'The CITY-zen Dubrovnik (Gruž) Roadshow'

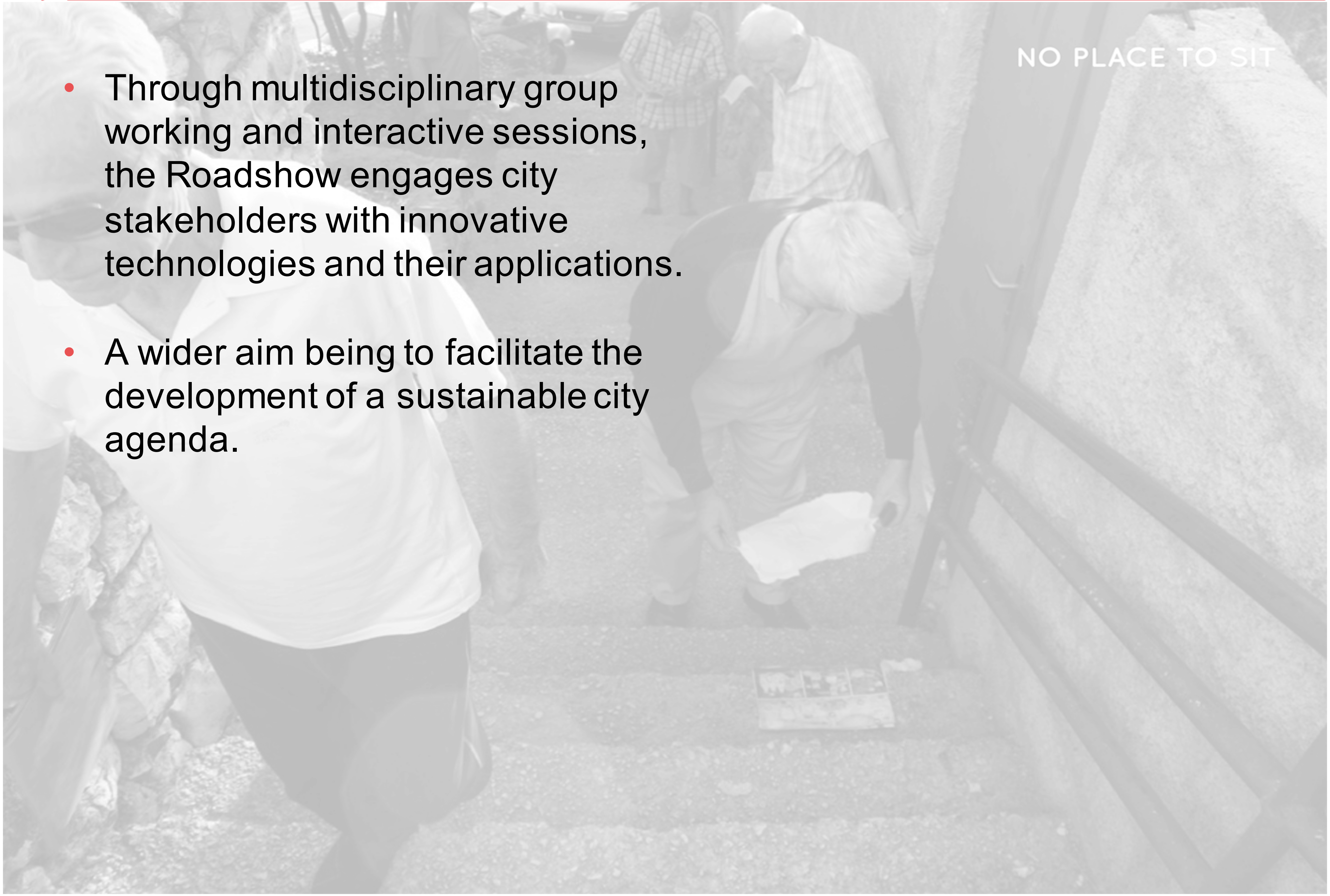
CITY-zen
New urban energy

THE CITY VISION

Monday 31st Oct to Friday 4th Nov 2016
Hosted by DURA – The City of Dubrovnik Development Agency

TU Delft
Technische Universiteit Delft
Queen's University Belfast
vito
vision on technology
Th!nk E
DURA
Razvojna agencija Grada Dubrovnika
City of Dubrovnik Development Agency
EE INFO
Info ured za energetsku efikasnost
Energy Efficiency Info Office
University of Zagreb

AIMS & AMBITION

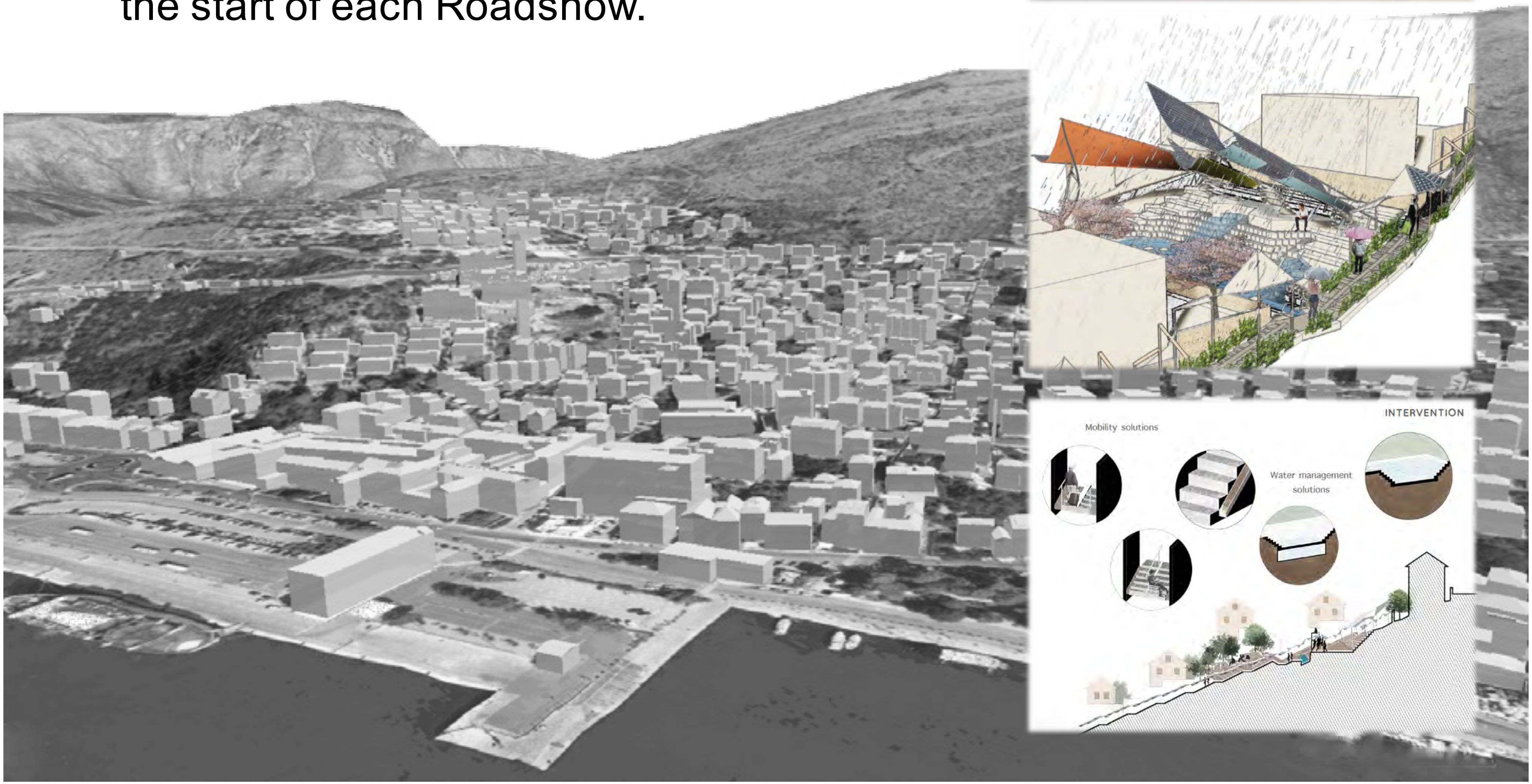


- Through multidisciplinary group working and interactive sessions, the Roadshow engages city stakeholders with innovative technologies and their applications.

- A wider aim being to facilitate the development of a sustainable city agenda.

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.

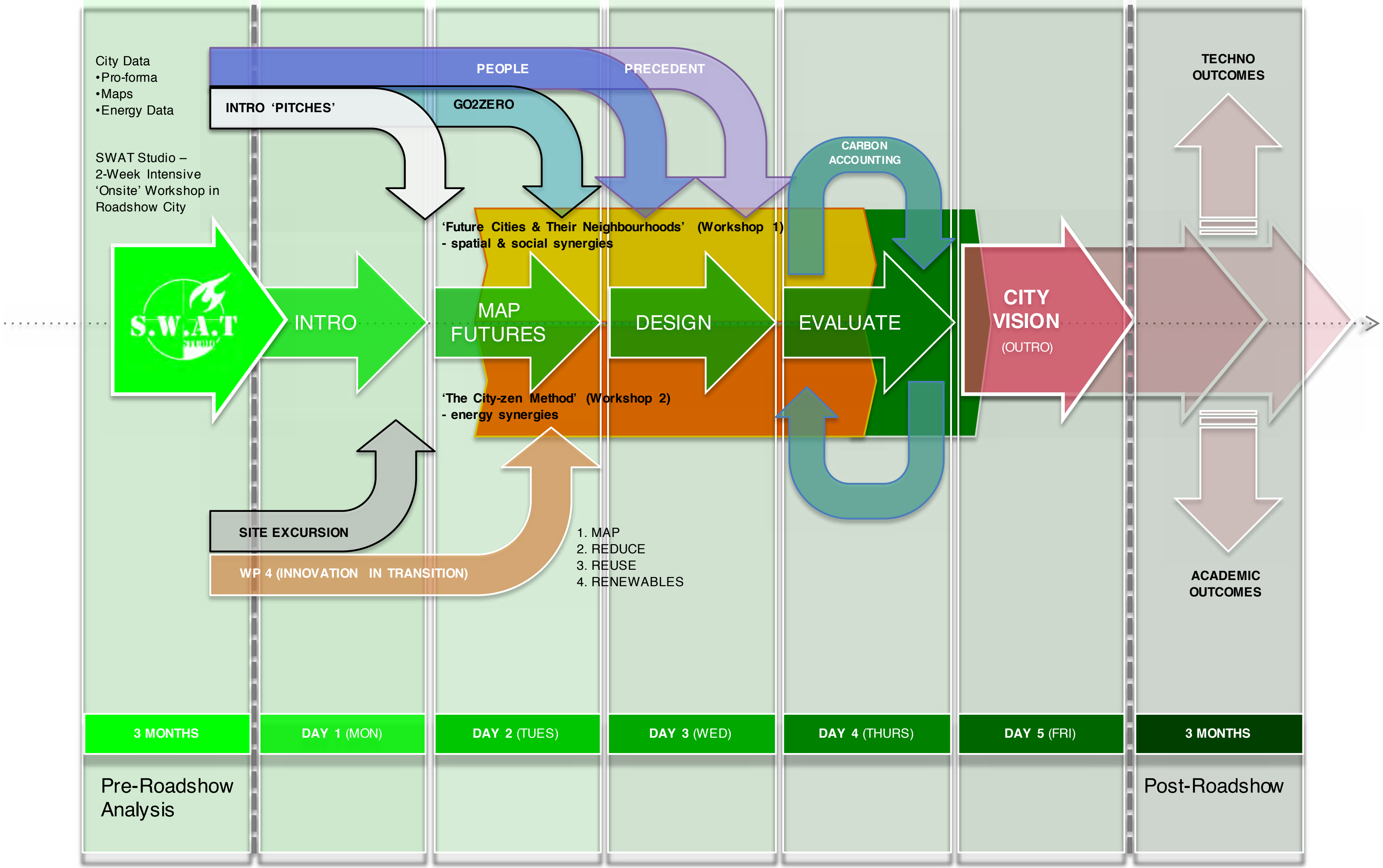


DAILY ACTIVITIES

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

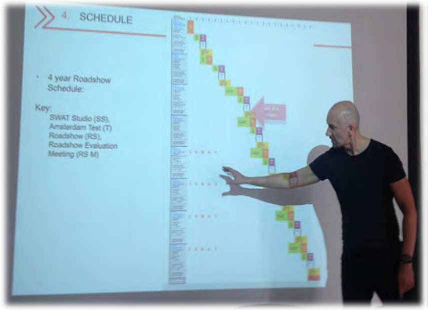
City Data
- Pro-forma
- Maps
- Energy Data

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

INTRO ‘PITCHES’

S.W.A.T STUDIO

INTRO

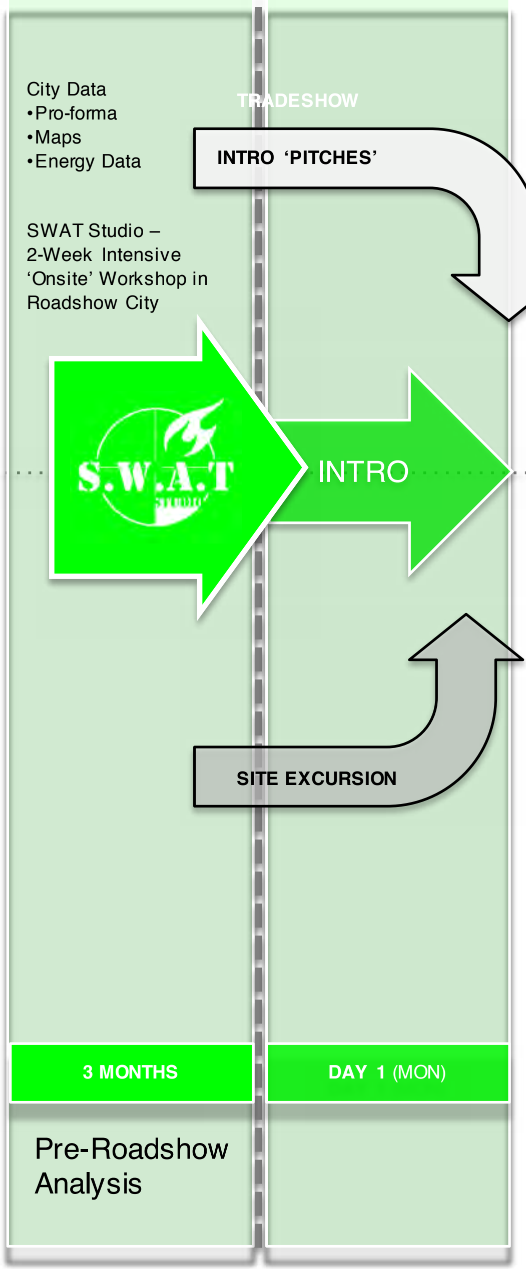


3 MONTHS

DAY 1 (MON)

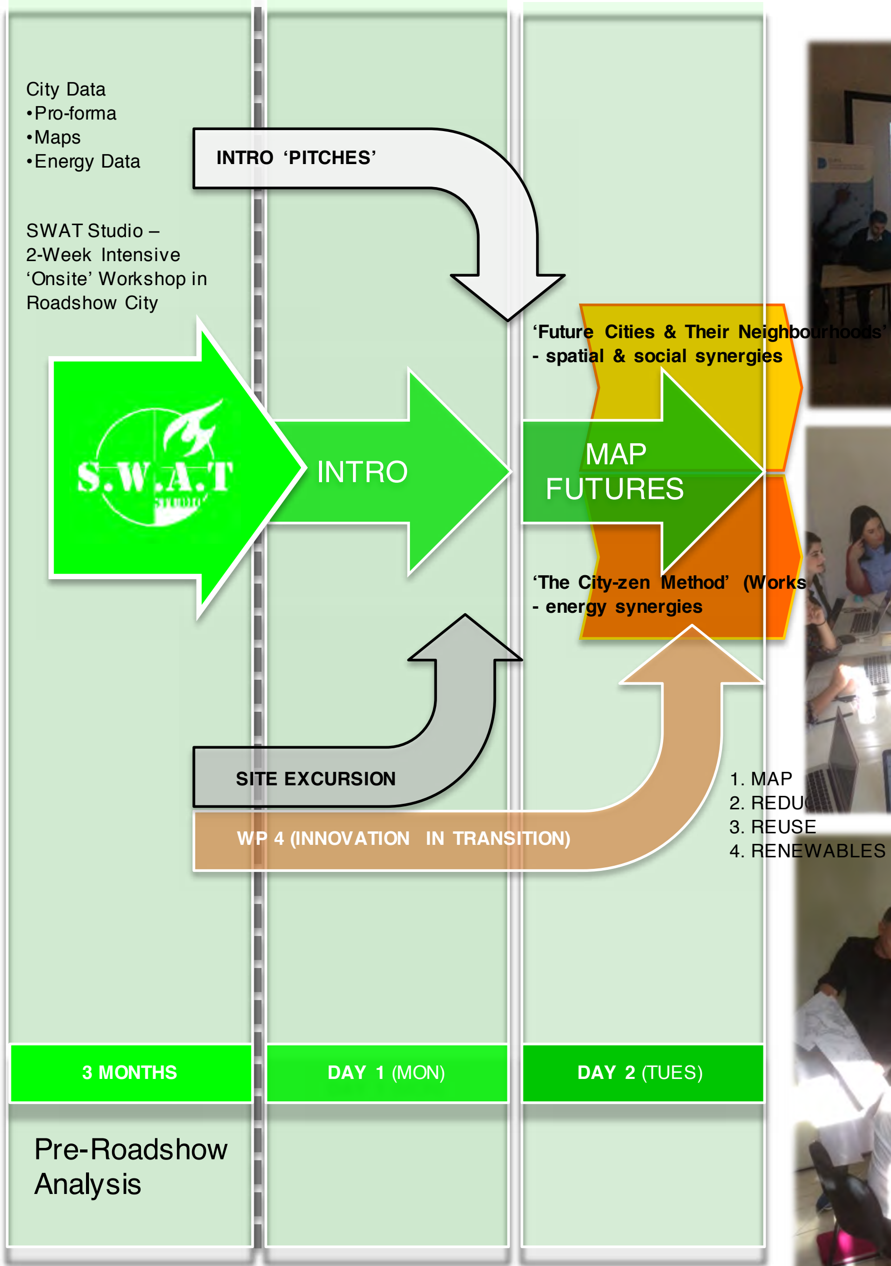
Pre-Roadshow Analysis

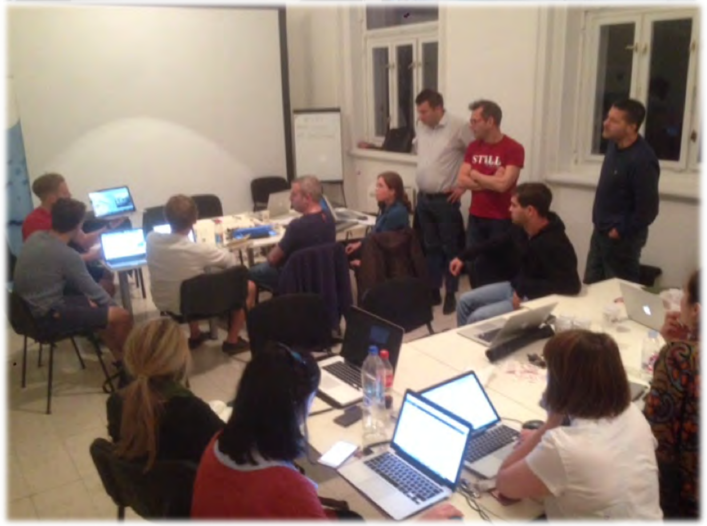
DAY 1 - SITE EXCURSION



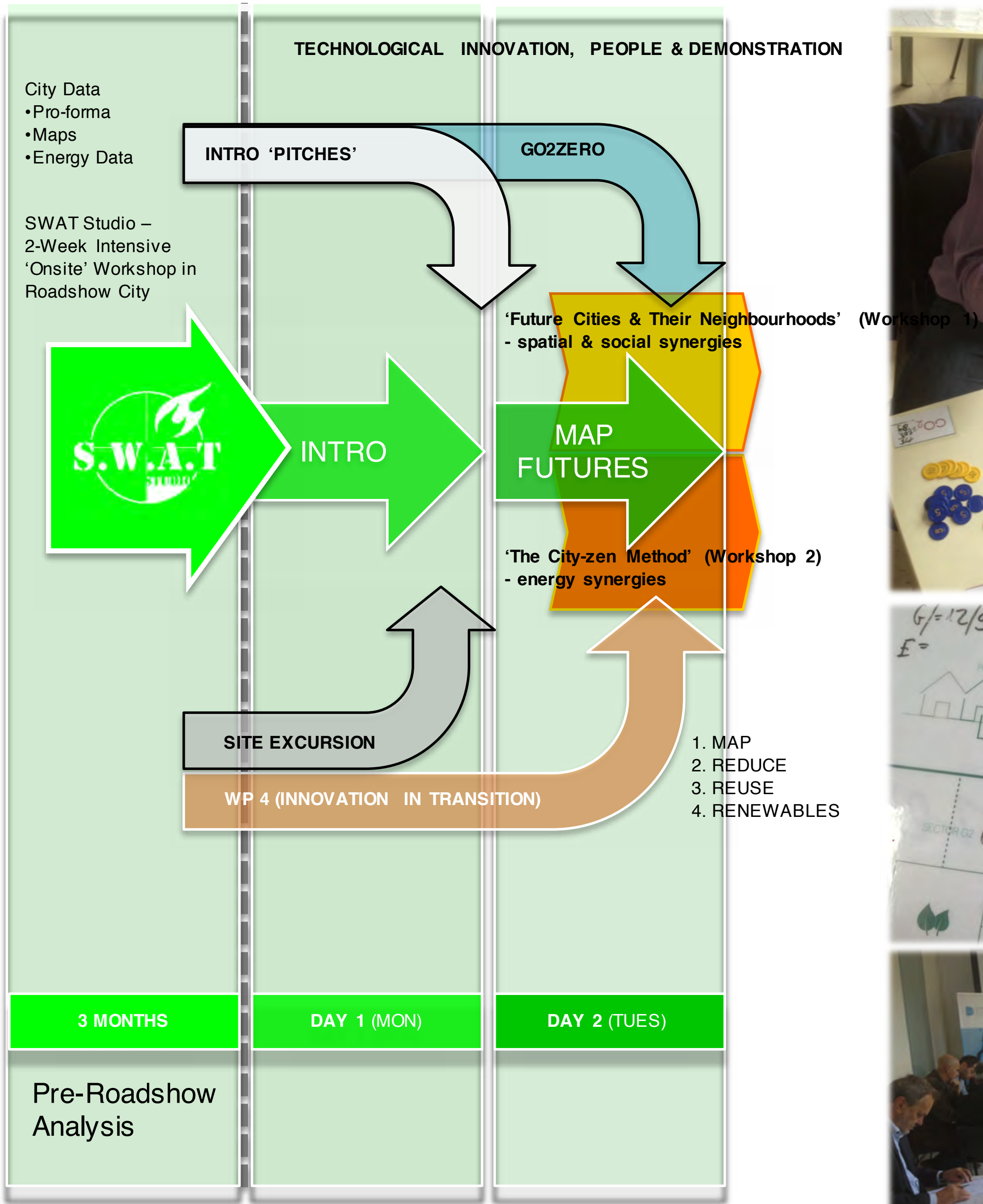
Gruz, Dubrovnik (Croatia).

DAY 2 - WORKSHOP BEGINS

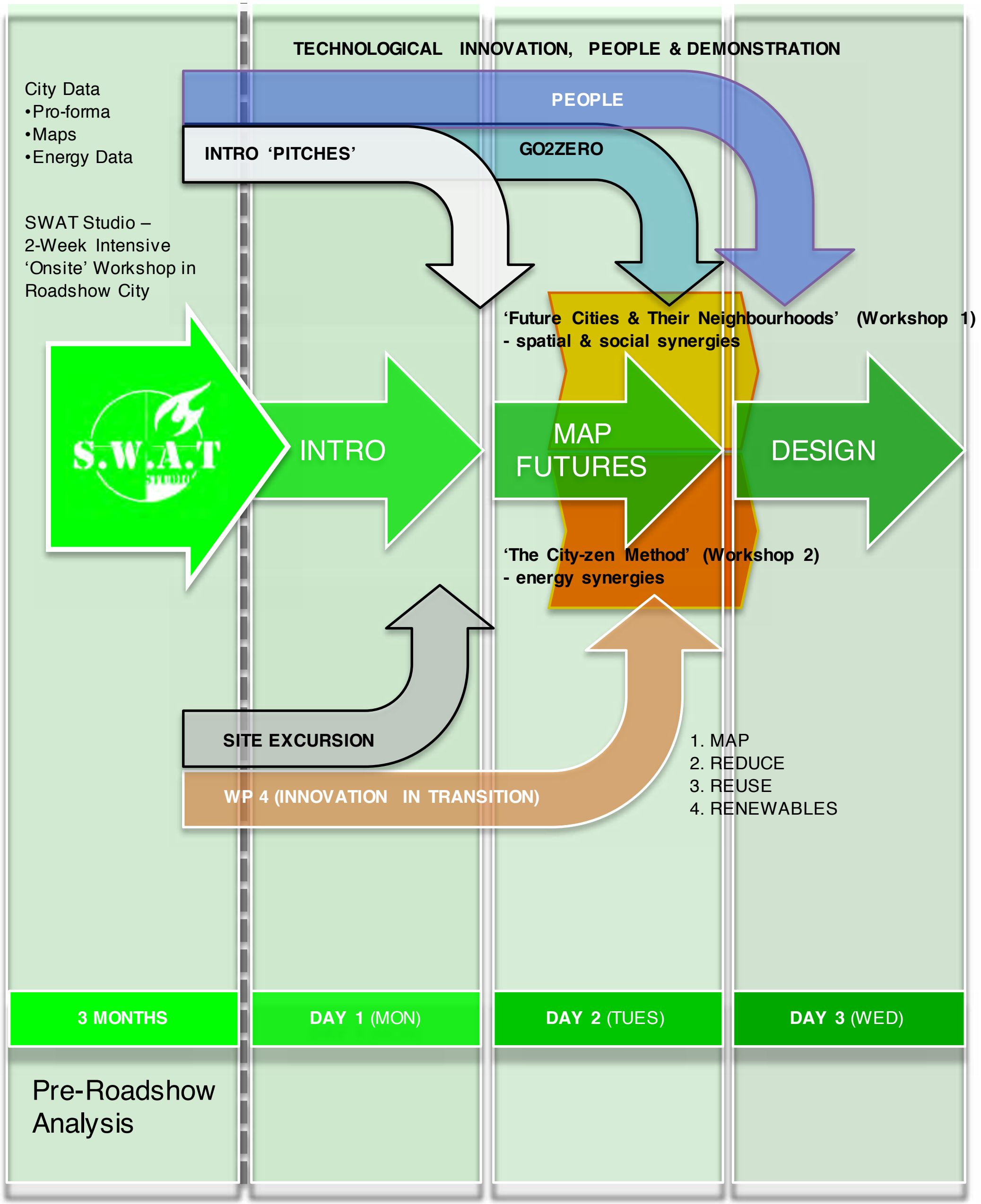


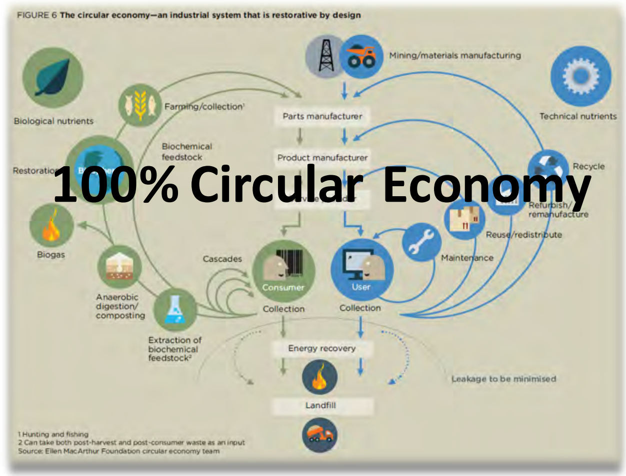


DAY 2 - GO2ZERO (SERIOUS GAME)

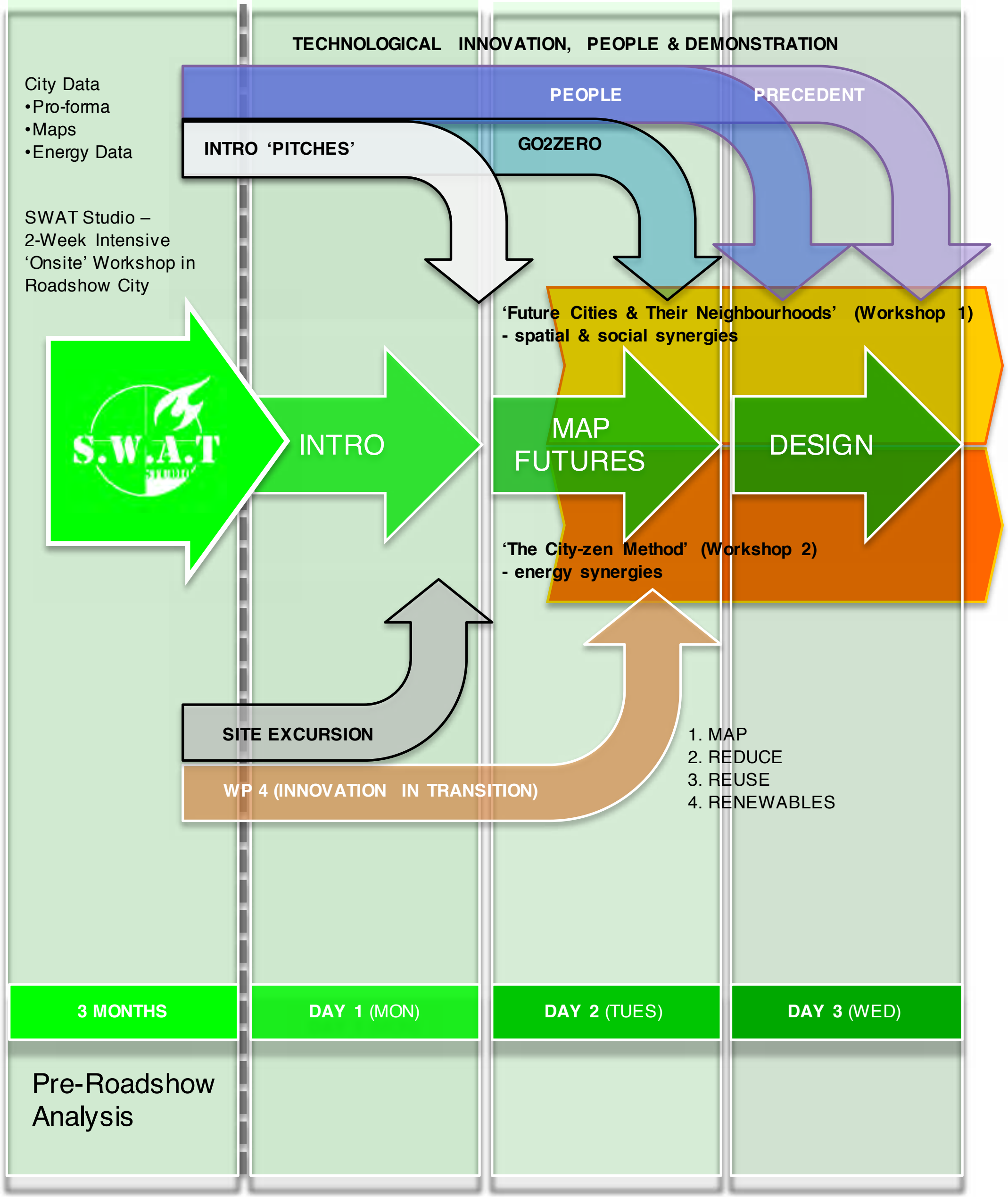


DAY 3 - MINI-MASTERCLASS 1 (PEOPLE & TECHNOLOGY)



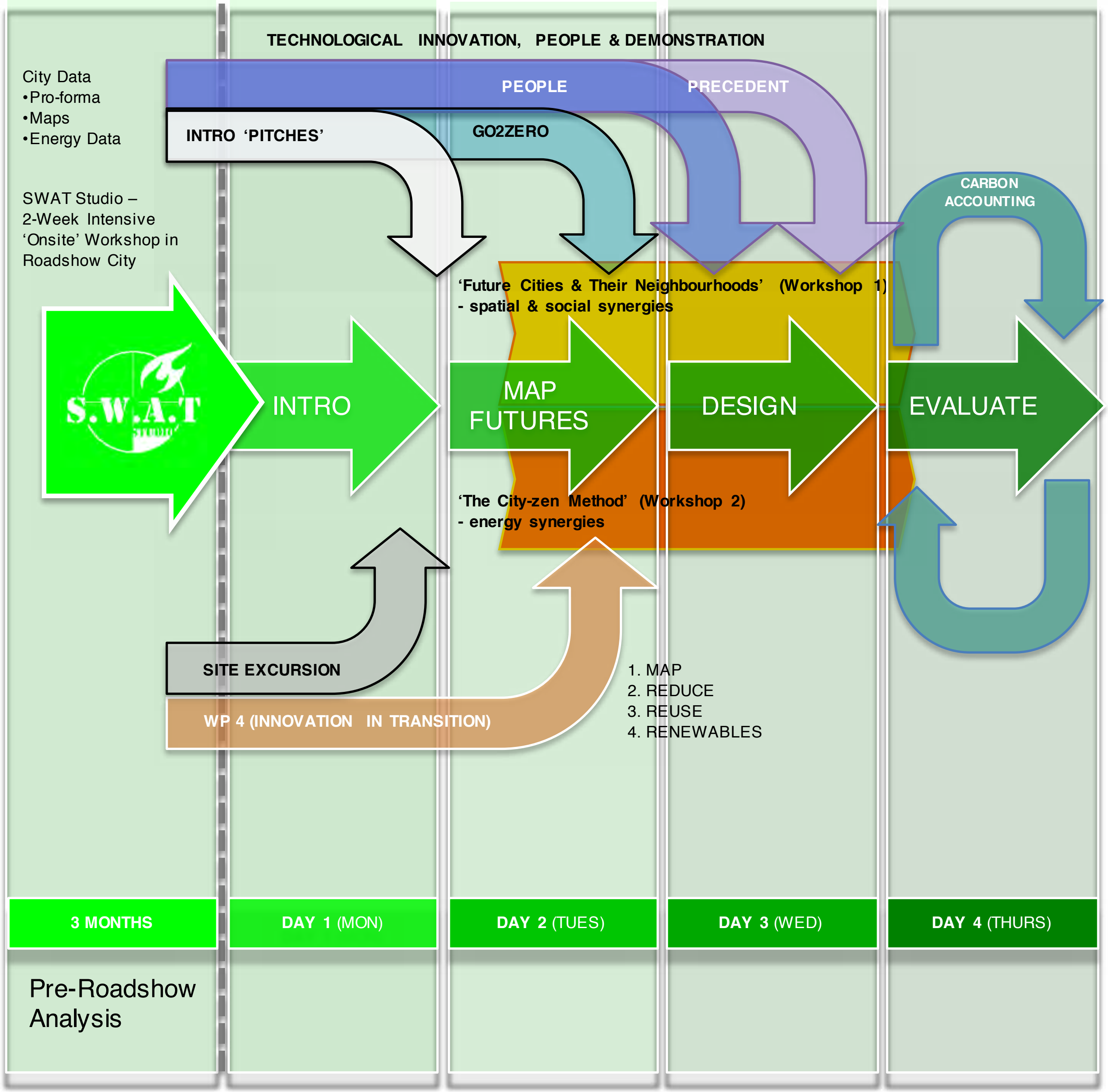


DAY 3 - FUTURE TECHNOLOGIES (SMART CITIES)

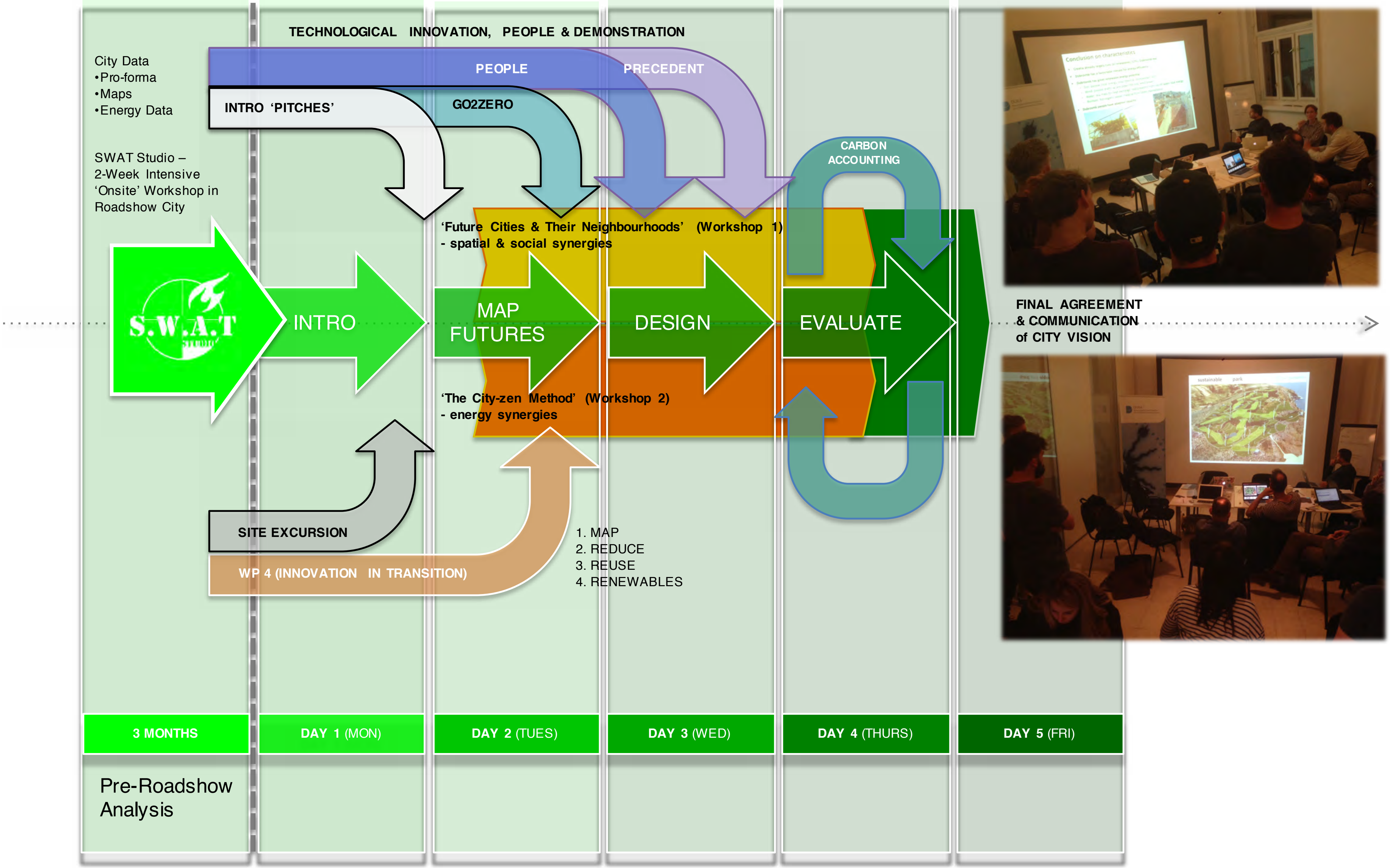


At the Dubrovnik Roadshow **Ceco Gakovic** (CityOS) gave a seminar on Smart Cities and technologies in Dubrovnik, Sarajevo & Croatia generally.

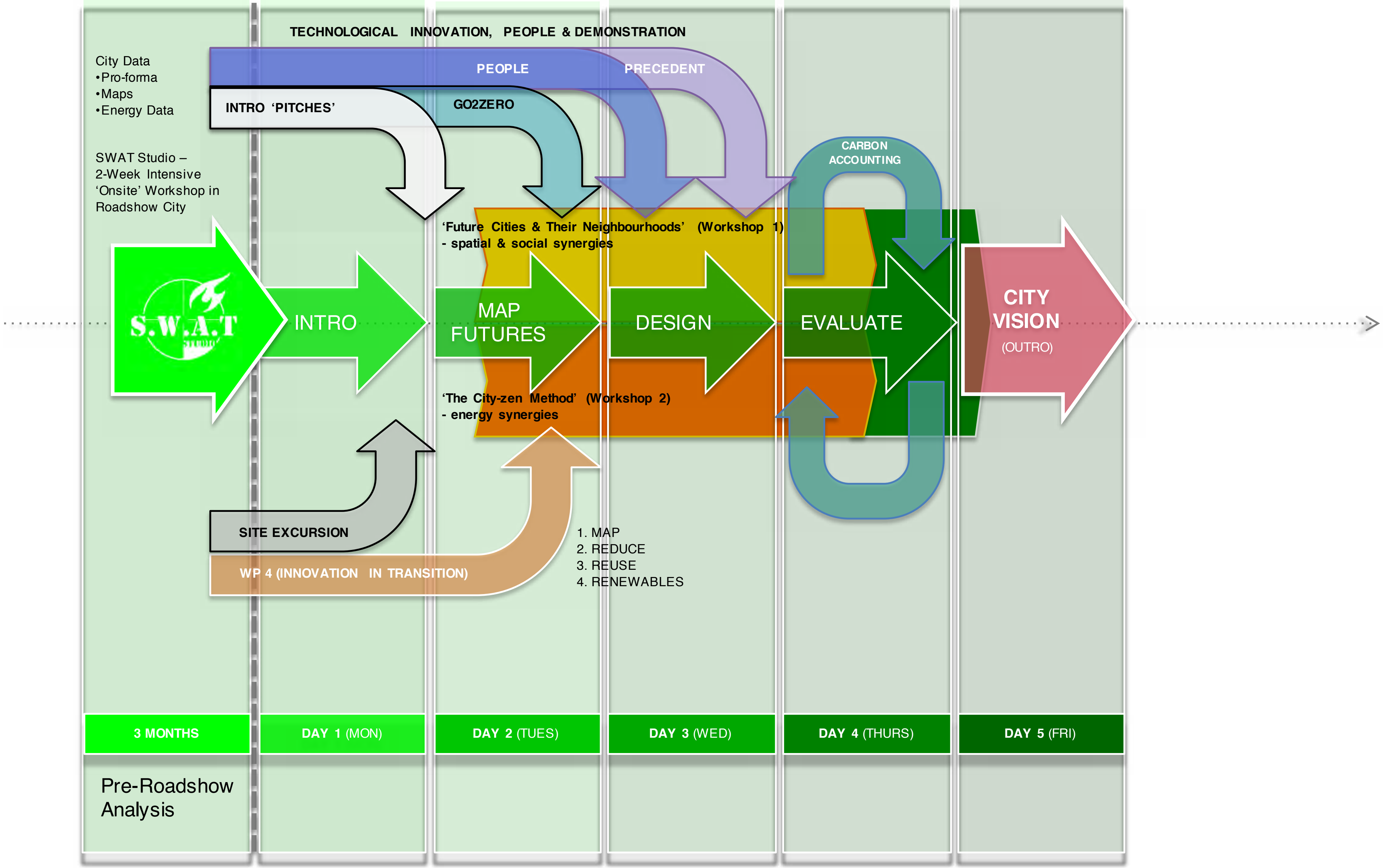
DAY 4 - MINI-MASTERCLASS 2 (CARBON ACCOUNTING)



DAY 4 - FINAL AGREEMENT & COMMUNICATION



DAY 5 - 'THE CITY VISION'



Gruž energy transition plan

Final presentation – DURA, Dubrovnik, 4 November 2016


Local typology, climate, geography

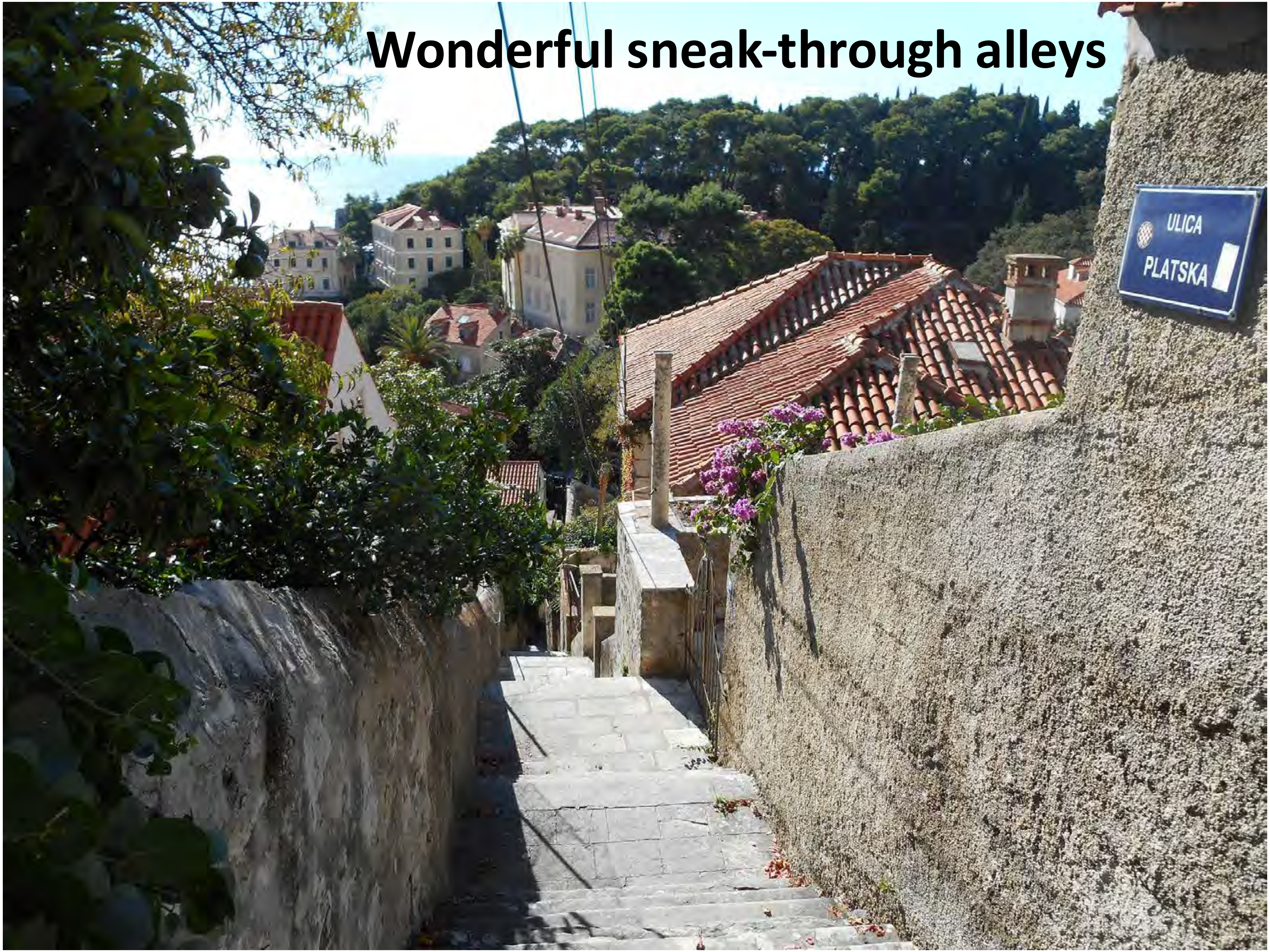
The site


Gruž harbour

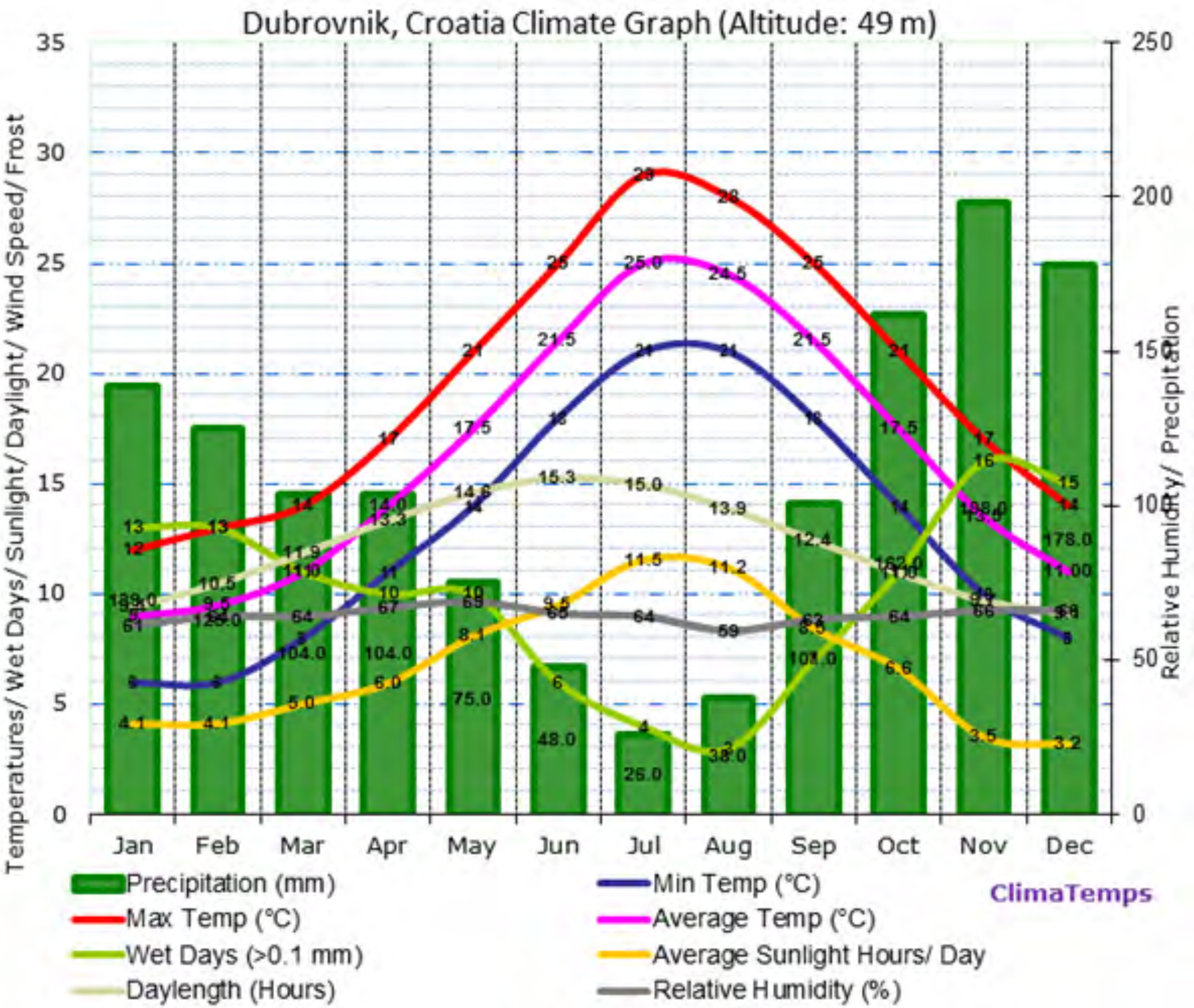
Gruž houses and apartment blocks

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.

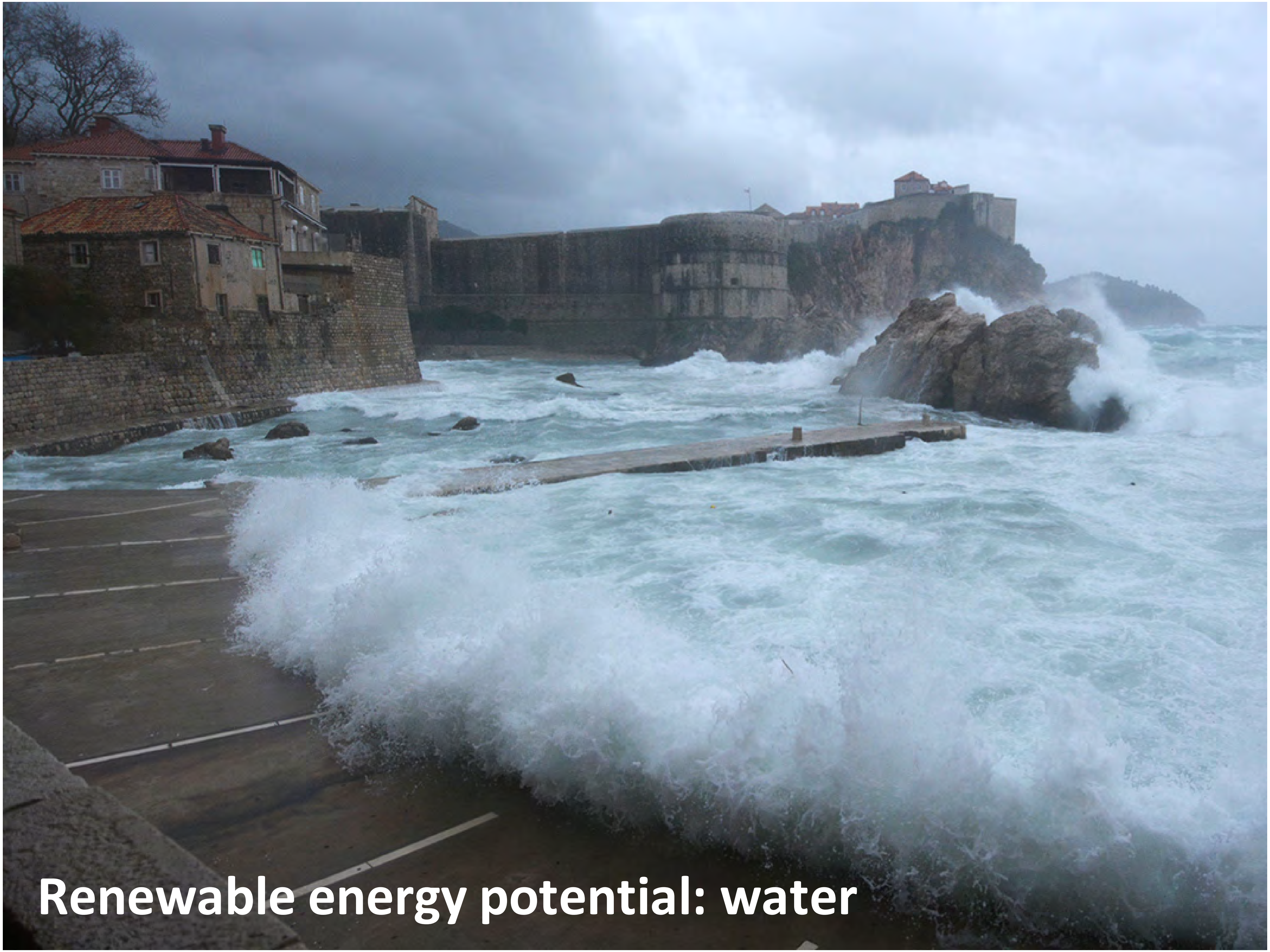
There are 2900 households in Gruž.

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

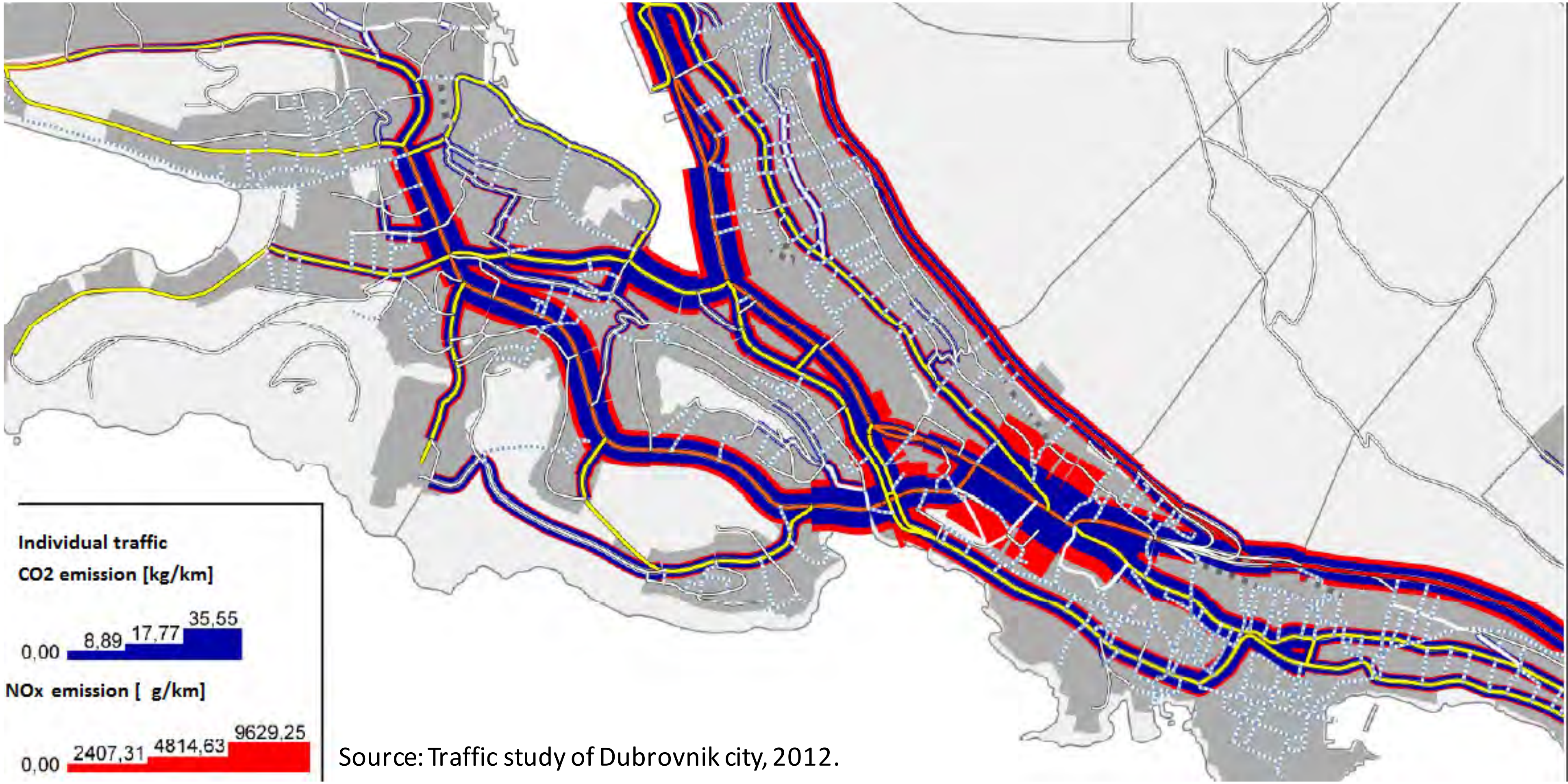

…and this
MSC ARMONIA
SILHOUETTE

…and this


STOLARIJA
staklo | OKVIRI
GRGA
P
… and this.

CO_2 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



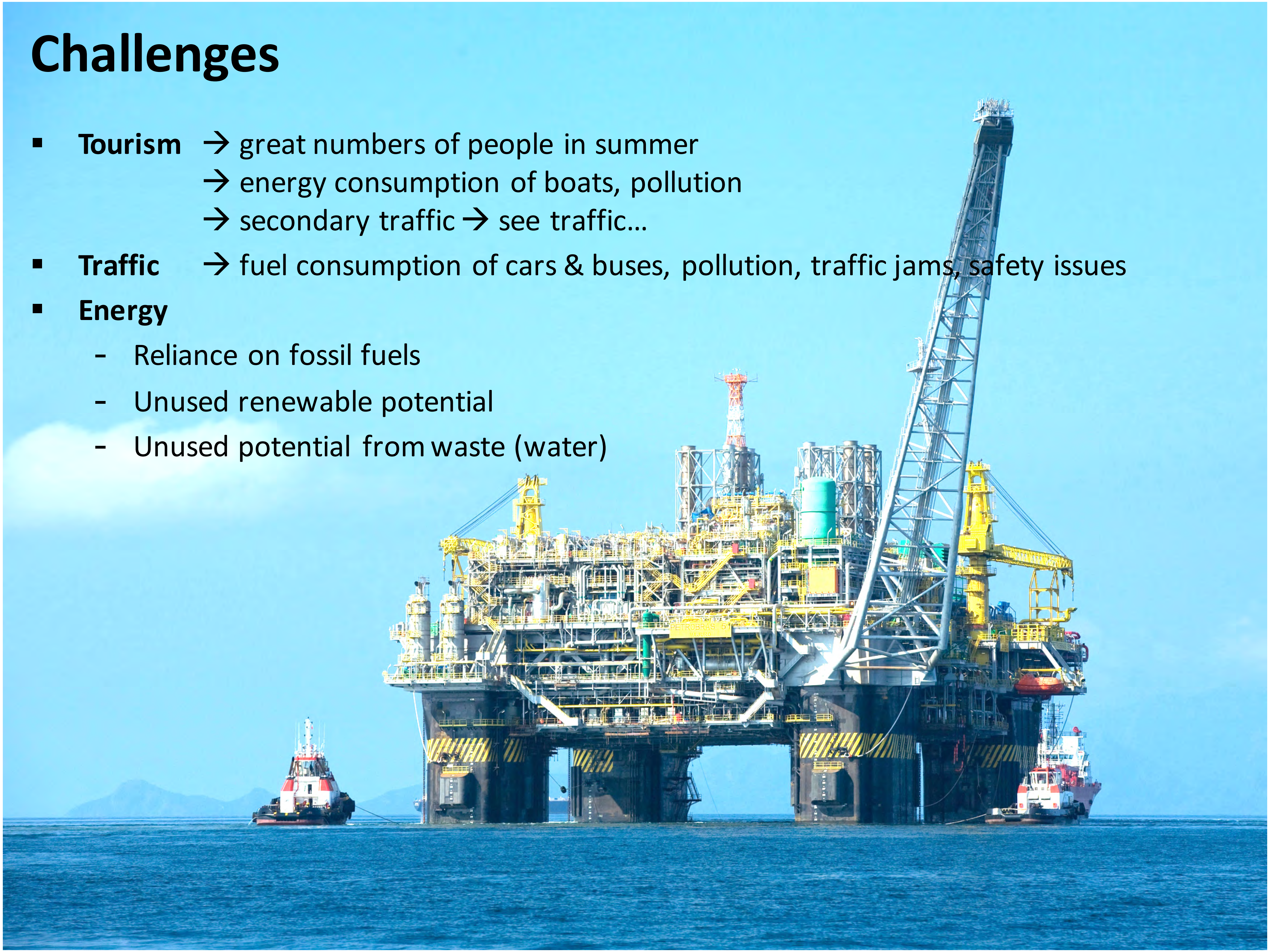
Source: Traffic study of Dubrovnik city, 2012.

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

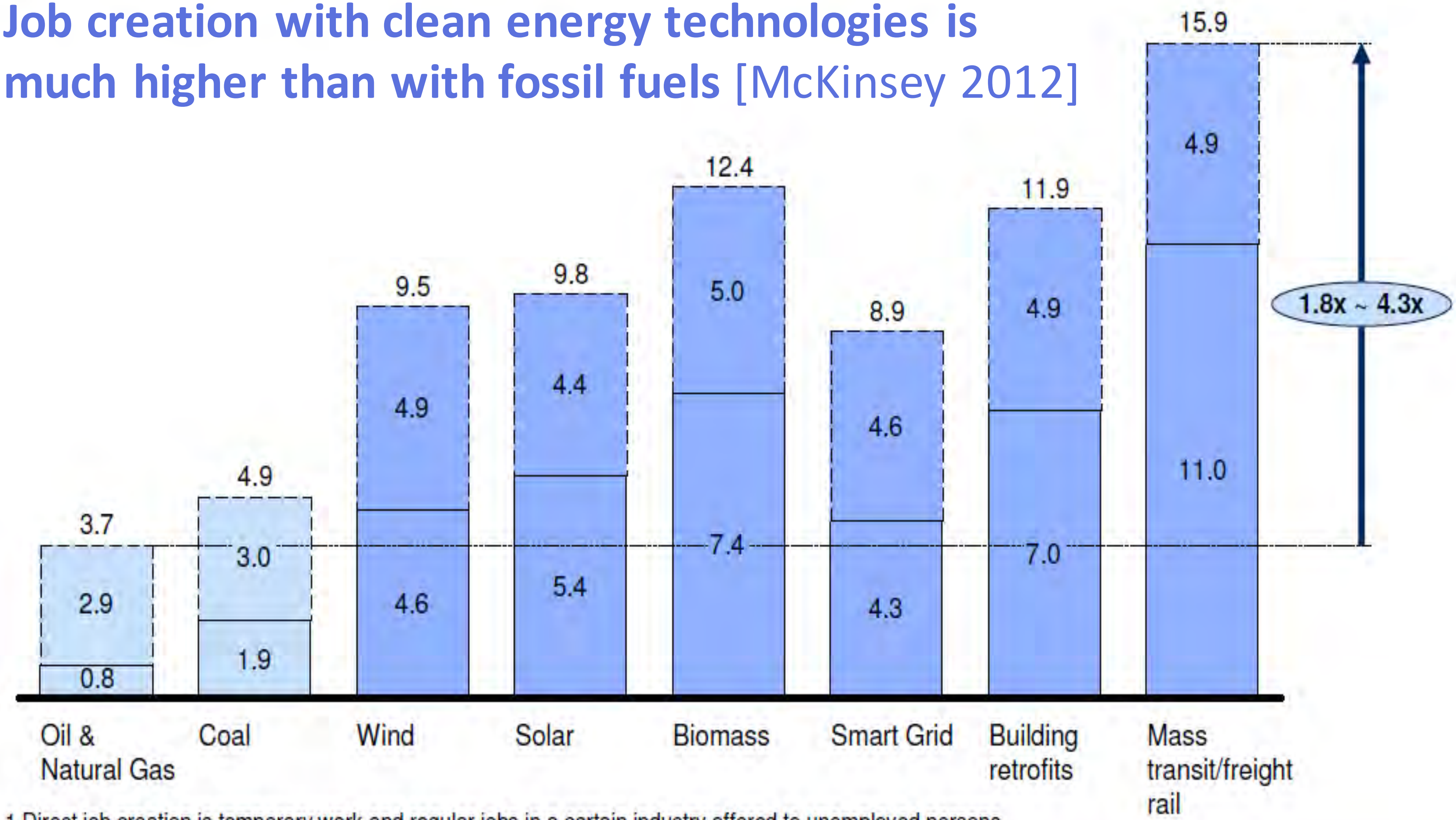
- **Saving energy in existing neighbourhoods**
- **(Micro) Grids for smart use of heat, cold and electricity**
- **Use of local renewables**
- **Making better use of cruise ship tourism**
  - Increase tax on cruise tourists
  - Waste water to bio-energy
  - Become a green fuel port

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
Green jobs
Direct job creation[1]
Indirect job creation[2]

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

SOURCE: PERI; Center for American Progress; SRP analysis: Yu Yang & Jessica Stuart

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

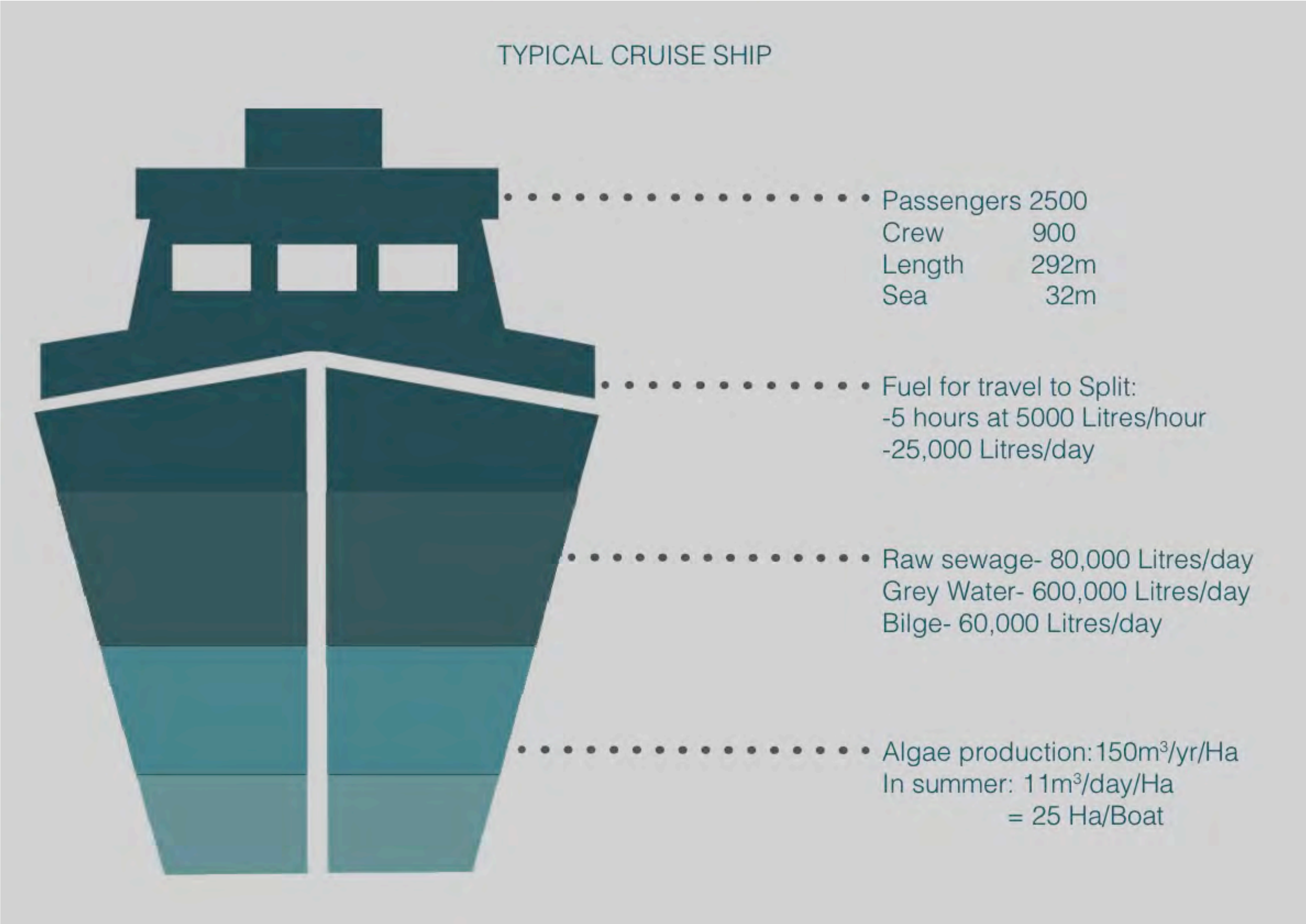
Can your city be sustainable, without a sustainable economy?

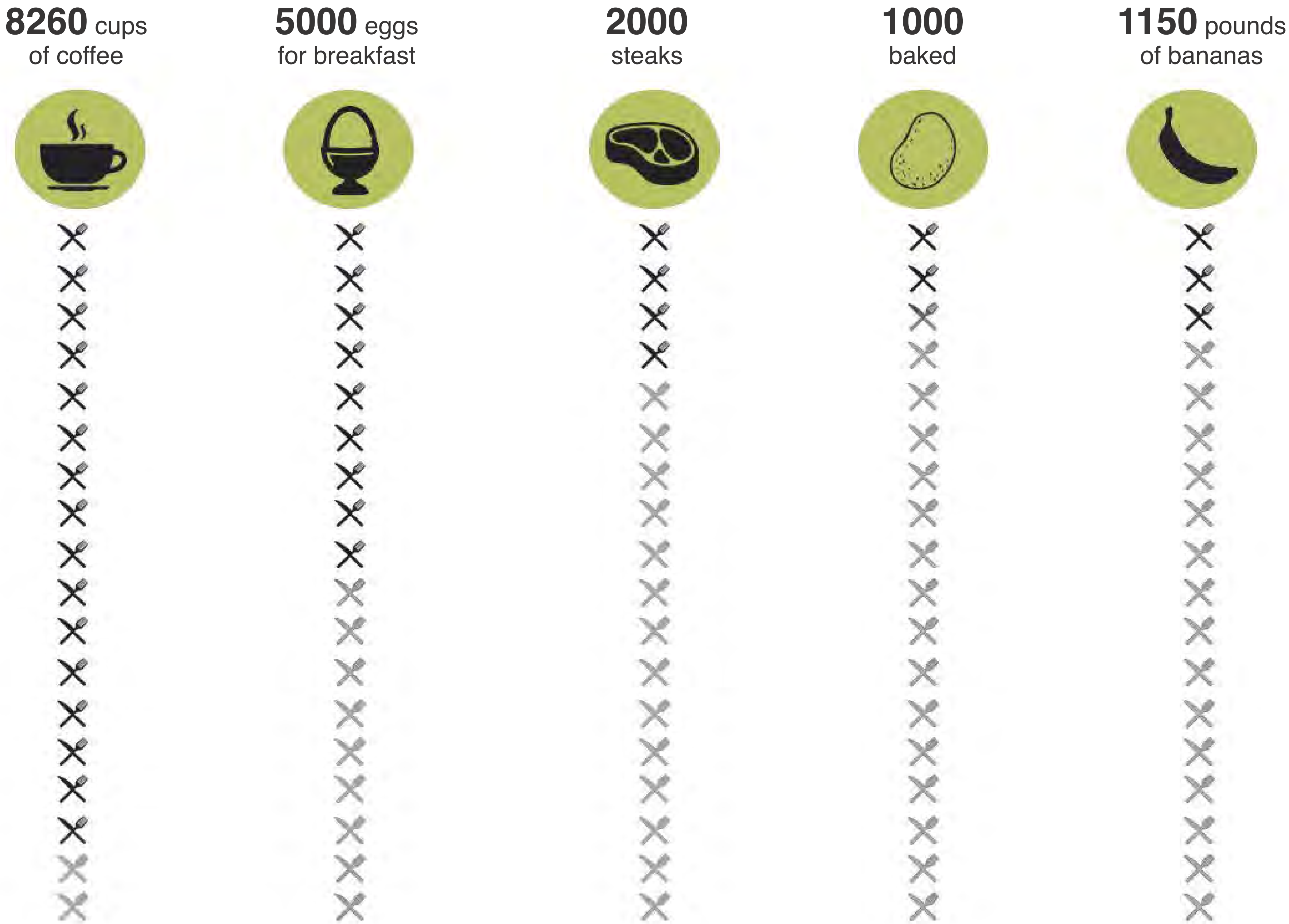
Four heated swimming pools, etc

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



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

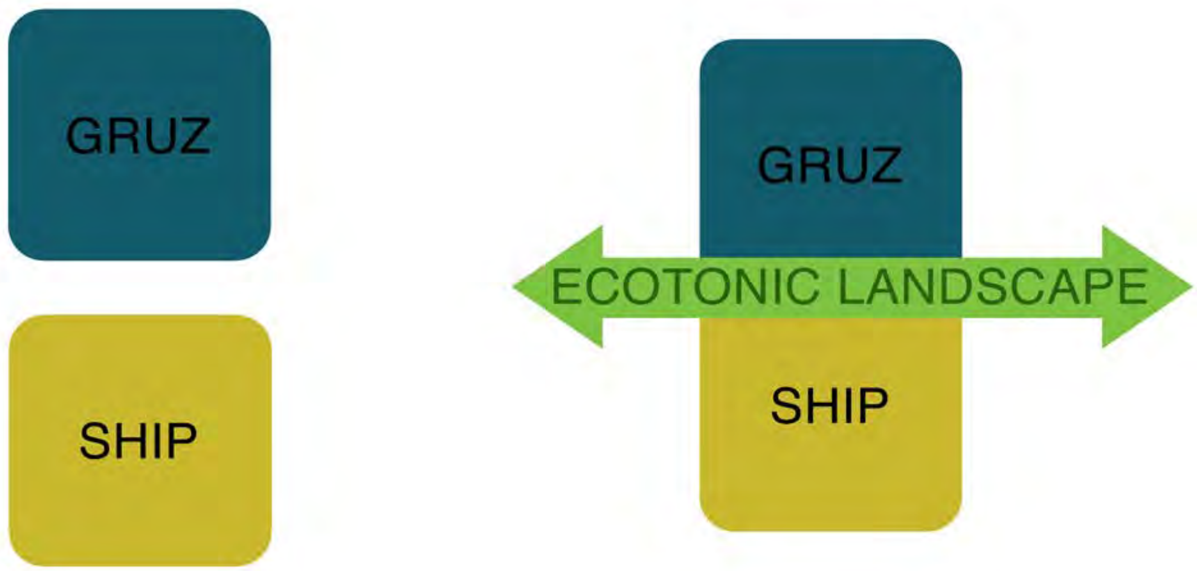
Generates the same amount of sulphur dioxide fumes as 13.1 Million cars on a daily basis

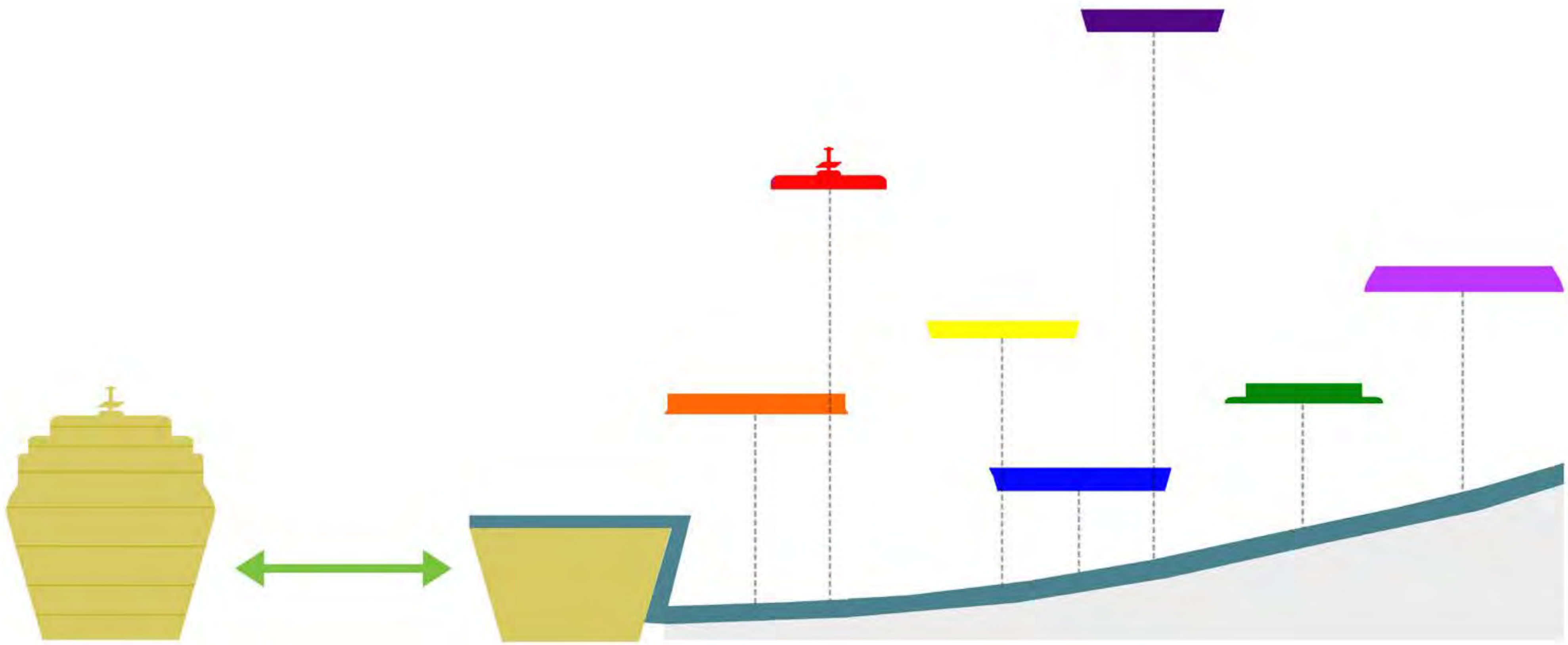
140,000 to 210,000 gallons of sewage per week

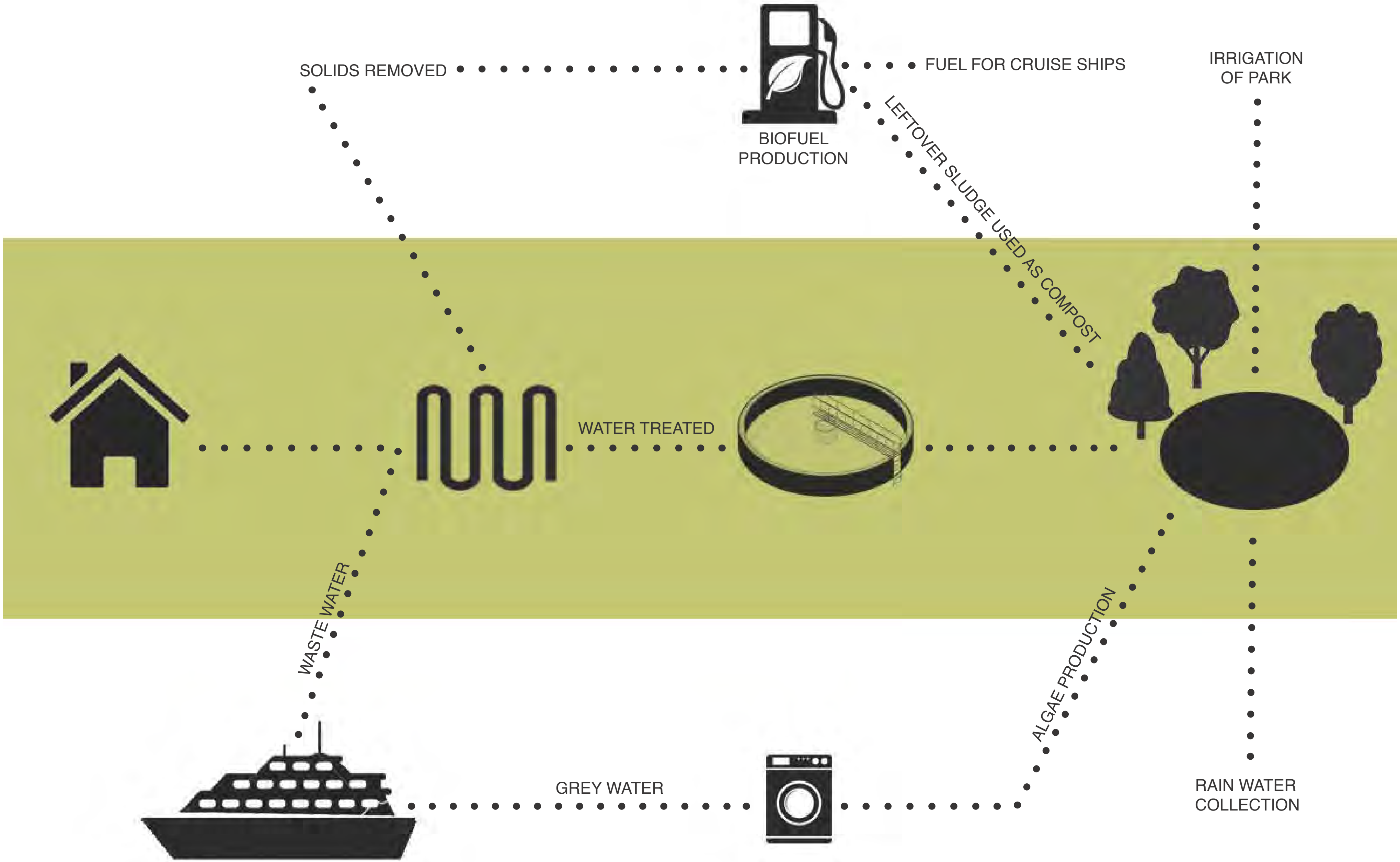
1,165,000 to 1,235,000 gallons of toxic water released per week

CARBON FOOTPRINT OF CRUISESHIPS							1 day		Season	**Tourist Season x 8**
item	value	unit	EF	unit	CF: t CO2eq/day	note	ha forest/day		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**

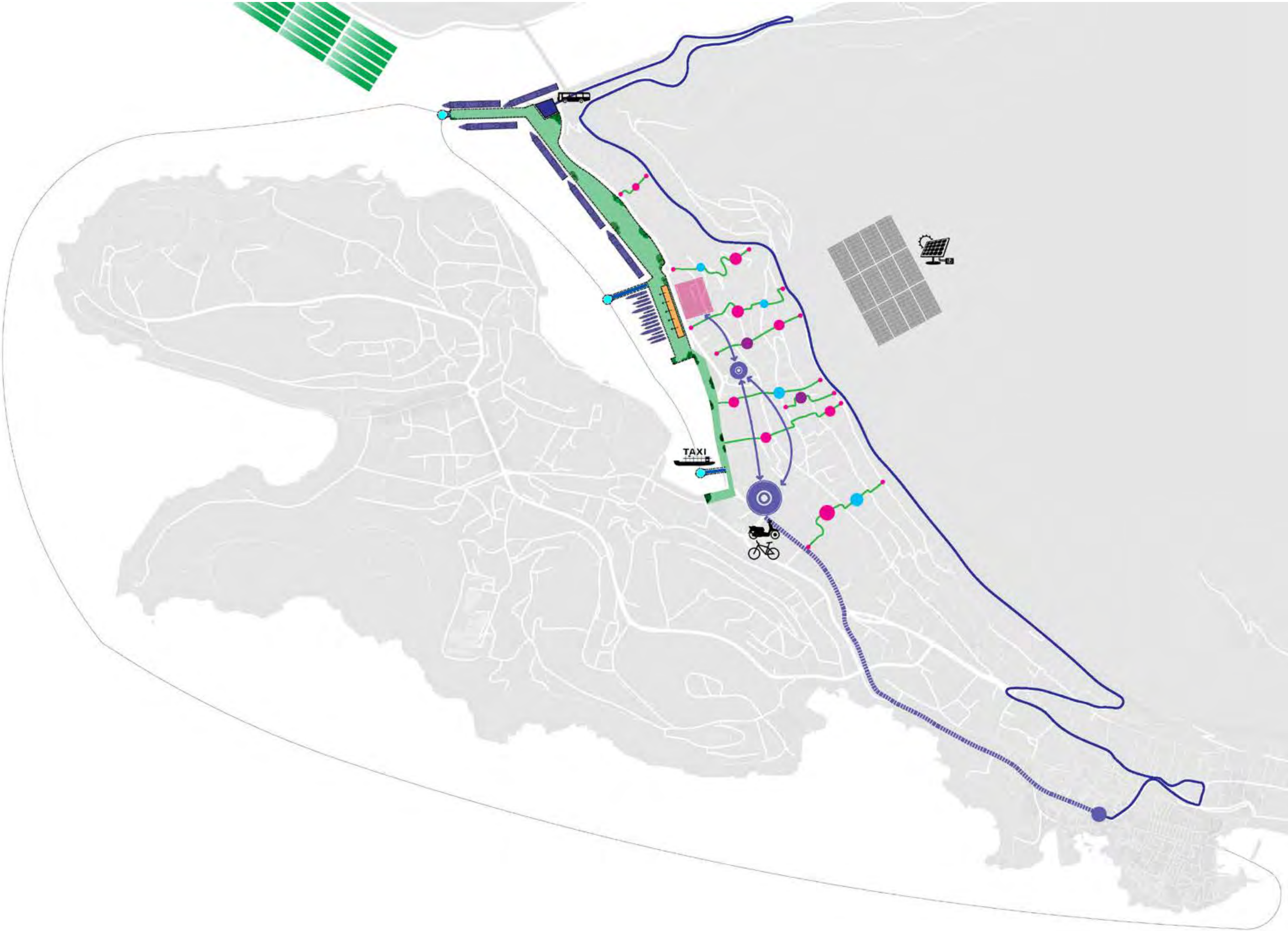
AVOIDED CARBON EMISSION										Possible income
item	value	unit	EF	unit	CF: t CO2eq/day	note	eq. ha forest over season			
BIOGAS production from sewage	3200	m3	1.31	kg CO2eq/m3	4.19	potential biogas production assumed to replace an equivalent quantity of natural gas (EF natural gas to assess avoided 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 h	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**			


GRUZ
SHIP
GRUZ
ECOTONIC LANDSCAPE
SHIP

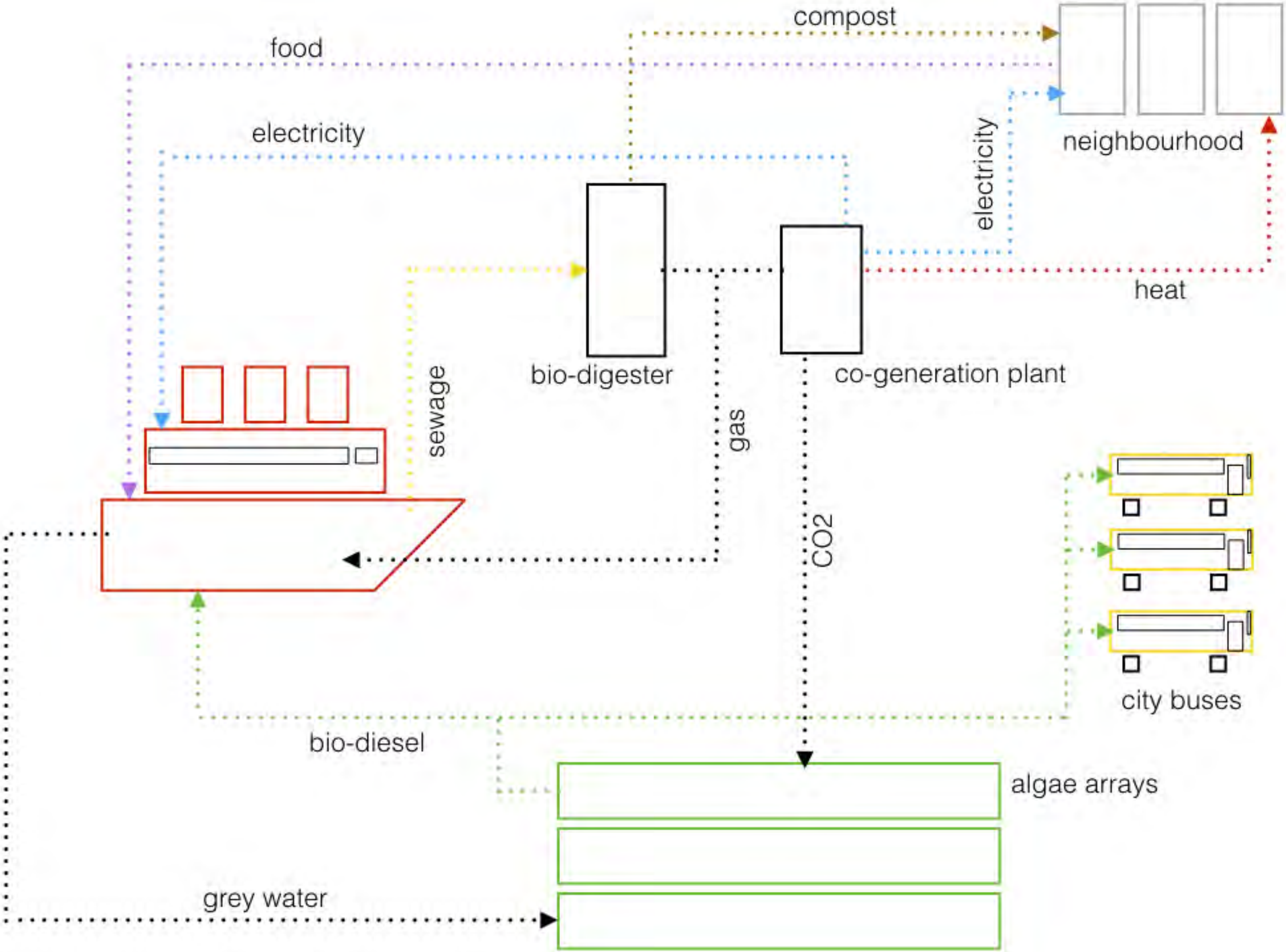




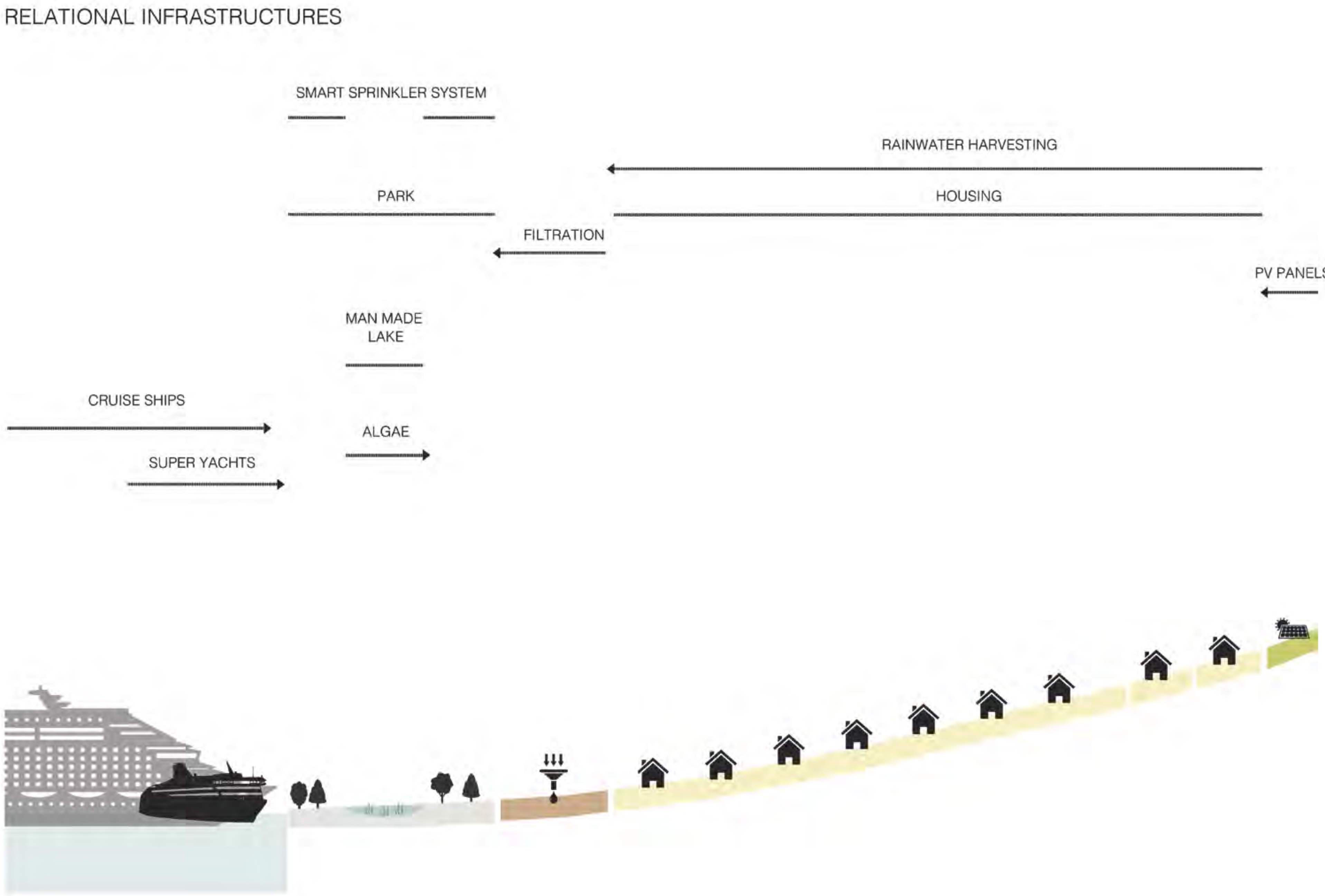
SOLIDS REMOVED
FUEL FOR CRUISE SHIPS
IRRIGATION OF PARK
BIOFUEL PRODUCTION
LEFTOVER SLUDGE USED AS COMPOST
WATER TREATED
WASTE WATER
ALGAE PRODUCTION
GREY WATER
RAIN WATER COLLECTION



Attenuated tourist experience

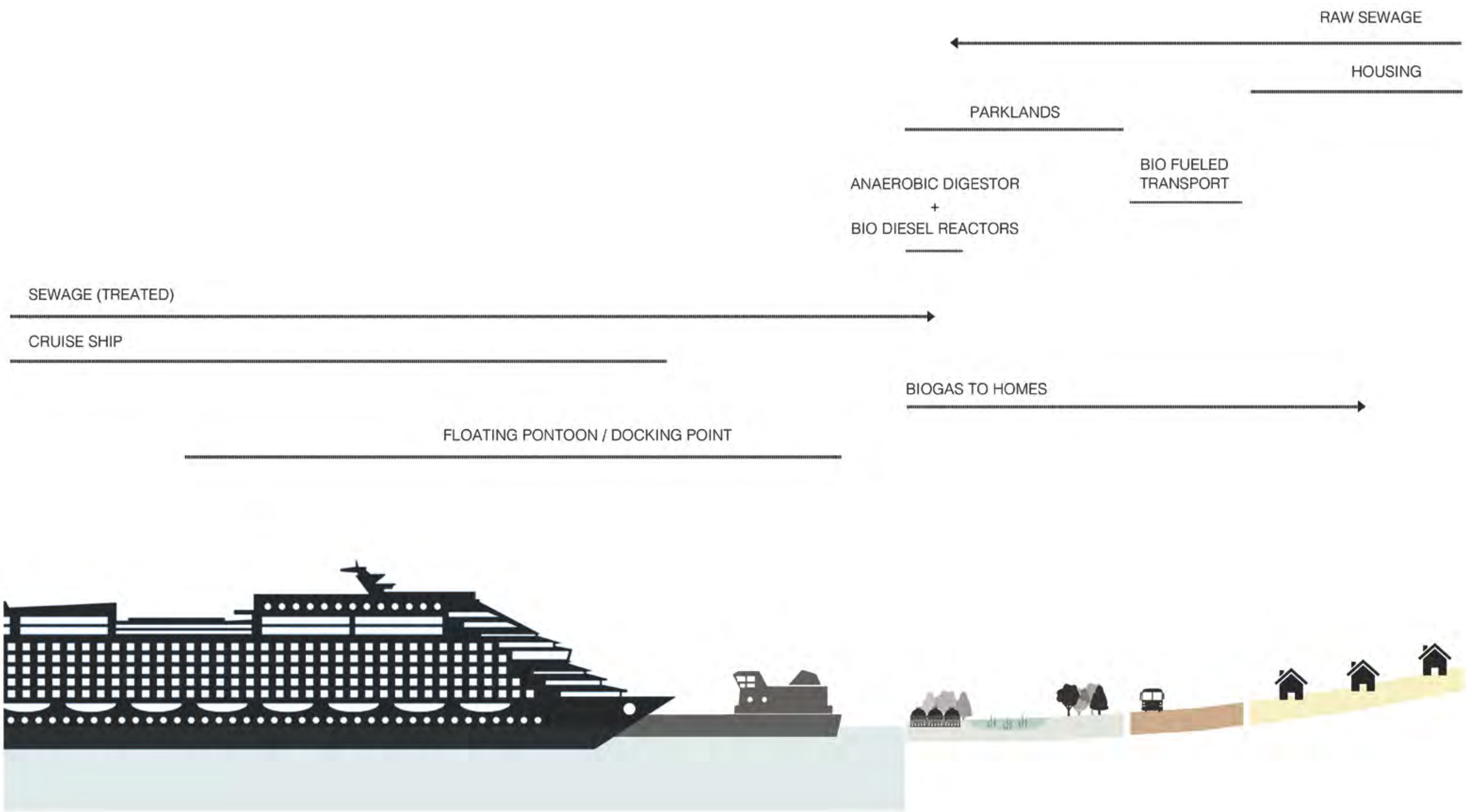


compost
food
electricity
neighbourhood
electricity
heat
bio-digester
co-generation plant
sewage
gas
CO2
city buses
bio-diesel
algae arrays
grey water

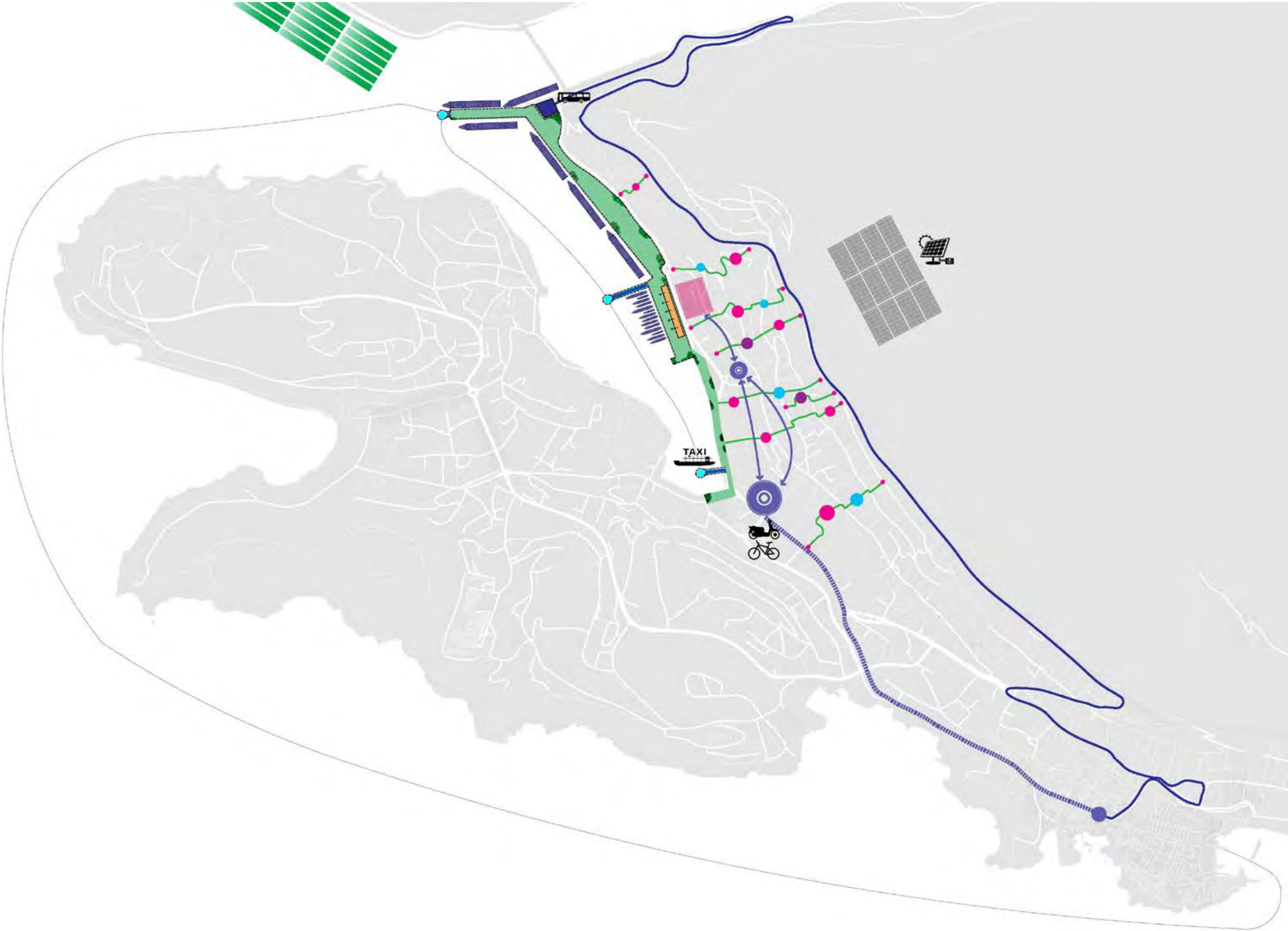


Attenuated landscape

RELATIONAL INFRASTRUCTURES



Attenuated landscape



Attenuated Landscape

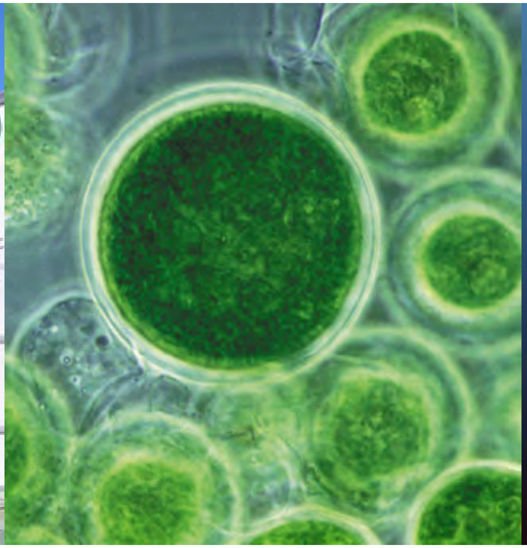
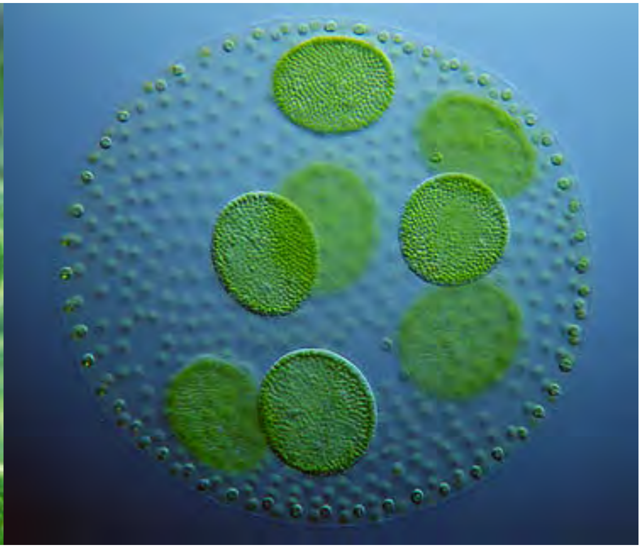
Algaculture

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.

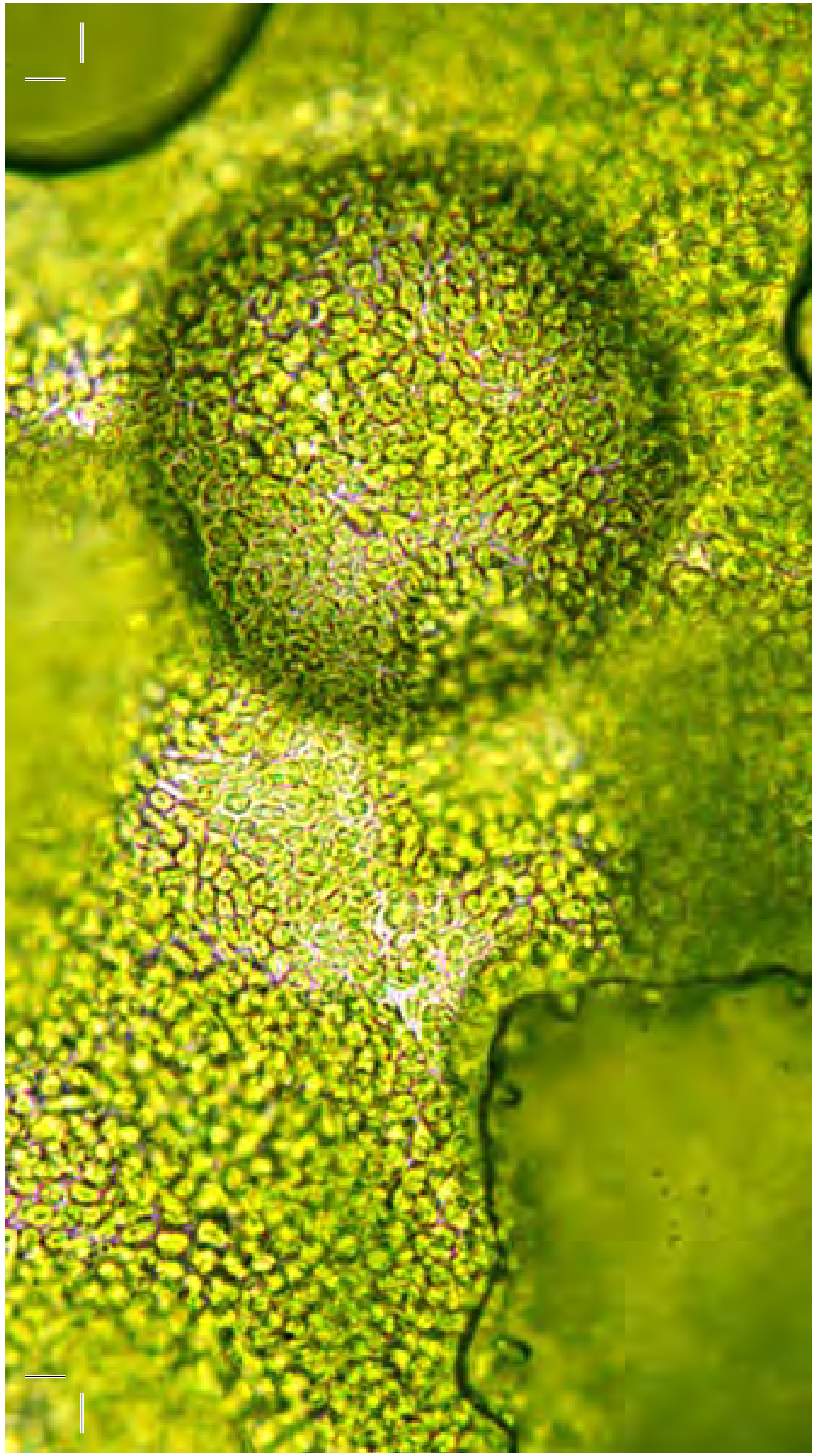
100x yield of rape

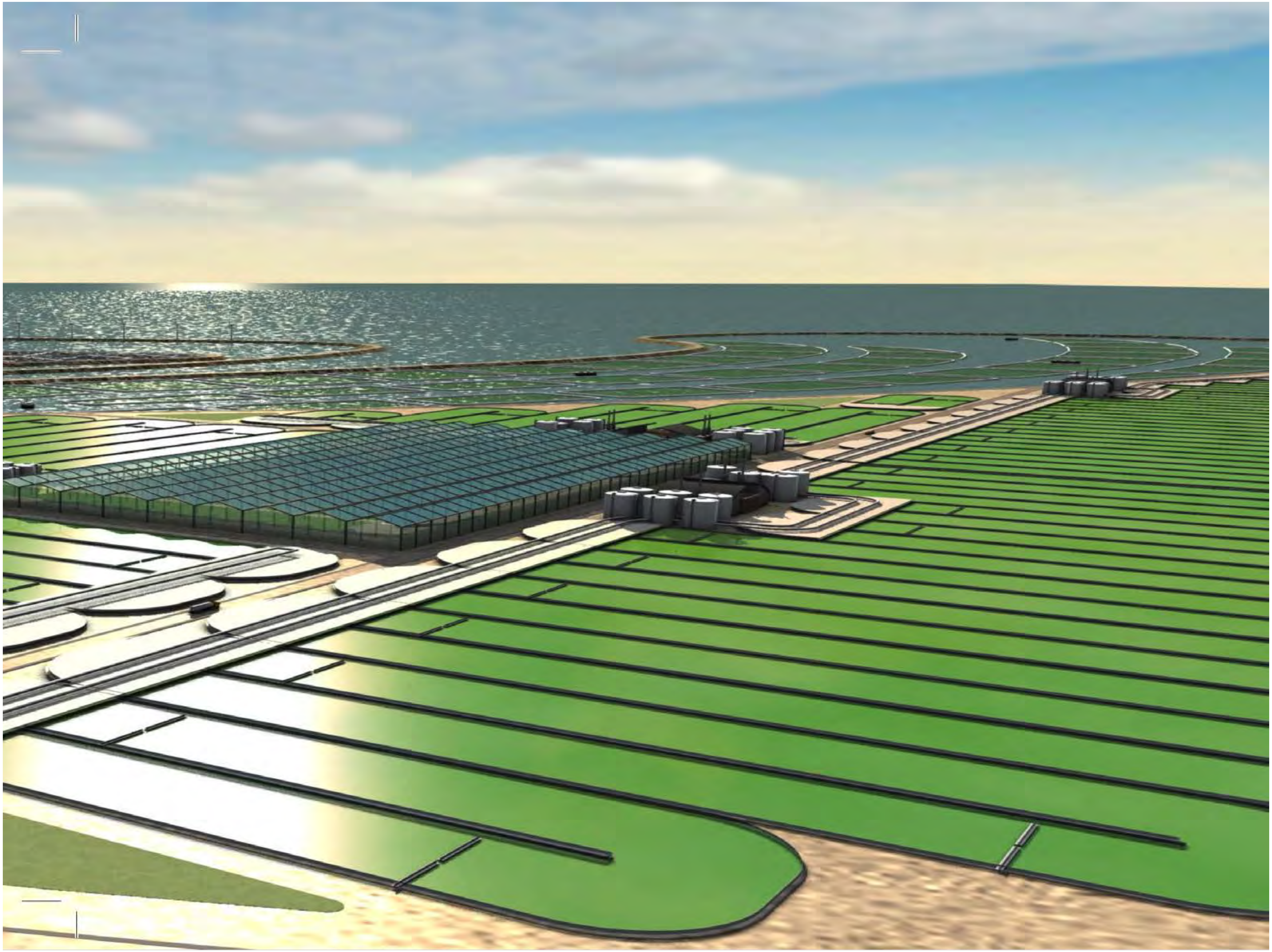
Produce up to 150,000 litres of bio-diesel per hectare/yr

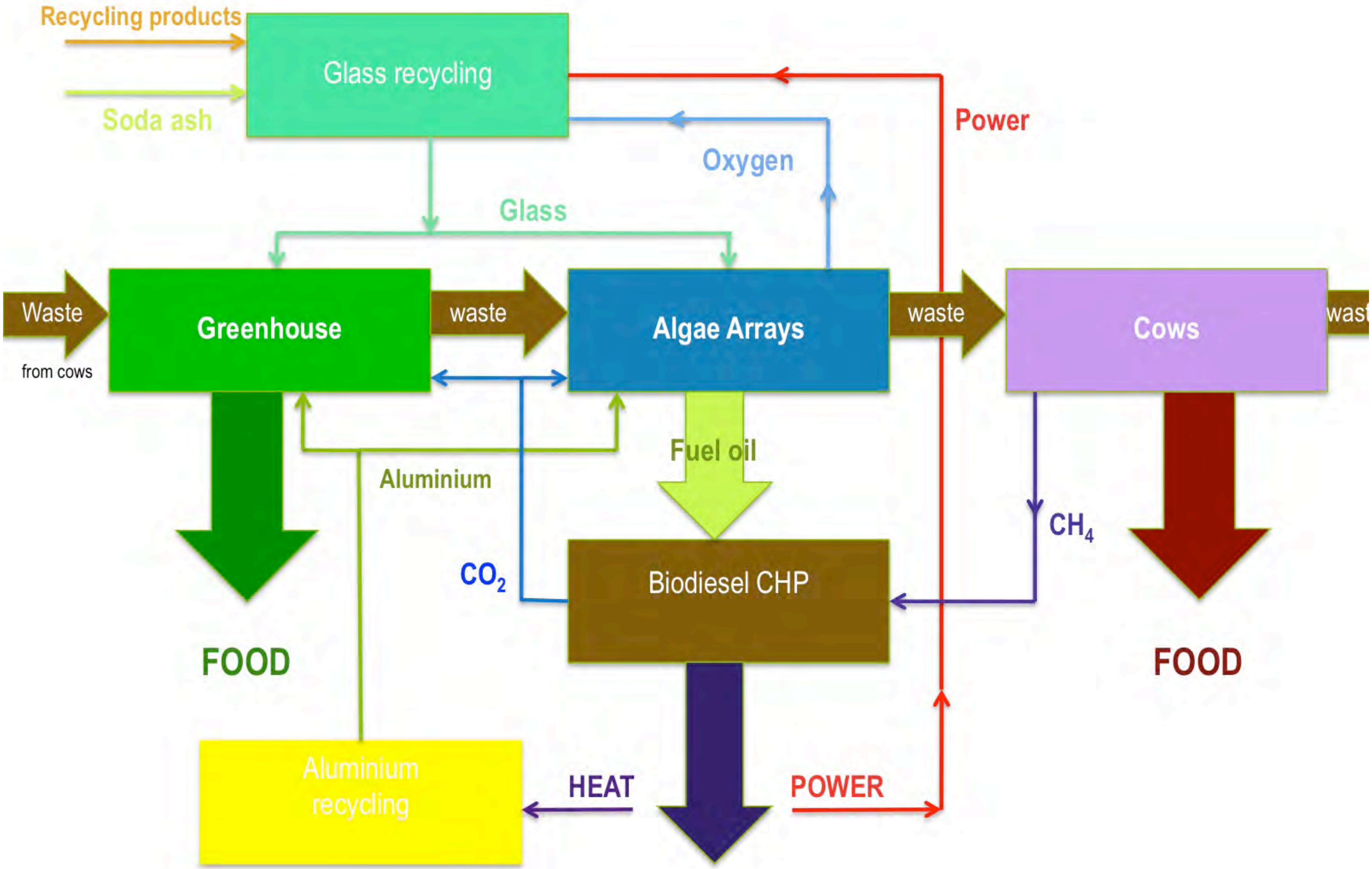
New technologies could increase this to 3,000,000 l/ha
Using lit technology.

Continuous production cycle, unlike land crops

Carbon neutral

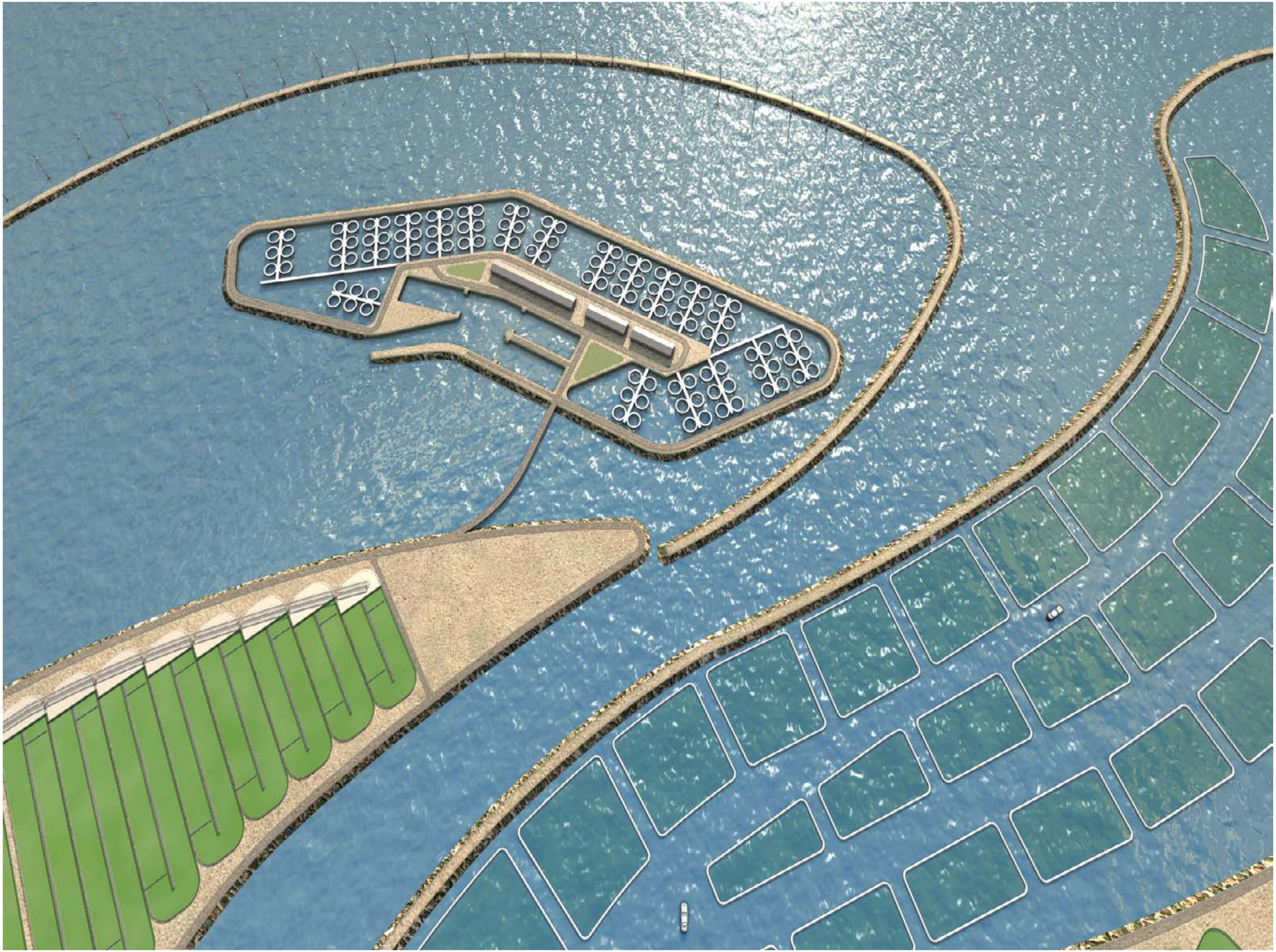


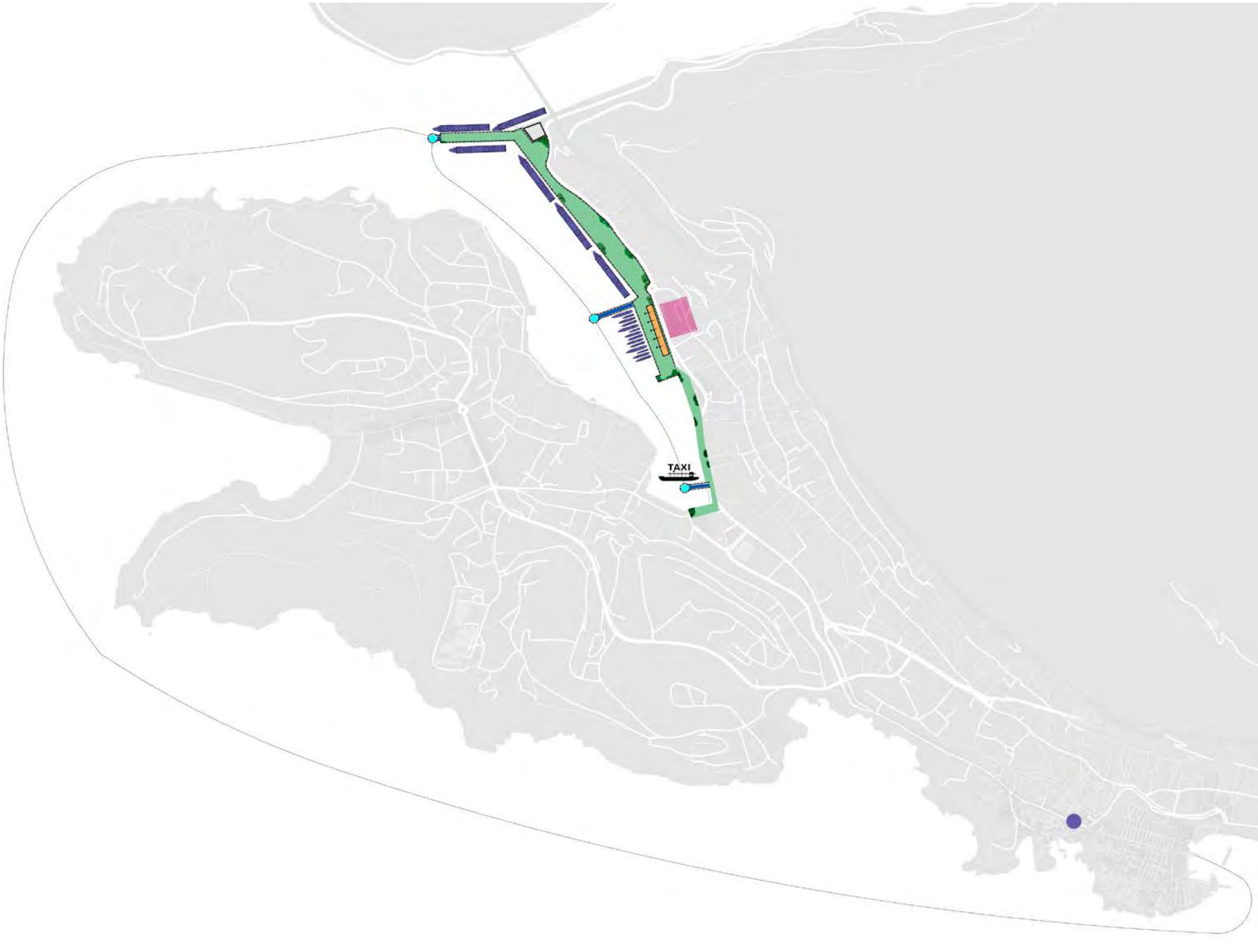




Recycling products
Soda ash
Glass recycling
Power
Oxygen
Glass
Waste
from cows
Greenhouse
waste
Algae Arrays
waste
Cows
wast
Fuel oil
Aluminium
CH4
CO2
Biodiesel CHP
FOOD
FOOD
Aluminium recycling
HEAT
POWER

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

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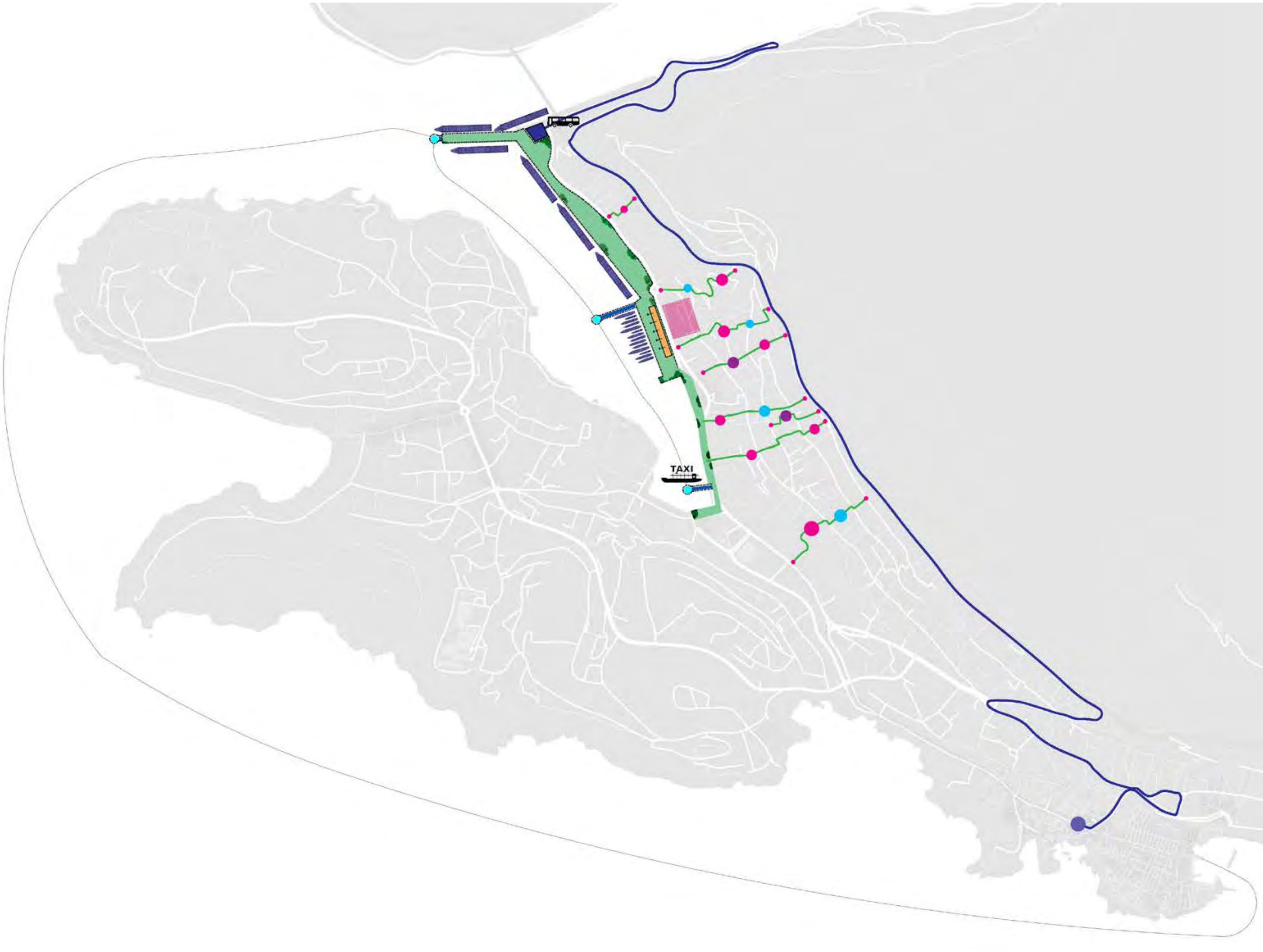
TAXI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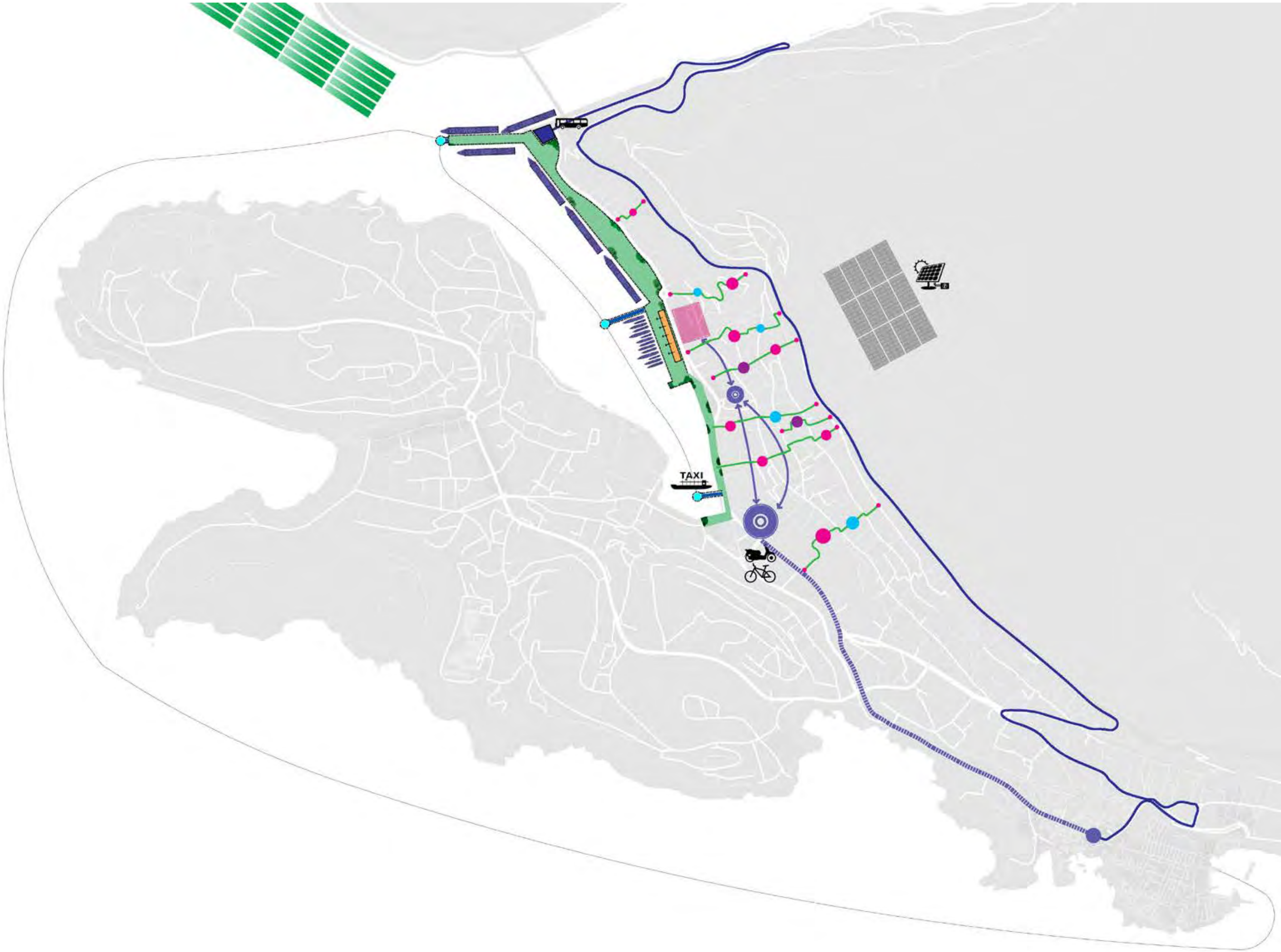
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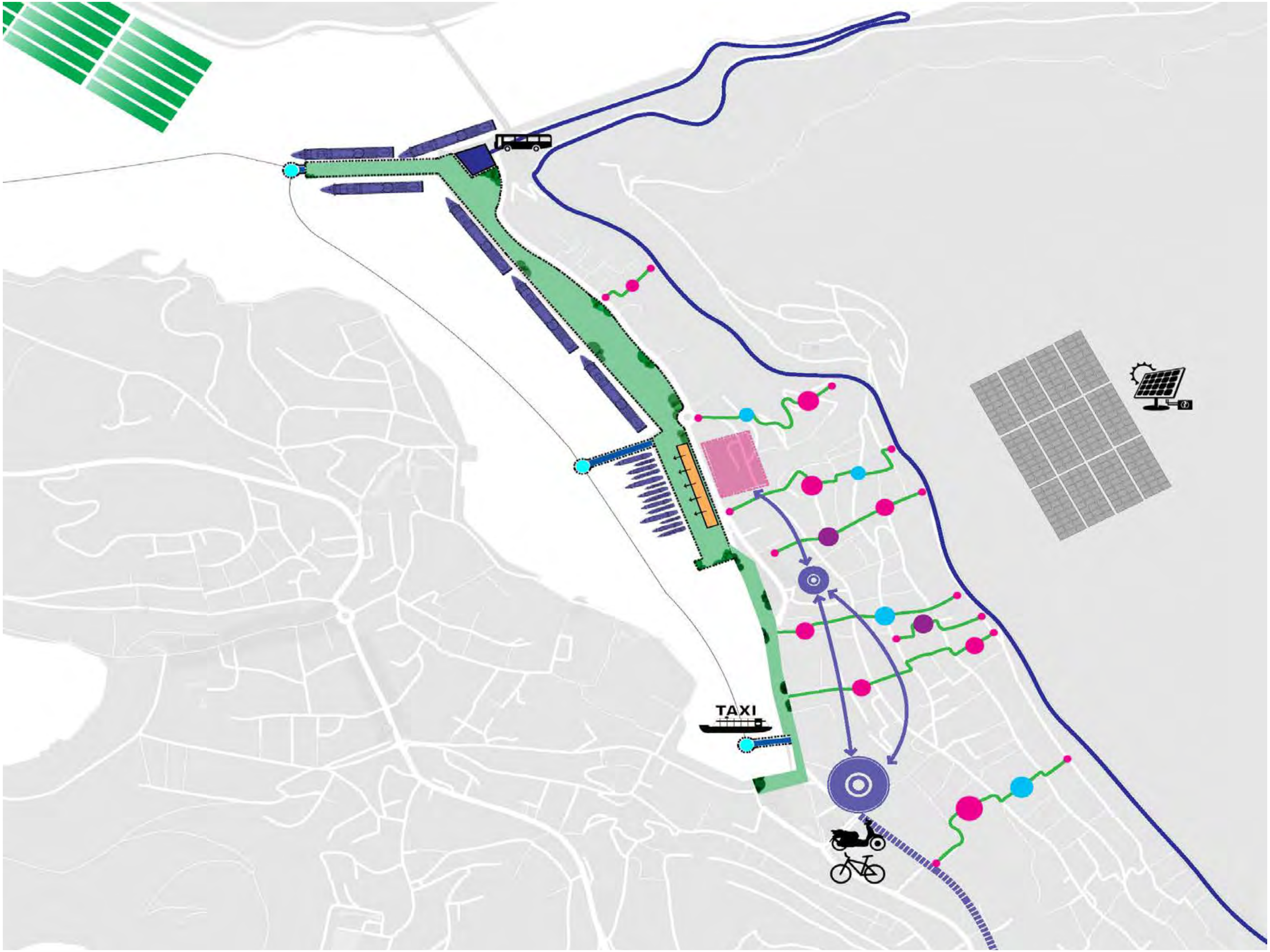
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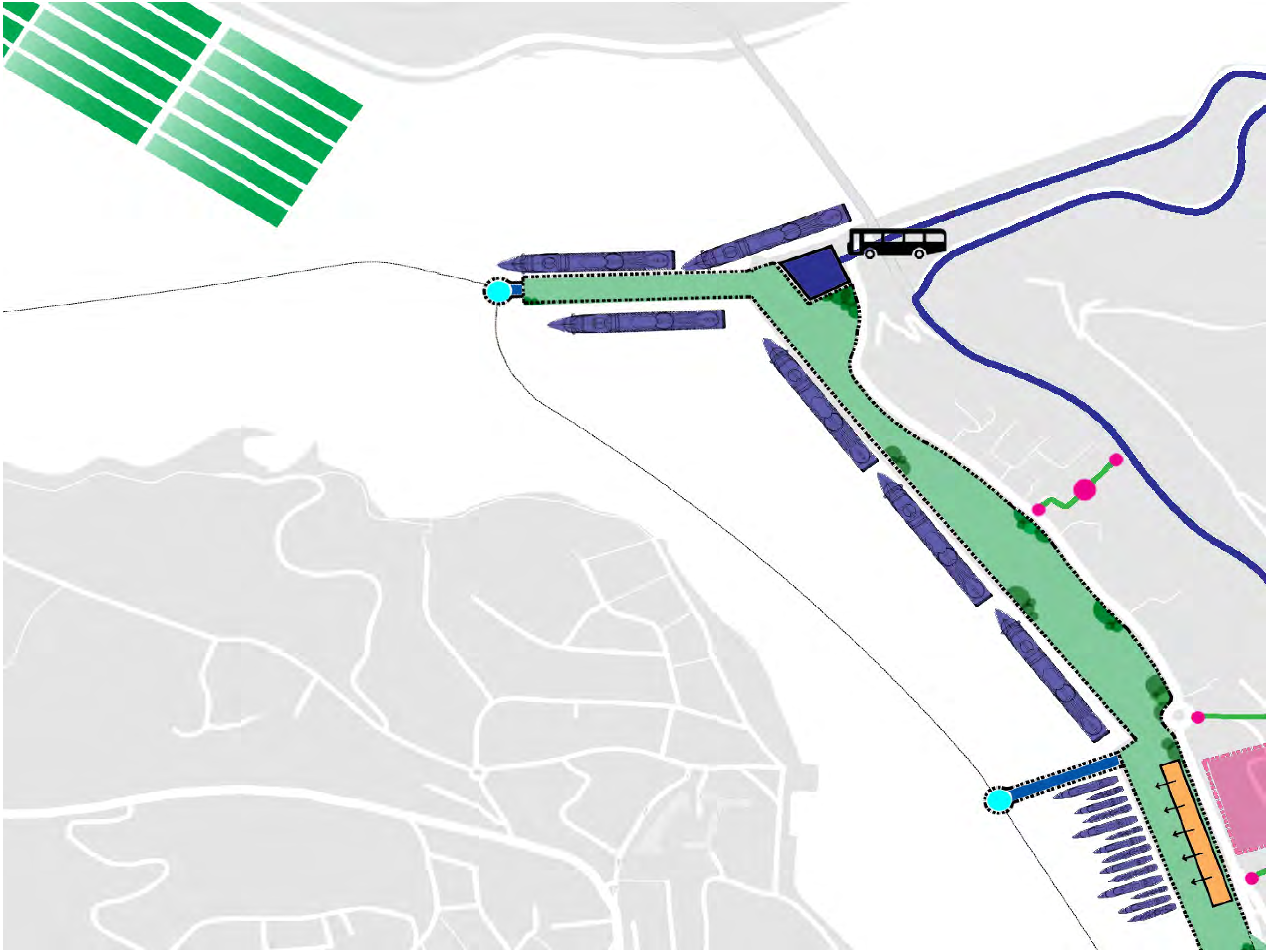
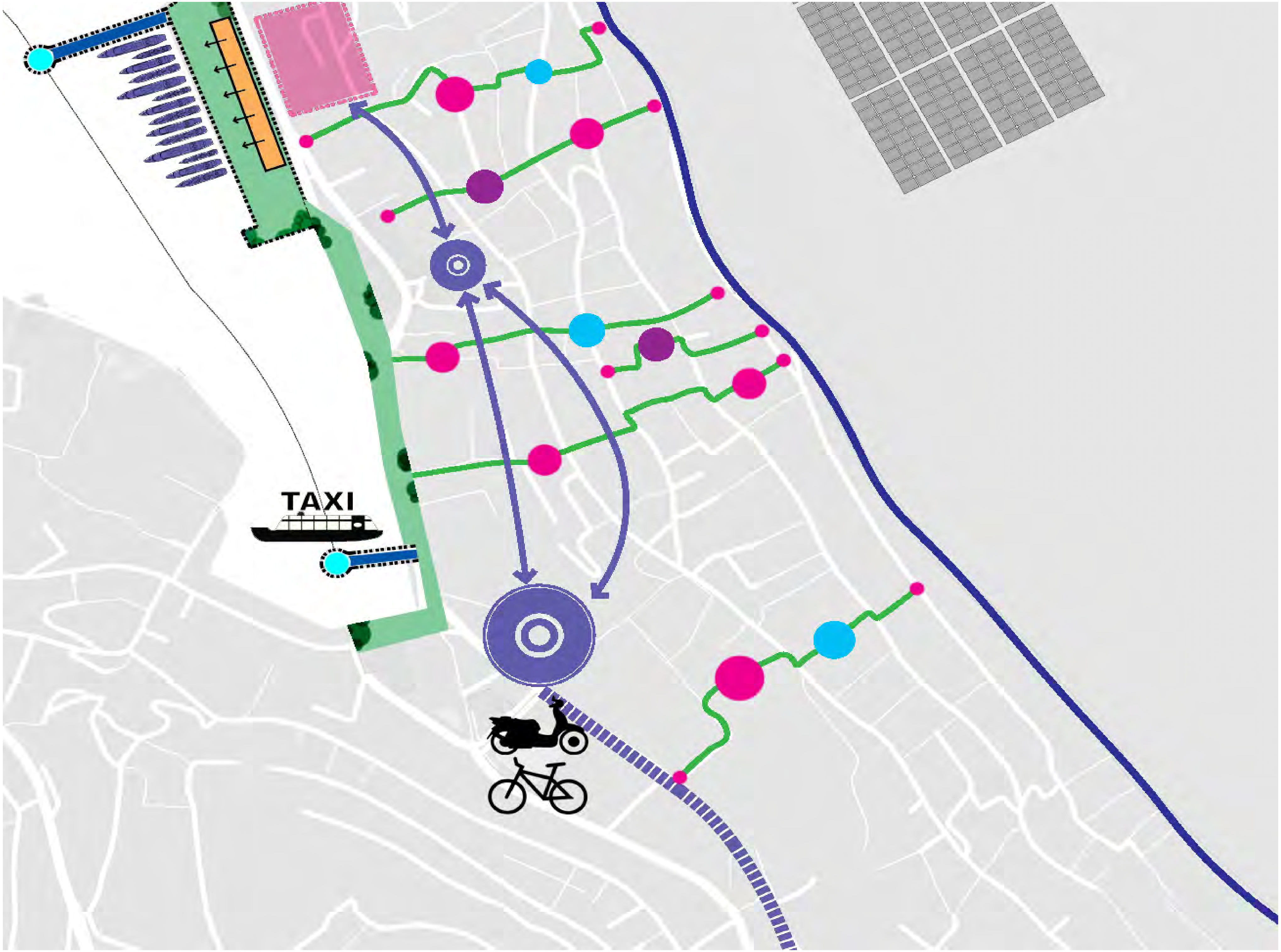


K.o.Sustjepan
140m
140m
280m
140m
140m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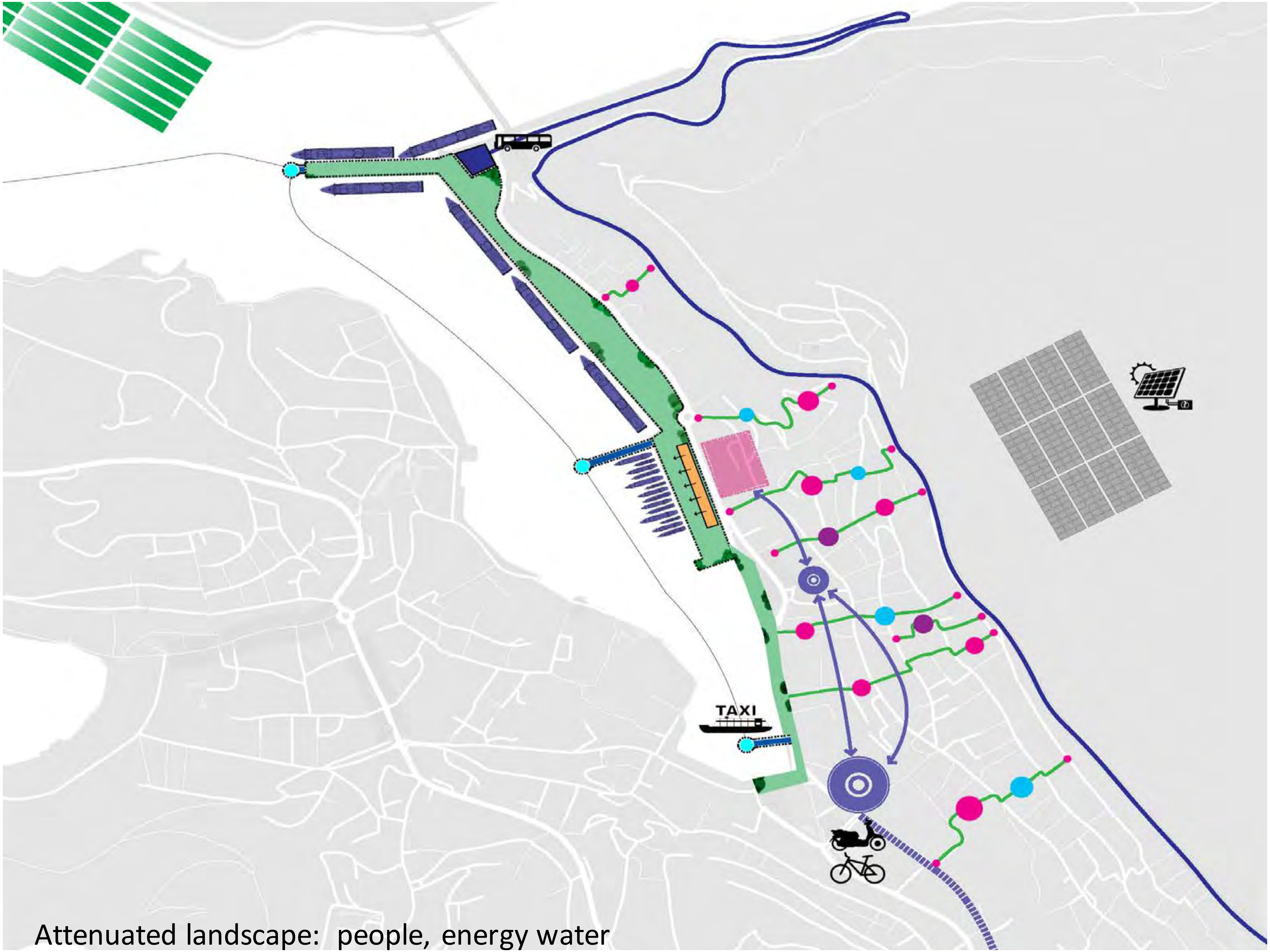
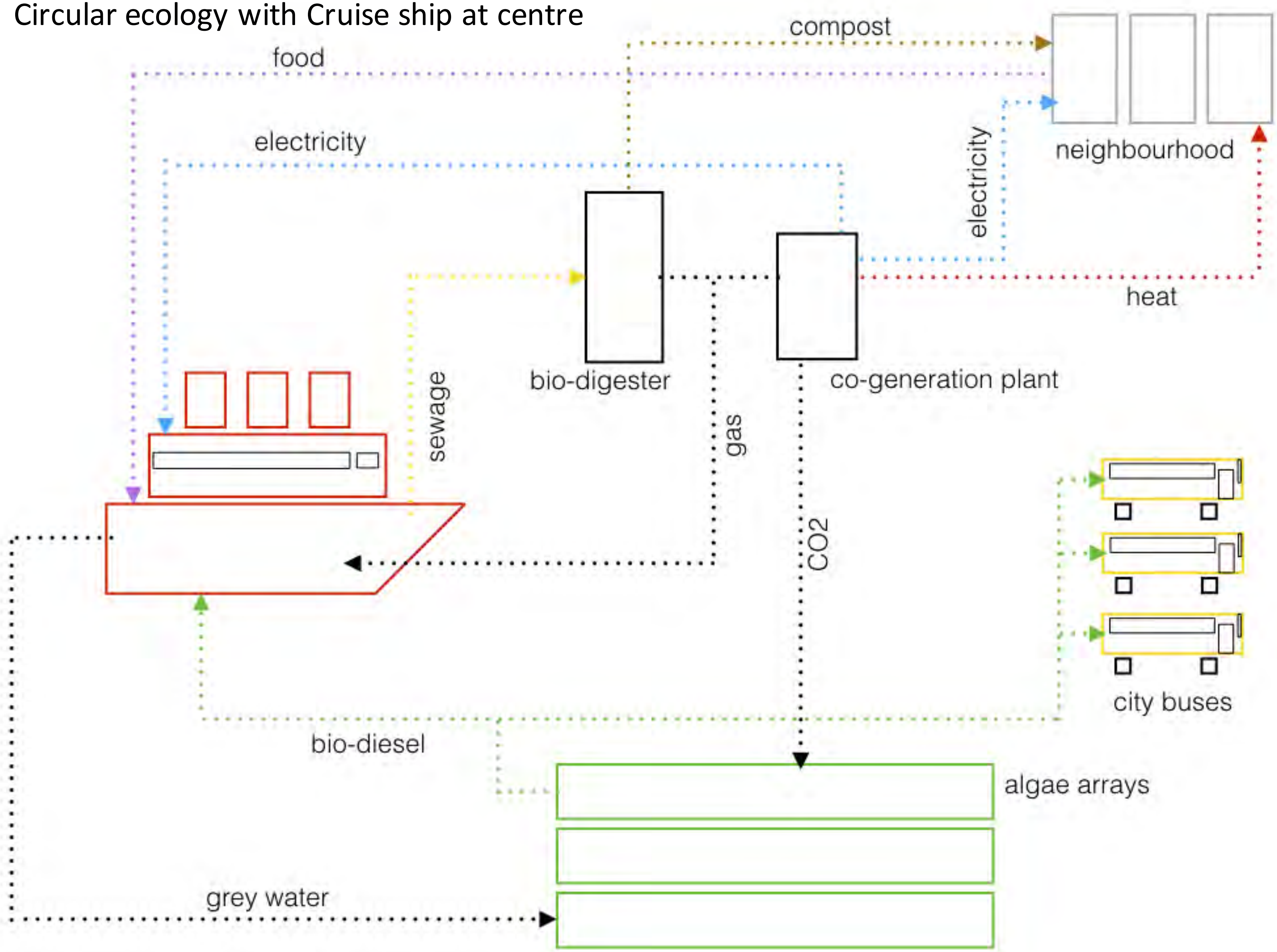
FLOW OF PEOPLE

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

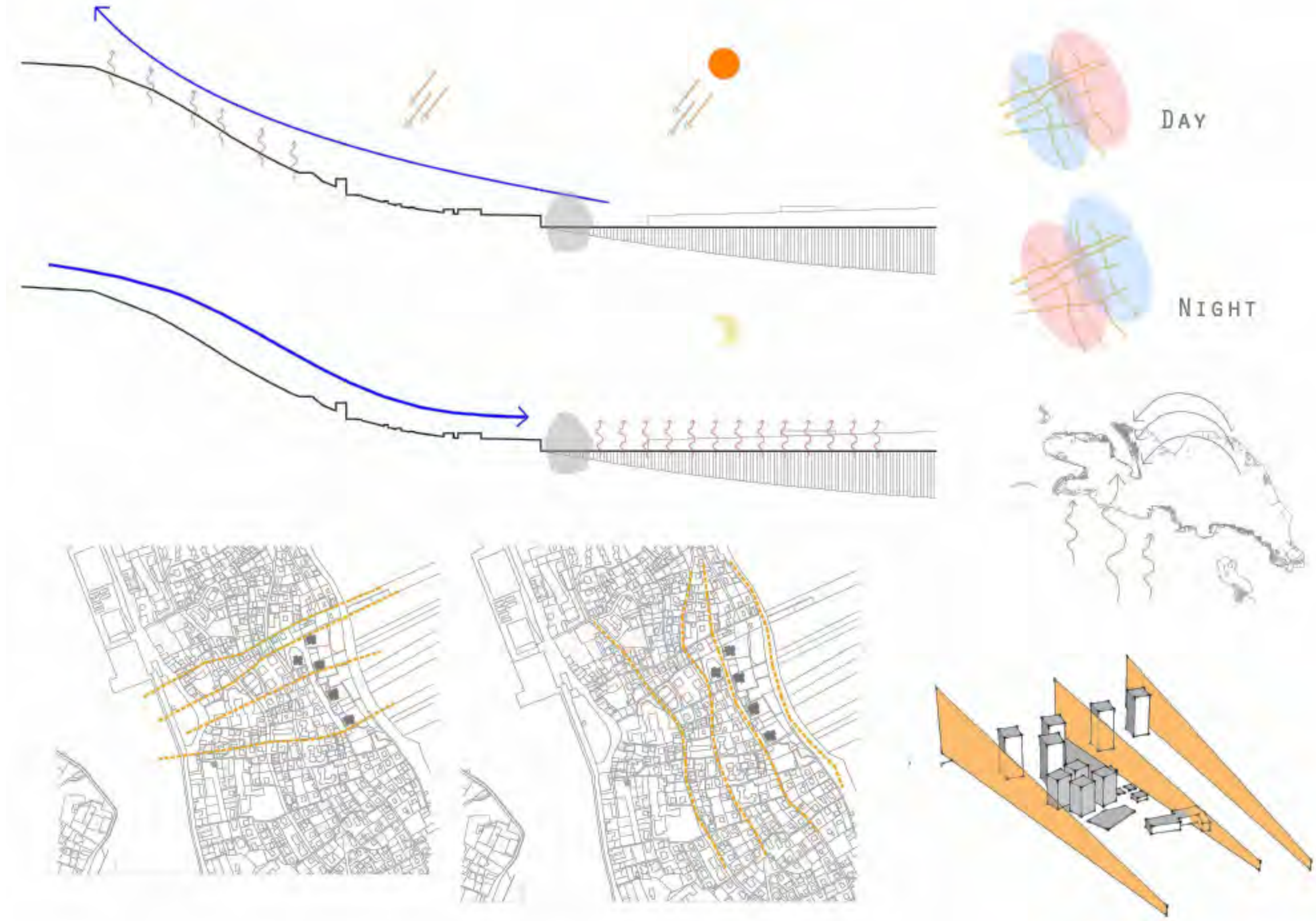
3. Produce renewable energy

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

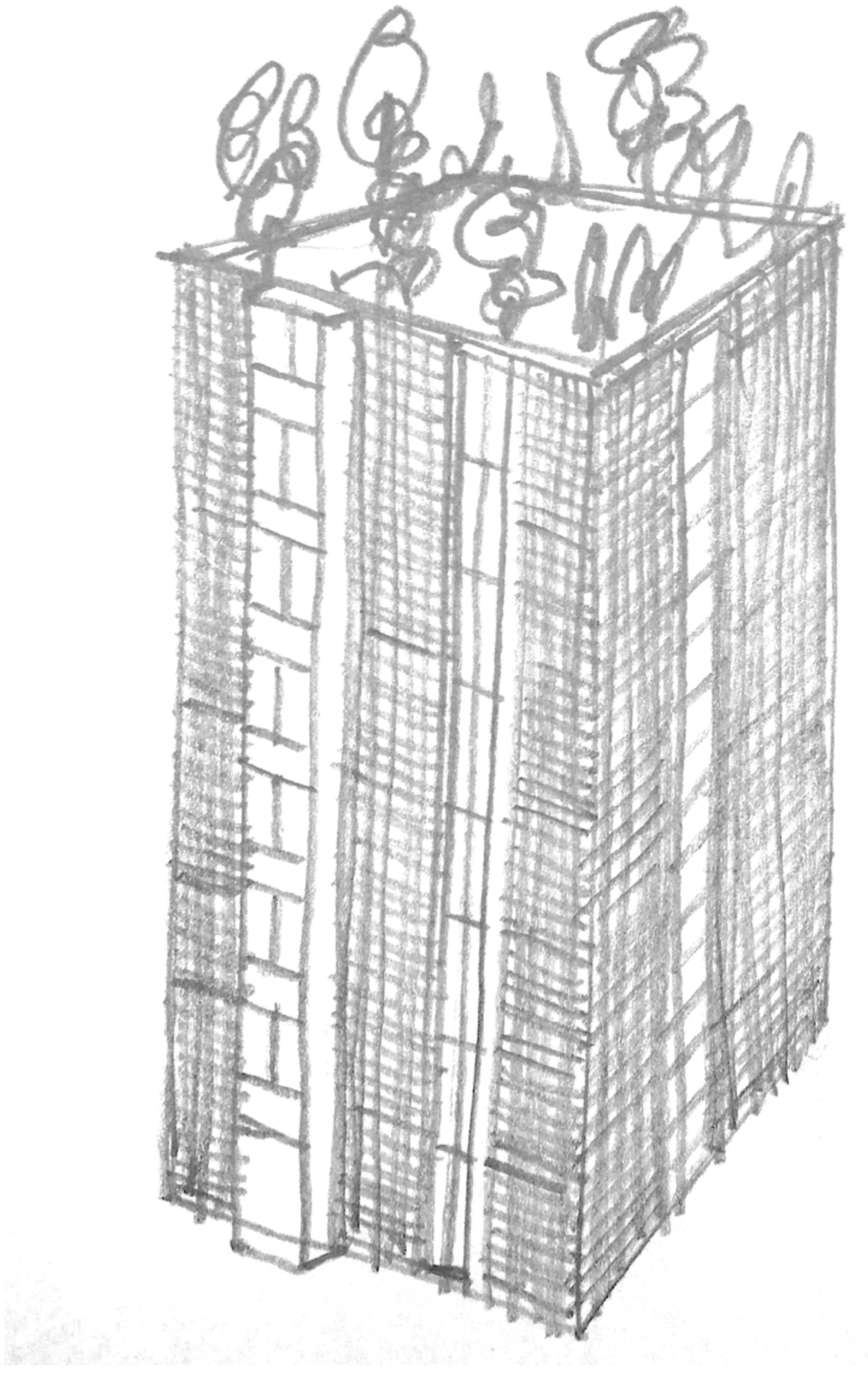
STEP		SCALE				
		individual house	**apartment block**	**neighbourhood**	**district (Gruž)**	**city (Dubrovnik)**
reduce	avoid heating	post-insulation on walls	post-insulation on walls			
energy demand	+ cooling	post-insulation on roofs	post-insulation on roofs			
		cavity wall insulation	cavity wall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

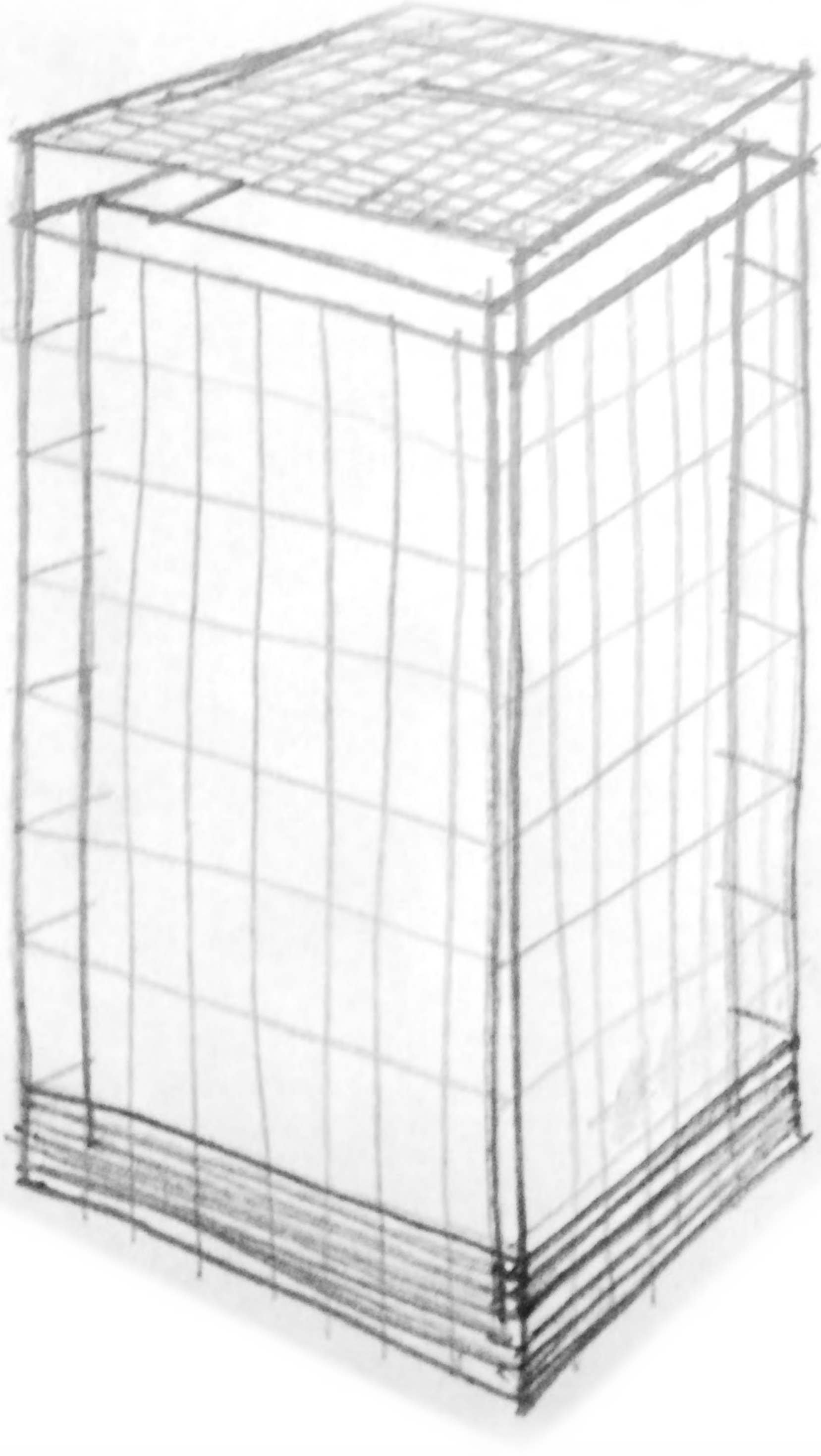
The Gruž lagoon

Passive use of valley breezes



The apartment building





Starting-point

Starting-point **+ post-insulation**

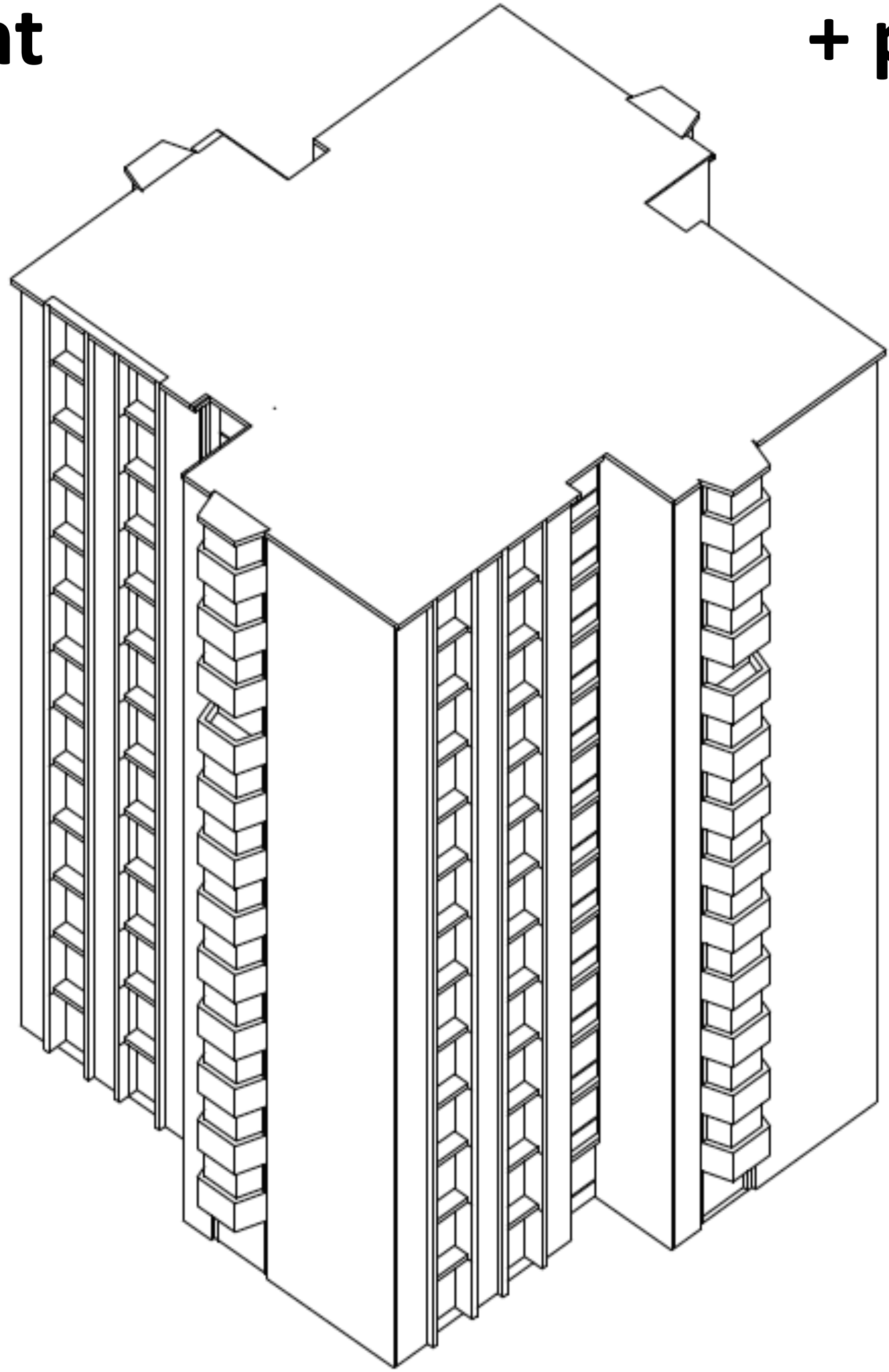


Image after post-insulation (and plaster finish)

PV façade cladding

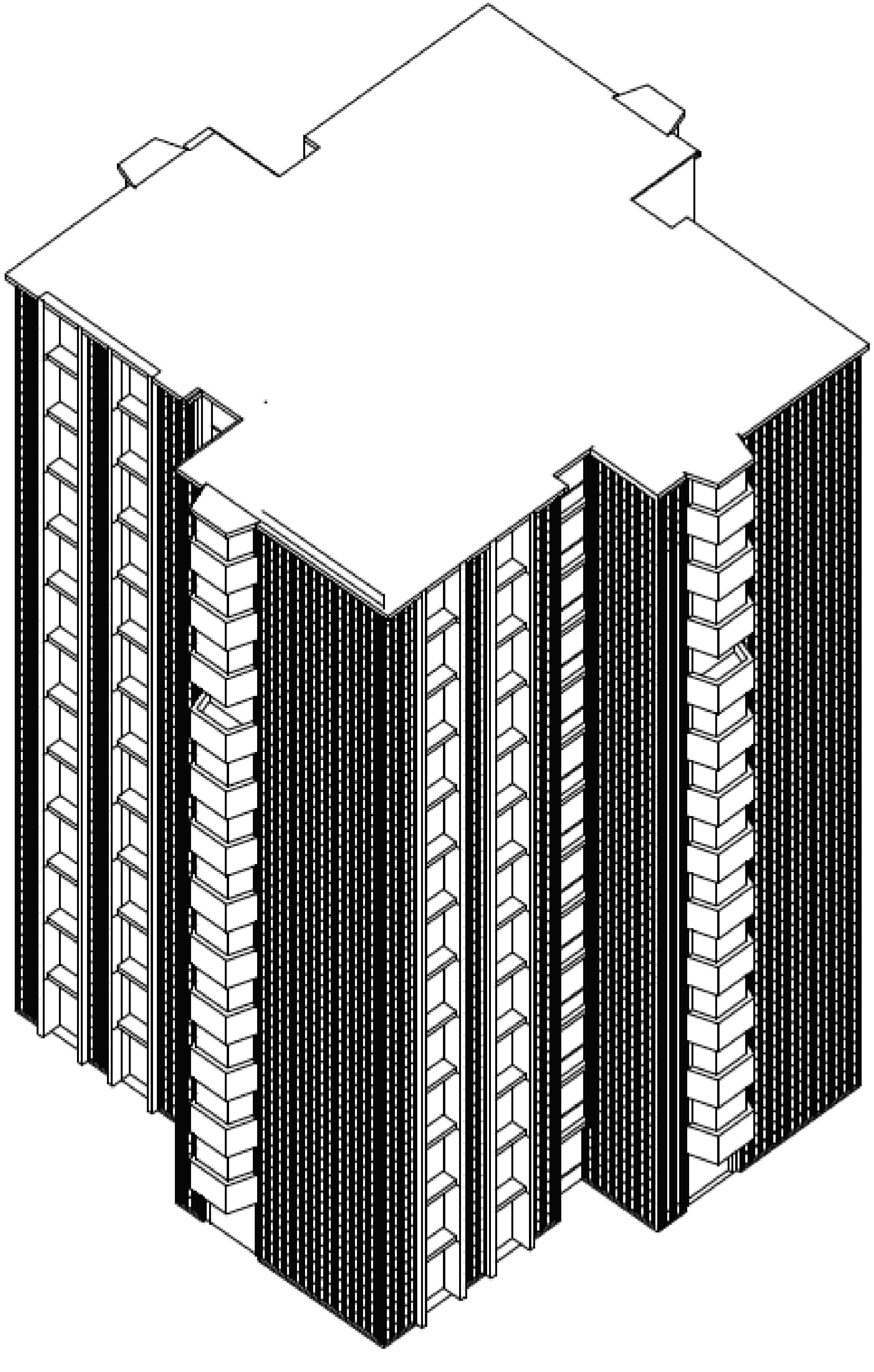
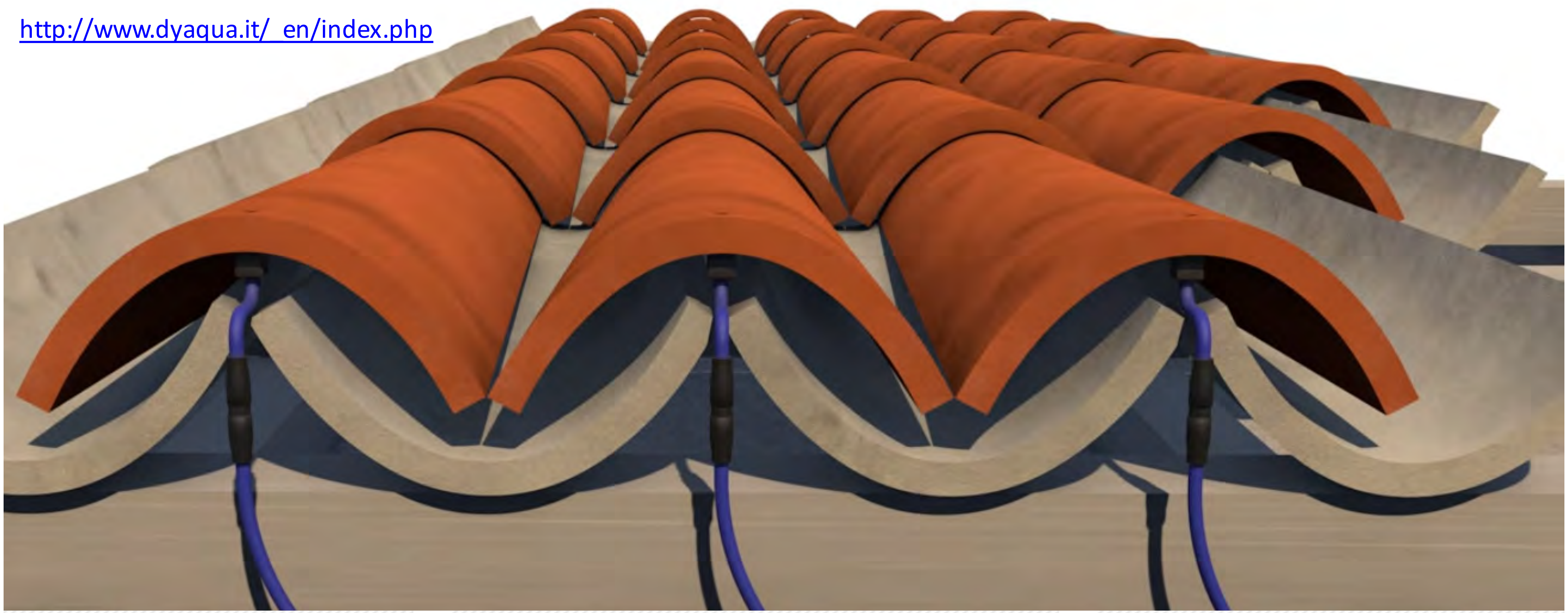


Image with PV façade cladding

Integrated PV for single houses

http://www.dyaqua.it/_en/index.php



4,5 Wp

Peak power

15 m2

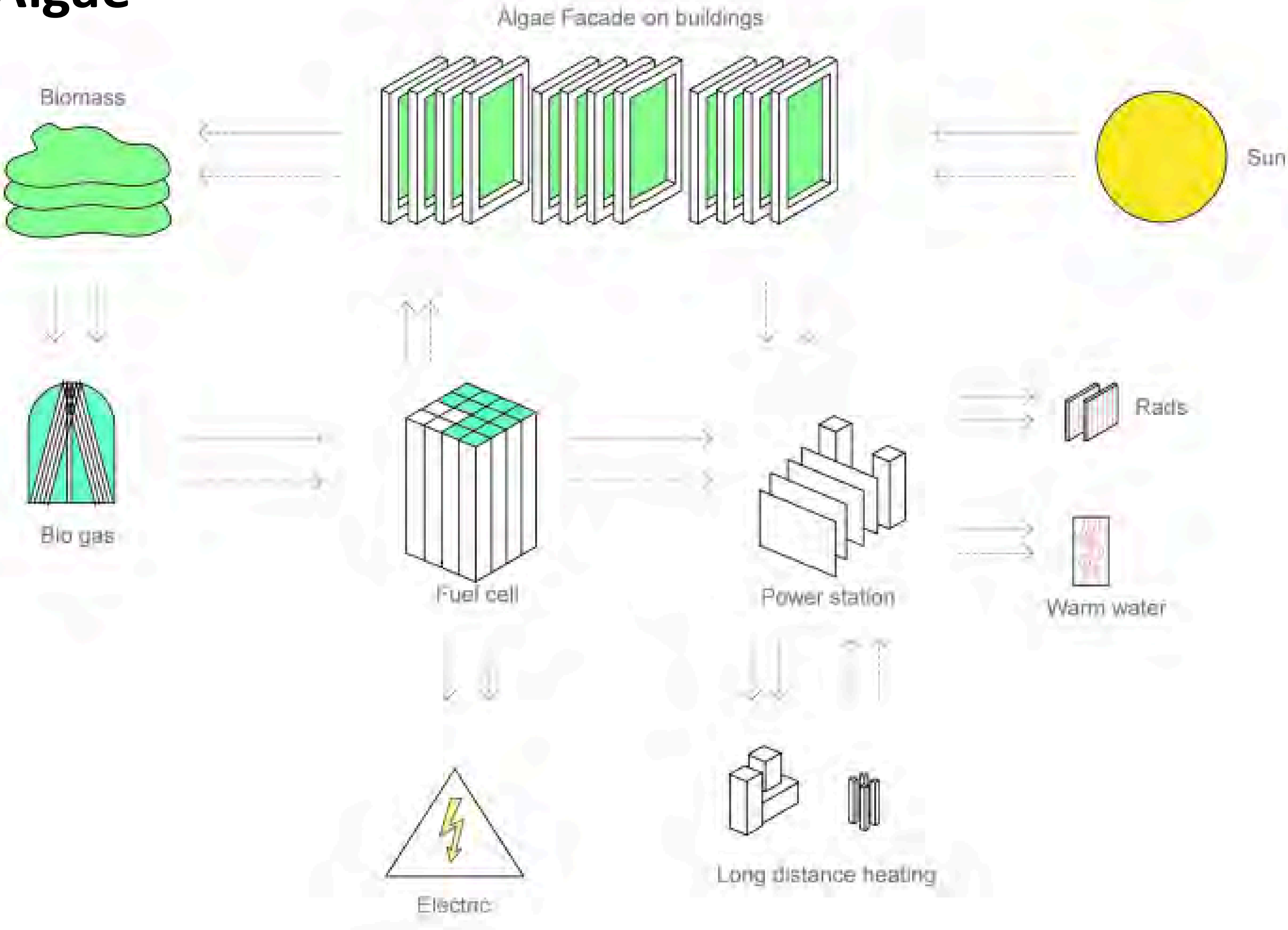
Required area for 1 kWp

223 Rooftiles

To generate 1 kWp

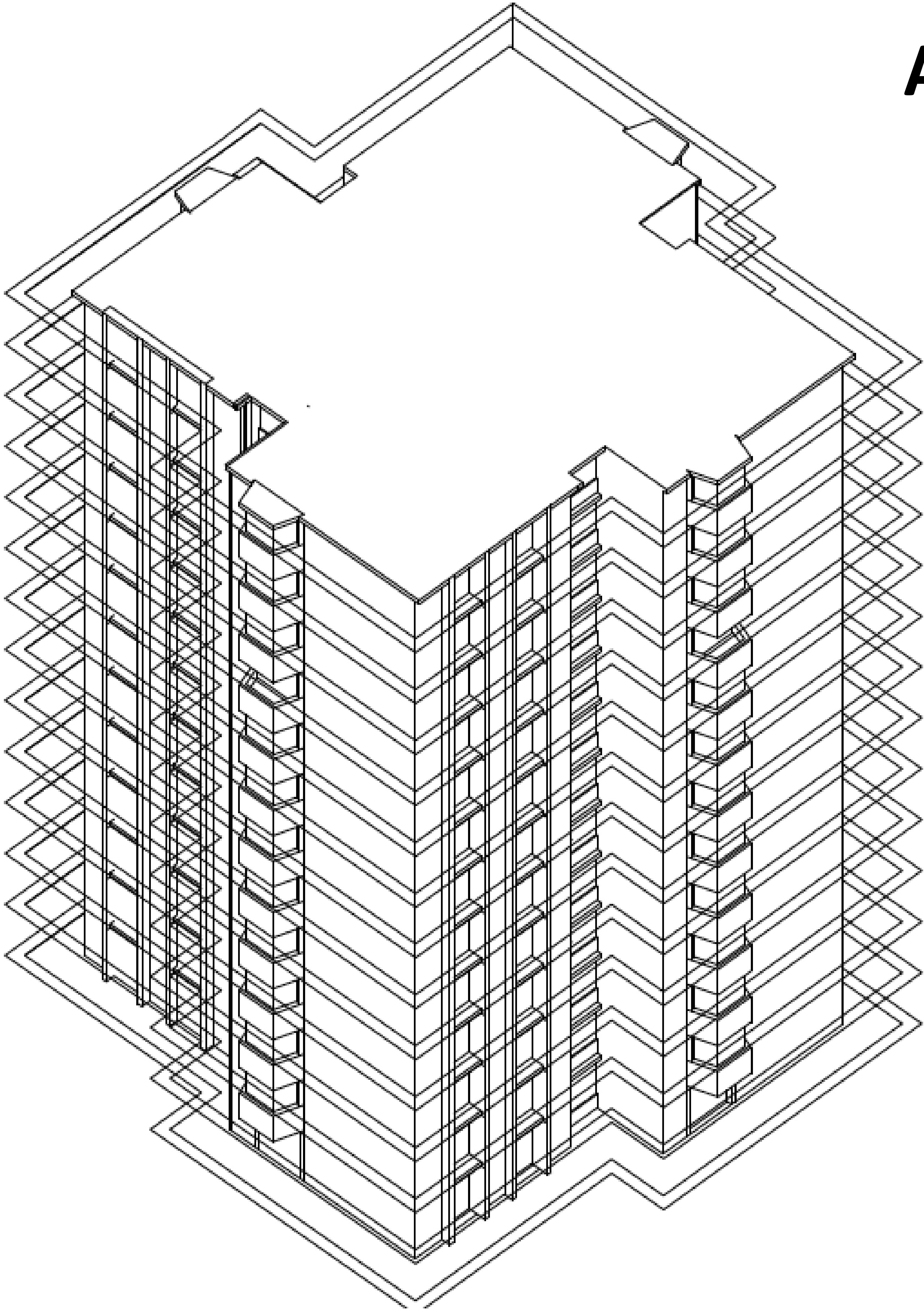
PV-covered parking lots

Algae



Algae Facade on buildings
Biomass
Sun
Bio gas
Fuel cell
Power station
Rads
Warm water
Electric
Long distance heating

Algae façade elements



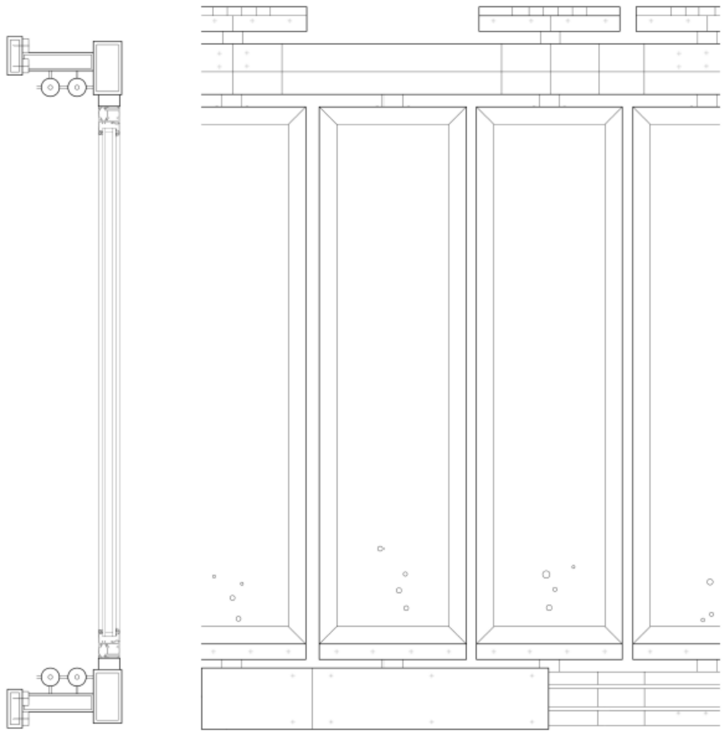


Image with algae façades

Algae façade

Solar glasshouse façade

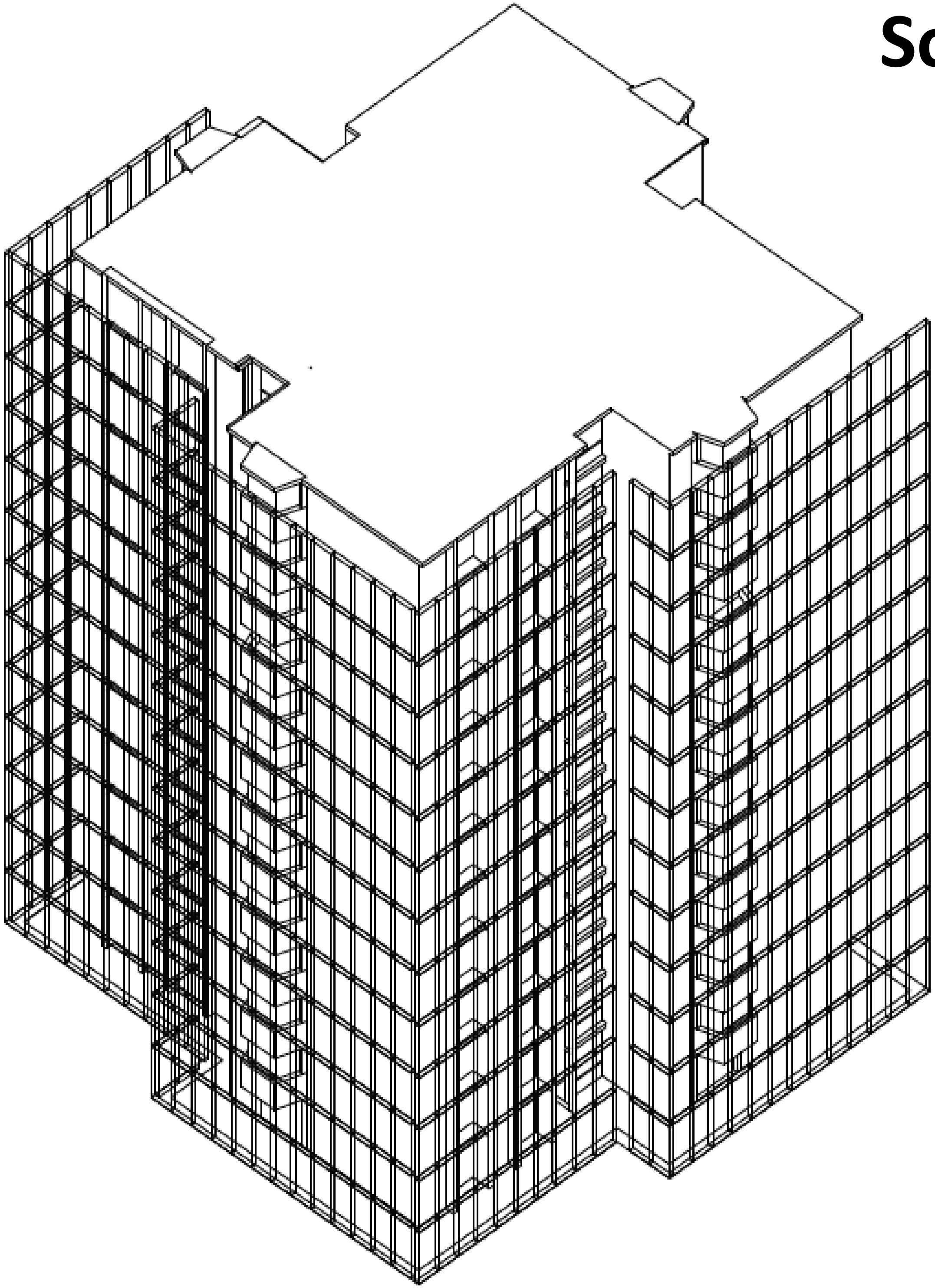
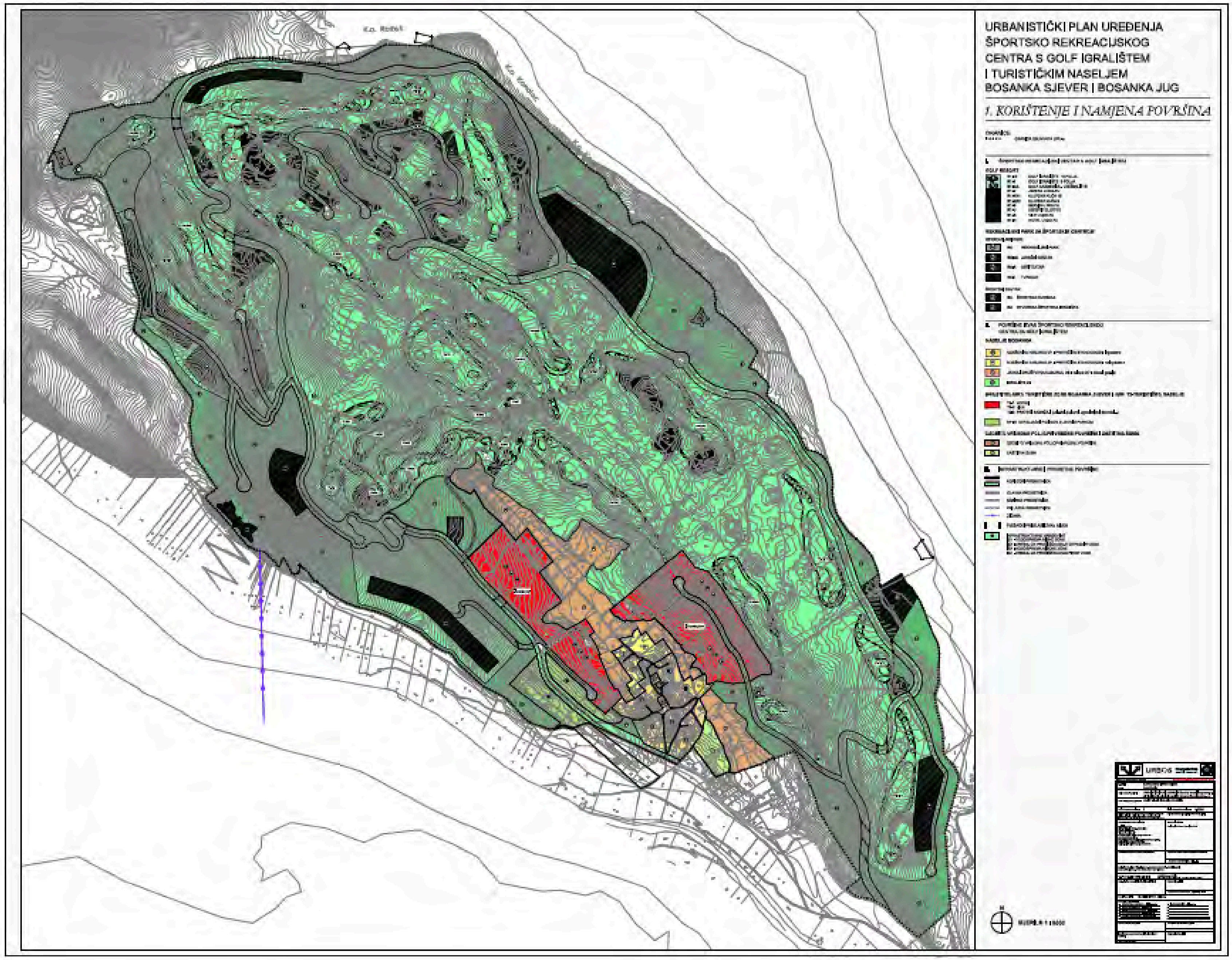


Image with solar glasshouse façade

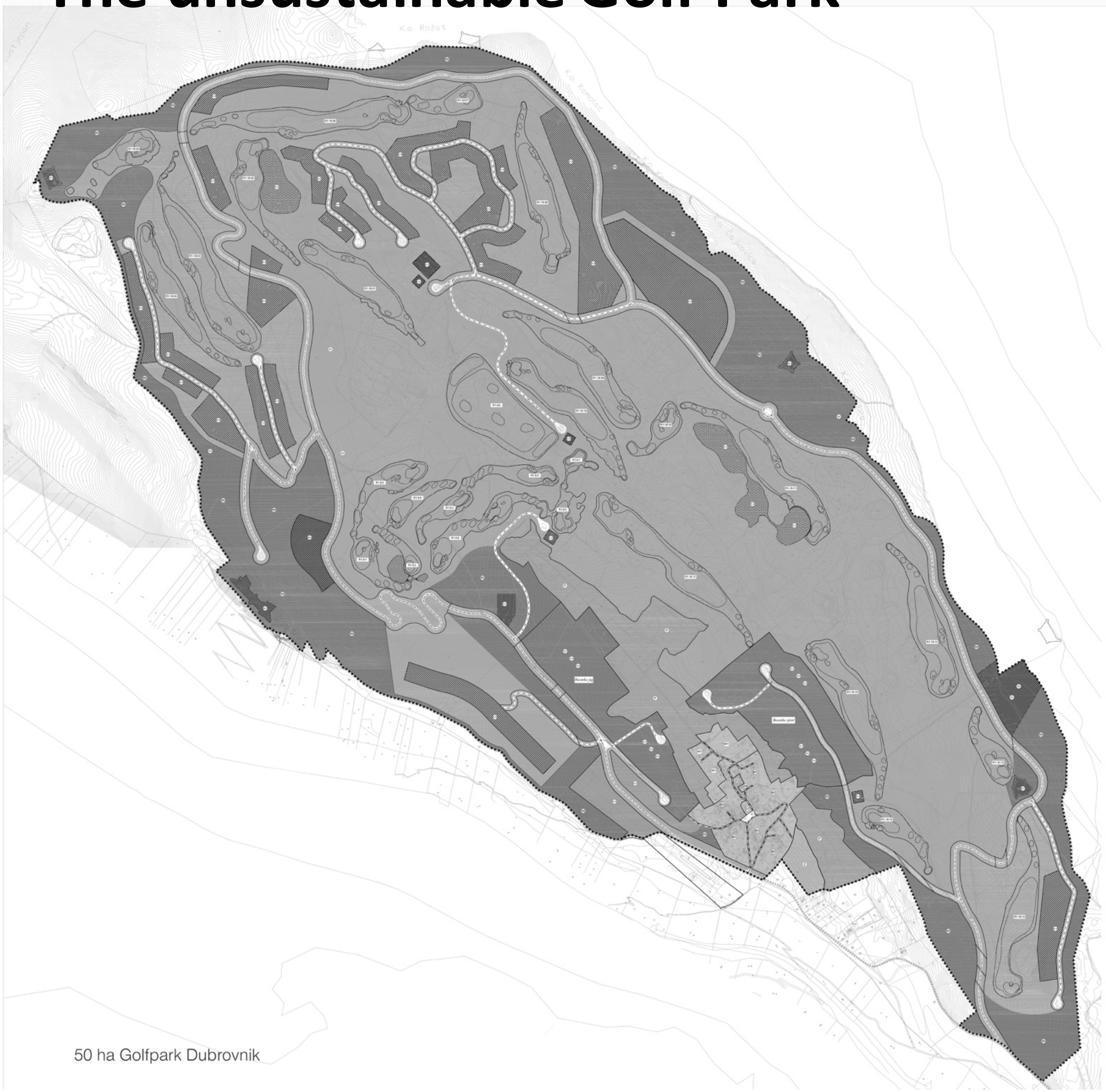
Example for a terraced house

Green façade

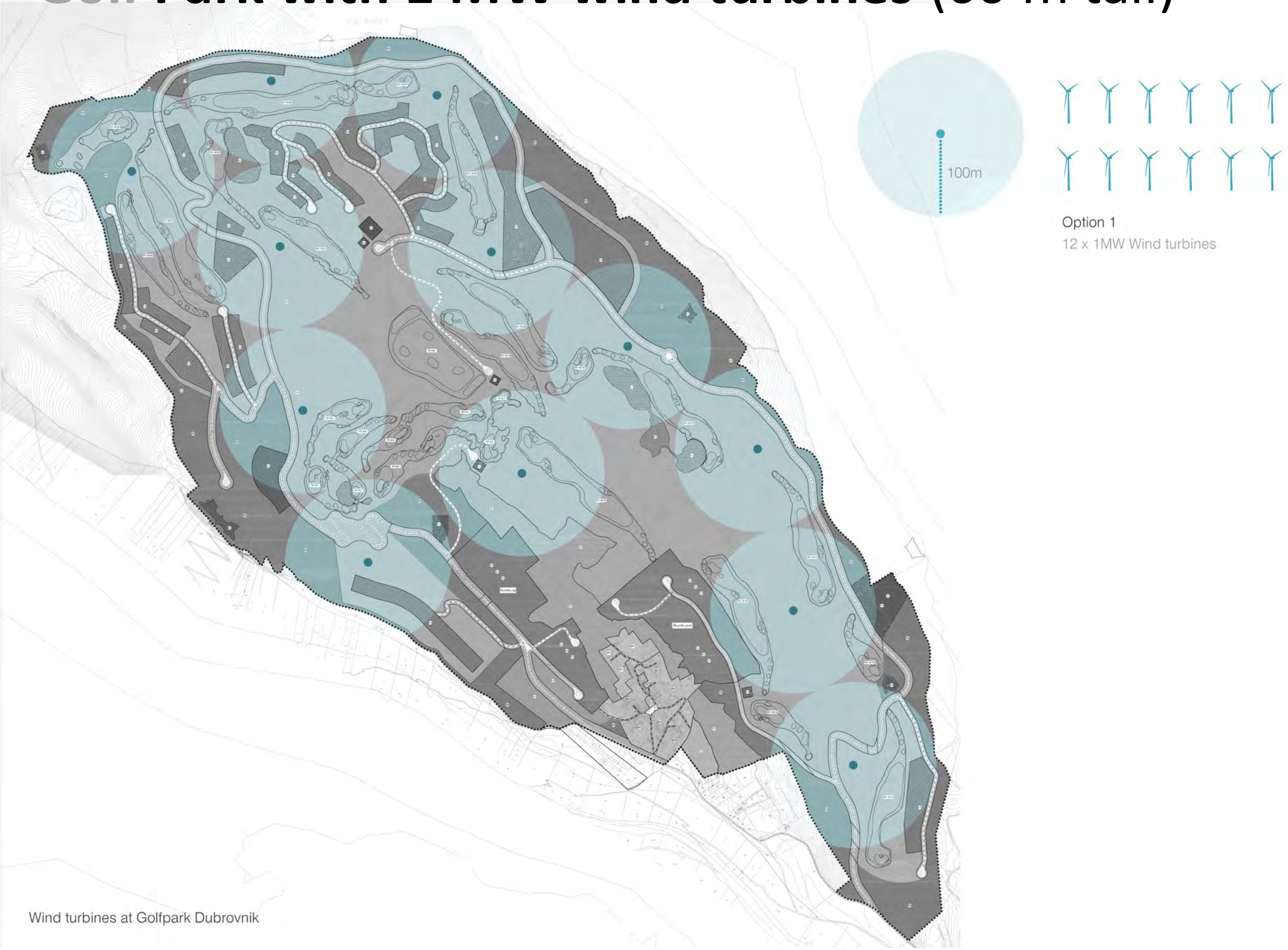
Talking about green: the Golf Park plan…



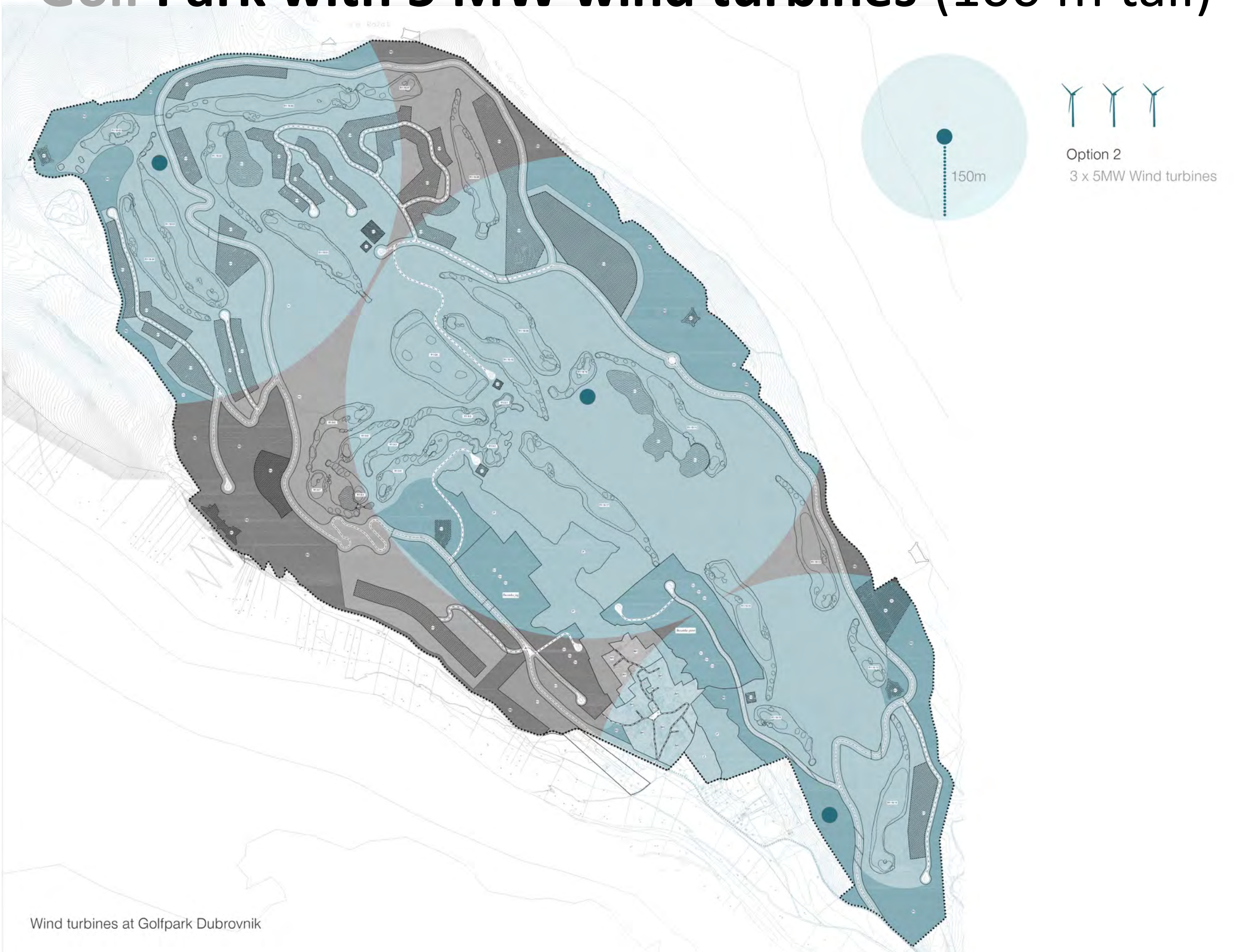
The unsustainable Golf Park



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



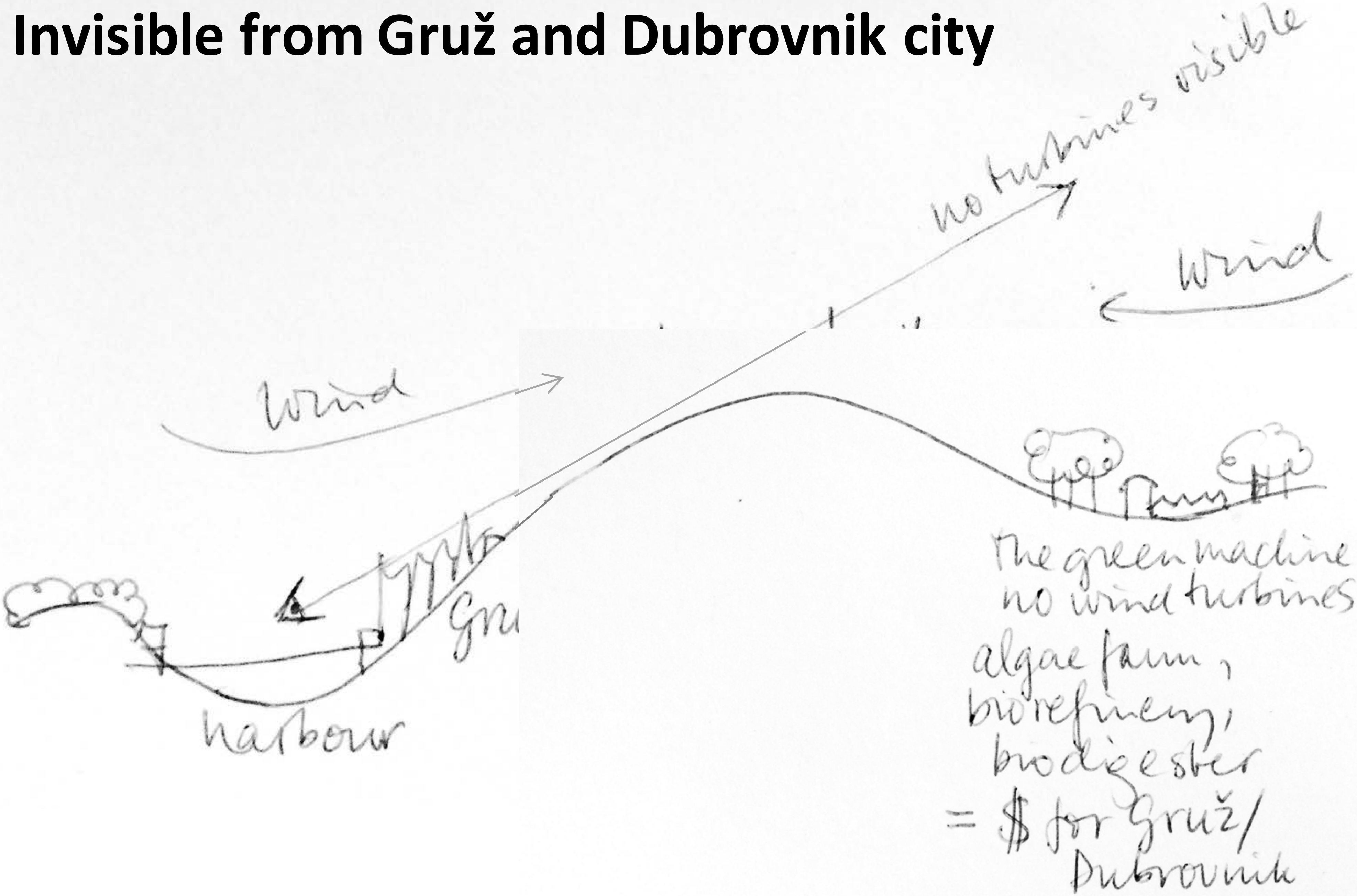
Golf Park with 5 MW wind turbines (100 m tall)



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

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

Nice, France

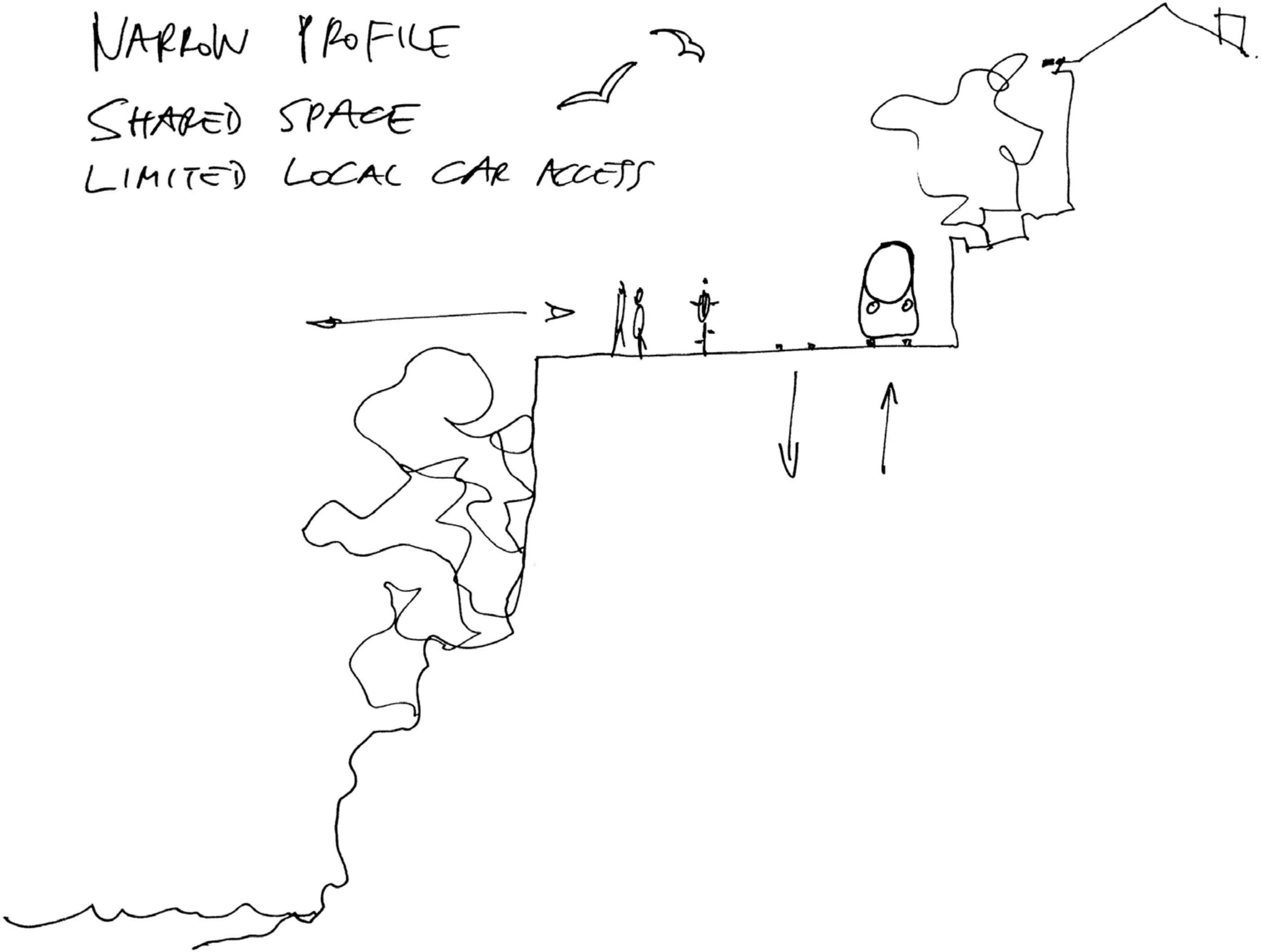
Bruges, Belgium

Combination with pedestrians and cyclists

NARROW PROFILE

SHARED SPACE

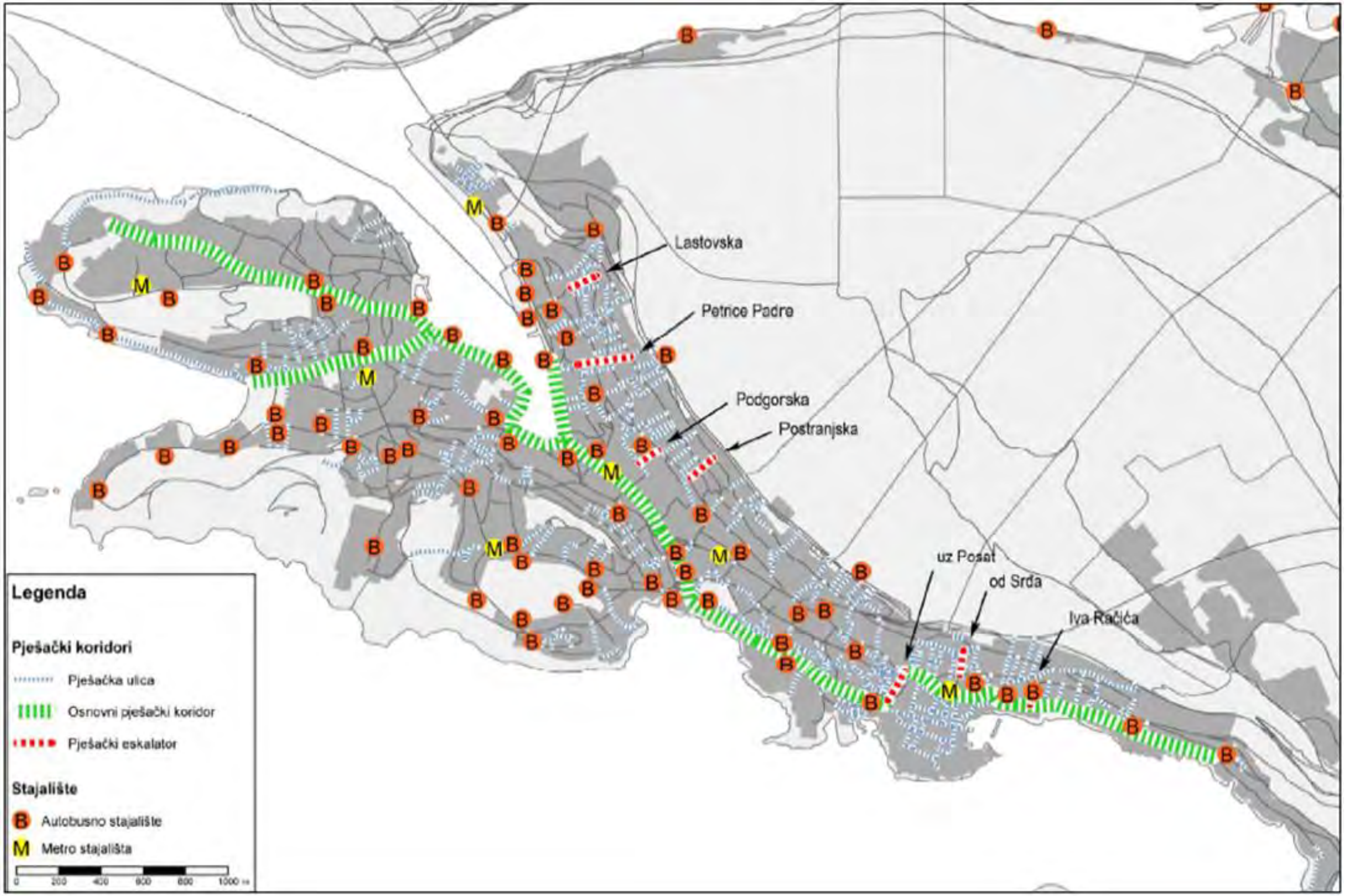
LIMITED LOCAL CAR ACCESS



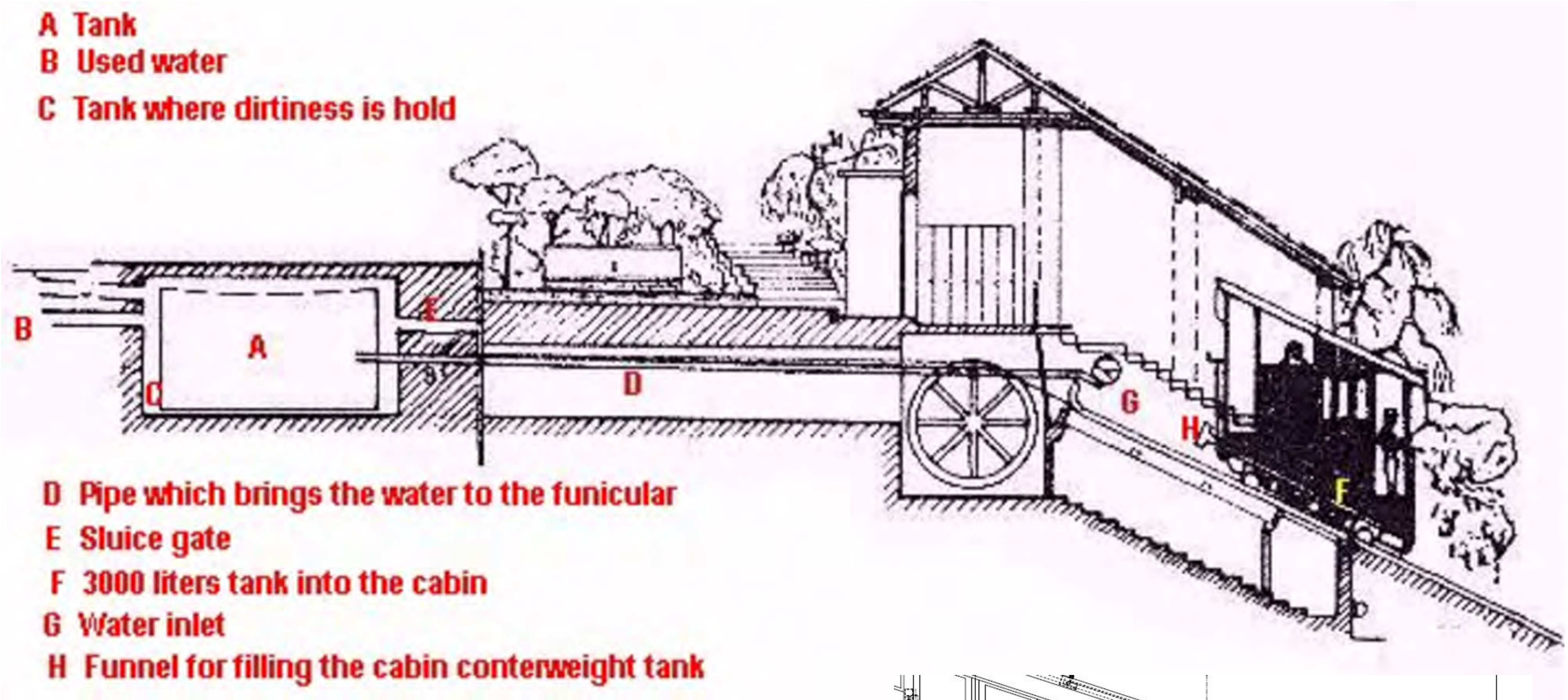
BROAD PROFILE DOUBLE ONE WAY ROADS
ONE CAR LANE PER DIRECTION

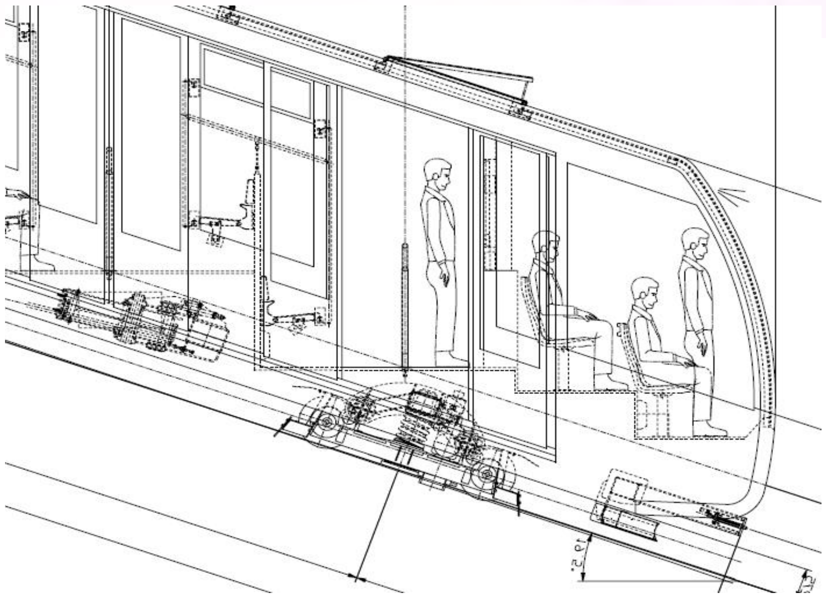
Similar proposals were formulated already before

[Traffic study of Dubrovnik city, 2012]



New cable cars?



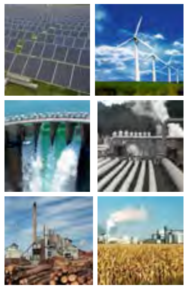


Water-powered escalator

Water-powered escalator

ELECTRICITY EMISSION FACTOR FOR CROATIA

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 CO_2eq/kWh

CARBON FOOTPRINT PER HOUSEHOLD IN GRUŽ

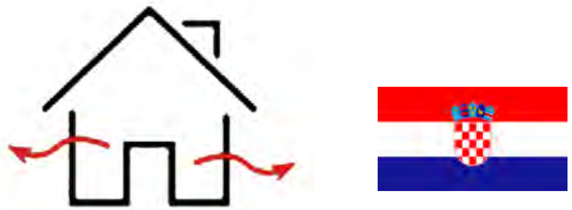
CITY-zen New urban energy

GRUŽ (DUBROVNIK) HOUSEHOLD

Average inhabitants	2.75		
Gross floor area	100	m^2	
ENERGY DEMAND	**2704**	**kg CO_2eq**	**47%**
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 CO_2eq**	**20%**
km by 1 car (80% work day)	15.3	km/day	
WASTE MANAGEMENT	**1726**	**kg CO_2eq**	**30%**
Waste per household	1,67	t/yr	
Waste to energy	0	%	
Waste to landfill	89	%	
Organic waste	1	%	
WATER MANAGEMENT	**164**	**kg CO_2eq**	**3%**
Water use per household	280	m^3/yr	

5.92 t CO_2eq/yr

5.04 t CO_2eq/yr



CARBON FOOTPRINT

5.70 t CO_2eq/yr

***5.16 t CO_2eq** per 80 m^2 household

CARBON FOOTPRINT PER HOUSEHOLD IN GRUŽ

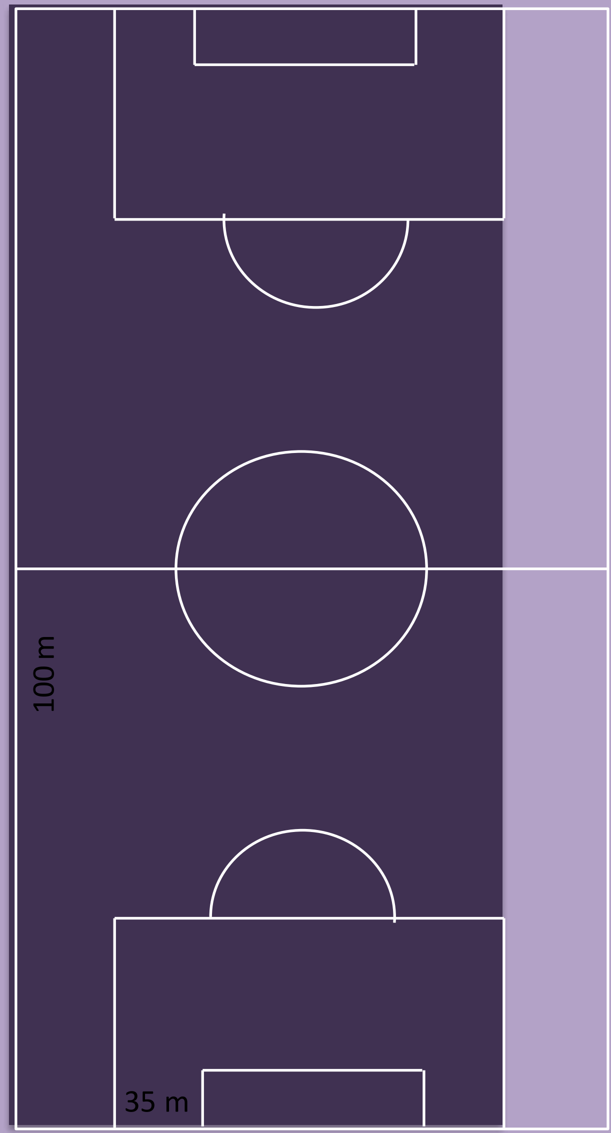
CARBON FOOTPRINT OFFSET

carbon uptake by urban forestry (i.e. 1.35 kg CO_2/m^2)

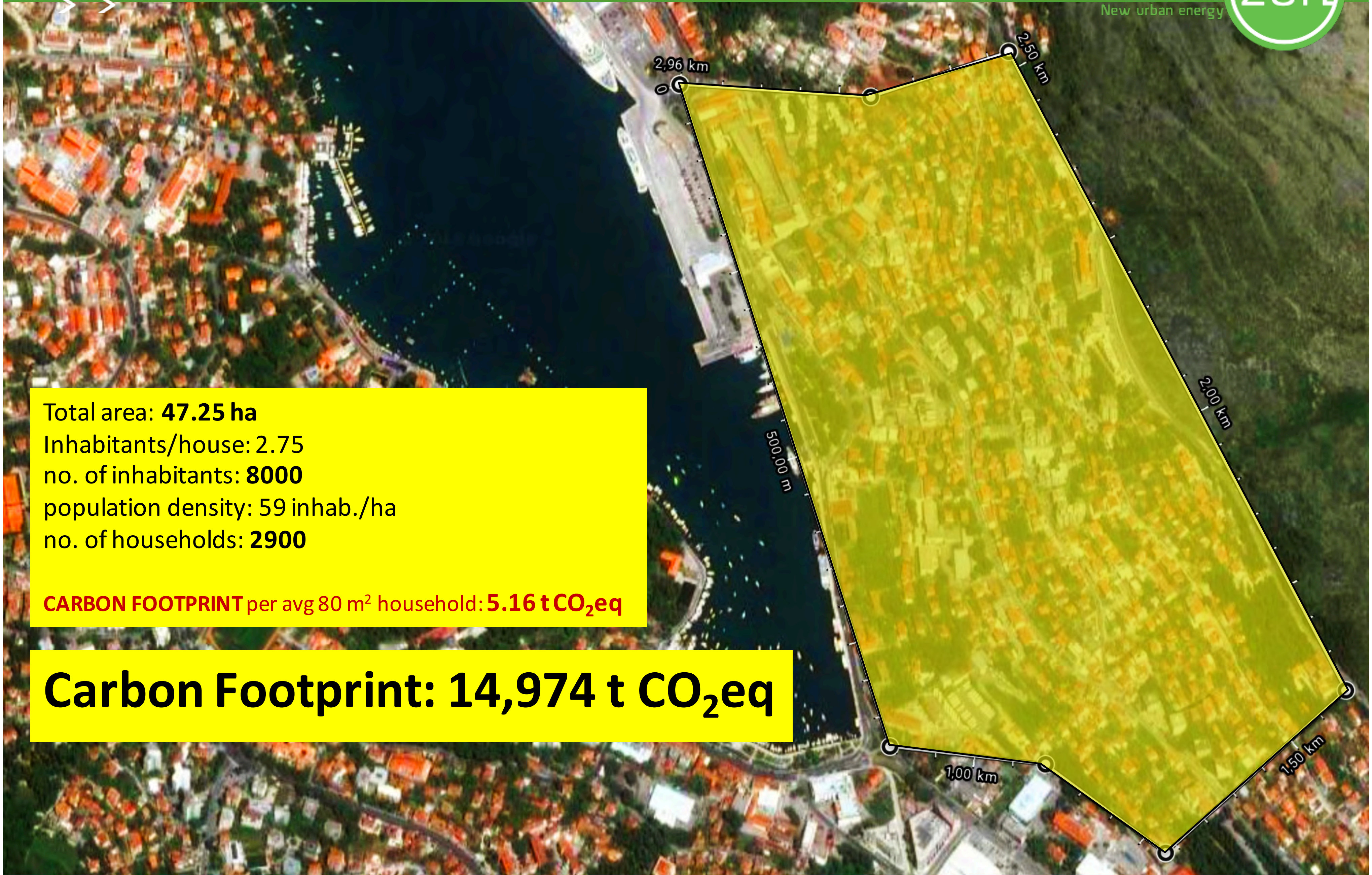
The carbon footprint of one household is equivalent to **14,300 km driven by car**

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

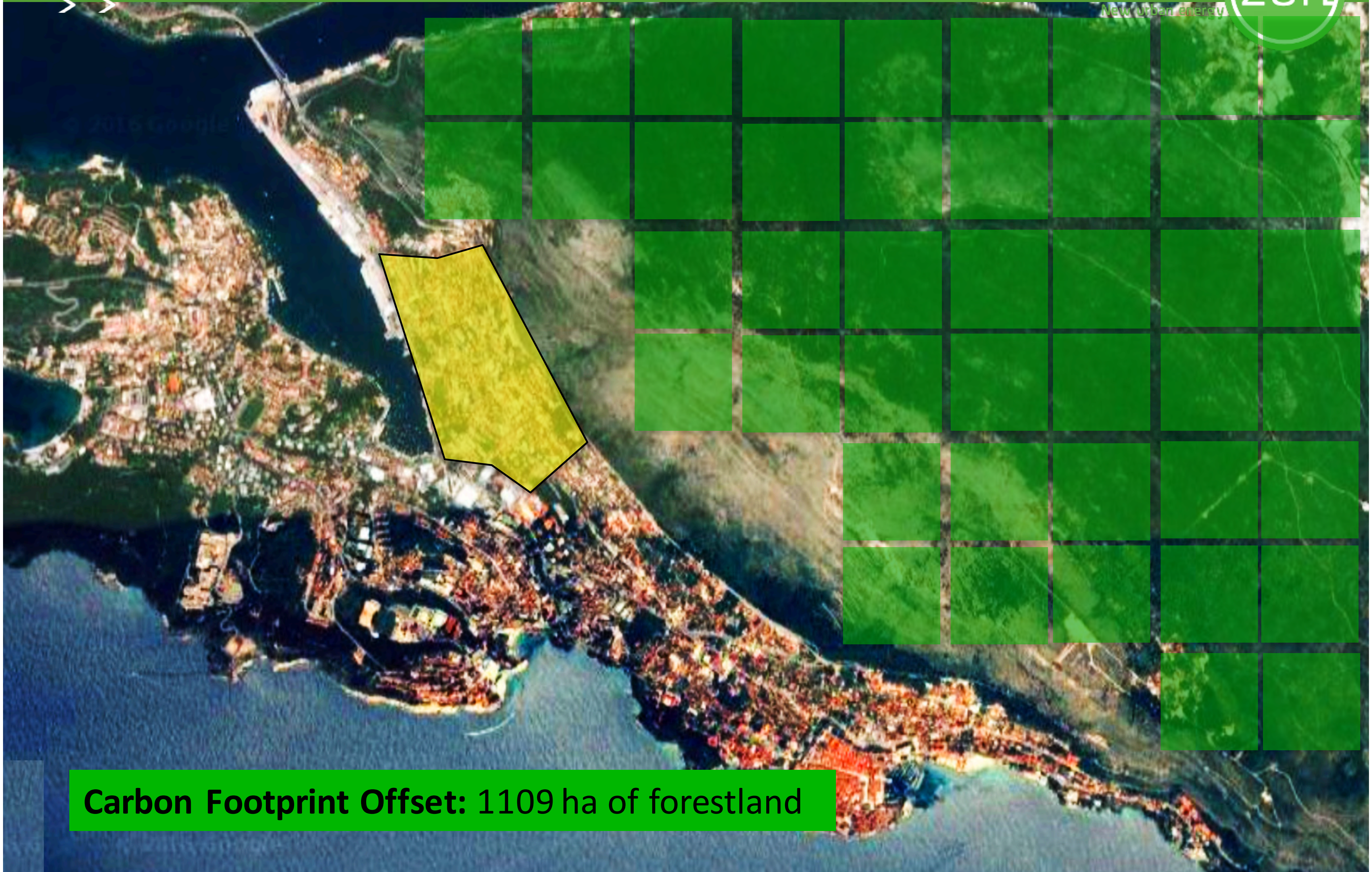


Total area: **47.25 ha**
Inhabitants/house: 2.75
no. of inhabitants: **8000**
population density: 59 inhab./ha
no. of households: **2900**

CARBON FOOTPRINT per avg 80 m^2 household: **5.16 t CO_2eq**

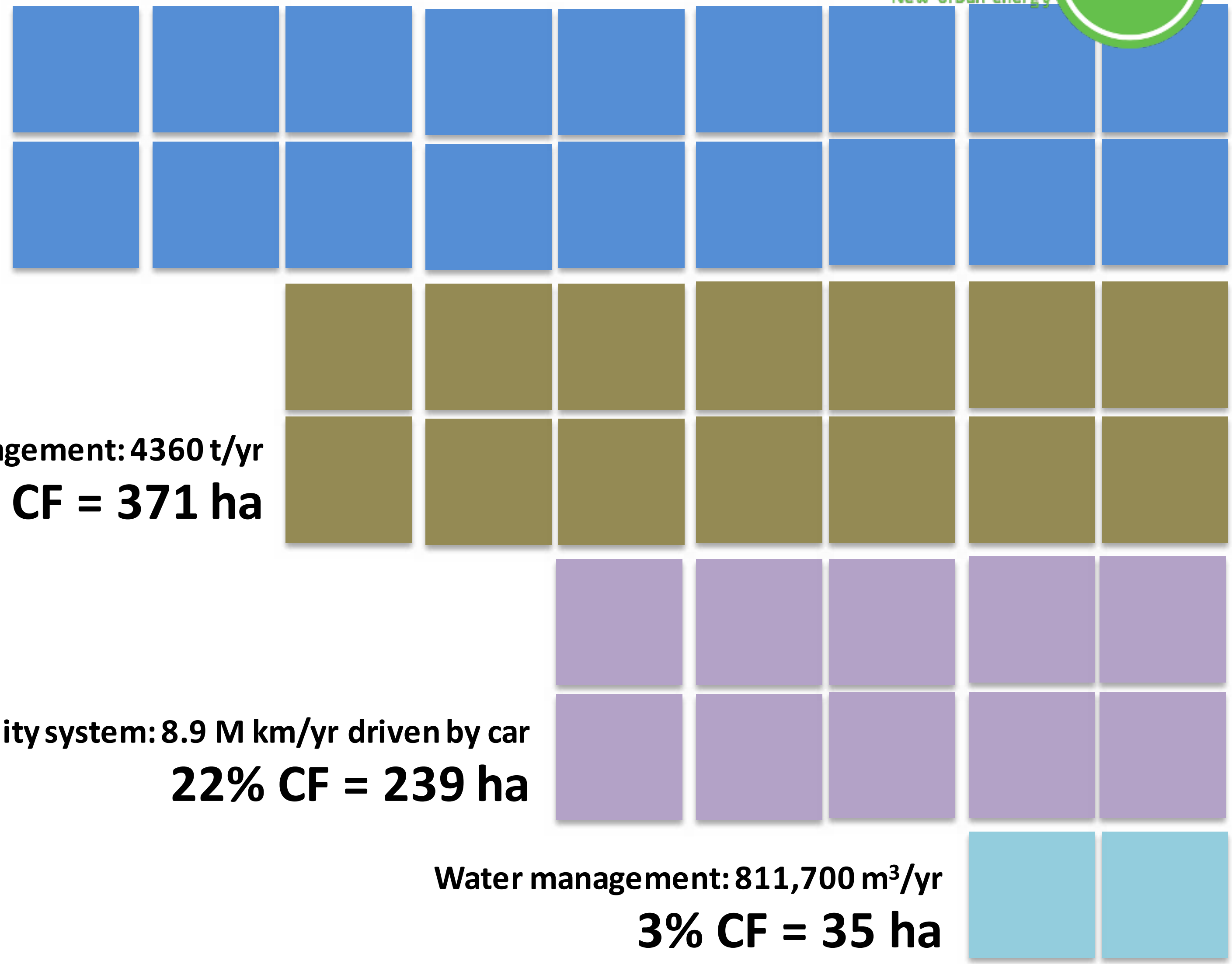
Carbon Footprint: 14,974 t CO_2eq

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

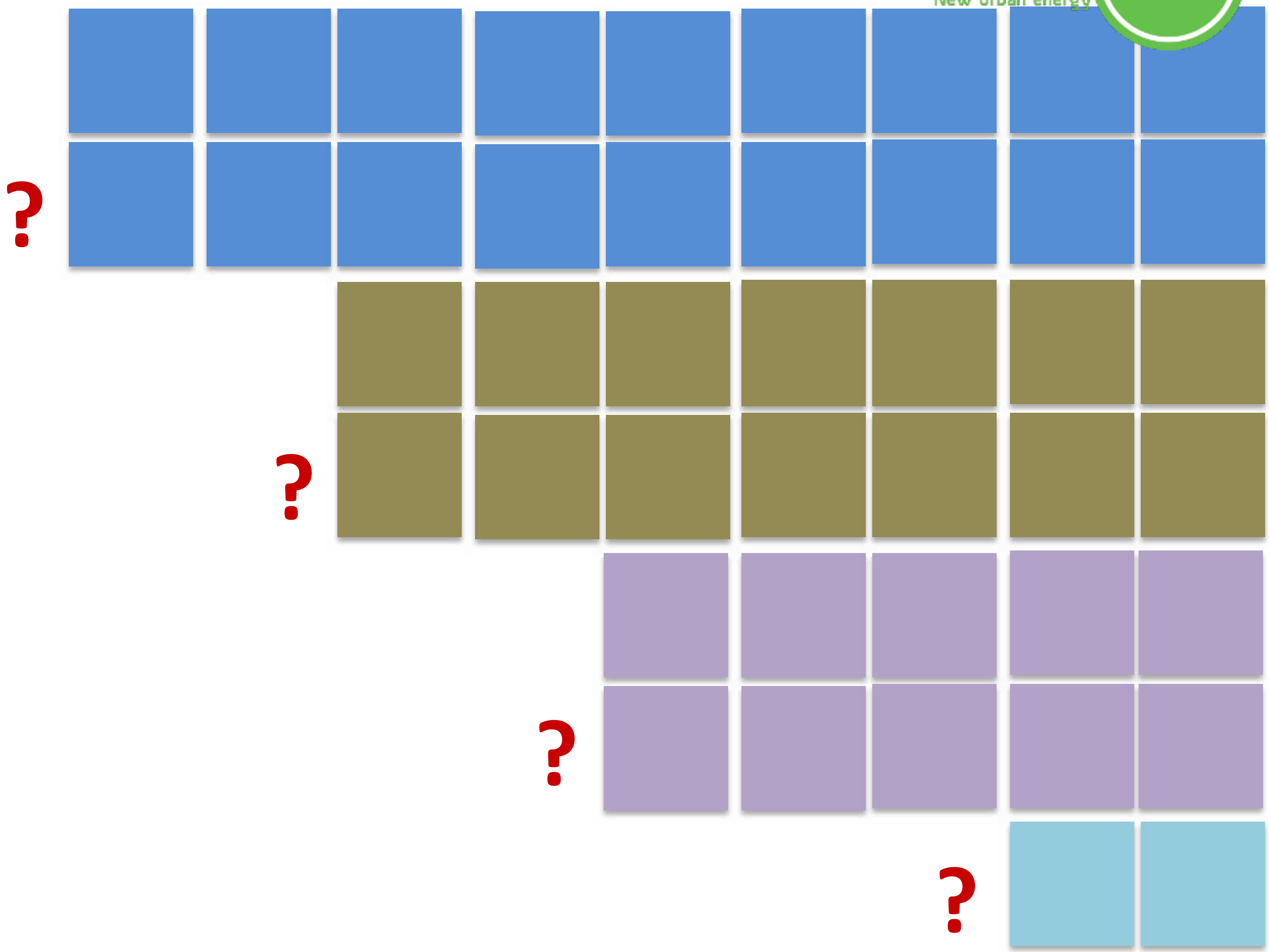
22% CF = 239 ha

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 (35º) → 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**
  - Ground- or water-source heat pump for 50% of households
  - COP heating season: 3
  - COP cooling season: 4
- **Total energy savings: 26%**

ENERGY MEASURES

Wind energy production assessment

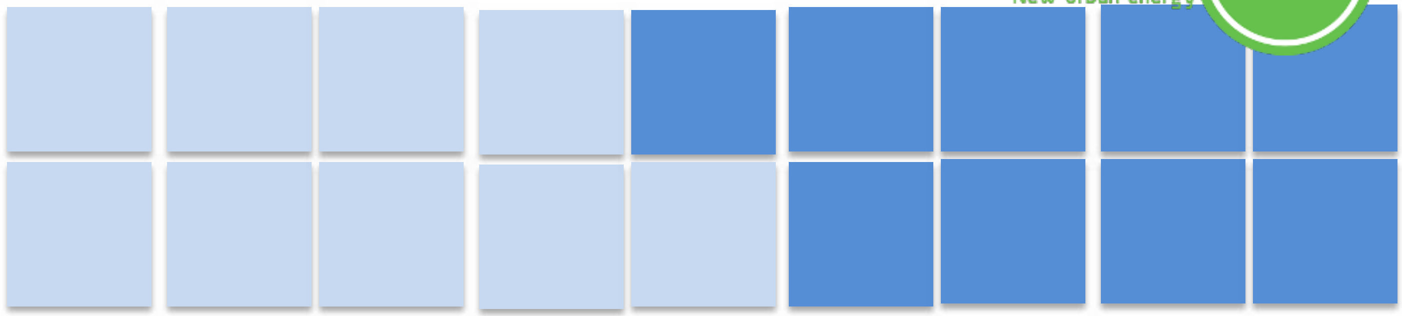
- **Small wind turbines**
  - Limited potential
  - Quite expensive
  - Proposed for GrUž: 50 x 5 kW wind turbines
  - 1300 full load hours (wind velocity 5 m/s)
  - **Total renewable energy production: 325 MWh**

- **Big wind turbines**
  - Great technical potential behind the hills
  - Building permit might be problem
  - Proposed for Grž: 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%

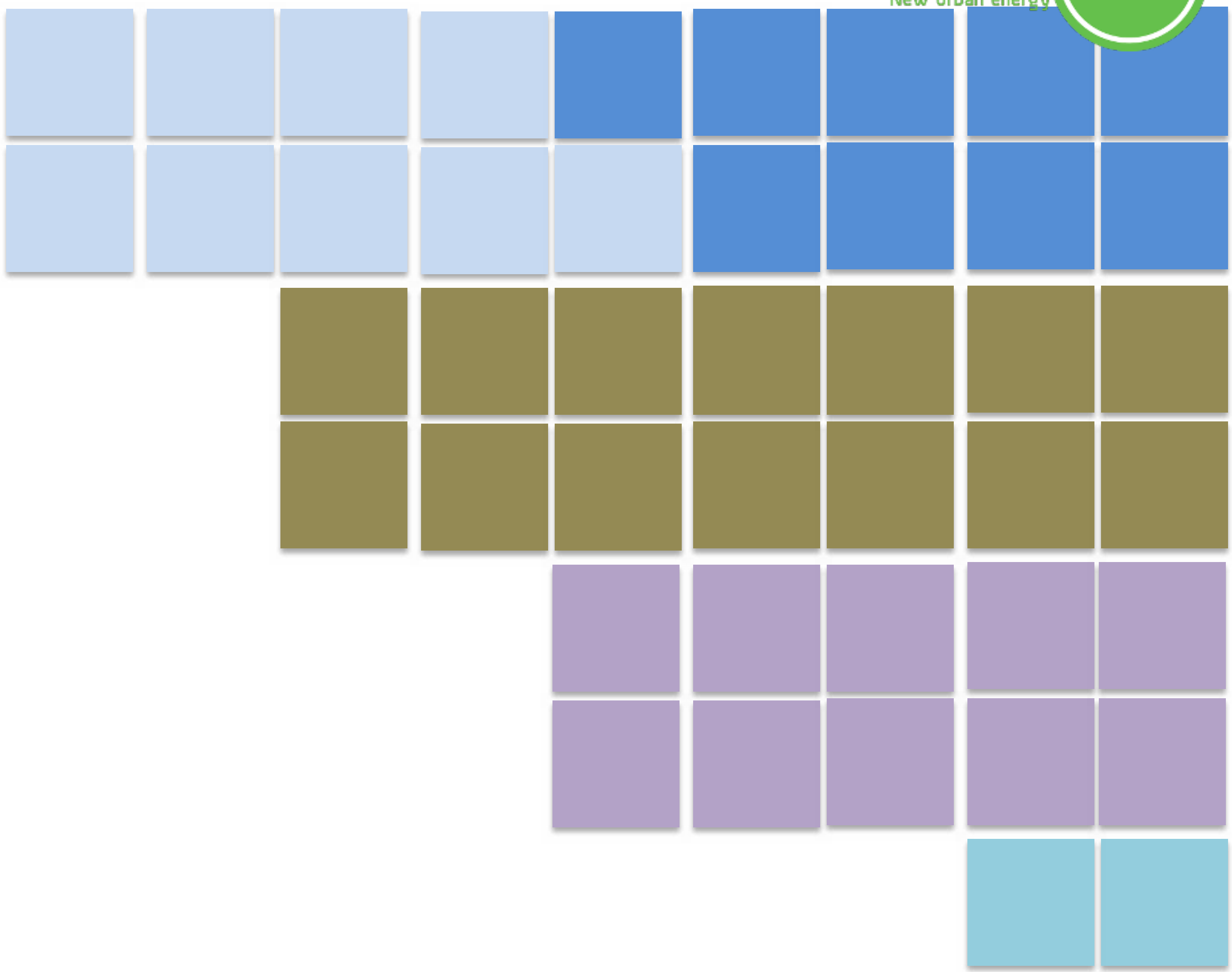
7
Mini-wind turbine
50 installed
- Total energy -4%

CF 49.4%

CARBON FOOTPRINT OFFSET OF GRUŽ

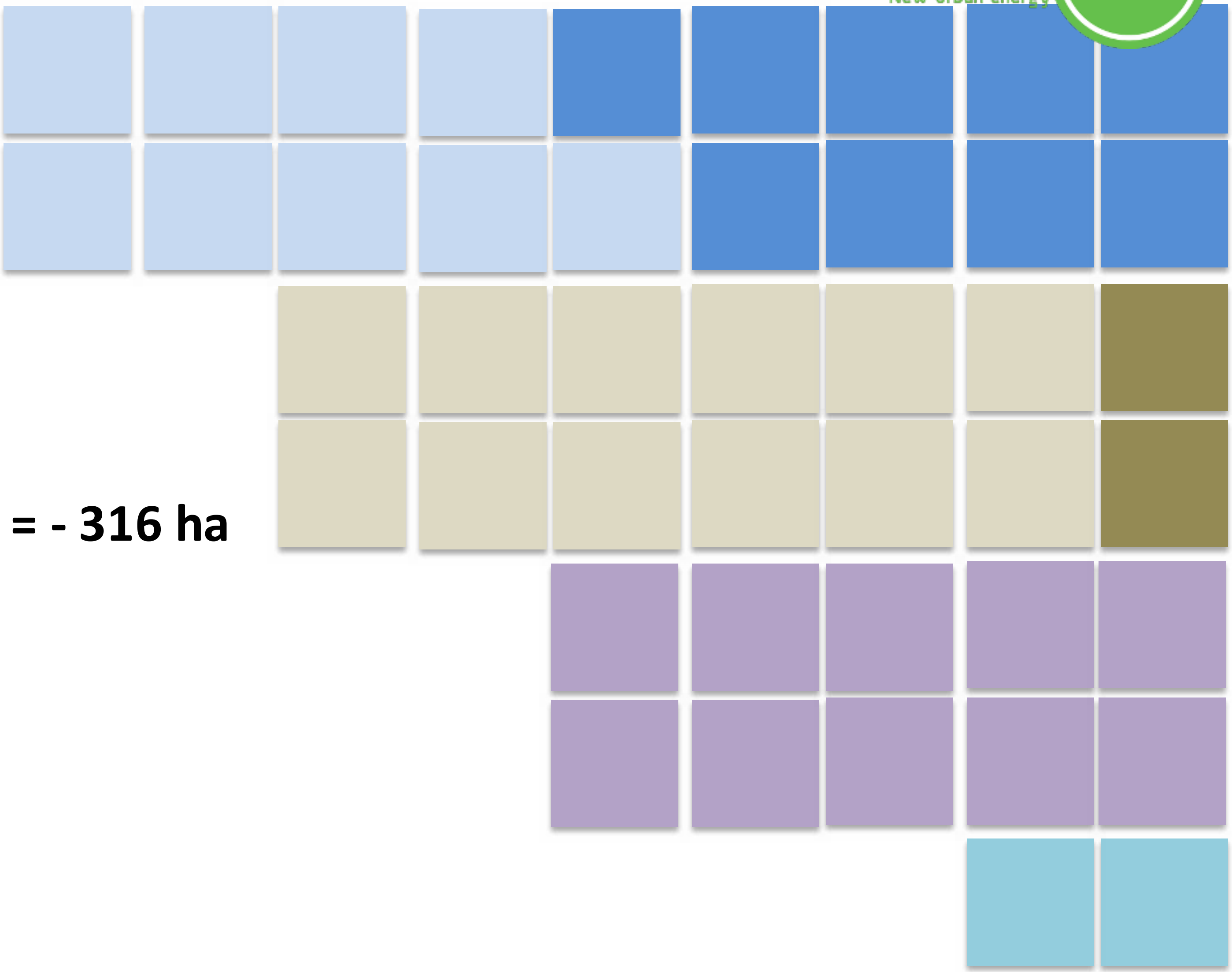
Integrated energy measures

9,000 MWh = - 235 ha



CARBON ACCOUNTING EXPLAINED

CARBON FOOTPRINT OFFSET OF GRUZ (DUBROVNIK)



Integrated energy measures

9,000 MWh = - 235 ha

Differenciated fractions of waste

Recycling 30%; Organic 40%;
Incinerator 20%; Landfill 10% = - 316 ha

CARBON FOOTPRINT OFFSET OF GRUŽ

Integrated energy measures

9,000 MWh = - 235 ha

Differenciated 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

CARBON FOOTPRINT OFFSET OF GRUŽ

Integrated energy measures

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

Differenciated 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**

Differenciated 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!

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