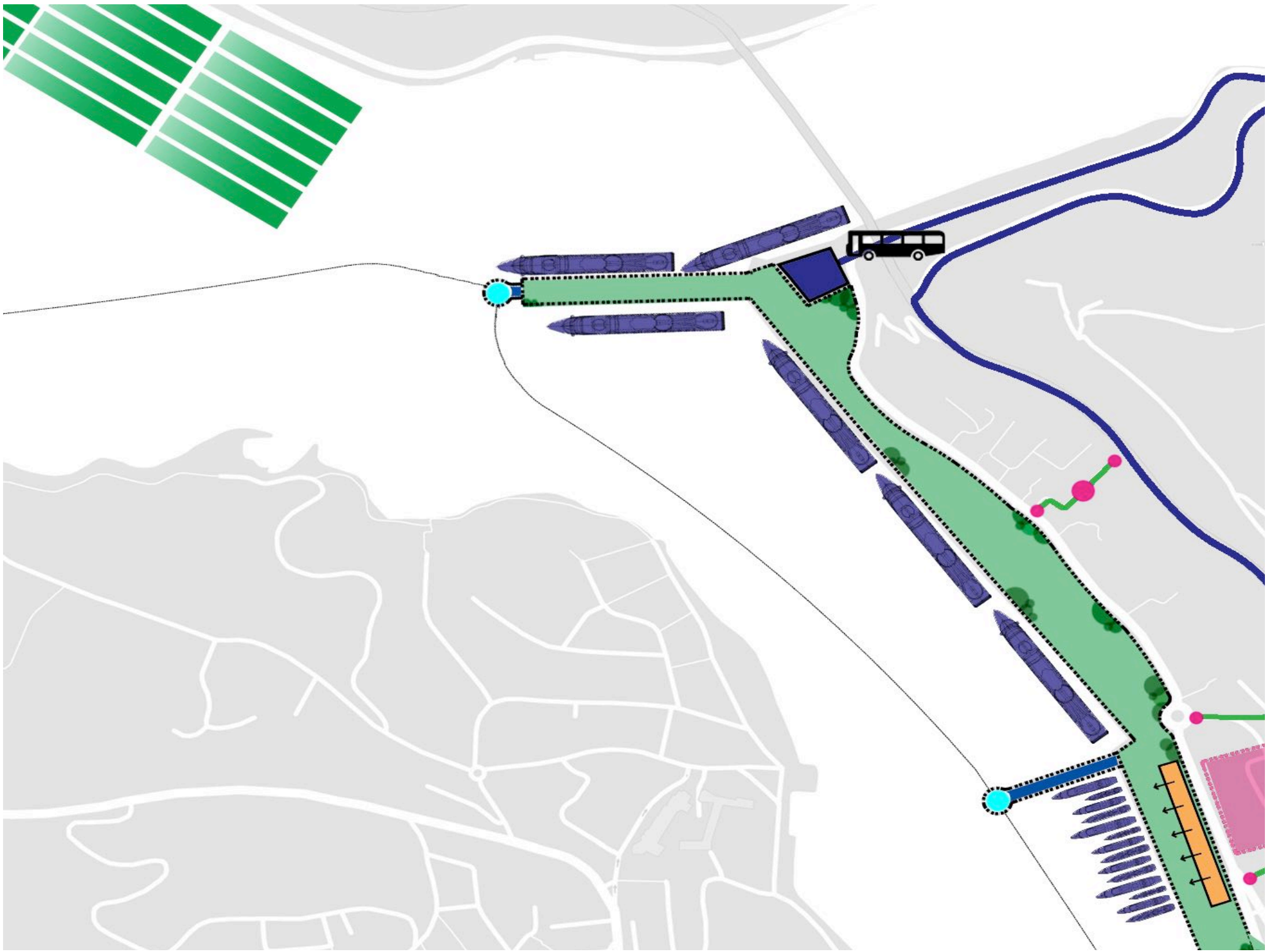








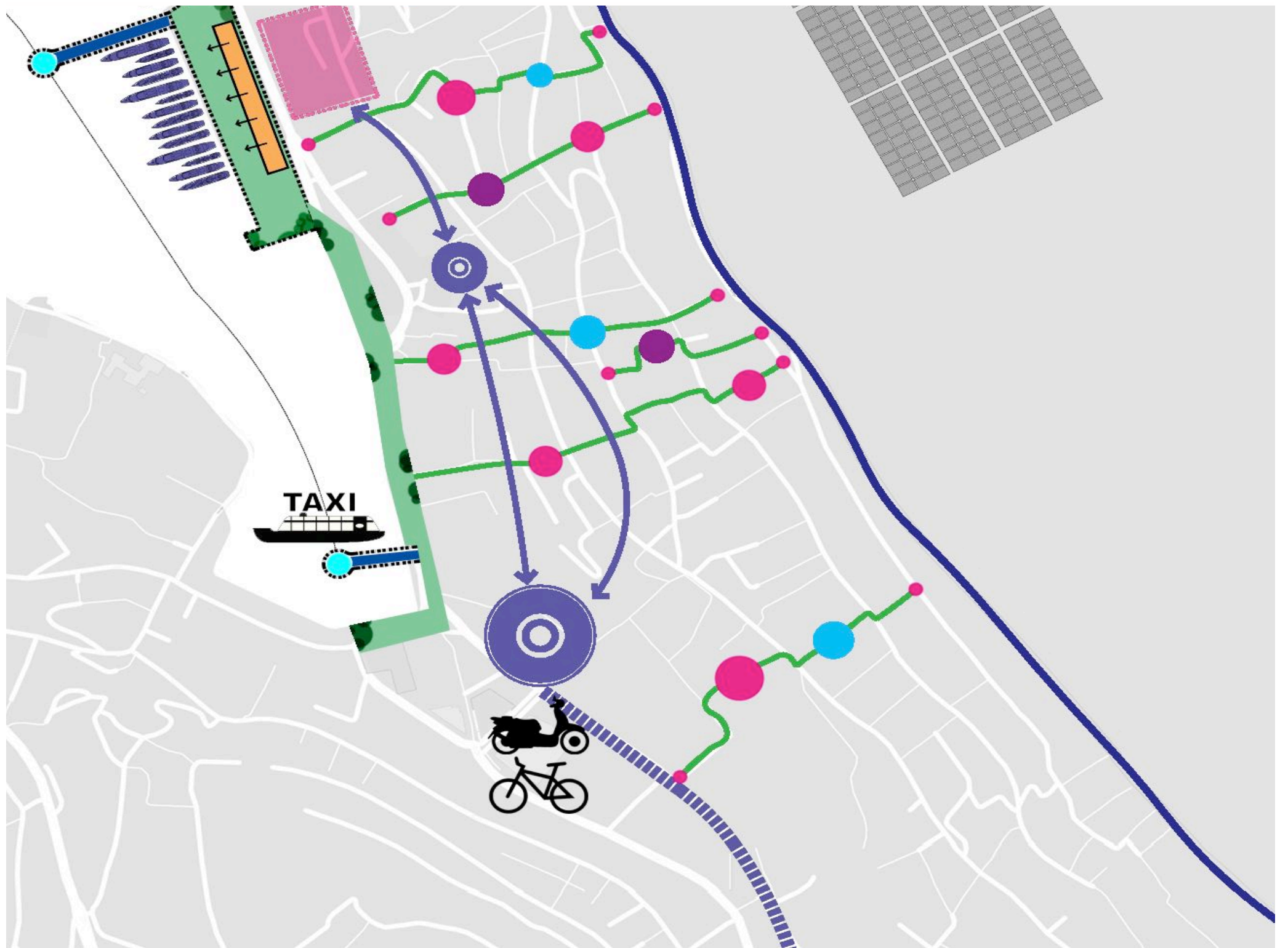










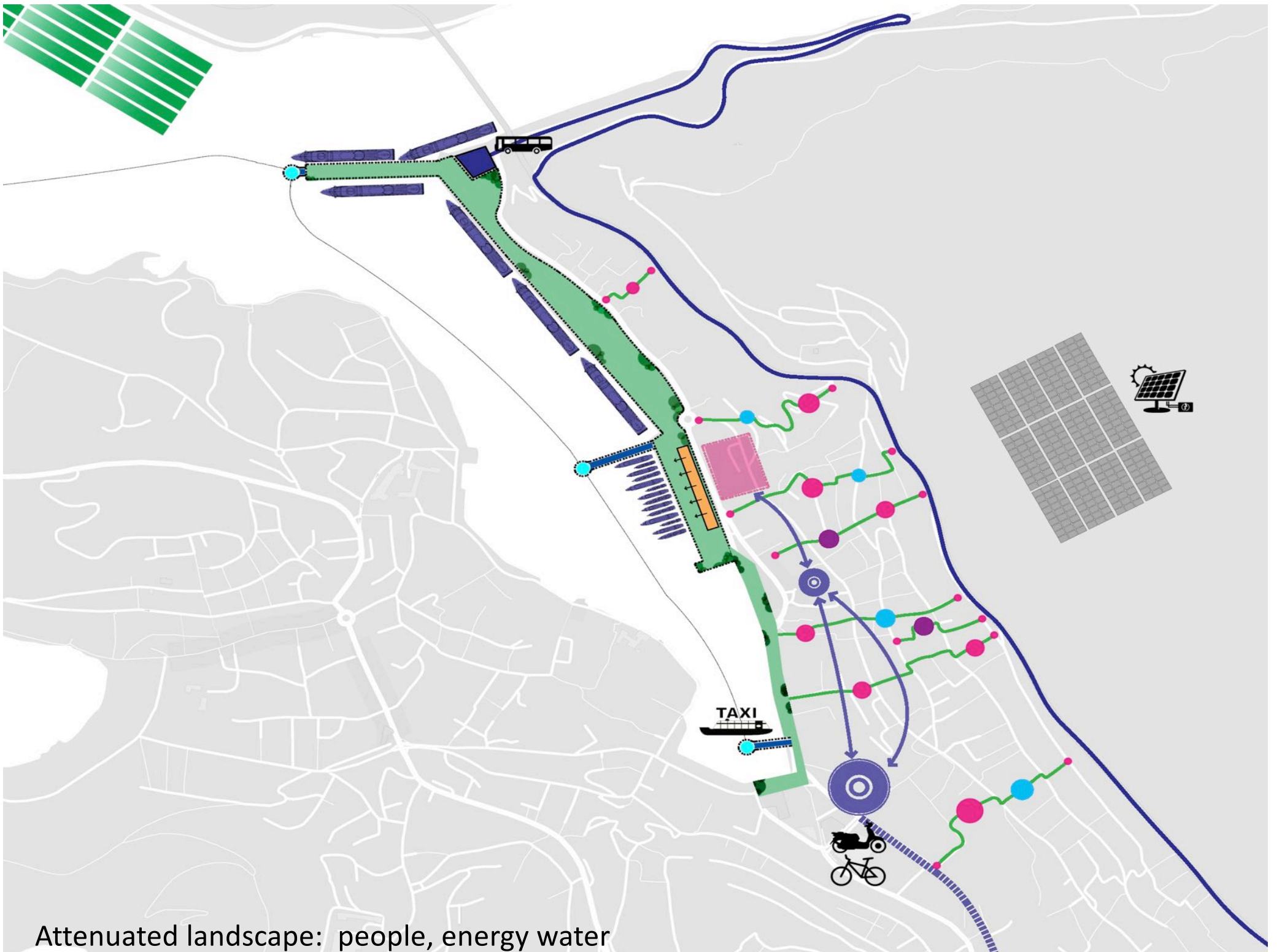


FLOW OF PEOPLE

Water taxi - foot - electric bike - bus

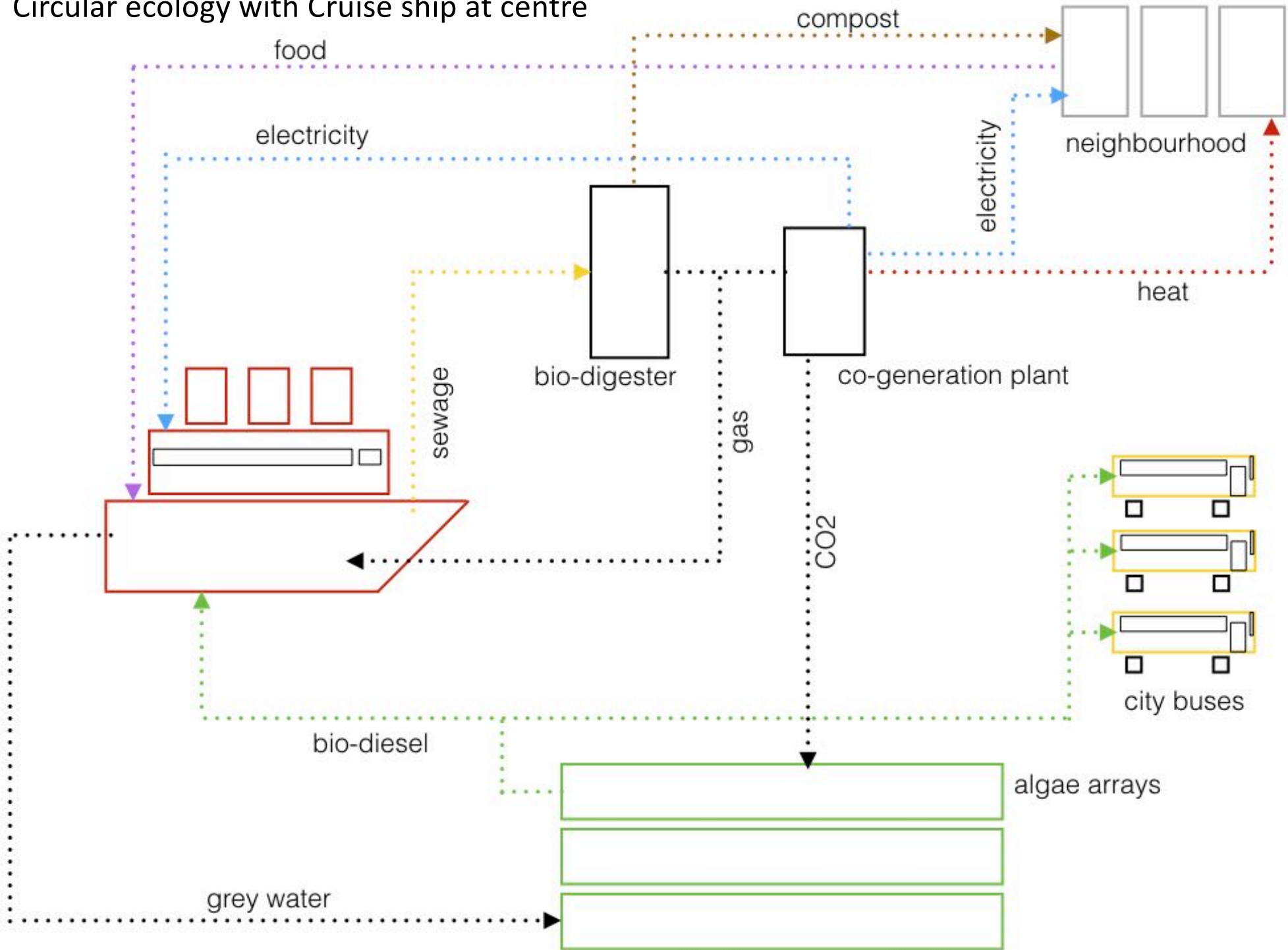






Attenuated landscape: people, energy water

Circular ecology with Cruise ship at centre



TECHNICAL MEASURES

Our New Stepped Strategy (for different scale levels)

1. Reduce the energy demand

- Urban planning & design
- Architectural design
- Passive, smart & bioclimatic design
- Using local characteristics, vernacularity

2. Reuse waste energy

- Attune supply and demand
- Exchange surpluses with shortages
- Cascade heat
- Store energy

3. Produce renewable energy

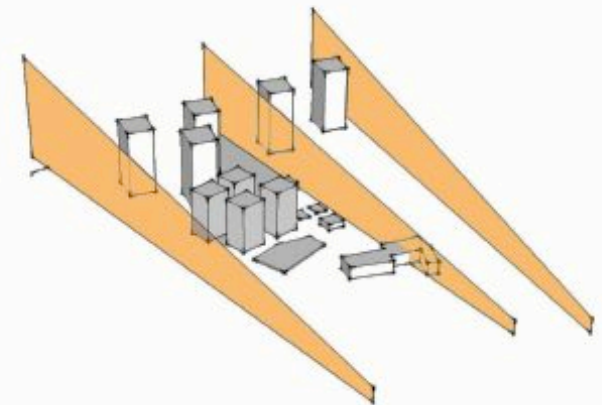
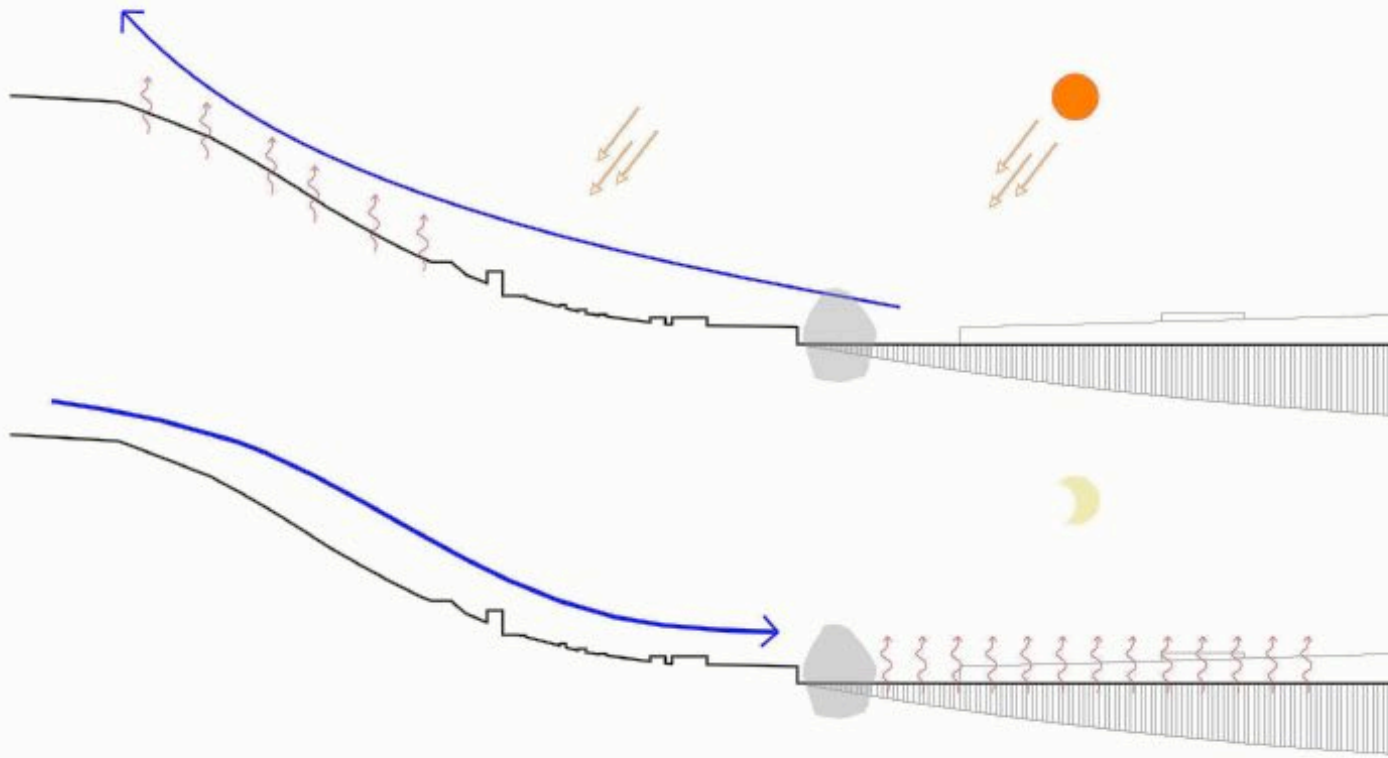
- Sun
- Wind
- Water
- Air
- Soil
- Biomass

STEP	SCALE				
	individual house	apartment block	neighbourhood	district (Gruž)	city (Dubrovnik)
reduce energy demand	avoid heating + cooling	post-insulation on walls post-insulation on roofs cavity wall insulation replace complete window-frames replace window-glazing	post-insulation on walls post-insulation on roofs cavity wall insulation replace complete window-frames replace window-glazing		
			clustering of buildings	clustering of buildings	density
	avoid heating	passive solar heat individual conservatory	passive solar heat conservatory - atrium - gallery	glass-covered spaces	
	avoid cooling	tropical roof system sunshading green shading	tropical roof system sunshading green shading	covering public spaces heat-collecting surfaces green lanes green gardens creating thermal drafts creating coolspots wind channels through streets	heat-collecting surfaces green lanes green parks creating thermal drafts creating coolspots planning coolspots planning a network of wind channels
	avoid electricity	optimised daylight access LED lighting domotics	optimised daylight access building management system	LED streetlights	LED streetlights LED streetlights on main roads
reuse waste energy	heat + cold		cisterne (cellar) for 17 deg (rain)water LT heat and HT cold storage (cellar)	heat exchange between buildings cisterne (cellar) for 17 deg (rain)water collective LT heat and HT cold storage aquifer thermal energy storage (ATES)	heat exchange between buildings collective LT heat and HT cold storage aquifer thermal energy storage (ATES)
	heat	heat recovery on ventilated air (air-air) heat recovery (air-water) + heatpump heat recovery of shower water water storage (55+ deg) for hot water	heat recovery on ventilated air (air-air) heat recovery (air-water) + heatpump heat recovery of shower water water storage (55+ deg) for hot water	heat recovery on sewage (water-water) collective water storage (55+ deg) for hot water	heat recovery on sewage (water-water) heat recovery on sewage (WWTP)
	electricity	battery system electric car as electricity storage individual peak-shaving	battery system electric car as electricity storage joint peak-shaving	collective battery system electric car park as electricity storage collective peak-shaving	battery system electric car park as electricity storage peak-shaving battery system electric car park as electricity storage peak-shaving
	fuel		waste water to algae	organic waste (water) to biogas waste water to algae	organic waste (water) to biogas (WWTP) waste water to biodiesel (algae, WWTP) biodigestion and biorefinery plant
produce renewable energy	heat + cold	ground ducts (for ventilated air) soil collector: vertical tubes soil collector: horizontal tubes heat pump on open water heat pump on air	ground ducts (for ventilated air) soil collector: vertical tubes soil collector: horizontal tubes heat pump on open water heat pump on air	heat exchanger on mountain run-off water collective soil collector: vertical tubes collective soil collector: horizontal tubes collective heat pump on open water	collective heat pump on open water collective heat pump on river, lake or sea
	heat	solar collector on the roof solar collector on the façade heat collecting walls	solar collectors on the roof solar collector on the façade heat collecting walls	solar collectors on large roofs solar collectors in park heat collecting urban surfaces	solar collectors on large roofs solar collectors in parks heat collecting urban surfaces geothermal heat plant geothermal heat plant
	electricity + heat	PVT on large roofs PVT on the façade	PVT on the roof PVT on the façade micro CHP (on biogas)	PVT on large roofs PVT above parking lots collective CHP (on biogas)	PVT on large roofs PVT above parking lots PVT in parks collective CHP (on biogas) hot rock bed heat and power
	electricity	PV on the roof PV on the façade small wind turbine	PV on the roof PV on the façade micro wind turbines	PV on large roofs PV above parking lots PV in parks small wind turbine	PV on large roofs PV above parking lots PV in park small wind turbine park PV in parks or surroundings large wind turbine parks blue energy plant wave energy plant tidal plant

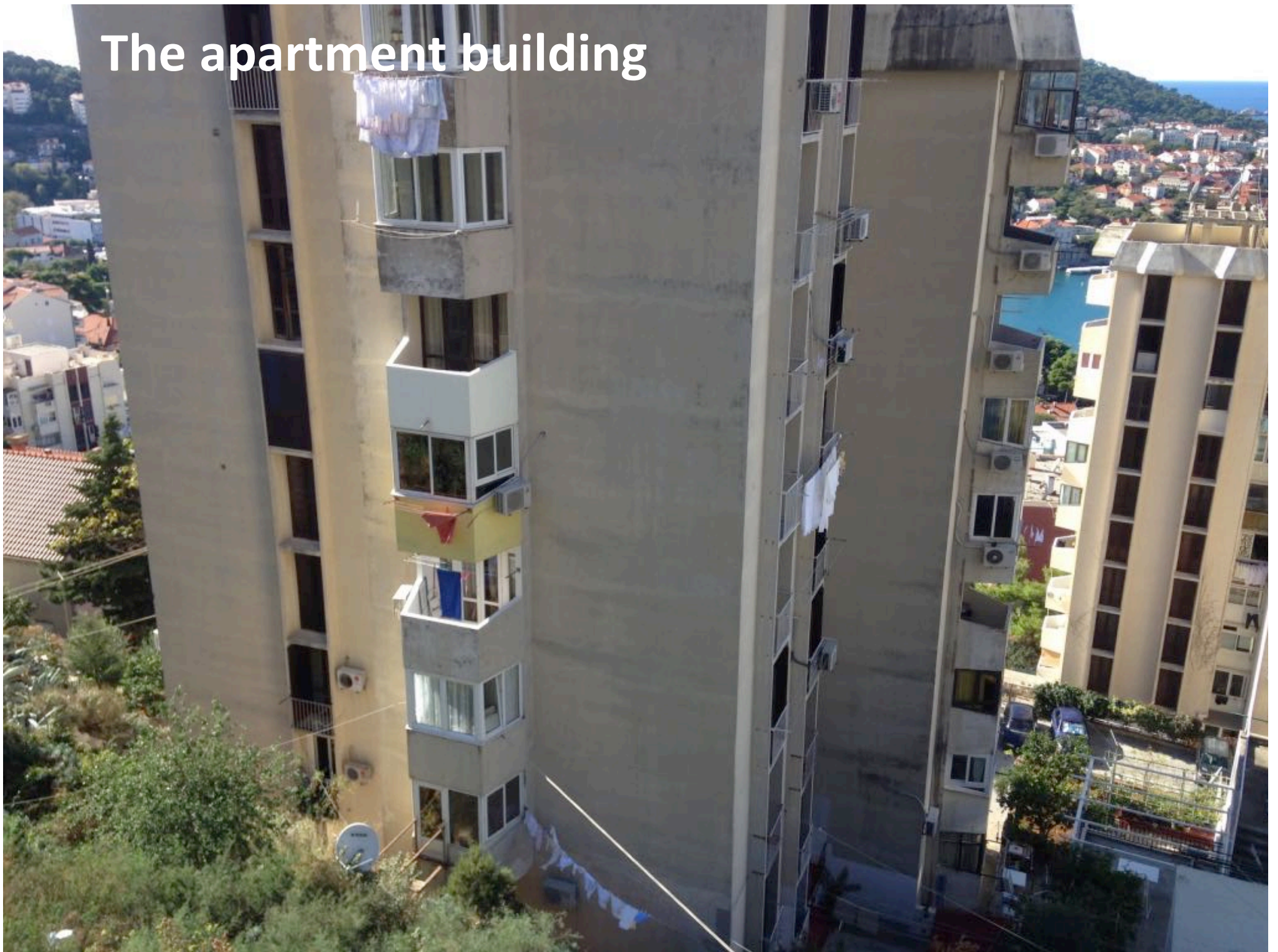
The Gruž lagoon

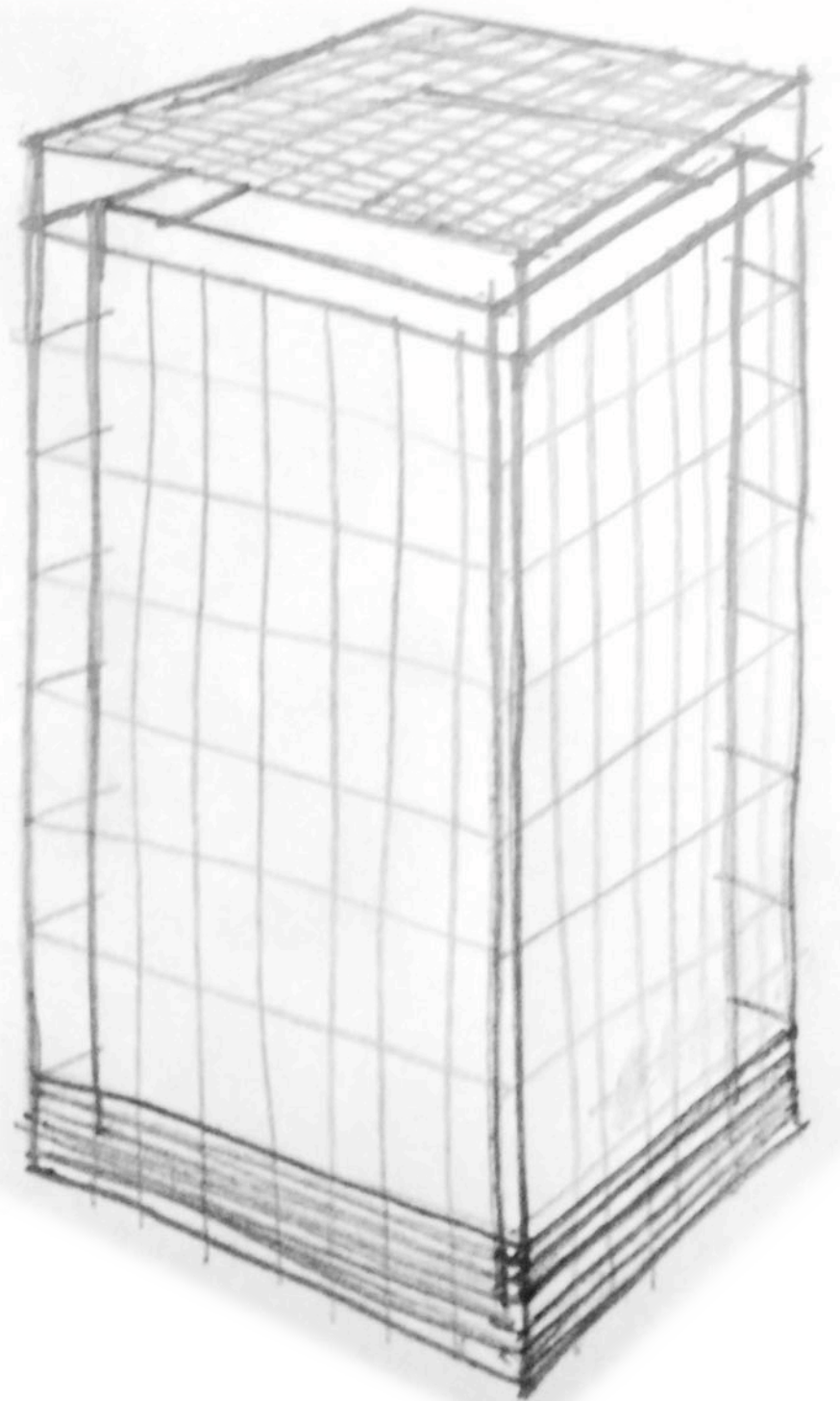
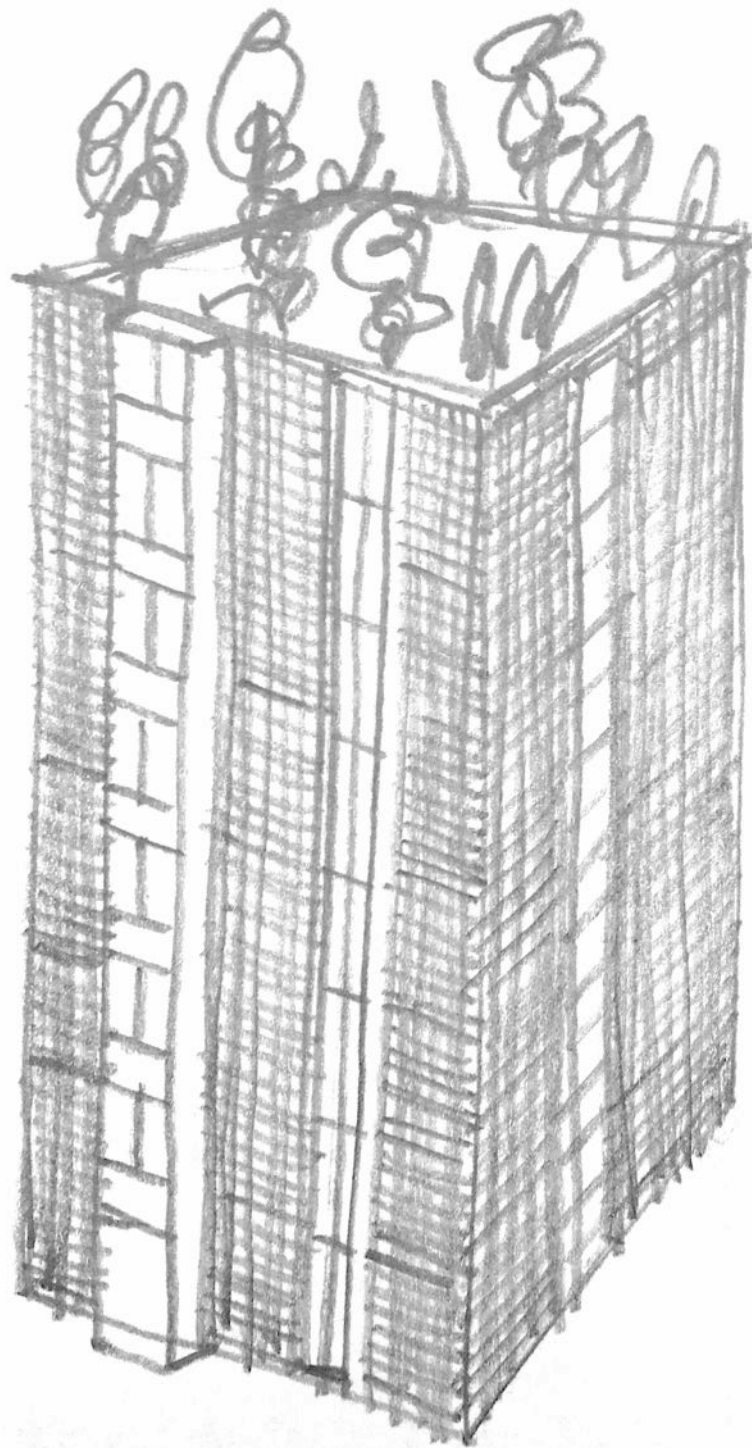


Passive use of valley breezes



The apartment building





Starting-point



Starting-point

+ post-insulation

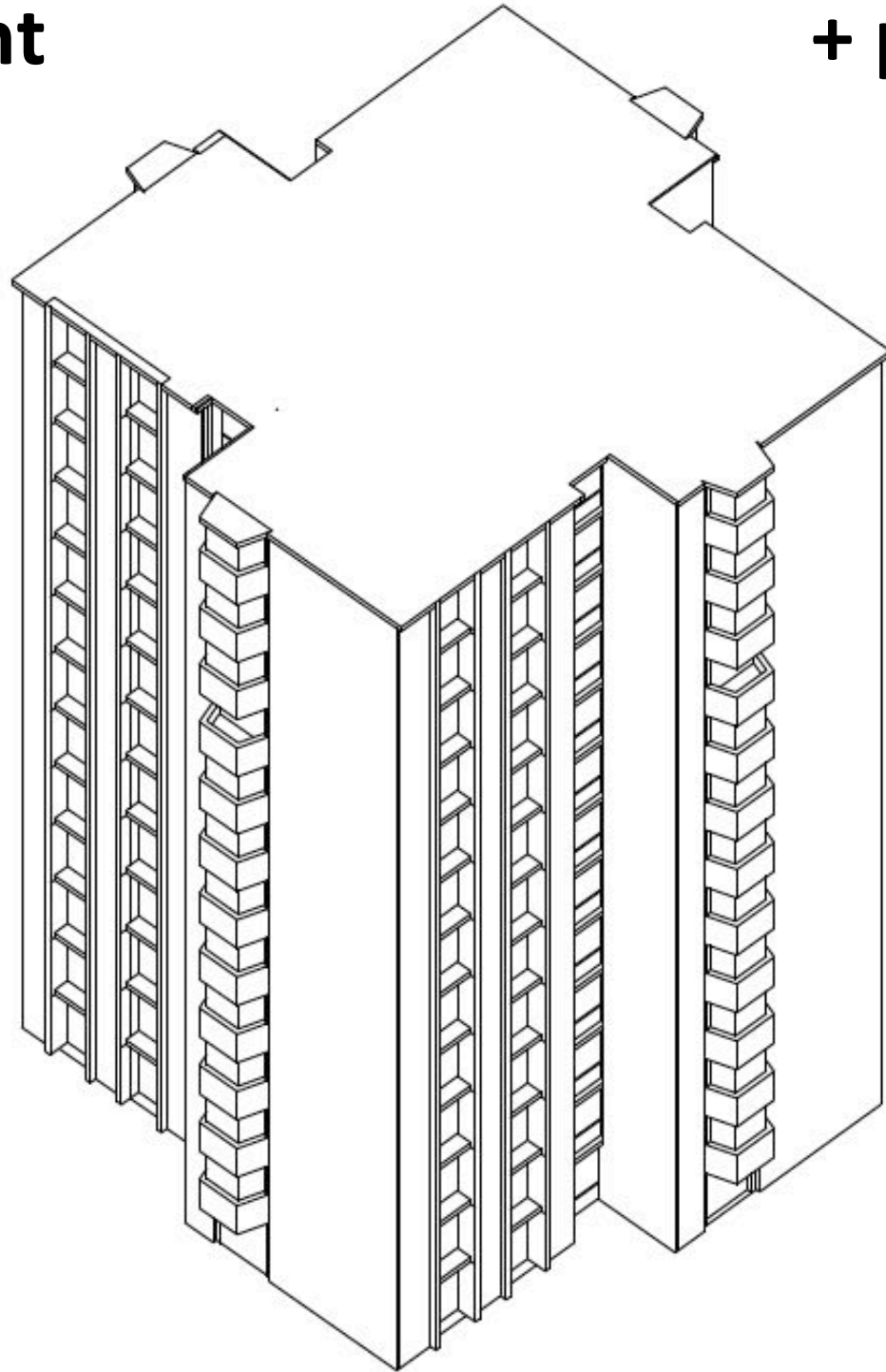


Image after post-insulation (and plaster finish)



PV façade cladding

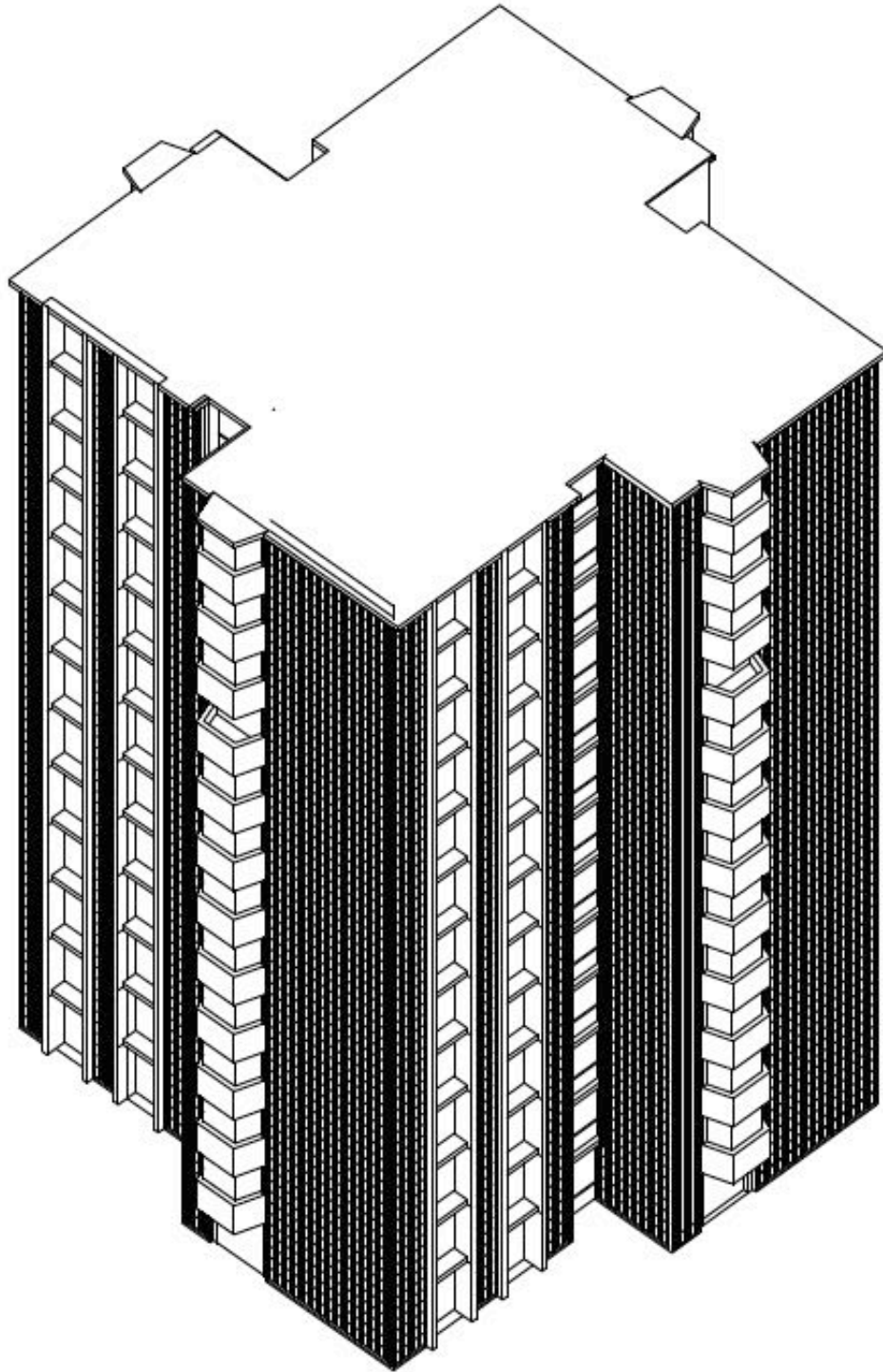


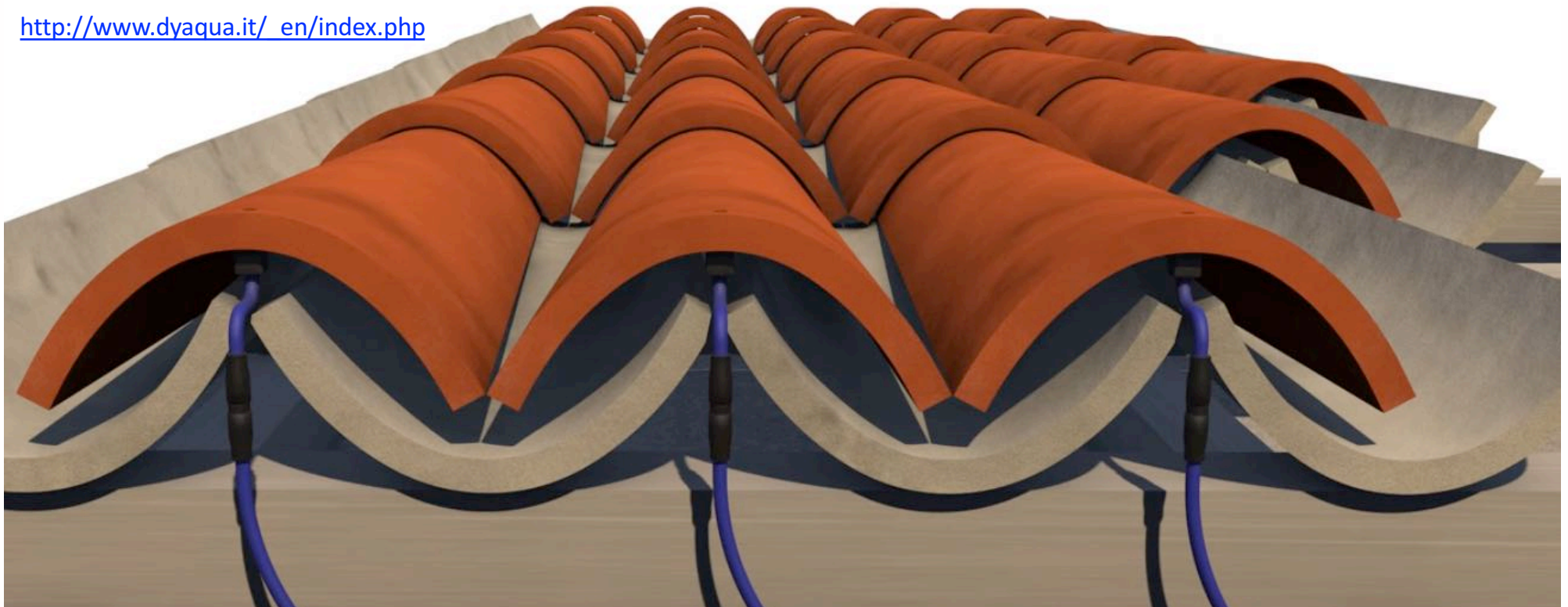
Image with PV façade cladding



Integrated PV for single houses



<http://www.dyaqua.it/en/index.php>



4,5 Wp

Peak power

15 m²

Required area for 1 kWp

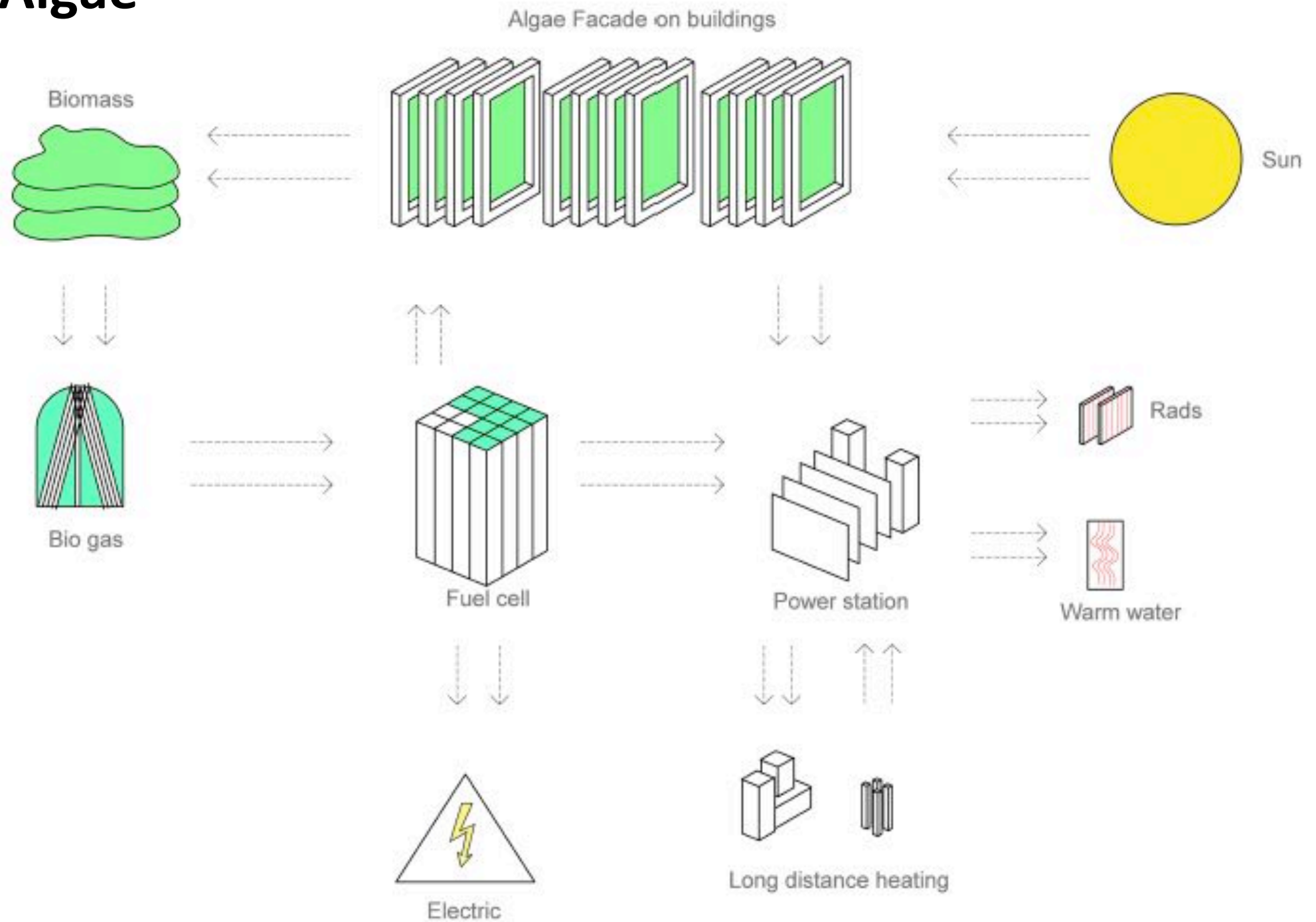
223 Rooftiles

To generate 1 kWp

PV-covered parking lots



Algae



Algae façade elements

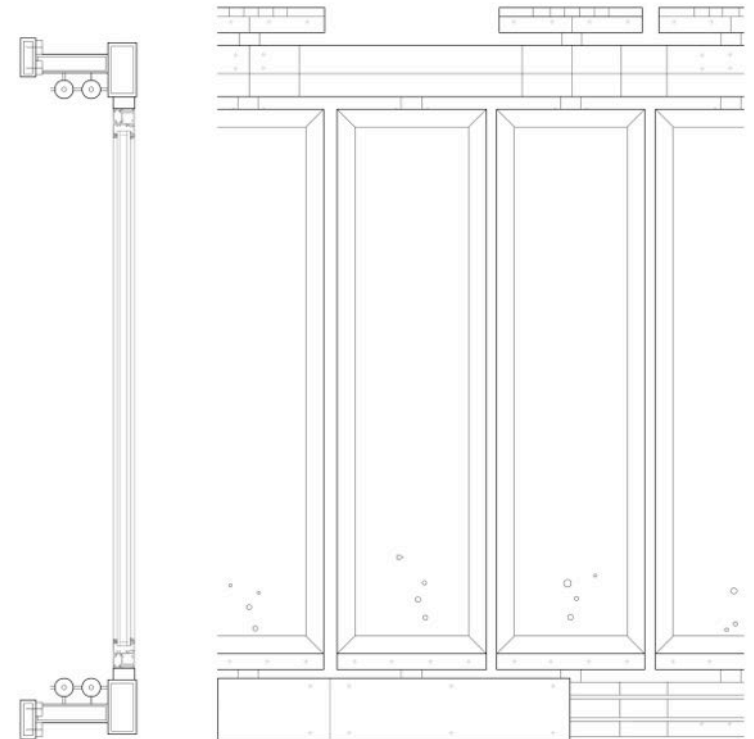
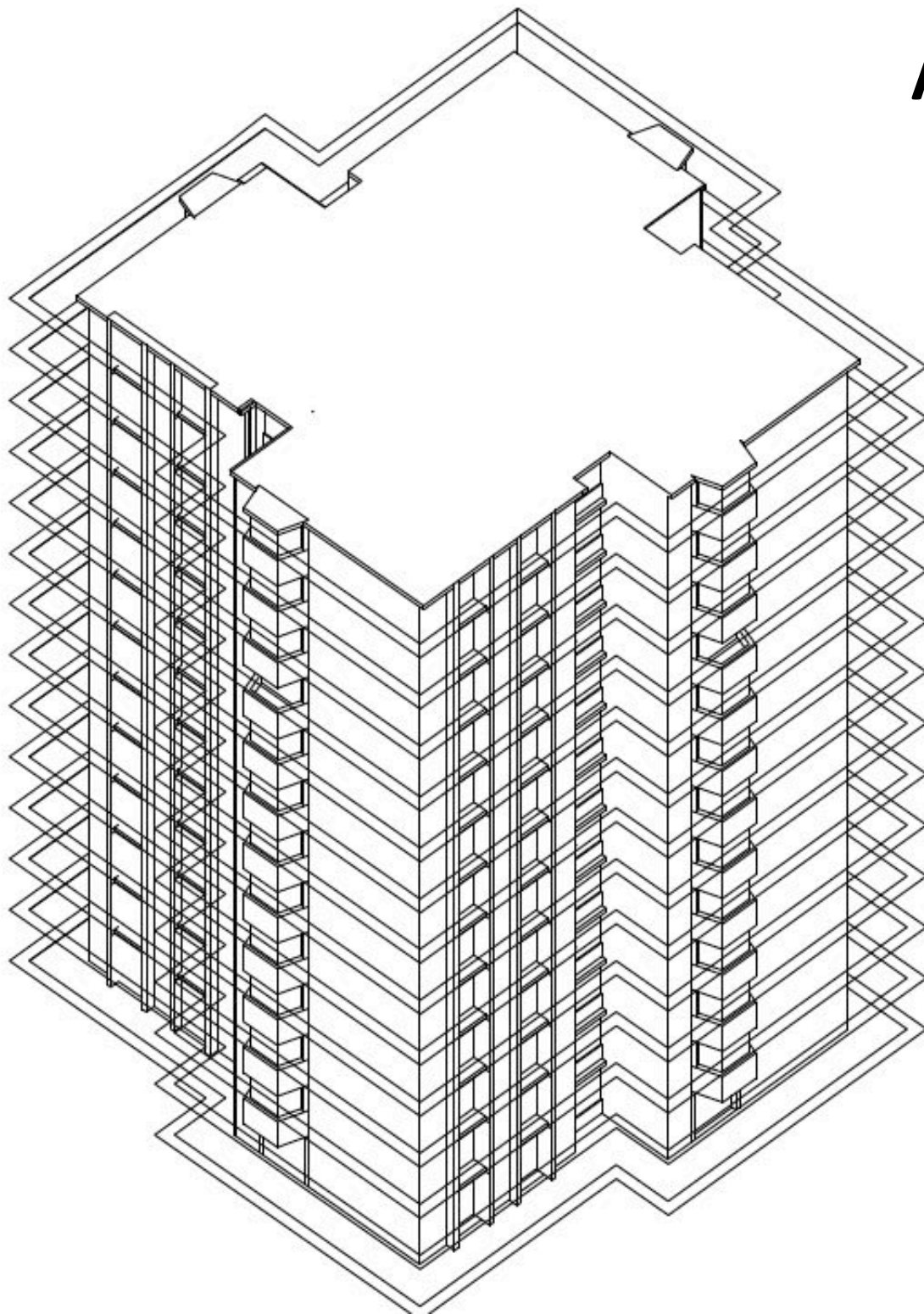


Image with algae façades



Algae façade



Solar glasshouse façade

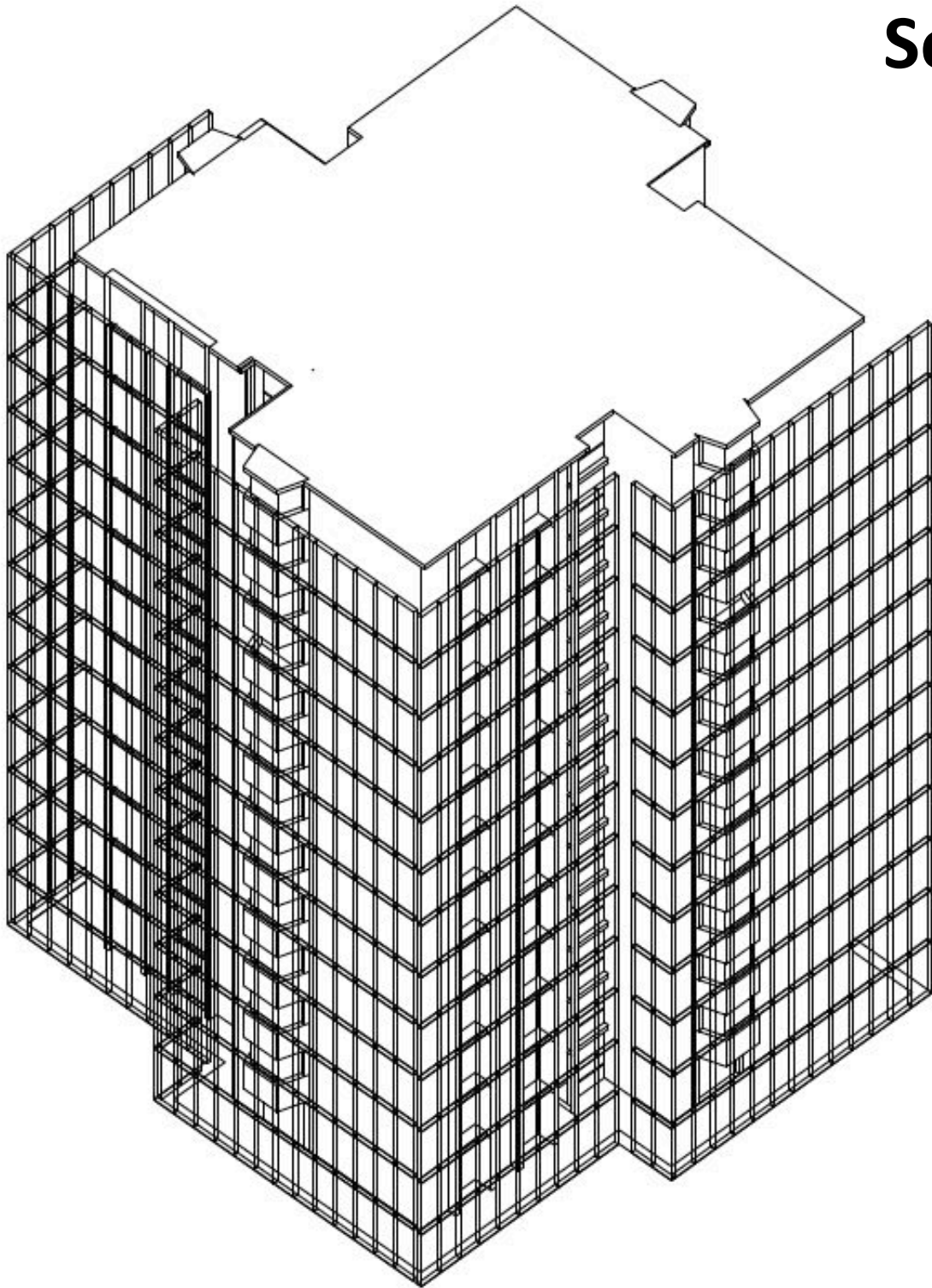


Image with solar glasshouse façade



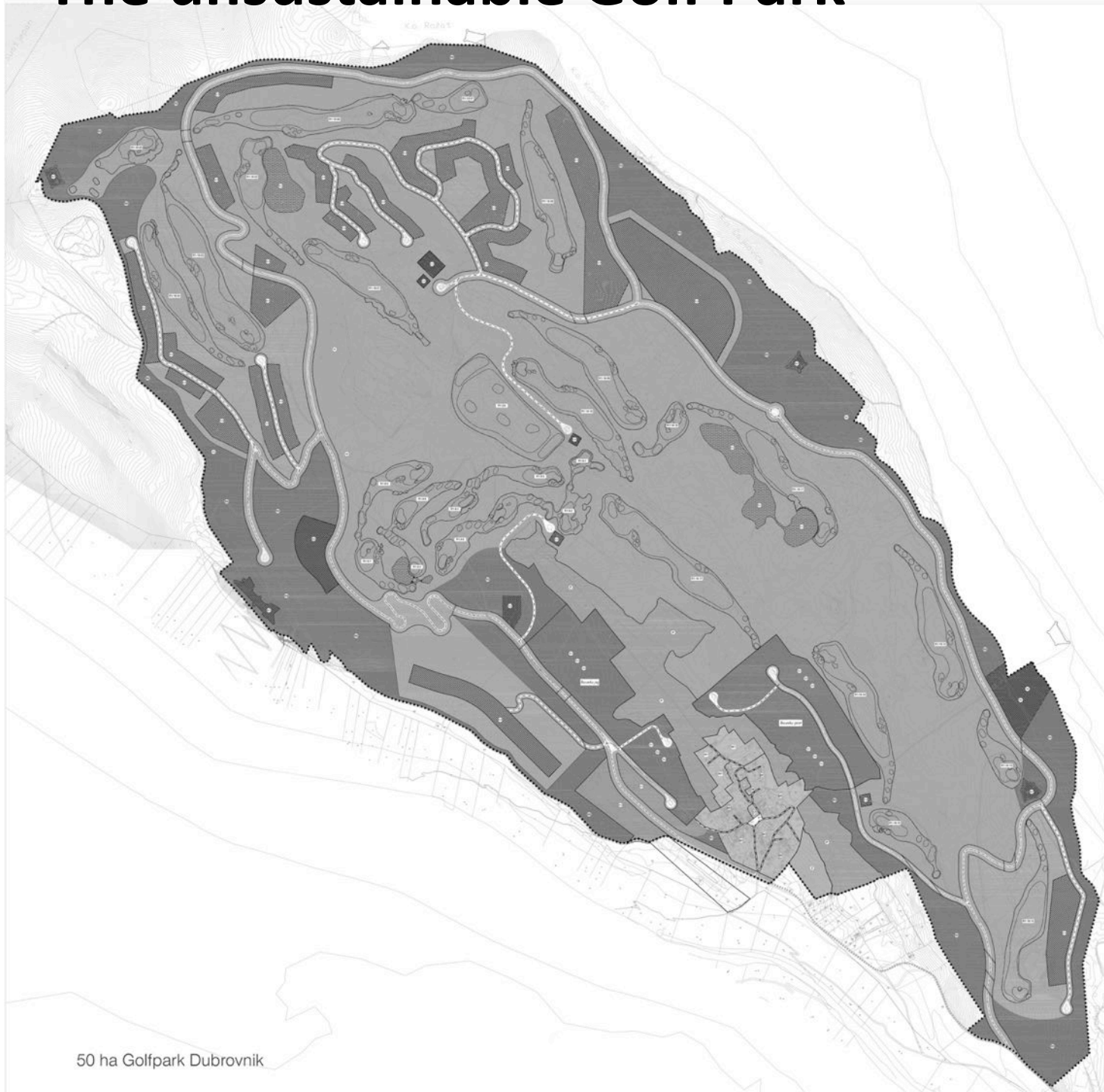
Example for a terraced house



Green façade

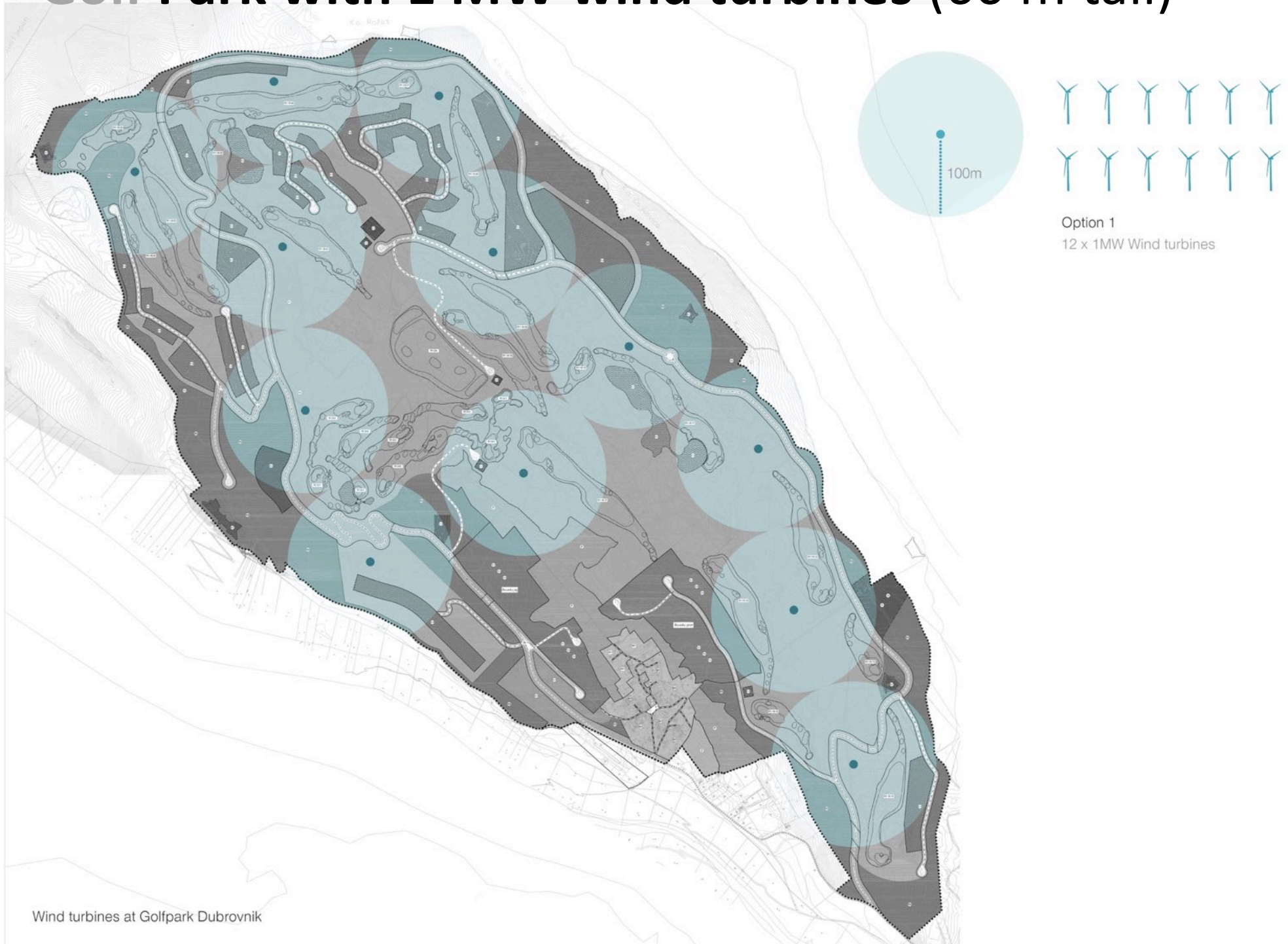


The unsustainable Golf Park

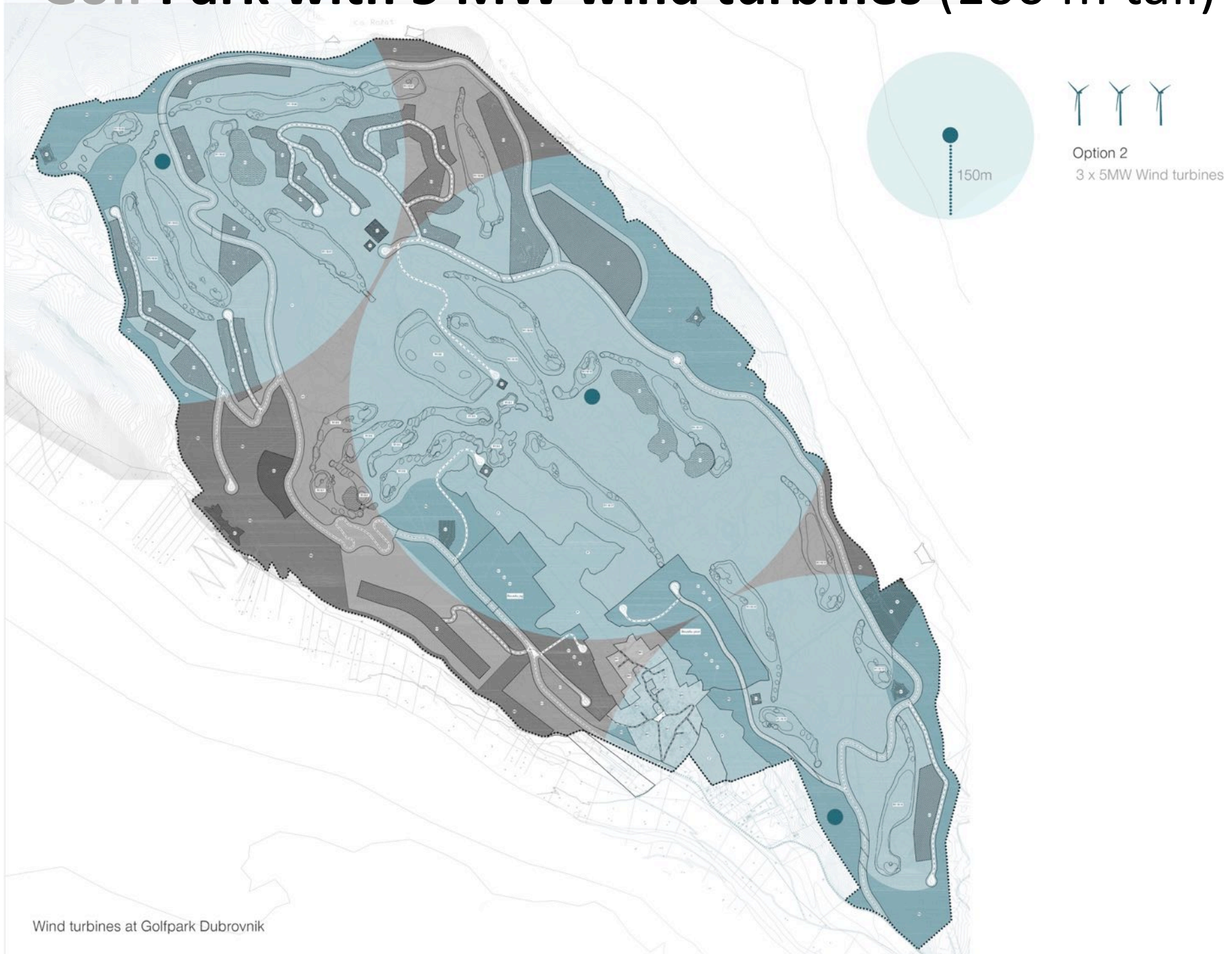


50 ha Golfpark Dubrovnik

Golf Park with 1 MW wind turbines (60 m tall)



Golf Park with 5 MW wind turbines (100 m tall)



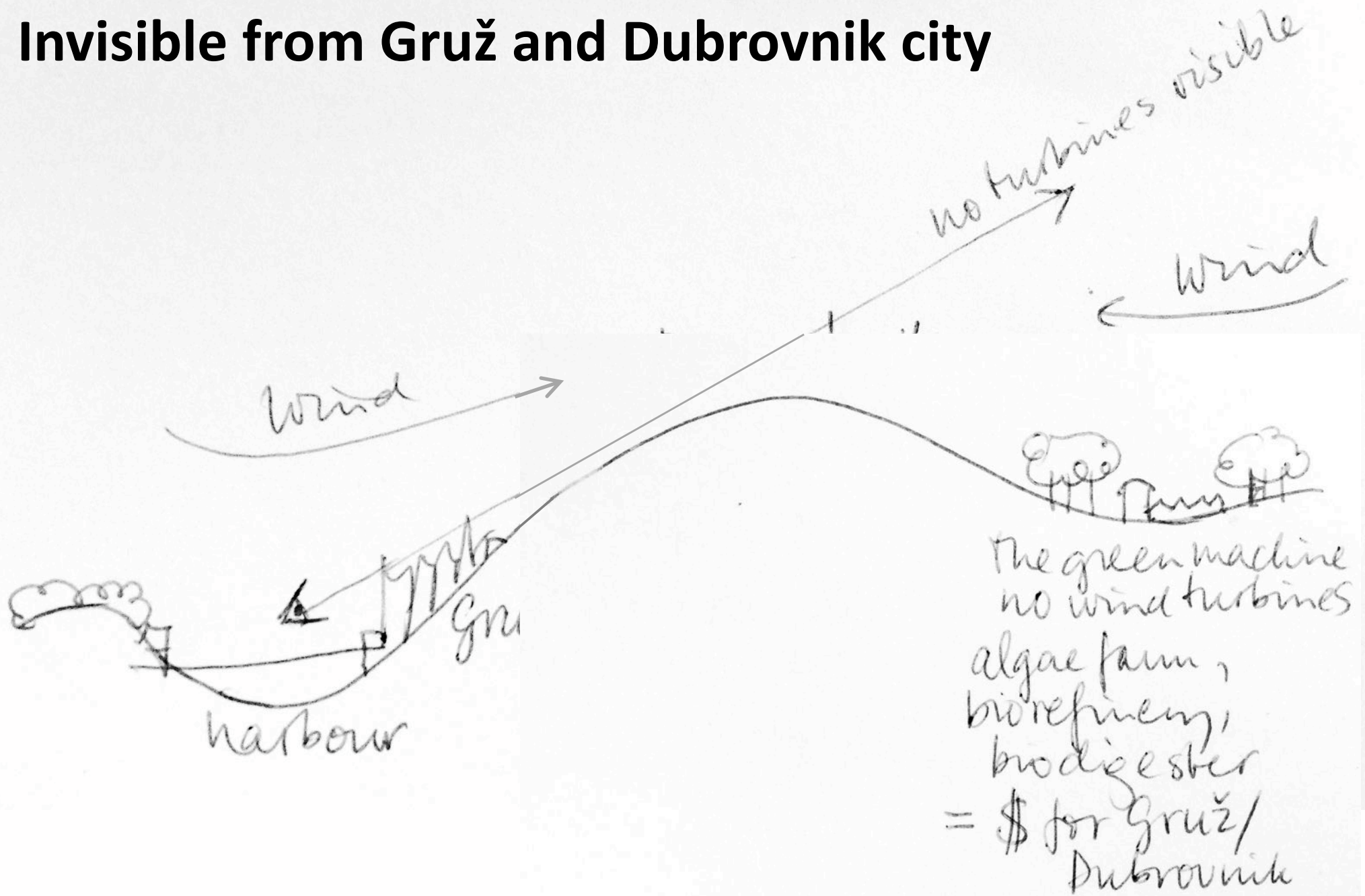
Unsustainable Golf Park



sustainable Golf Park → 16 GWh/yr **Gruž power**



Invisible from Gruž and Dubrovnik city



Golf courts can be sustainable



Wind power, PV golf carts, PV mowing machines, sheep, micro-clover, turkey manure on green



Wind turbines with hydro-power station



Wind turbines connected to a hydro-electric power plant by a channel to the valley [Max Boegl Wind]

Wind-powered water towers [GE]

Mobility: bottlenecks from Gruž to the Old Town



Mobility: bottlenecks from Gruž to the Old Town



Mobility: bottlenecks from Gruž to the Old Town



92% not satisfied with pedestrian infrastructure
100% not satisfied with biking infrastructure

[Dubrovnik energy study]



‘A developed country is not a place where the poor have cars.
It's where the rich use public transportation.’

Petro Gustavo, Mayor of Bogotá

Game of Roads: carbon-free healthy travel

- Motorway
- Main access roads
- (E-)Bike lanes
- New tramway



kiss & ride

Google

Proposal: tram - e-bike - pedestrian in shared space



Nice, France



Bruges, Belgium

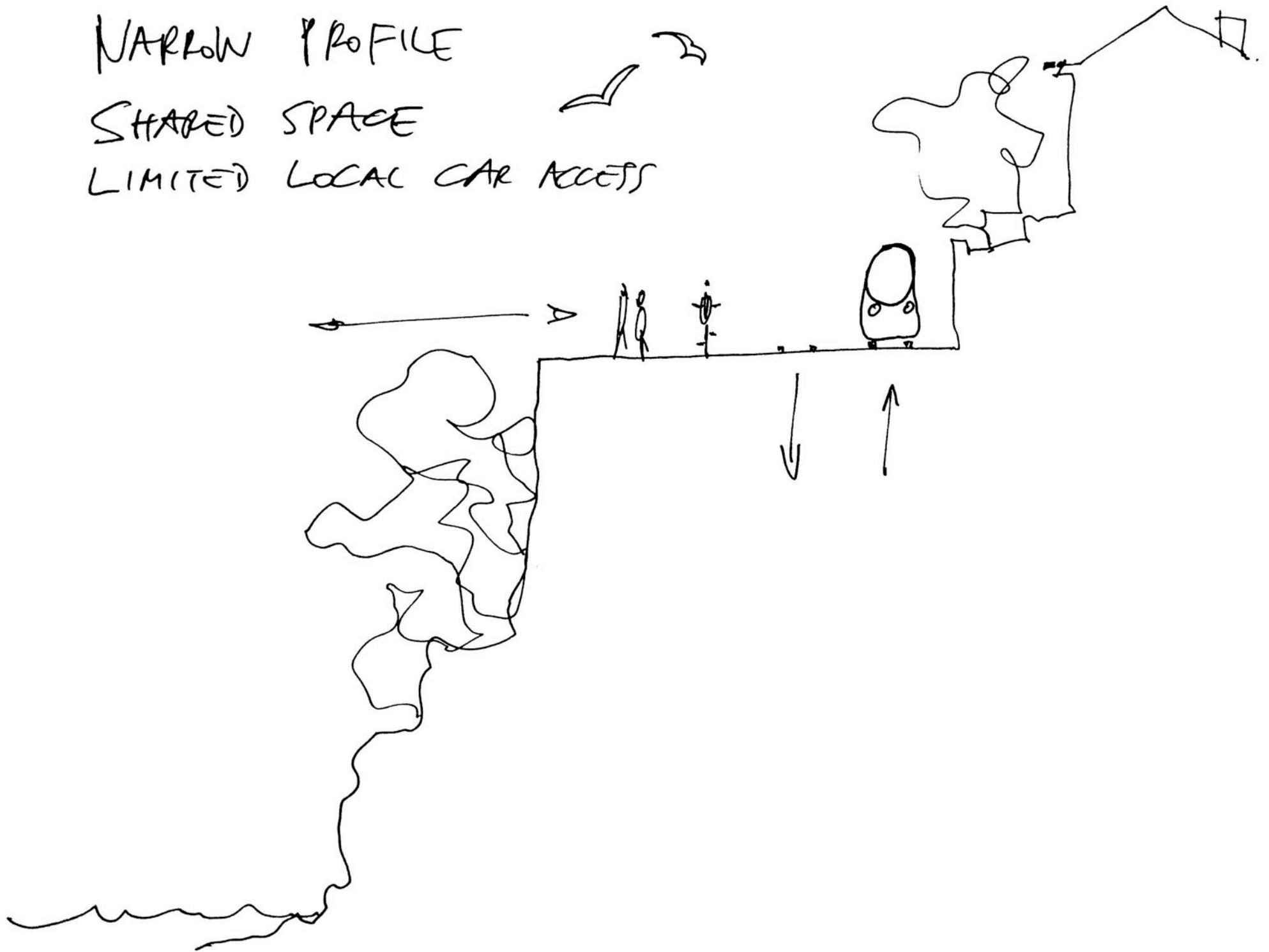


Combination with pedestrians and cyclists

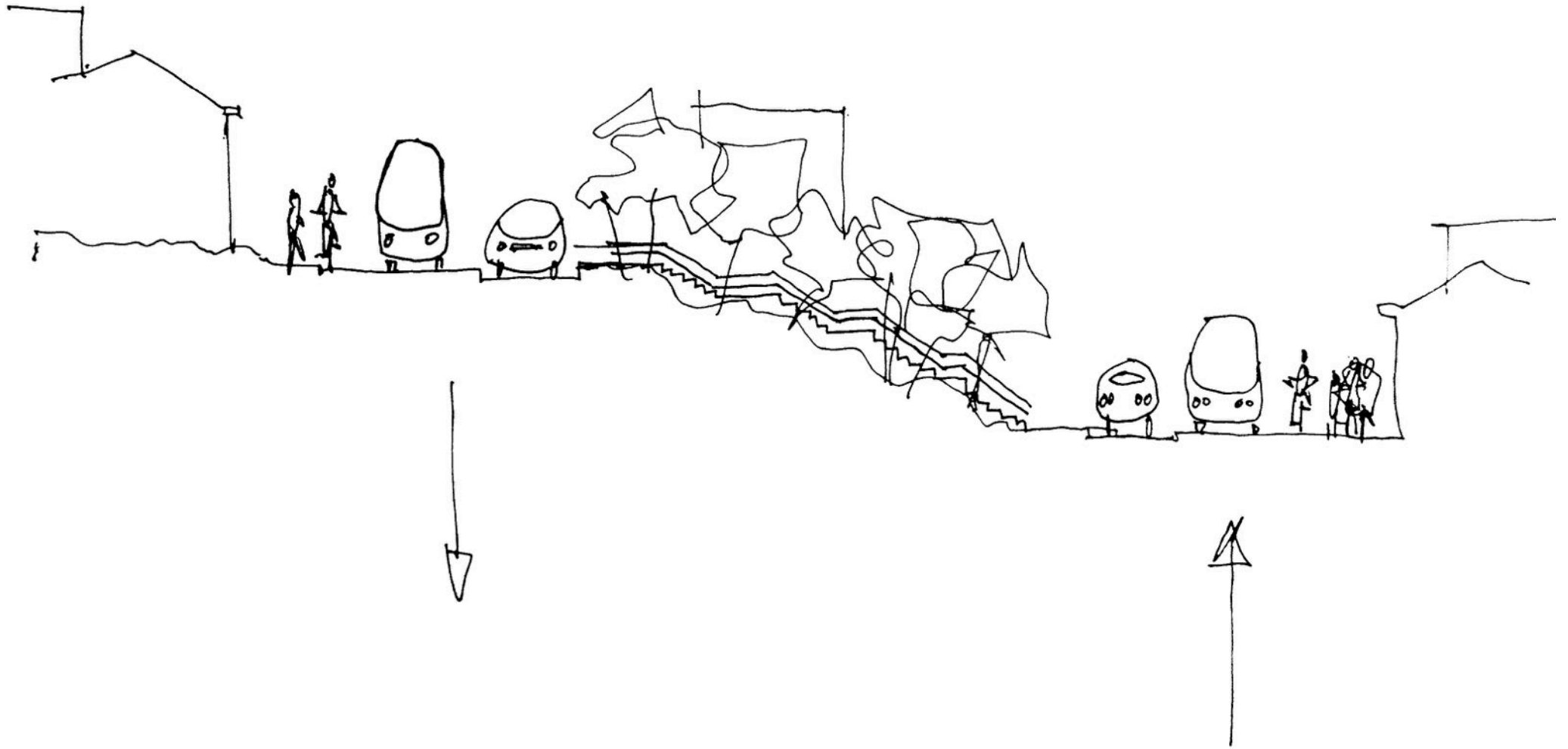
NARROW PROFILE

SHARED SPACE

LIMITED LOCAL CAR ACCESS

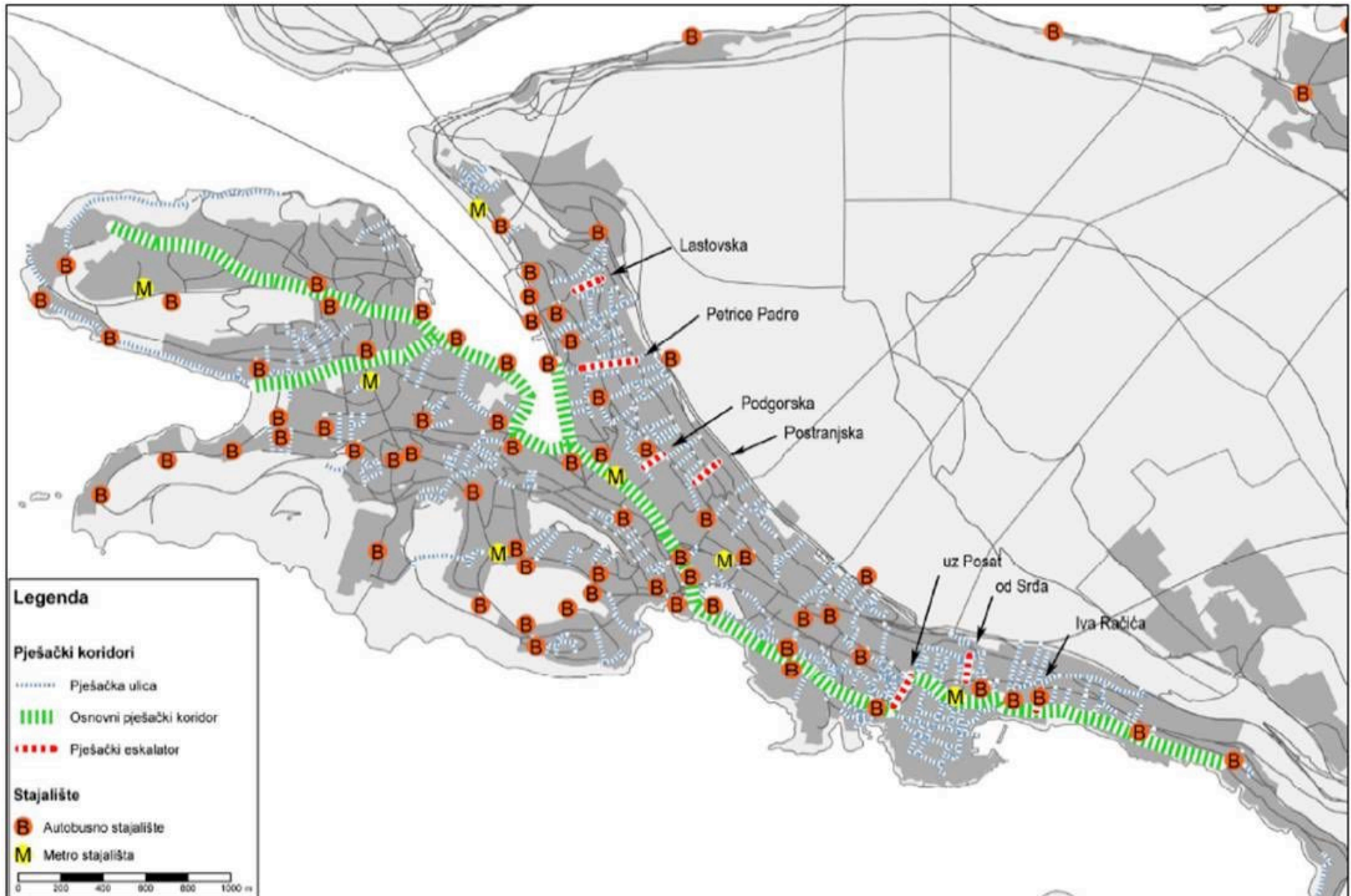


BROAD PROFILE DOUBLE ONE WAY ROADS
ONE CAR LANE PER DIRECTION



Similar proposals were formulated already before

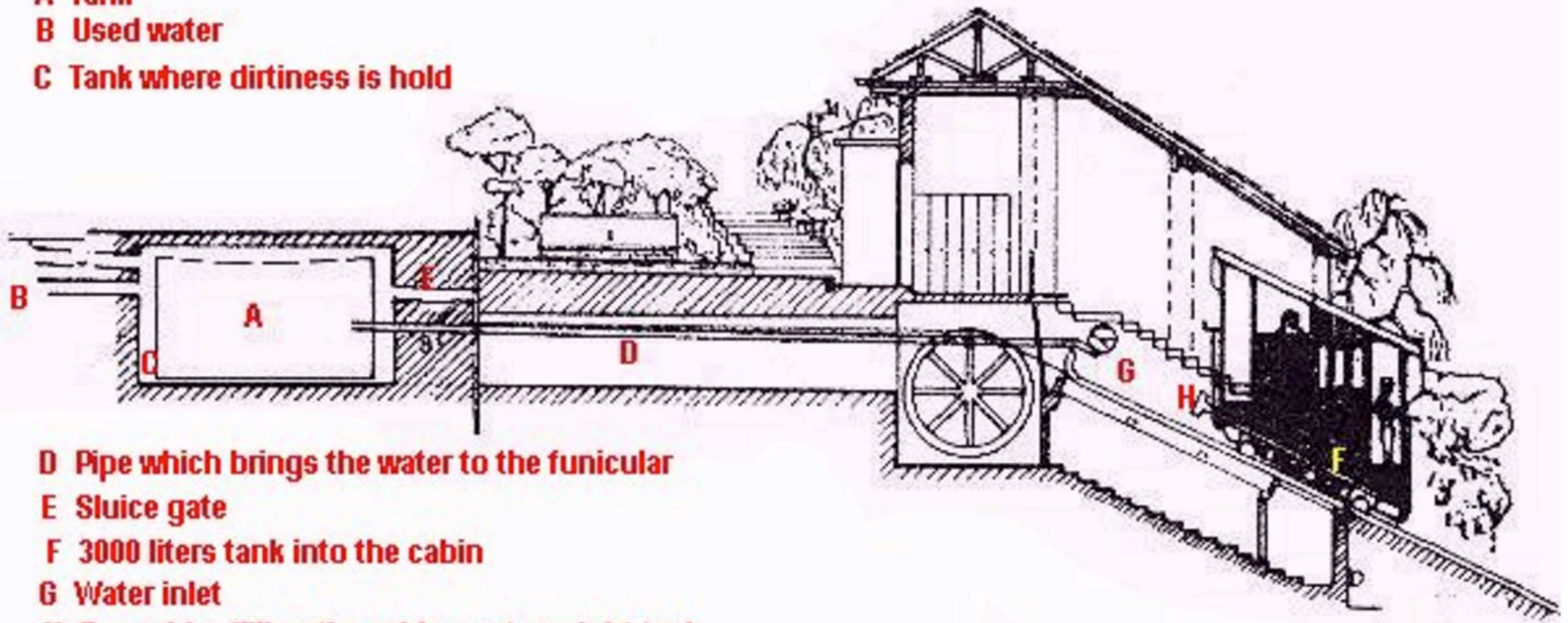
[Traffic study of Dubrovnik city, 2012]



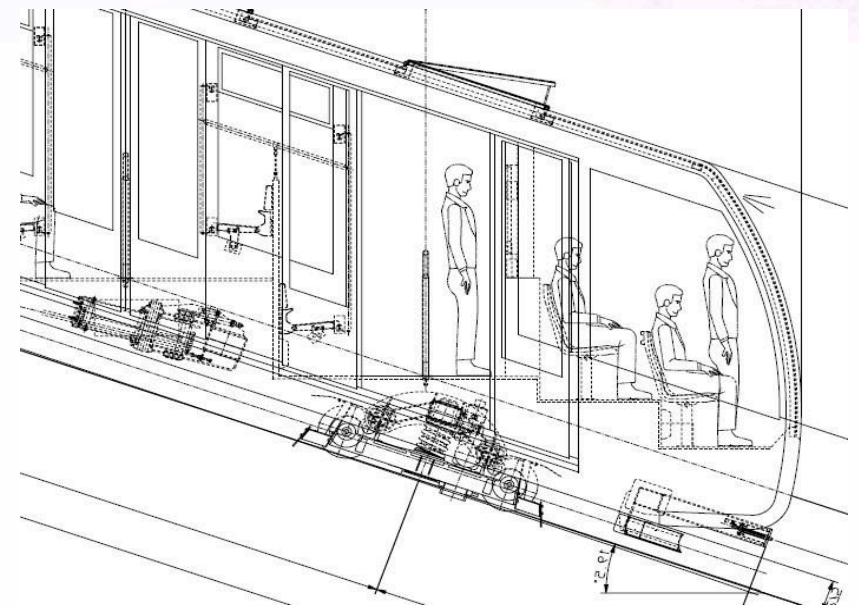
New cable cars?



- A Tank**
- B Used water**
- C Tank where dirtiness is hold**



- D Pipe which brings the water to the funicular**
- E Sluice gate**
- F 3000 liters tank into the cabin**
- G Water inlet**
- H Funnel for filling the cabin conterweight tank**



Water-powered escalator

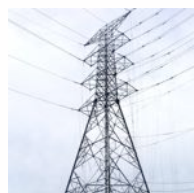
Water-powered escalator



CROATIA



annual values



Electricity demand **17.5 TWh**

Electricity production **13.6 TWh**

NET IMPORT (22.6%) **3.95 TWh**

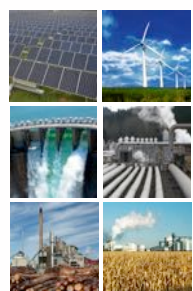


THERMO-ELECTRICITY (20%) **3.50 TWh**

natural gas (5.7%) **1.00 TWh**

oil (0.7%) **0.13 TWh**

coal (13.5%) **2.37 TWh**



RENEWABLE (57%) **10.1 TWh**

PV (0.2%) **0.035 TWh**

hydro (52.1%) **9.12 TWh**

wind (4.2%) **0.73 TWh**

geothermal -

biomass (0.9%) **165 MWh**

biofuel -



NUCLEAR

nuclear -

ELECTRICITY EMISSION FACTOR

0.341 kg CO₂eq/kWh

CARBON FOOTPRINT PER HOUSEHOLD IN GRUŽ

GRUŽ (DUBROVNIK) HOUSEHOLD

Average inhabitants 2.75
Gross floor area 100 m²

ENERGY DEMAND

Cooling electricity	1850 kWh _e /yr	} 7930 kWh/yr
Lighting & appliances	2450 kWh _e /yr	
Heating energy	900 kWh _e /yr	
Water heating	2210 kWh _e /yr	
Cooking	520 kWh _e /yr	

MOBILITY

1110 kg CO₂eq 20%
km by 1 car (80% work day) 15.3 km/day

WASTE MANAGEMENT

1726 kg CO₂eq 30%
Waste per household 1,67 t/yr
Waste to energy 0 %
Waste to landfill 89 %
Organic waste 1 %

WATER MANAGEMENT

164 kg CO₂eq 3%
Water use per household 280 m³/yr



5.92 t CO₂eq/yr



5.04 t CO₂eq/yr

CARBON FOOTPRINT
5.70 t CO₂eq/yr

*5.16 t CO₂eq per 80 m² household



CARBON FOOTPRINT OFFSET

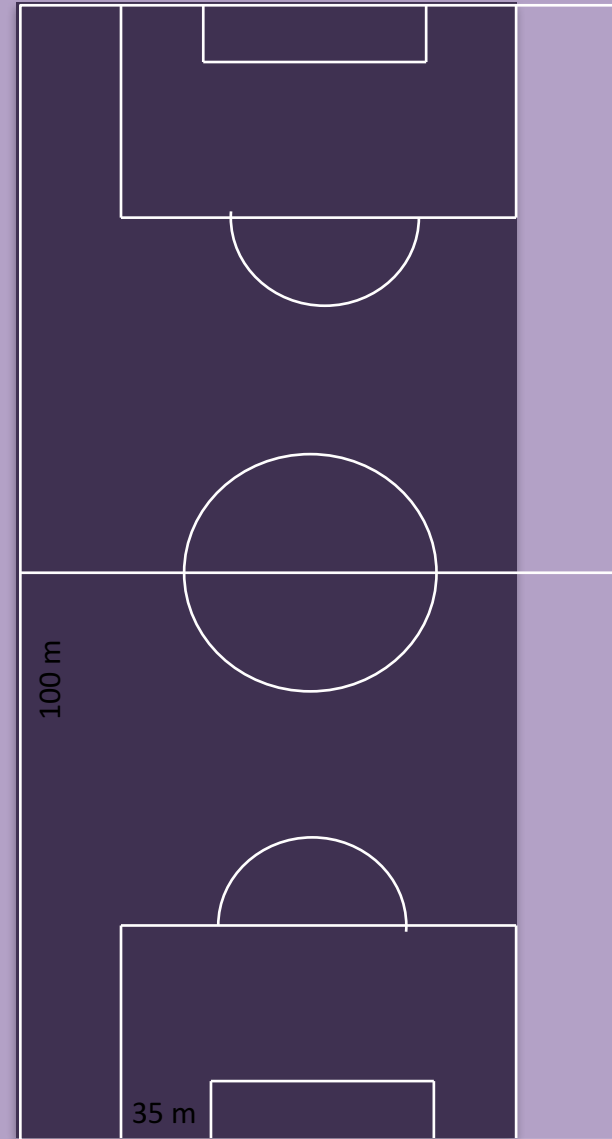
carbon uptake by urban forestry (i.e. 1.35 kg CO₂/m²)

The carbon footprint of one household is equivalent to 14,300 km driven by car



The carbon footprint offset of one household is equivalent to 0.42 ha forestland

*0.38 ha per 80 m² household



CARBON FOOTPRINT OF GRUŽ

Total area: **47.25 ha**

Inhabitants/house: 2.75

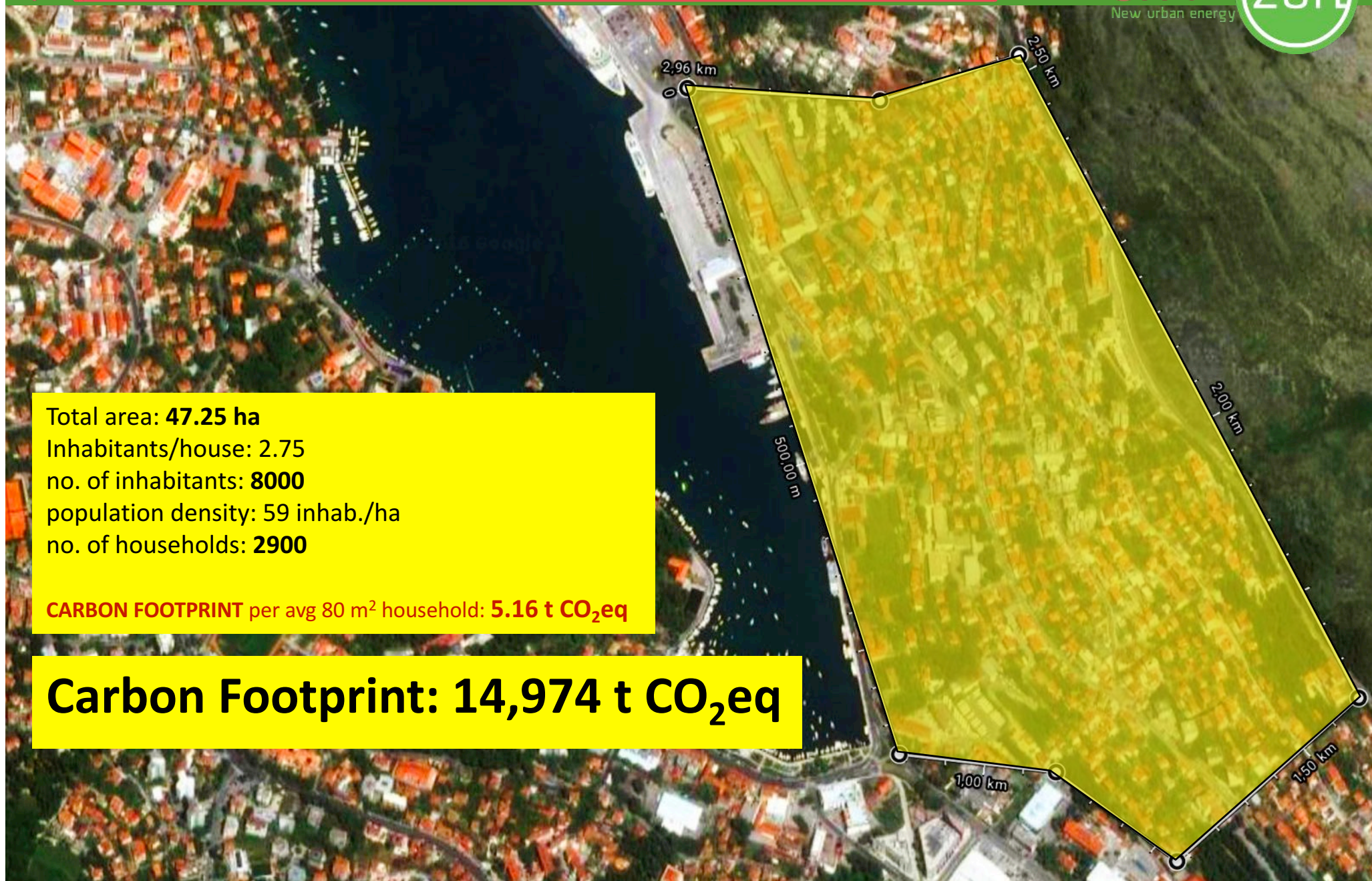
no. of inhabitants: **8000**

population density: 59 inhab./ha

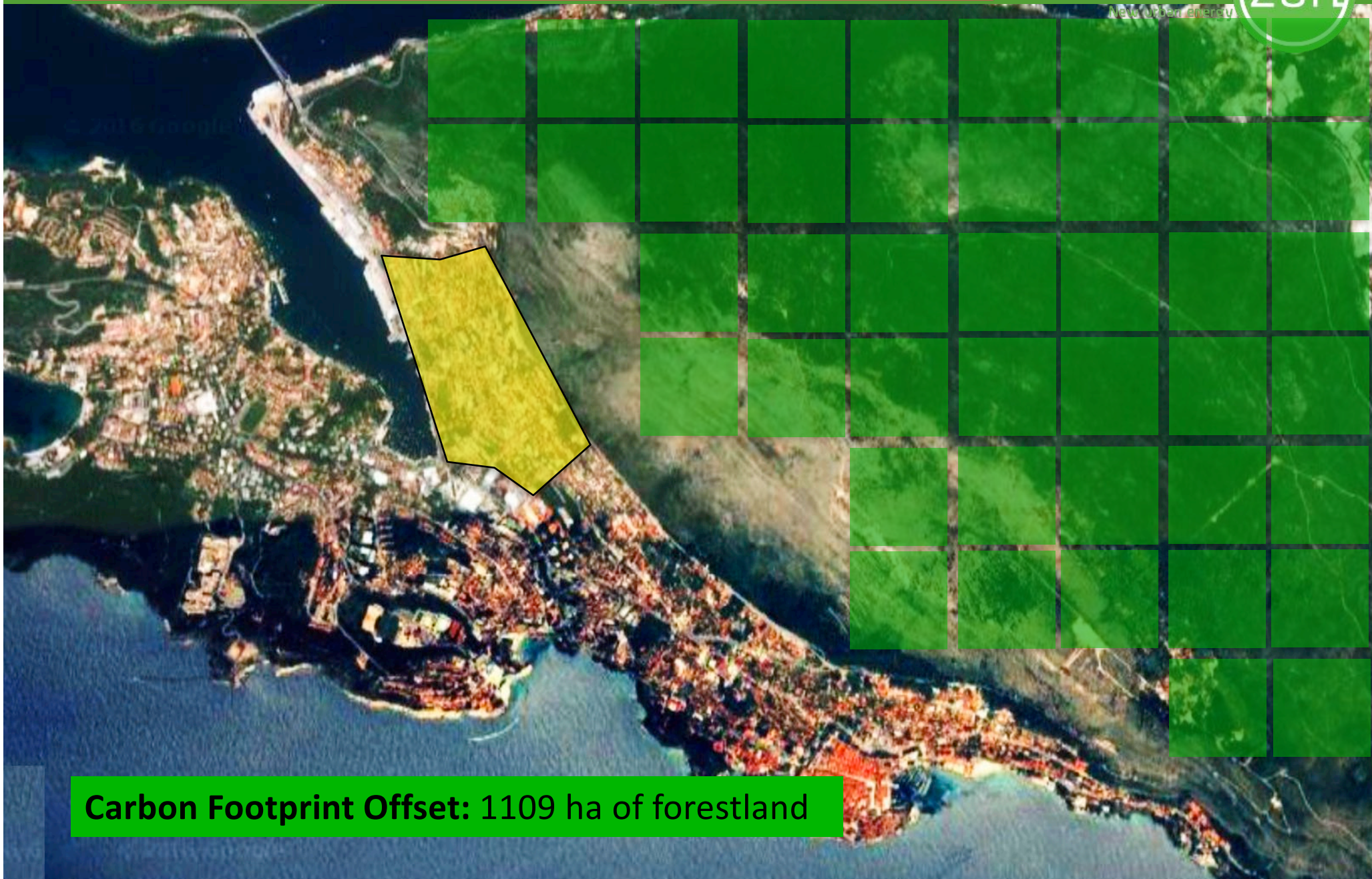
no. of households: **2900**

CARBON FOOTPRINT per avg 80 m² household: **5.16 t CO₂eq**

Carbon Footprint: 14,974 t CO₂eq



CARBON FOOTPRINT OFFSET OF GRUŽ

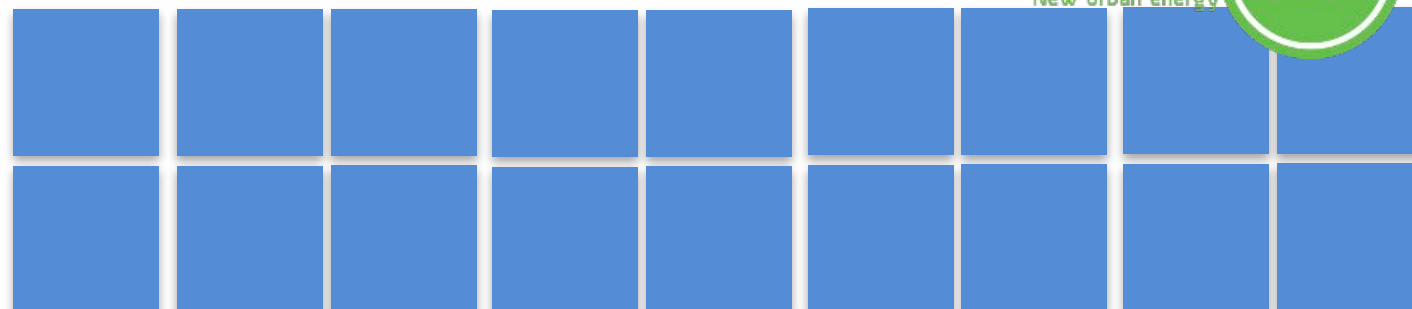


Carbon Footprint Offset: 1109 ha of forestland

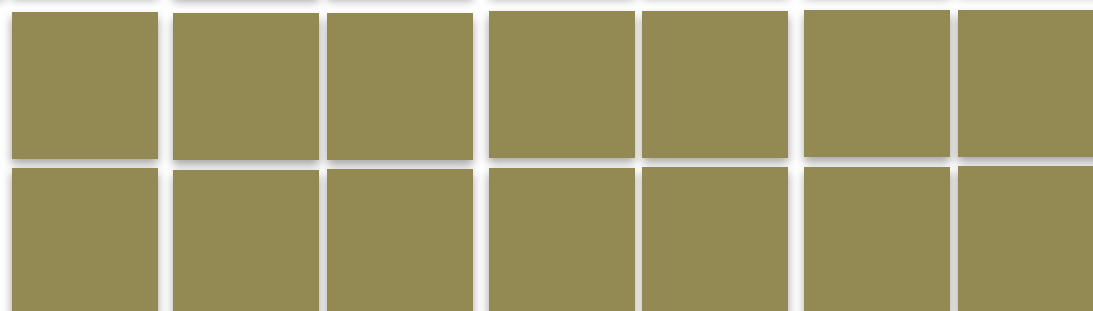
CARBON FOOTPRINT OFFSET OF GRUŽ



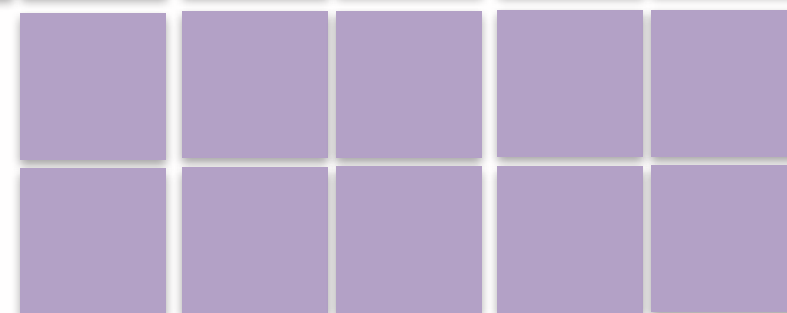
Electricity demand: 18,400 MWh/yr
42% CF = 465 ha



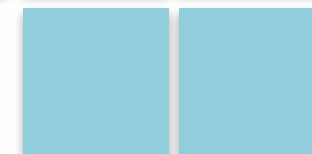
Waste management: 4360 t/yr
33% CF = 371 ha



Mobility system: 8.9 M km/yr driven by car
22% CF = 239 ha

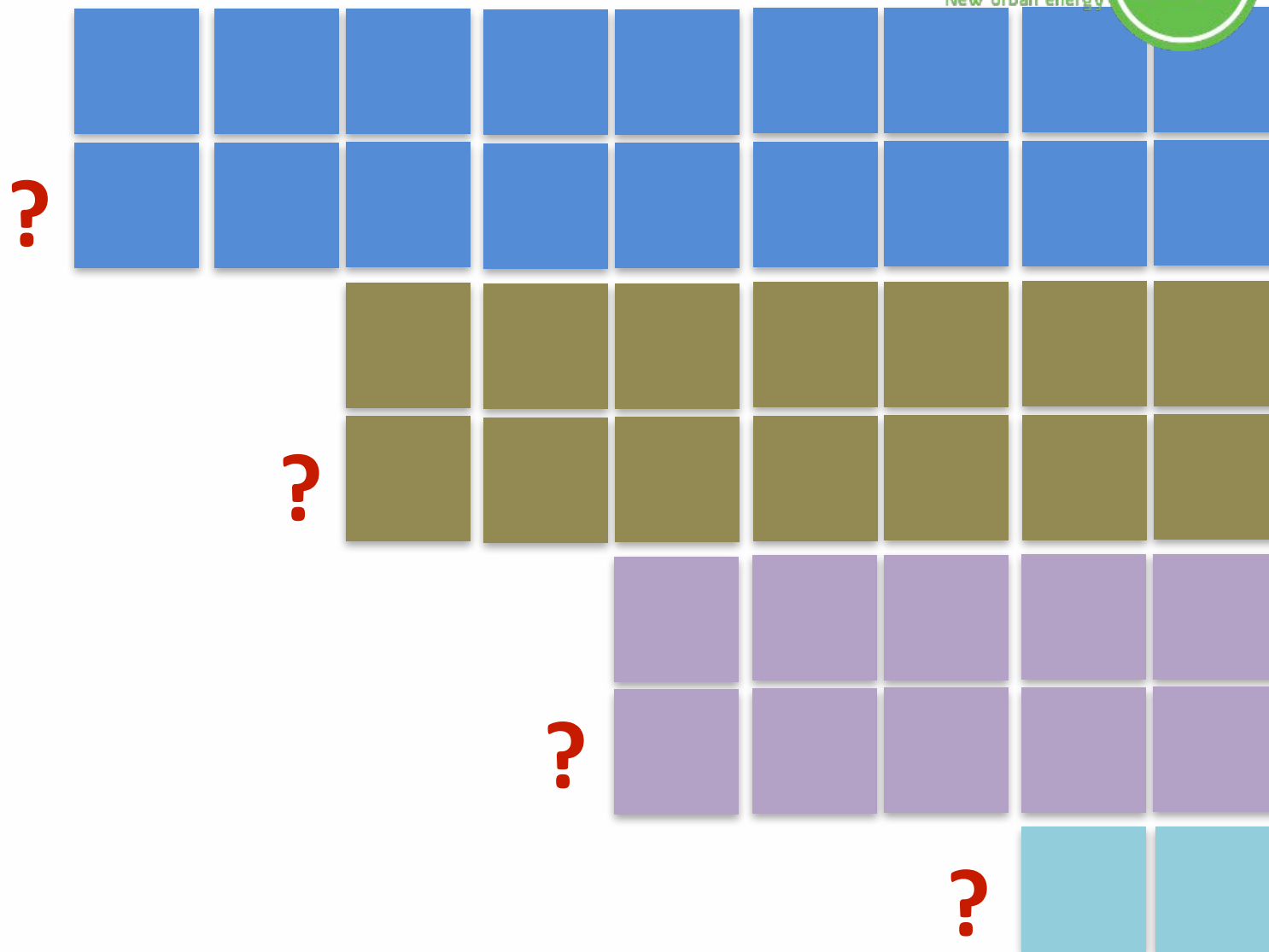


Water management: 811,700 m³/yr
3% CF = 35 ha



Carbon Footprint Offset: 1109 ha of forestland

CARBON FOOTPRINT OFFSET OF GRUŽ



Carbon Footprint Offset: 1109 ha of forestland

ENERGY MEASURES

Energy efficiency assessment

- **Roof and façade shading**
 - Reduction of cooling demand: 10%
 - For 50% of households
- **Greening the building**
 - Reduction of cooling demand: 10%
 - For 60% of households
- **Insulation of roofs/walls/glazing**
 - Reduction of heating demand: 35%
 - Reduction of cooling demand: 5%
 - For 80% of households
- **Greening the street block**
 - Reduction of cooling demand: 5%
 - For all buildings

ENERGY MEASURES

Solar energy production assessment

- **Big potential for solar energy production**
 - 2480 hours of sunshine per year
 - Average solar irradiation: 1810 kWh/m² (SW orientation)
 - Good orientation of buildings (mainly parallel to coast)
 - 73% pitched roofs (35°) → 6% South-East (SE) ; 6% South (S); 61% South-West (SW)
 - 27% flat surfaces → free choice
 - Big apartment blocks → wall surfaces available
- **Proposed solution for Gruž area**
 - ± 750 roofs available
 - Average roof area: 80 m² (useful: 24 m² for PV, 2 m² for solar panels)
 - Orientation of panels on roofs: 20% SE; 20% S ; 60% SW
 - 285 m² of apartment walls SE and SW orientated
- **Total production for Gruž area**
 - 3616 MWh electricity
 - 685 MWh hot water

ENERGY MEASURES

Assessment for heat pumps

- **Big potential for heat pumps**
 - Suitable for space heating, district heating and cooling
 - More efficient than conventional electric heating
- **Proposed solution for Gruz area**
 - Air source heat pump for 50% of households
 - COP heating season: 3
 - COP cooling season: 4
- **Total energy savings: 26%**

Wind energy production assessment

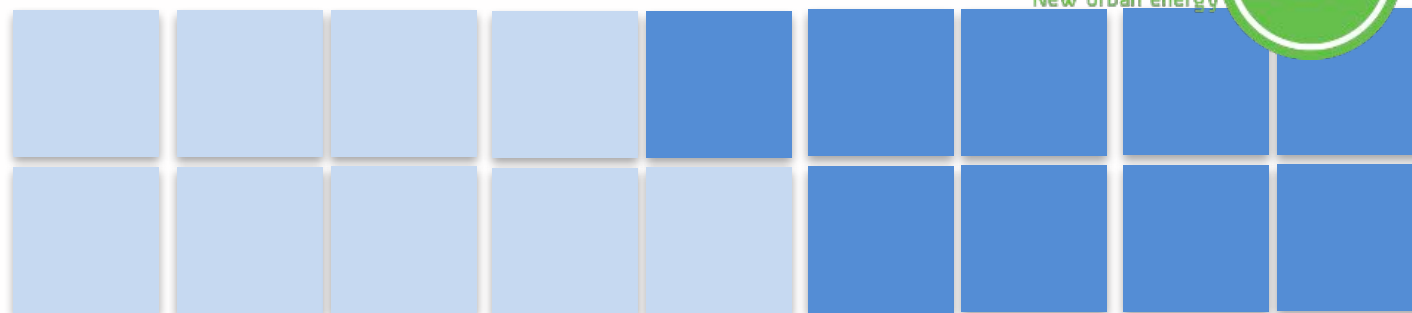
- **Small wind turbines**
 - Limited potential
 - Quite expensive
 - Proposed for Gruž: 50 x 5 kW wind turbines
 - 1300 full load hours (wind velocity 5 m/s)
 - **Total renewable energy production: 325 MWh**

- **Big wind turbines**
 - Great technical potential behind the hills
 - Building permit might be problem
 - Proposed for Gruž: 12 x 1 MW wind turbines
 - 1300 full load hours (wind velocity 5 m/s)
 - **Total renewable energy production: 15,600 MWh**

CARBON FOOTPRINT OFFSET OF GRUŽ



Integrated energy measures
9,000 MWh = - 235 ha



1

Roof and facade shading

Applied to 50% households
- Cooling energy -10%

CF 98.8%

2

Building greening up

Applied to 60% households
- Cooling energy -10%

CF 97.5%

3

Building envelope insulation

Applied to 80% households
- Heating energy - 35%
- Cooling energy - 5%

CF 93.5%

4

Solar PV & thermo-panels

Applied to all feasible surfaces
- Water heating -13%
- Electricity (appliances) -52%

CF 70.1%

5

Greening street blocks

Applied to street blocks
- Cooling demand -5%

CF 69.1%

6

Heat pump system

Applied to 50% households
- Total energy -26%

CF 51.1%

7

Mini-wind turbine

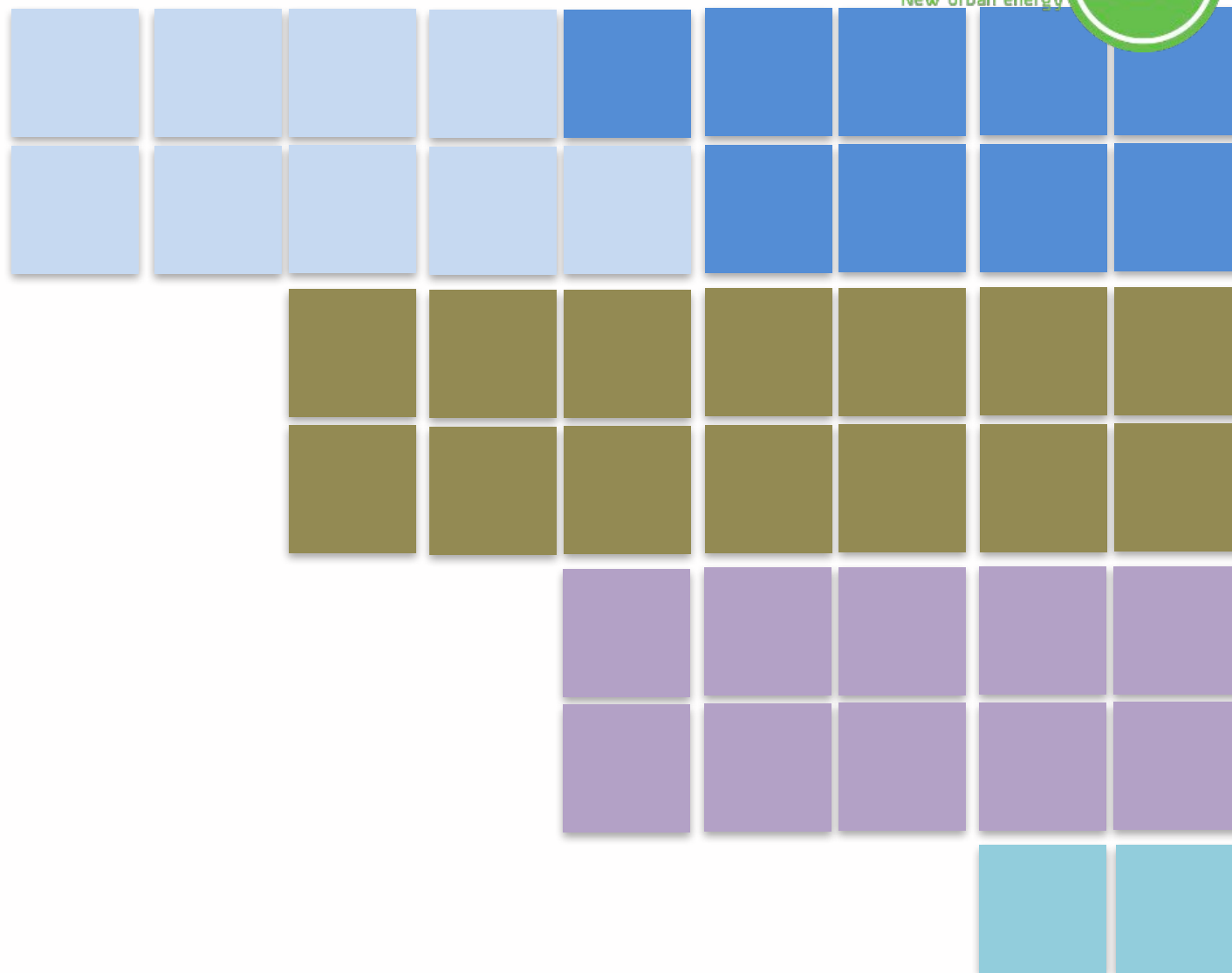
50 installed
- Total energy -4%

CF 49.4%

CARBON FOOTPRINT OFFSET OF GRUŽ



Integrated energy measures
9,000 MWh = - 235 ha



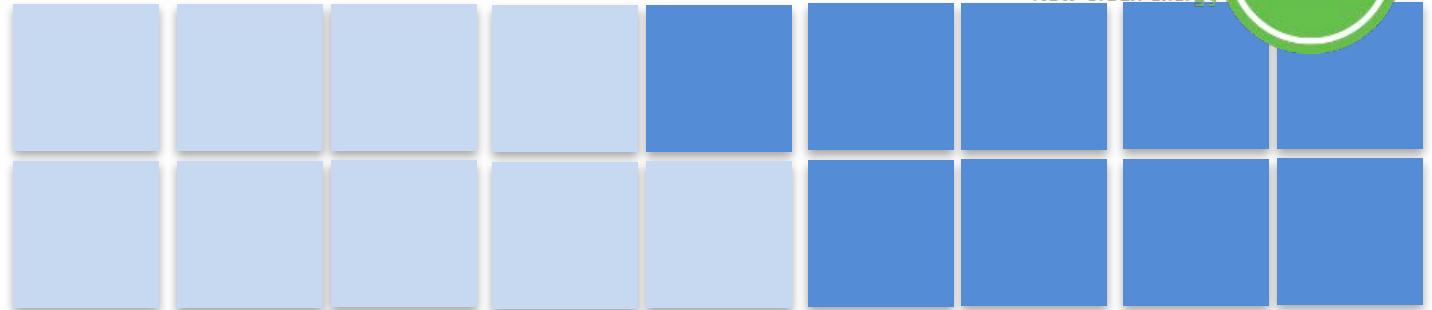
CARBON ACCOUNTING EXPLAINED

CARBON FOOTPRINT OFFSET OF GRUZ (DUBROVNIK)



Integrated energy measures

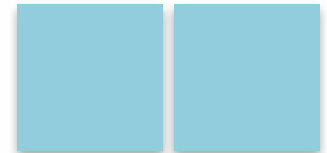
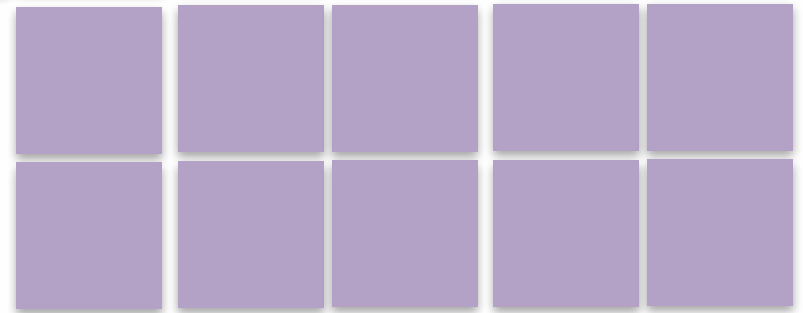
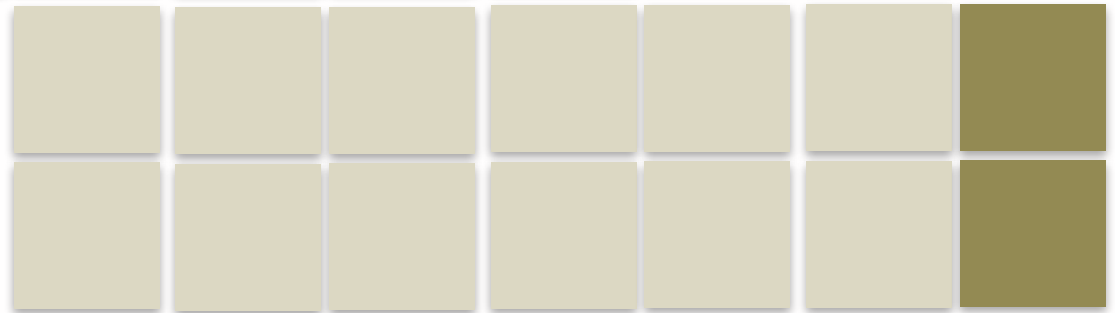
9,000 MWh = - 235 ha



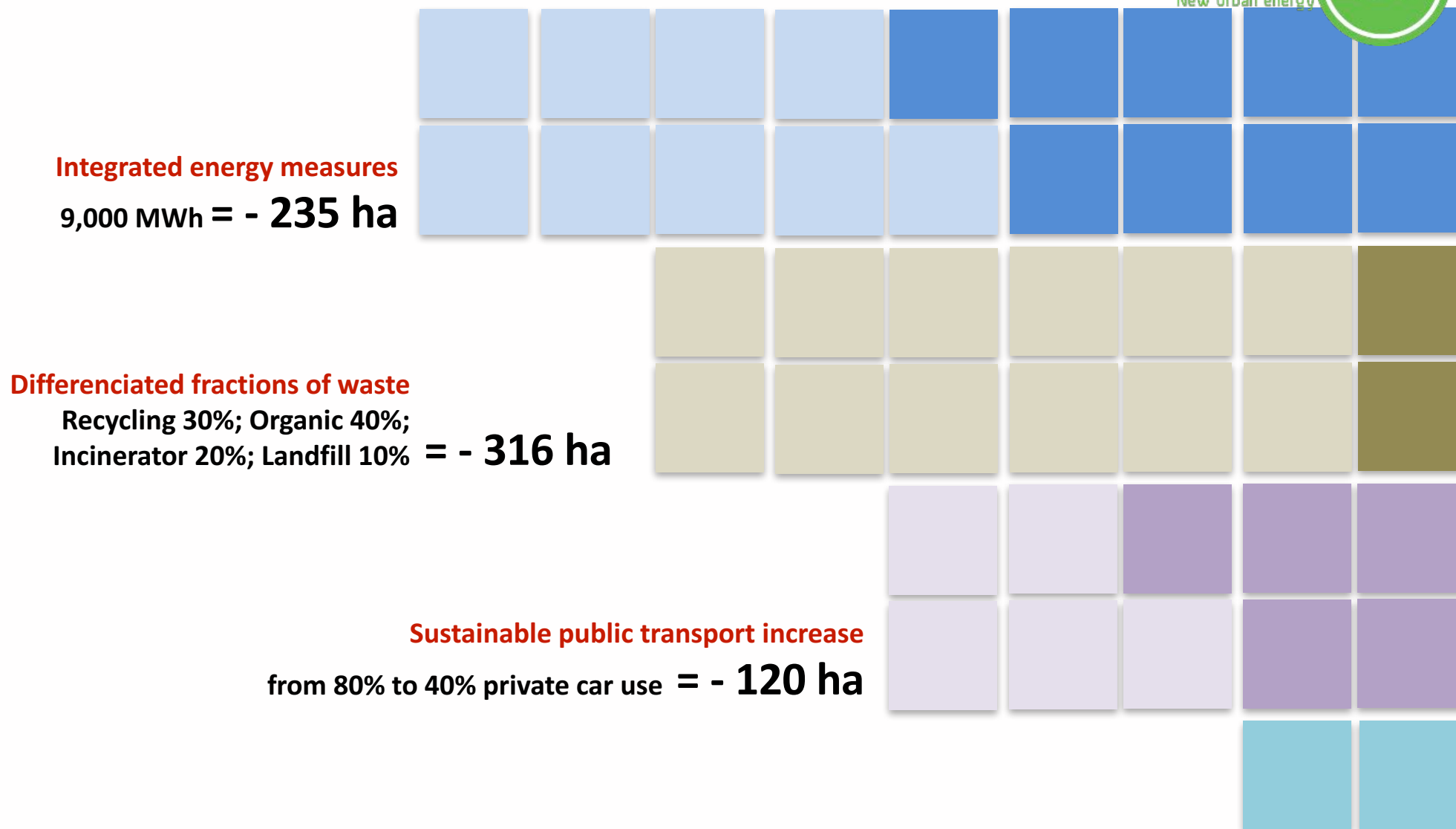
Differentiated fractions of waste

Recycling 30%; Organic 40%;

Incinerator 20%; Landfill 10% = - 316 ha



CARBON FOOTPRINT OFFSET OF GRUŽ

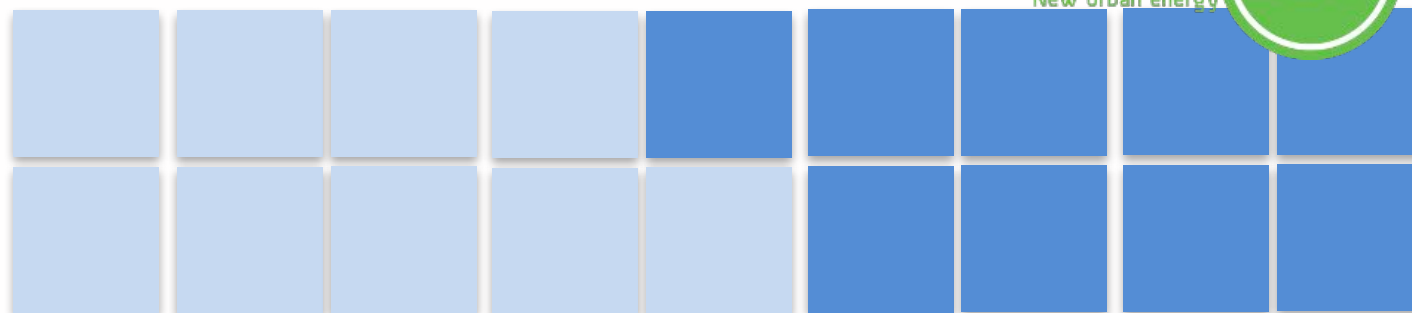


CARBON FOOTPRINT OFFSET OF GRUŽ



Integrated energy measures

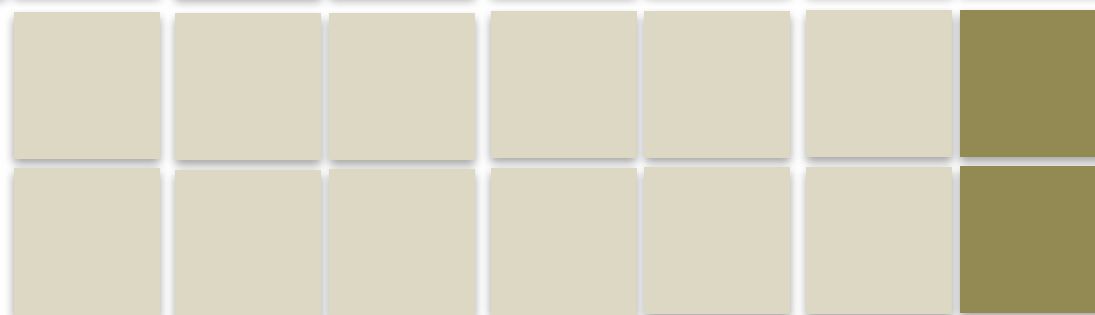
9,000 MWh = - **235 ha**



Differentiated fractions of waste

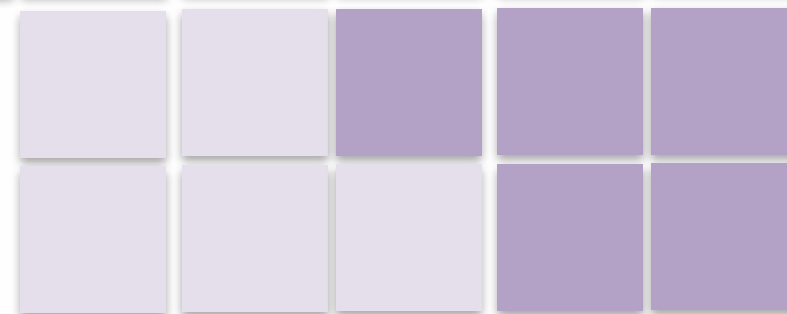
Recycling 30%; Organic 40%;

Incinerator 20%; Landfill 10% = - **316 ha**



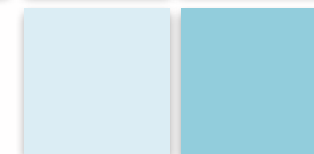
Sustainable public transport increase

from 80% to 40% private car use = - **120 ha**



Water saving

Rainwater collection for gardening = - **10 ha**



CARBON FOOTPRINT OFFSET OF GRUŽ



+ WIND FARM

12 x 1 MW turbine = - 394 ha

Integrated energy measures

9,000 MWh = - 235 ha

Differentiated fractions of waste

Recycling 30%; Organic 40%;

Incinerator 20%; Landfill 10% = - 316 ha

Sustainable public transport increase

from 80% to 40% private car use = - 120 ha

Water saving

Rainwater collection for gardening = - 10 ha

Carbon Footprint Offset: 36 ha of forestland

Conclusion

- **With a realistic set of measures and some reforestation, Gruž ...**
 - can be made energy neutral and carbon neutral
 - will have its own energy cooperation
 - will become resilient, healthier and much more liveable
- **There are great potentials in a large green energy plant, for ...**
 - waste water processing of cruise ships (cleaner ocean)
 - production of biogas, biodiesel, fibres and nutrients
 - food and bio-based material production
 - job creation
 - money making, for Dubrovnik and the local population of Gruž
 - health and safety





Thank you, Dank u wel, Grazie mille, Go raibh maith agat!
Hvala!



Co-funded by the European Union's Seventh Programme for research, technological development and demonstration