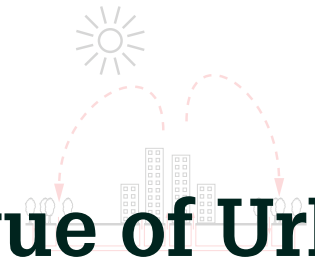
A Catalogue of Urban Strategies towards better air quality in cities

S.Hoogewerf
06-04-2011

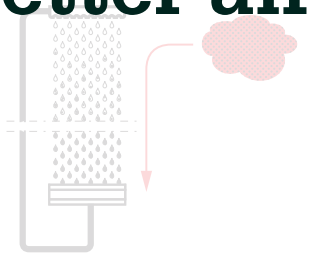
Extreme zoning


Fresh air tubes

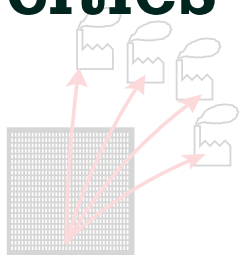
New mountains

Funneling towers

$1 billion vacuum cleaner


Falling water


Gasmasks


Exodus of industry

Special street profiles

Road roof

Crowdsourcing

Electric cars

Industry emission cuts

Street ventilators

Tree filters

Structure of presentation

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1. Inventarisation
- Why?
- What?

2. Solutions
- Model description
- Catalogue
- Subconclusion

3. Application
- Beijing

4. Conclusion
- Investment vs deathtoll
- Other cities
- Recommendations for the future city

1. Healthy City

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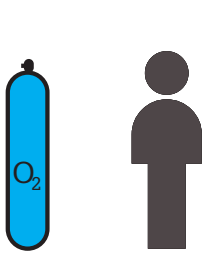
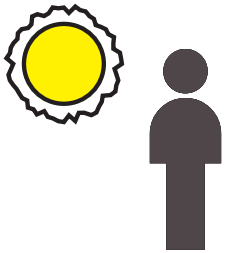


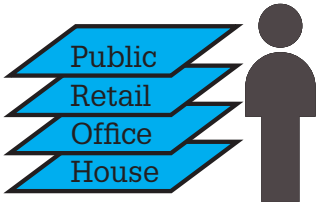
1300L

40min

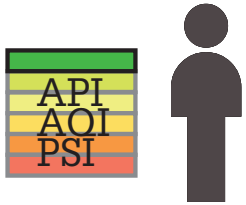
1000steps



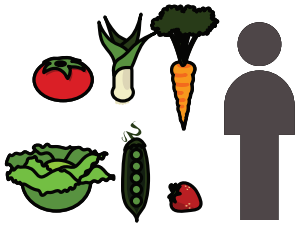
20min



100m²



Quality Air



2000calories

32,1%

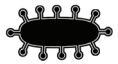
Communicable diseases, maternal and perinatal conditions and nutritional deficiencies

58,8%

Noncommunicable conditions

9,1%

Injuries



19,1%

Infectious and parasitic diseases

29,3%

Cardiovascular diseases

2,1%

Road traffic accidents

6,9%

Respiratory infections

12,6%

Ischaemic heart disease

1,5%

Self-inflicted

4,9%

HIV/AIDS

12,5%

Malignant neoplasms

0,3%

War

4,3%

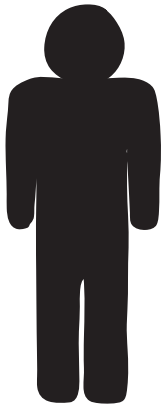
Perinatal conditions

9,7%

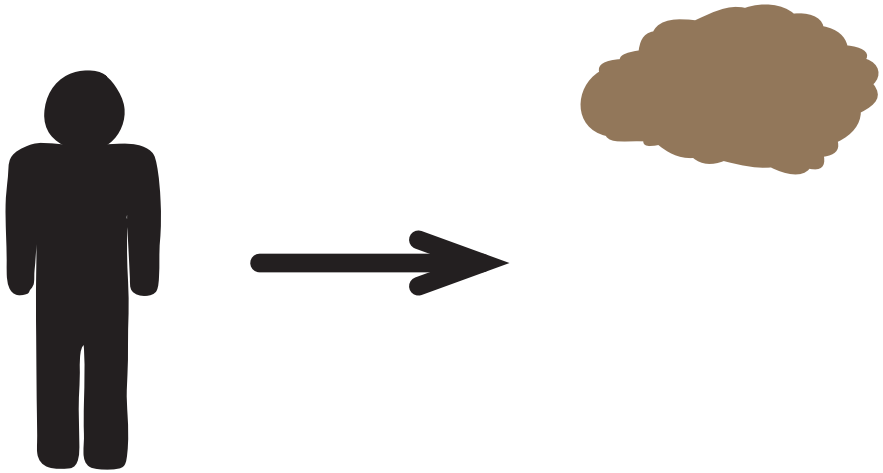
Cerebrovascular disease

23,7% = ill at any given time!

1. Urgency



1. Urgency



SO_x
CO_x
NO_x
PM_x
VOC's
Toxic metals
CFC's
NH_3
Radio actives
Odours
O_3
PAN

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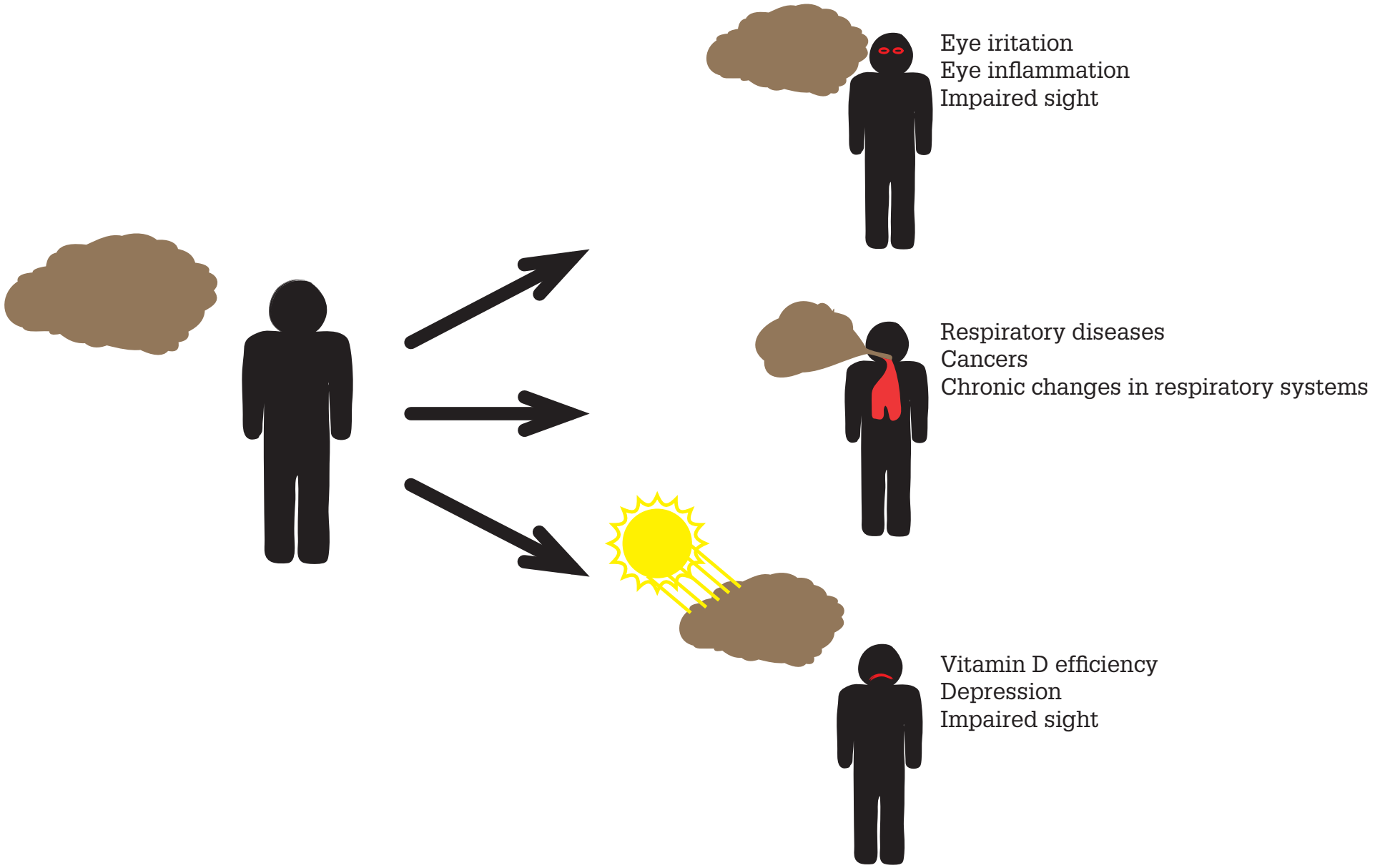
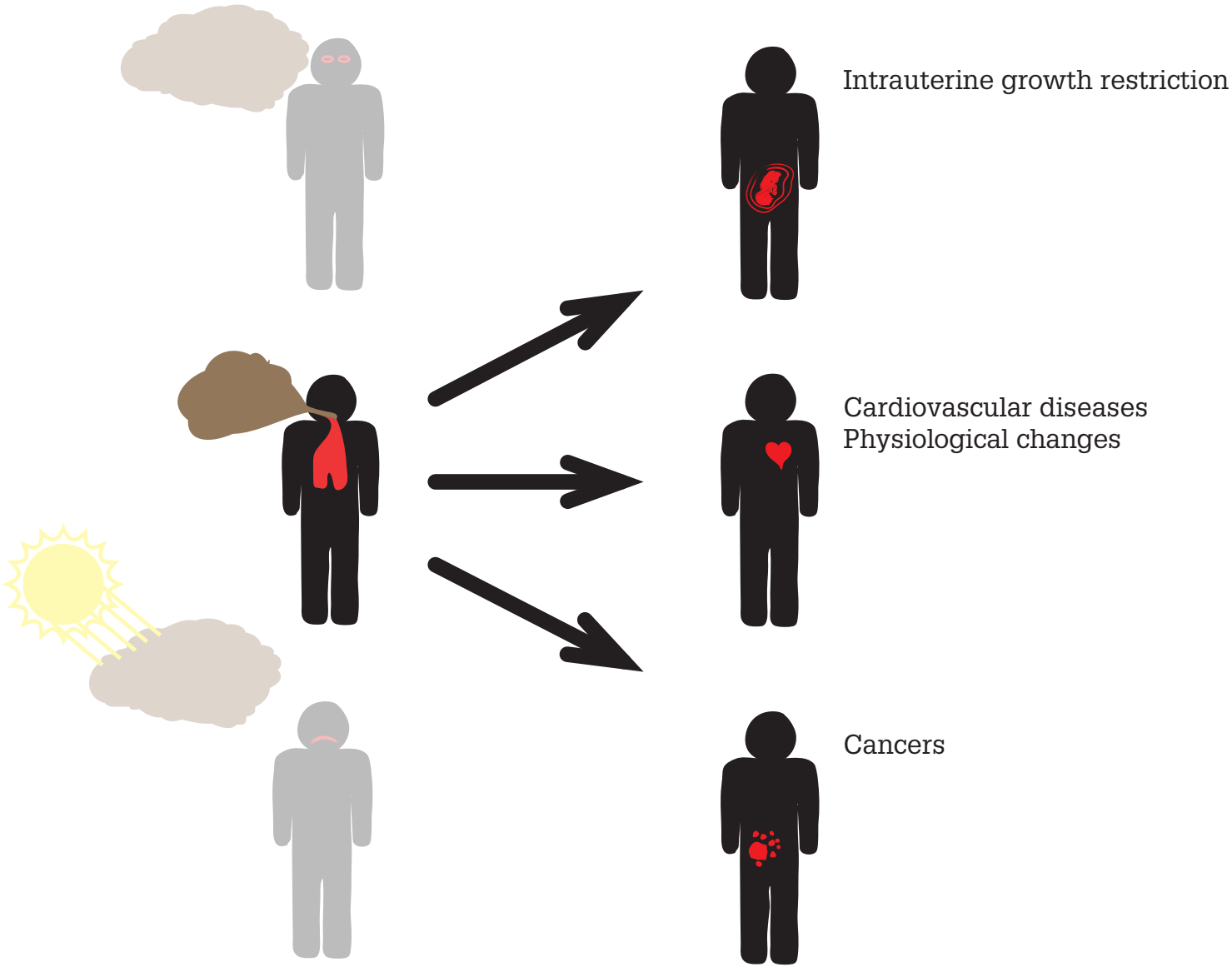
1. Urgency


Eye iritation
Eye inflammation
Impaired sight
Respiratory diseases
Cancers
Chronic changes in respiratory systems
Vitamin D efficiency
Depression
Impaired sight

1. Urgency



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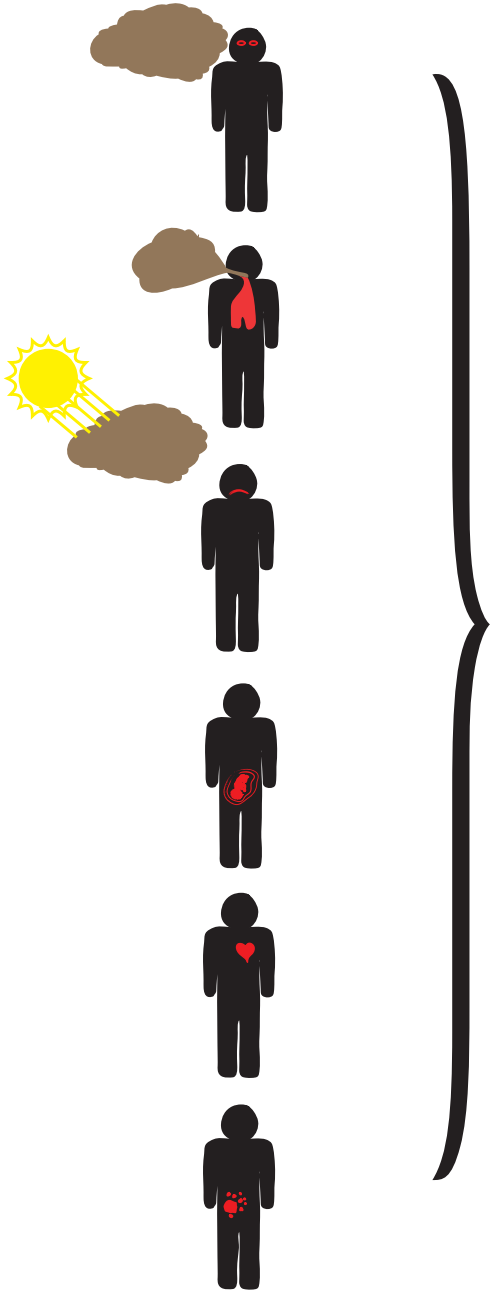

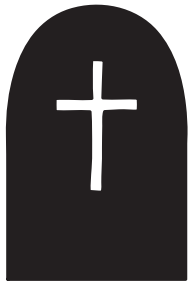

Death (up to 6 million/year)

Hospital admissions
Emergency department visits
Days of restricted activity

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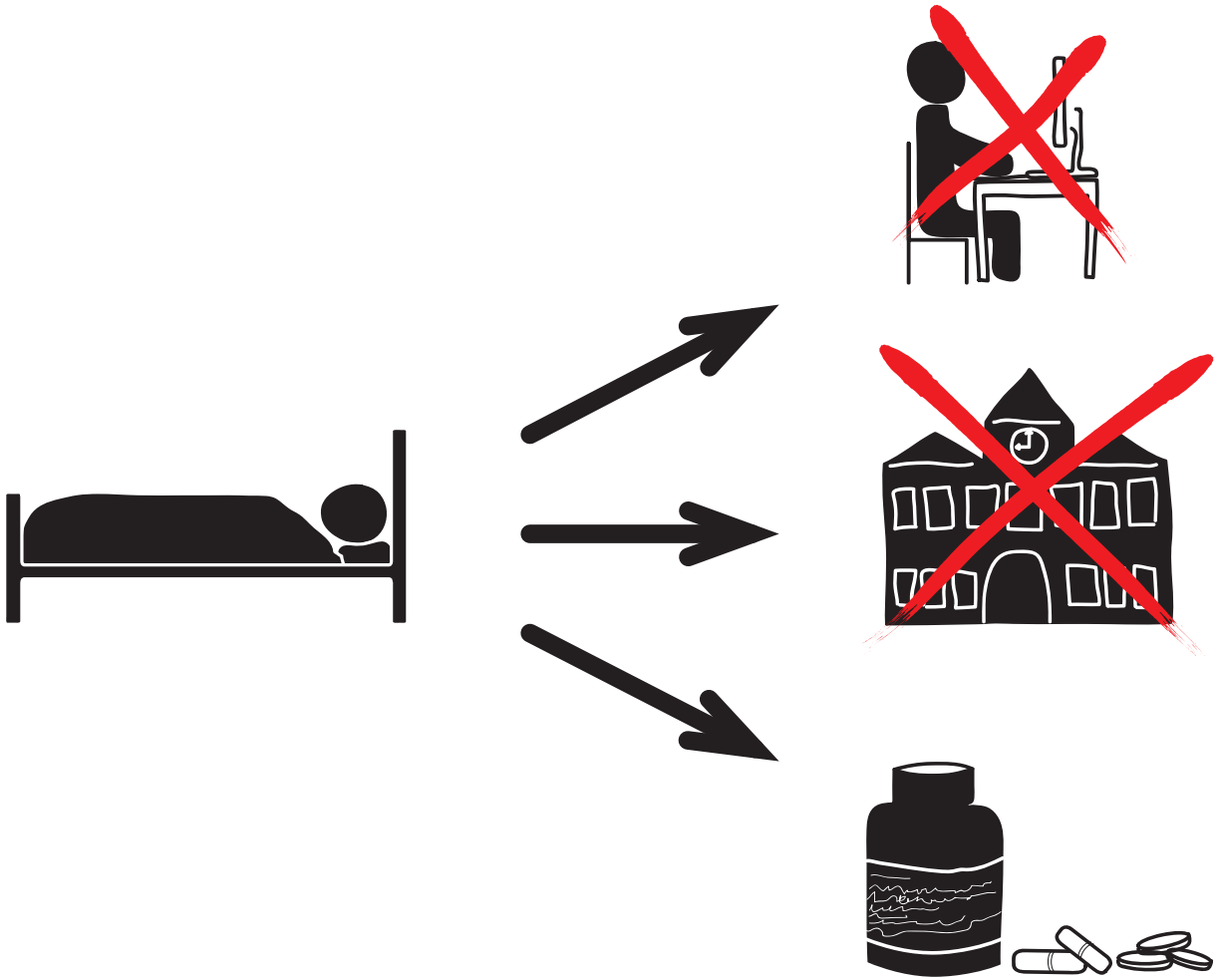
1. Urgency



Work absenteism

School absenteism

Medication
Medical treatment

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1. Urgency

=

€

1.304.667.000.000

= -27% income
€1.890/capita globally

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World Health Statistics 2010, WHO
How much does it really cost when youget sick? Desjardins Financial Security 2008
http://www.super-solutions.com/Employee-Absenteeism-Costing-Your-Business.asp
http://www.boston.com/news/world/articles/2007/10/07/average_earnings_worldwide/
http://knol.google.com/k/economic-cost-and-health-care-workforce-effects-of-school-closures-in-the-u-s#(24)_Valuing_Lost_Production

1. Urgency

= € **1.304.667.000.000**

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€1.890/capita globally

= € **483.210.000.000**

€700/capita globally

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= € **9.664.200.000**

= -2% income for past-school absenteeism
€140/capita globally

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€140/capita globally

= € **41.419.000.000**
€60/capita globally
High income countries: €315/capita

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€140/capita globally/year

= € **41.419.000.000**
€60/capita globally/year
High income countries: €315/capita/year

+

1.838.960.200.000
€2.664/capita globally/year

World Health Statistics 2010, WHO
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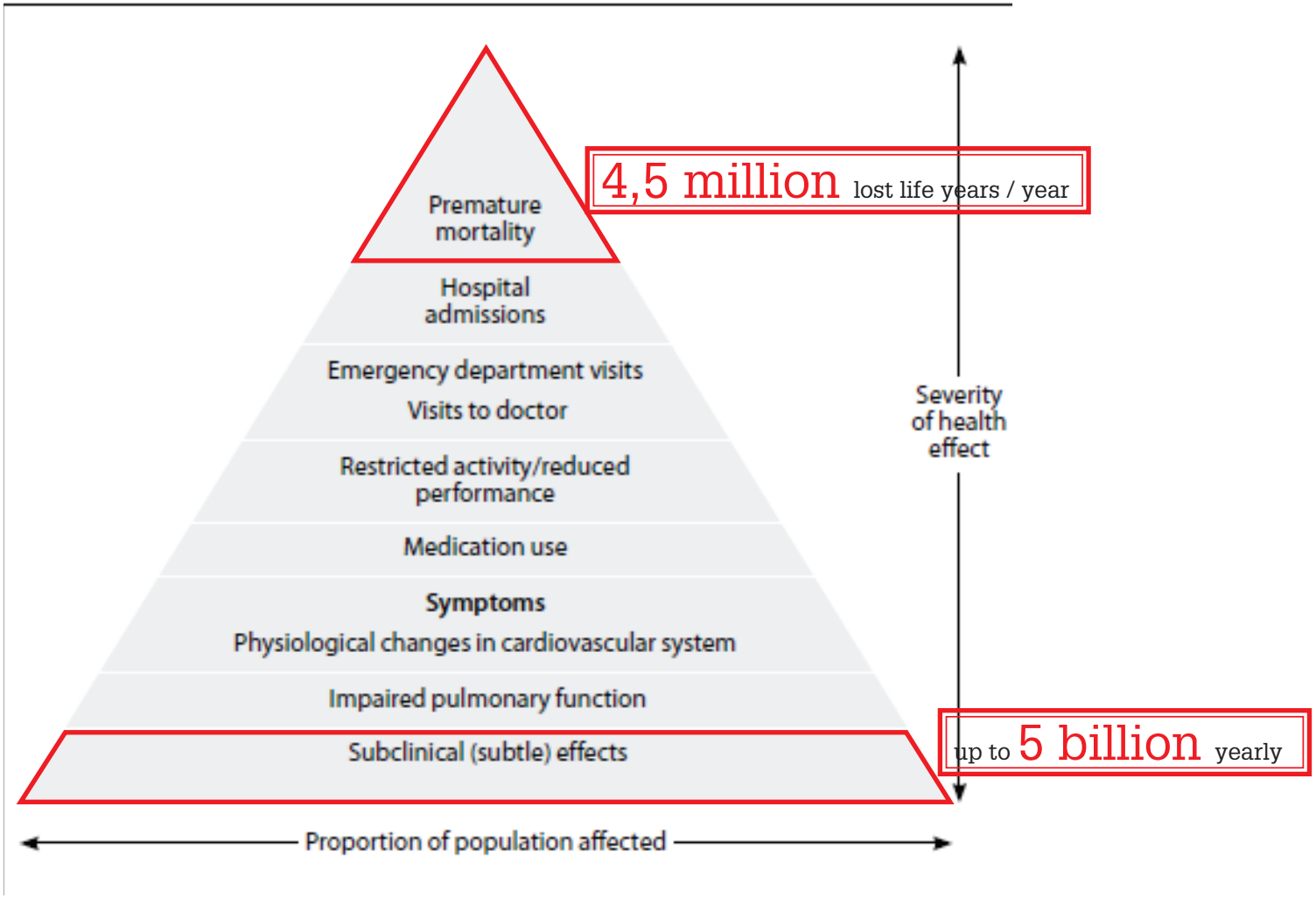
1. AQ + health statistics

Fig. 1. Pyramid of health effects associated with air pollution



Air quality guidelines, Global update 2005; World Health Organization, 2006
Radio1, labyrint radio, VPRO, 3 april 2011 20:00-21:00

1. THE formula

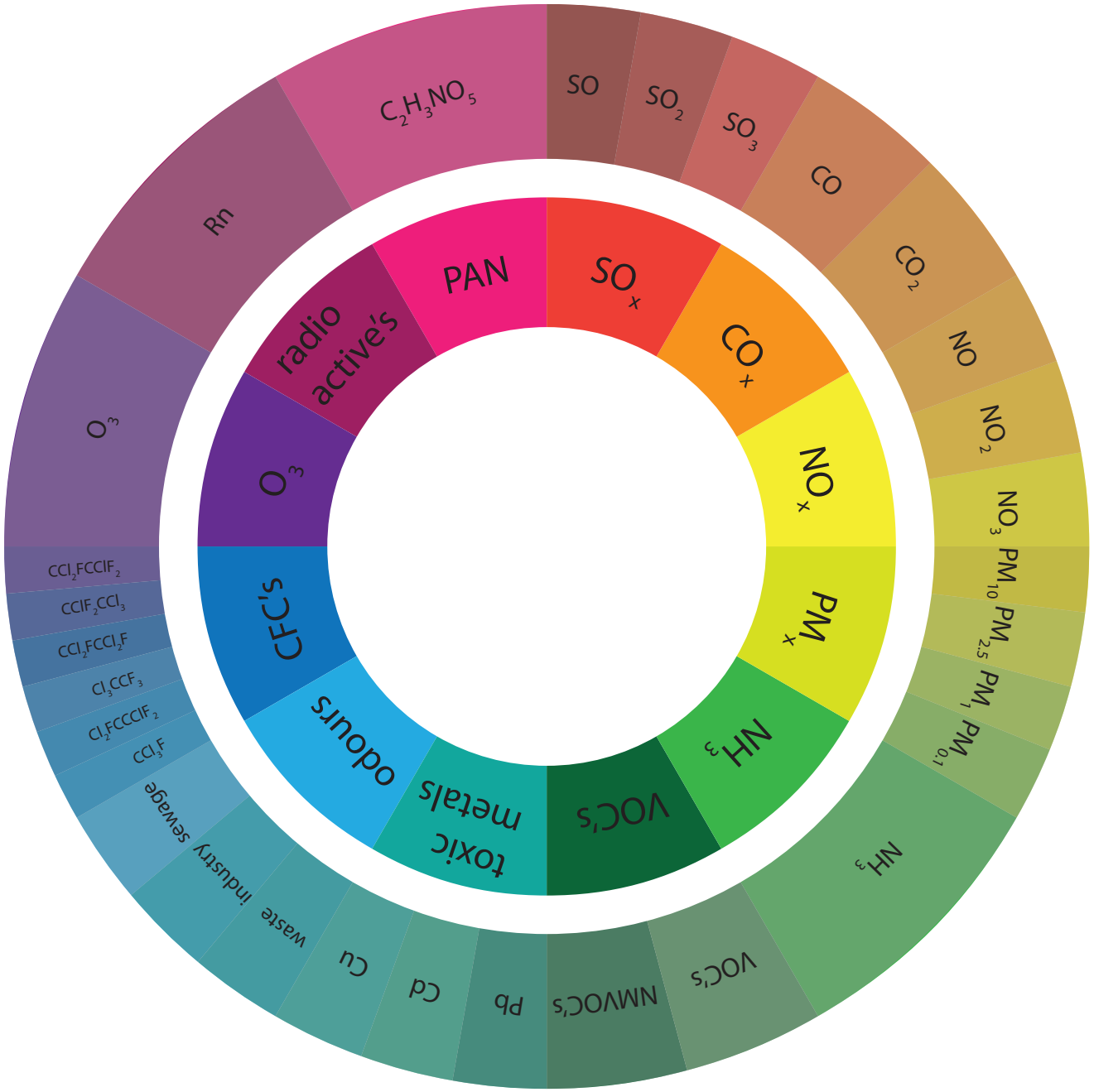
To calculate the expected number of deaths due to air pollution (E), we take the product of:

$$E = beta \times B \times P \times C$$

where:
E = expected number of premature deaths due to short-term exposure
beta = percentage change in mortality per 10-µg/m3 change in PM10
B = incidence of the given health effect (deaths per 1000 people)
P = relevant exposed population for the health effect
C = change in PM10 concentration (µg/m3 × 0.1).

E90038.pdf page91

1. Air Pollutants



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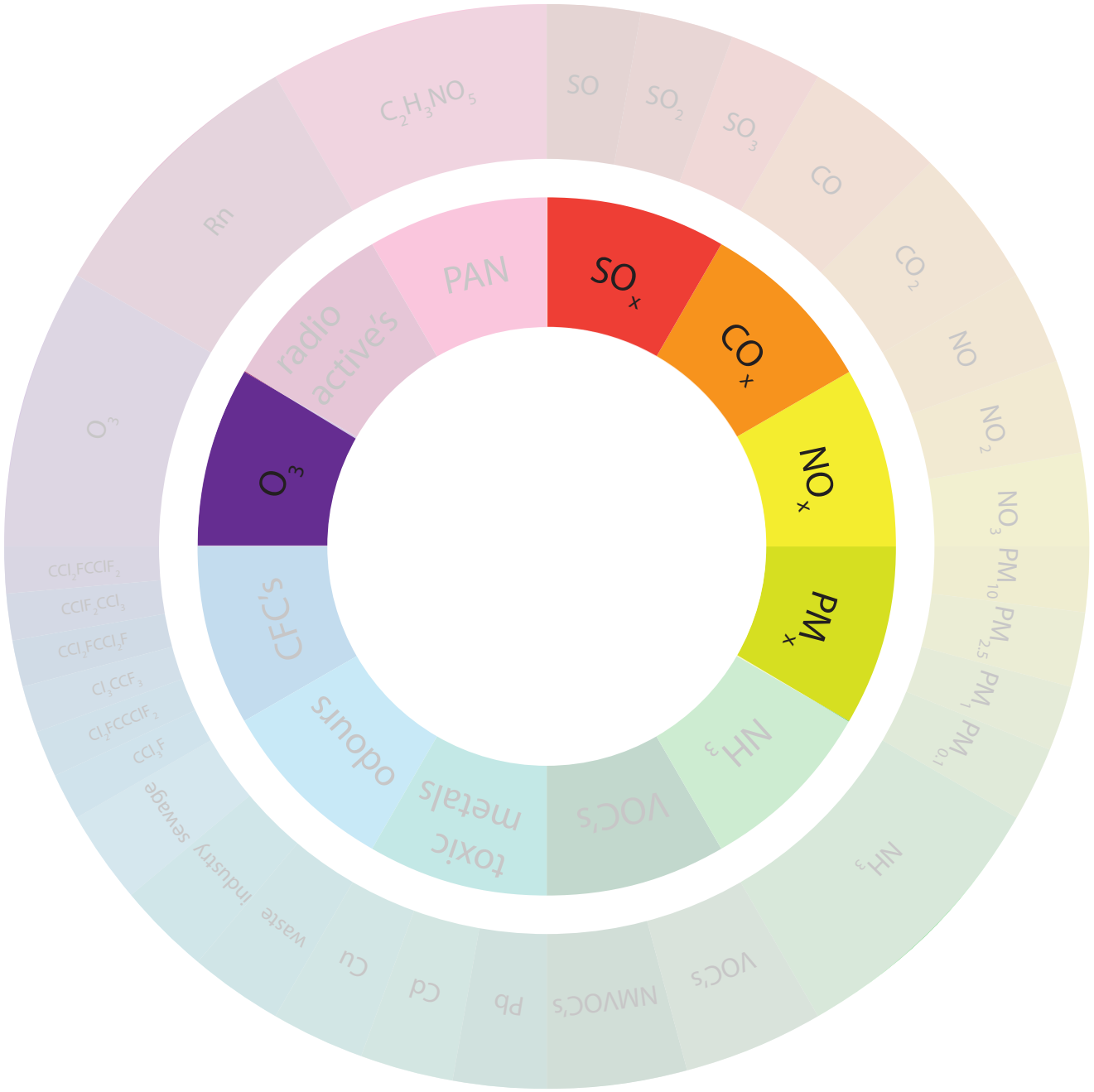
1. Air Pollutants



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Air quality guidelines, Global update 2005; World Health Organization, 2006

1. The Big 5

NO_2
Nitrogendioxide

PM_{10}
Particulate Matter

O_3
Ozone

CO
Carbonoxide

SO_2
Sulfurdioxide

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Air quality guidelines, Global update 2005; World Health Organization, 2006

1. Sources

NO_2
Nitrogendioxide

- Traffic
- Power plants
- Pulp mills
- Butane heaters
- Stoves

PM_{10}
Particulate Matter

- Traffic(diesel)
- Power plants
- Industry
- Soil dust
- Sea salt
- NOx, SO2, NH3, O3

O_3
Ozone

- Traffic
- Chemical plants
- Refineries
- Industry
- NOx + VOC's

CO
Carbonoxide

- Traffic
- Power plants
- Pulp mills
- Butane heaters
- Stoves

SO_2
Sulfurdioxide

- Industry
- Smelting mineral ores
- Power plants
- Traffic

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Air quality guidelines, Global update 2005; World Health Organization, 2006

1. Diseases

NO_2
Nitrogendioxide

- Respiratory illness in young children.
- Harm lung function in people with existing respiratory illnesses.
- Increased susceptibility to respiratory infection.
- Alterations in the lung.

PM_{10}
Particulate Matter

- Tens of thousands of premature deaths every year.
- Increased emergency room visits.
- Asthma attacks.
- Decreased lung function .

O_3
Ozone

- Coughing, irritation of the airways, discomfort in the chest or when breathing.
- Premature aging of the lungs.
- Faster or more shallow breathing.
- Aggravation of asthma, emphysema, and other respiratory diseases.
- Increased risk of respiratory infections.

CO
Carbonoxide

- Reduced oxygen delivery to the body's organs and tissues.
- Poisonous.
- Visual impairment.
- Reduced work capacity.
- Reduced manual dexterity.
- Poor learning ability.
- Difficulty in performing complex tasks.

SO_2
Sulfurdioxide

- Breathing problems with asthmatic children and adults who are active outdoors.
- Wheezing, chest tightness and shortness of breath.
- Respiratory illness.
- Alterations in the lungs' defenses .
- Aggravation of existing cardiovascular disease.

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Air quality guidelines, Global update 2005; World Health Organization, 2006

1. Guidelines

NO_2 Nitrogendioxide

PM_{10} Particulate Matter

O_3 Ozone

CO Carbonoxide

SO_2 Sulfurdioxide

	NO2			PM10		O3				CO		SO2		
	1h	24h	1y	24h	1y	1h	8h	24h	1y	1h	1y	10m	1h	24h
WHO		200	40	50	20		100	200	40	200	40	500		20
China I	120	80	40	50	40	120						150	50	20
China II	120	80	40	100	60	160						250	150	50
China III	240	120	80	150	120	200						700	500	150

China I: tourist, historical and conservation areas;
China II: residential urban and rural areas;
China III: industrial and heavy traffic areas.

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Air quality guidelines, Global update 2005; World Health Organization, 2006

1. The Big 5

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NO_2 Nitrogendioxide

- Internal combustion engines
- Thermal power stations
- Pulp mills
- Butane heaters
- Stoves

- Respiratory illness in young children.
- Harm lung function in people with existing respiratory illnesses.
- Increased susceptibility to respiratory infection.
- Alterations in the lung.

	NO2		
	1hour	24hours	annual
WHO		200	40
China I	120	80	40
China II	120	80	40
China III	240	120	80

Class I: tourist, historical and conservation areas;
Class II: residential urban and rural areas;
Class III: industrial and heavy traffic areas.

- Car exhaust filters
- Electric cars
- Façade filters
- Gas masks

β

PM_{10} Particulate Matter

- Diesel combustion engines
- Traffic
- Power plants
- Soil dust
- Sea salt
- Industry
- NO_x, SO_2, NH_3, O_3

- Tens of thousands of premature deaths every year.
- Increased emergency room visits.
- Asthma attacks.
- Decreased lung function .

	PM10	
	24hours	annual
WHO	50	20
China I	50	40
China II	100	60
China III	150	120

- Car exhaust filters
- Electric cars
- Façade filters
- Gas masks
- Tree filters
- Industry emission cut
- Exodus of indutry
- Falling water filter
- Street ventilators
- Road roof

reduction from 70 to 20 µg/m3 means 15% less deaths

O_3 Ozone

- Vehicules
- Chemical plants
- Refineries
- Industry
- NO_x + VOC's

- Coughing, irritation of the airways, discomfort in the chest or when breathing.
- Premature aging of the lungs.
- Faster or more shallow breathing.
- Aggravation of asthma, emphysema, and other respiratory diseases.
- Increased risk of respiratory infections.

	O3			
	1hour	8hours	24hours	annual
WHO		100	200	40
China I	120			
China II	160			
China III	200			

- Car exhaust filters
- Electric cars
- Gas masks
- New mountain
- Industry emission cut
- Policy making
- Exodus of indutry
- Fresh air tubes

daily mortality rises by 0.3% and that for heart diseases by 0.4 %, per 10 µg/m3 increase in ozone exposure

CO Carbonoxide

- Internal combustion engines
- Thermal power stations
- Pulp mills
- Butane heaters
- Stoves

- Reduced oxygen delivery to the body's organs and tissues.
- Poisonous.
- Visual impairment.
- Reduced work capacity.
- Reduced manual dexterity.
- Poor learning ability.
- Difficulty in performing complex tasks.

	CO	
	1hour	annual
WHO	200	40
China I		
China II		
China III		

- Car exhaust filters
- Electric cars
- Gas masks
- Industry emission cut
- Exodus of indutry

SO_2 Sulfurdioxide

- Burnig fossil fuels
- Smelting mineral ores
- Burning oil and coal
- Power plants
- Industry

- Breathing problems with asthmatic children and adults who are active outdoors.
- Wheezing, chest tightness and shortness of breath.
- Respiratory illness.
- Alterations in the lungs' defenses .
- Aggravation of existing cardiovascular disease.

	SO2		
	10min	1hour	24hours
WHO	500		20
China I	150	50	20
China II	250	150	50
China III	700	500	150

- Car exhaust filters
- Electric cars
- Gas masks
- Industry emission cut
- Exodus of indutry
- Road roof

Air quality guidelines, Global update 2005; World Health Organization, 2006

1. Aim

Create a CATALOGUE with URBAN STRATEGIES that work towards reducing air pollution in cities.

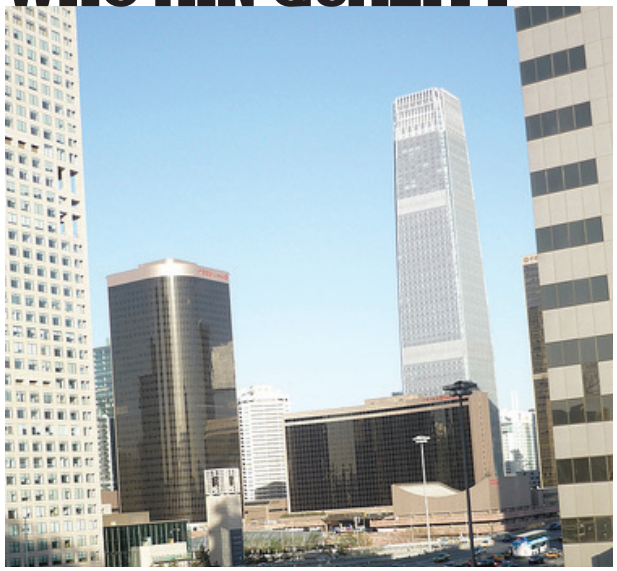
By reducing air pollution we can reduce the loss of life years/ healthy life years.

The air quality of every city should be as the air quality guidelines of the World Health Organization prescribe.

CITY X'S AIR QUALITY

URBAN STRATEGY

WHO AIR QUALITY



Clean Air Action Plan 2008, Baudirektion Kanton Zürich; http://www.awel.zh.ch/internet/baudirektion/awel/de/luft_asbest_elektrosmog/massnahmenplan/_jcr_content/contentPar/downloadlist_0/downloaditems/1763_1298962210591.spooler.download.pdf/Mapla_Poster_e.pdf

2. Solutions

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2. Generic city

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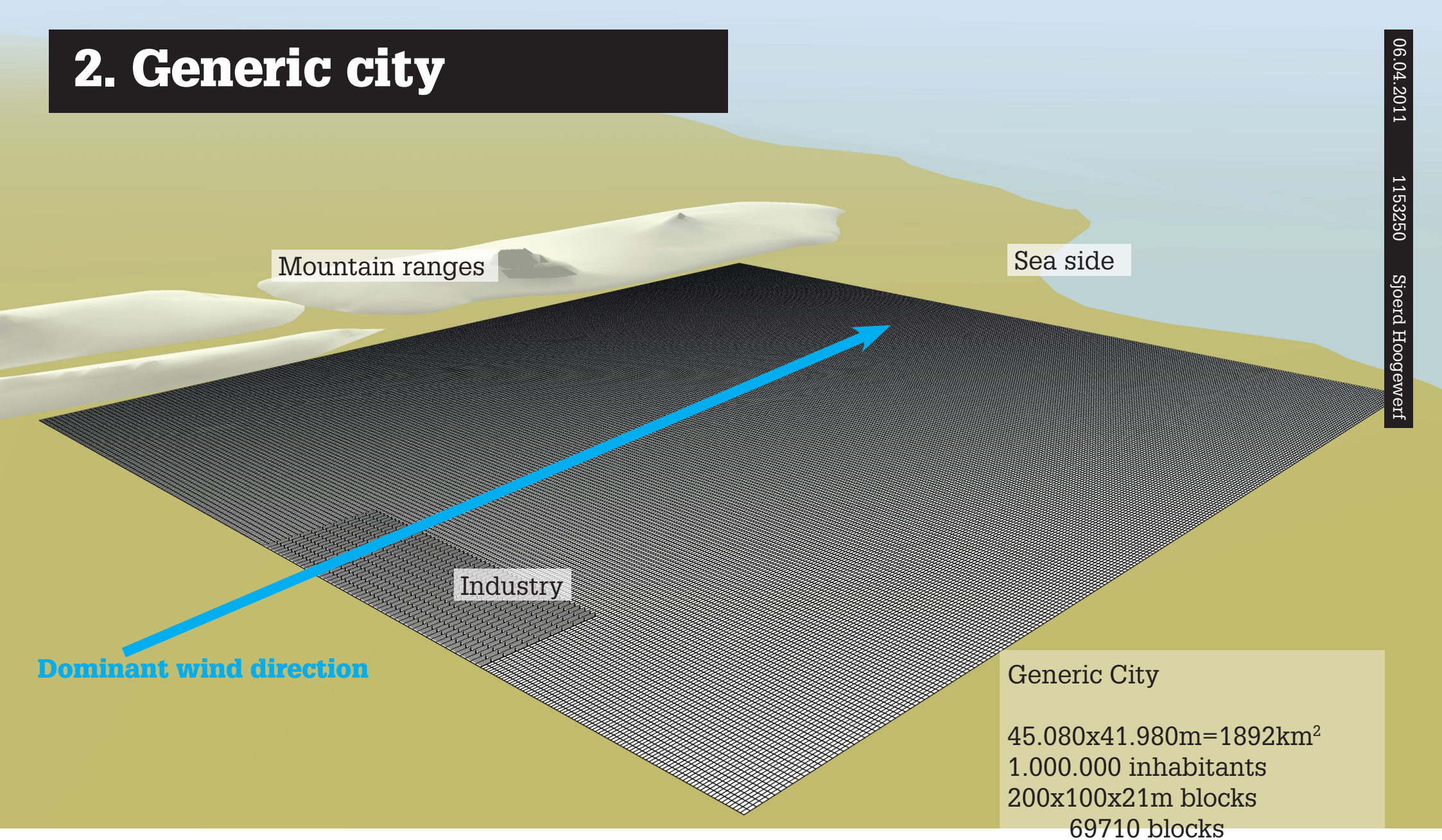
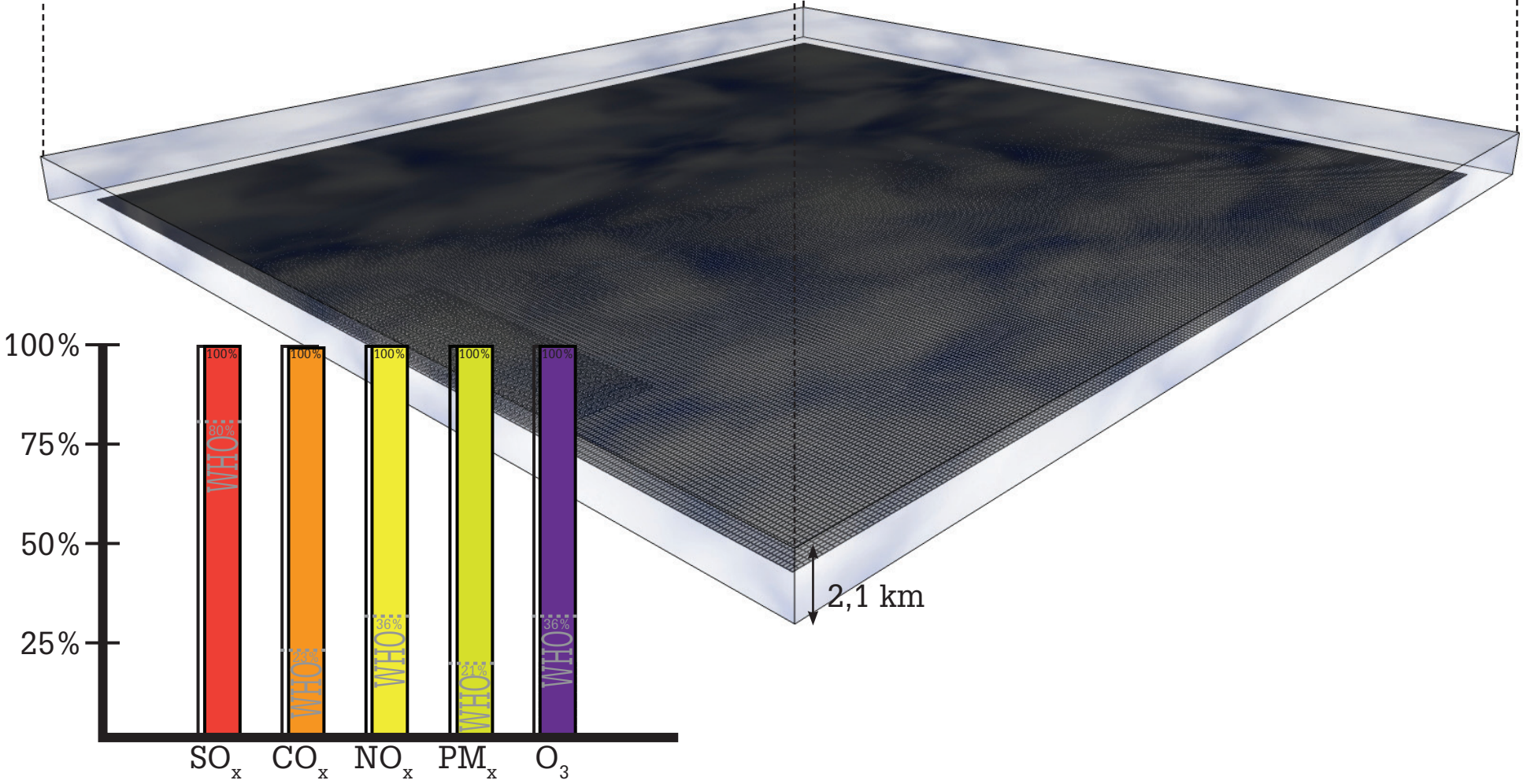


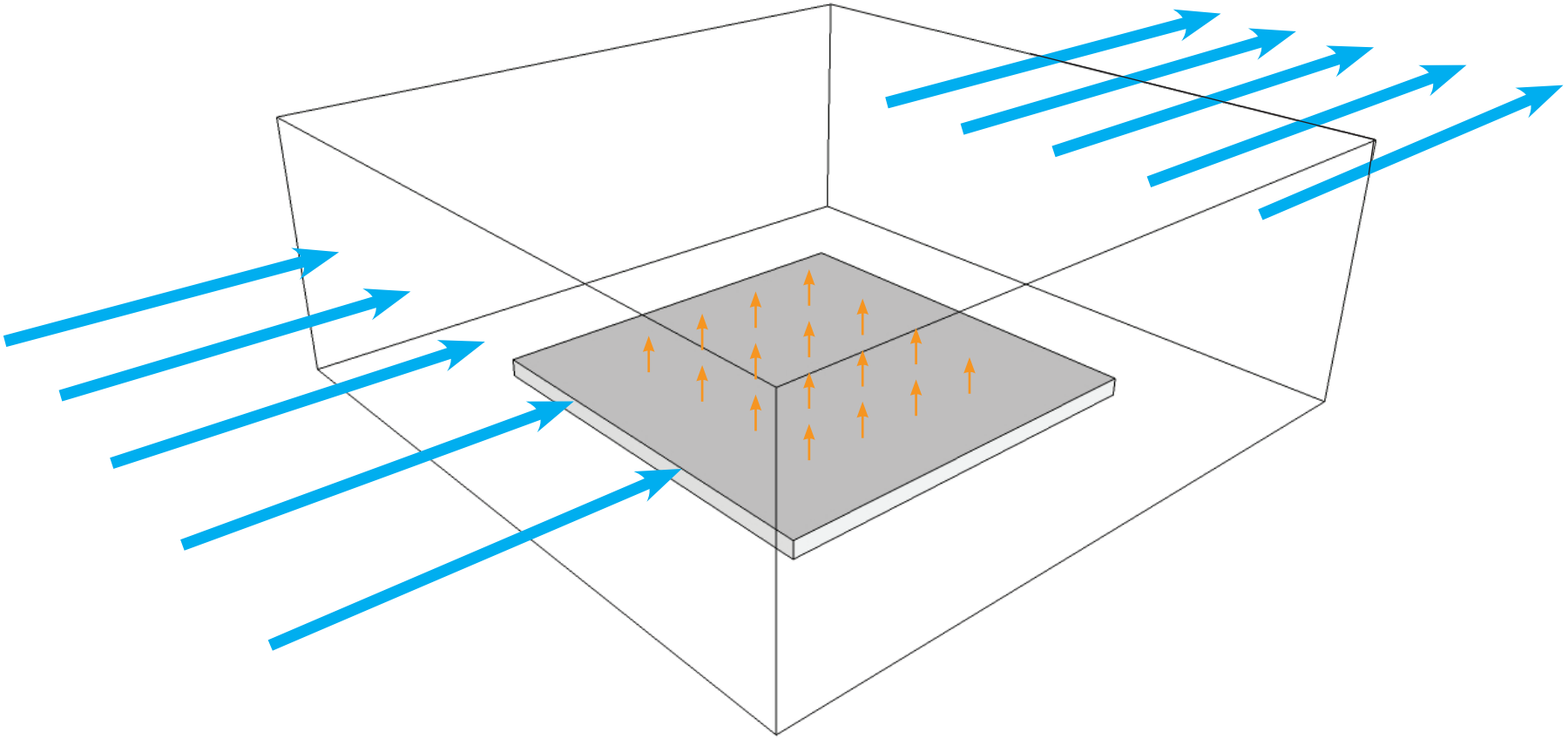
Generic City

45.080x41.980m=1892km^2
1.000.000 inhabitants
200x100x21m blocks
69710 blocks
1 block = 14 persons
400x200x21m industry blocks
510 blocks

2. City model


100%
75%
50%
25%
100%
80%
WHO
100%
WHO
100%
36%
WHO
100%
21%
WHO
100%
36%
WHO
SO$_x$
CO$_x$
NO$_x$
PM$_x$
O$_3$
2,1 km

2. City model



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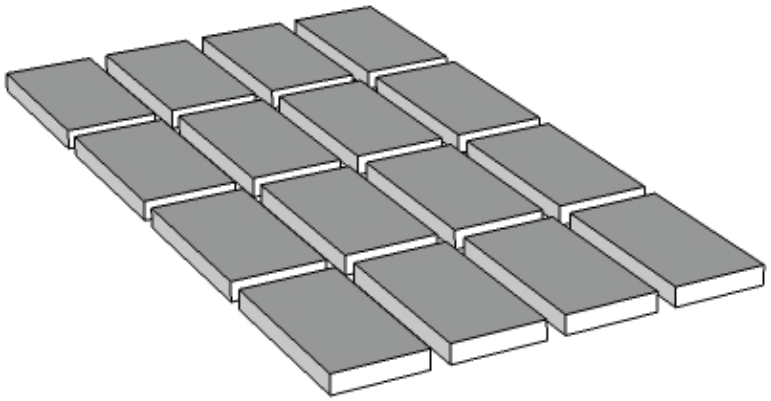
2. City model



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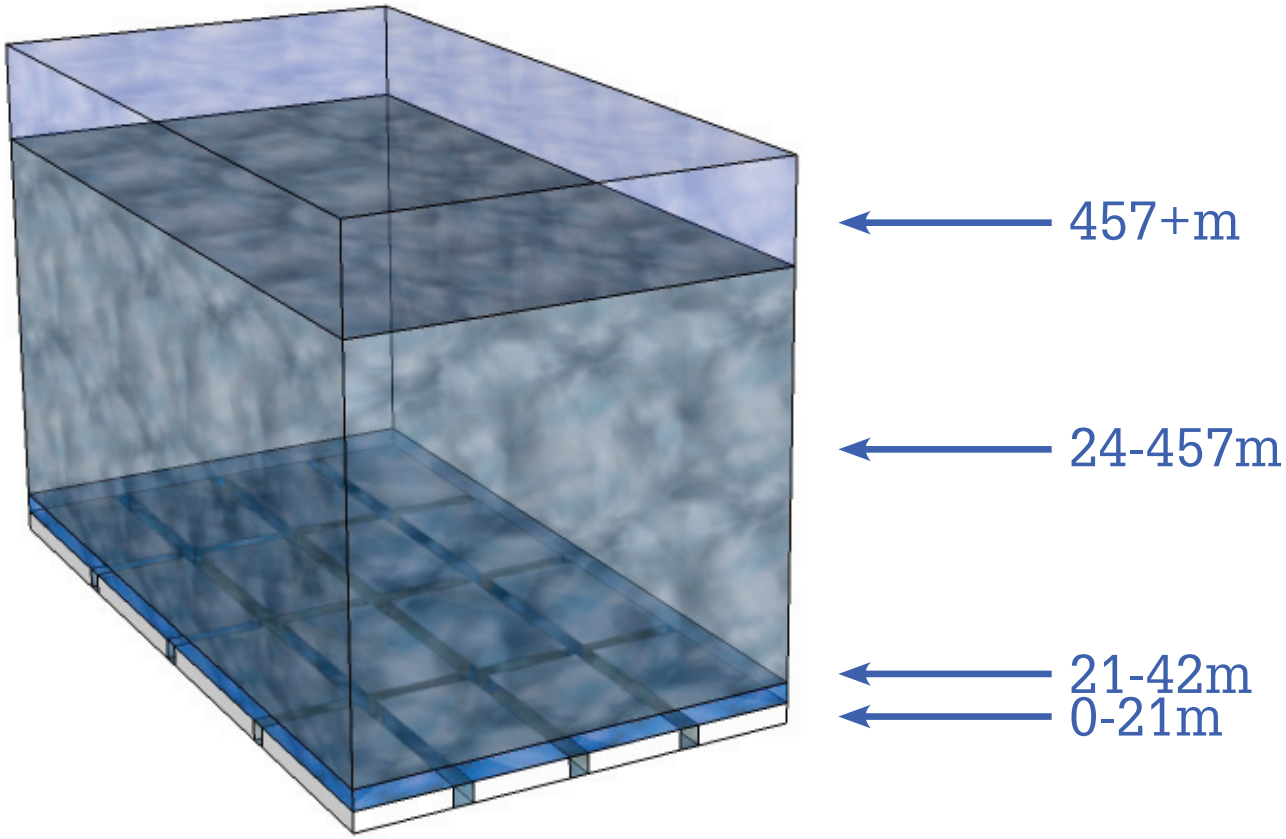

2. Categories

Prevent

- Electric cars
- Exodus of industry
- Industry emission cut
- Behavioural restrictions

Filter

- Gas masks
- Façade filters
- Car exhaust filters
- Tree filters
- Algae lakes
- Falling water
- Road roof
- Air purifying dress

Ventilate

- Street ventilators
- Special street profiles
- New mountains
- Funneling towers
- Fresh air tubes
- $1 billion vaccum cleaner

Shift

- Extreme zoning
- Exodus of industry
- New mountains
- Behavioural restrictions

2. Catalogue layers

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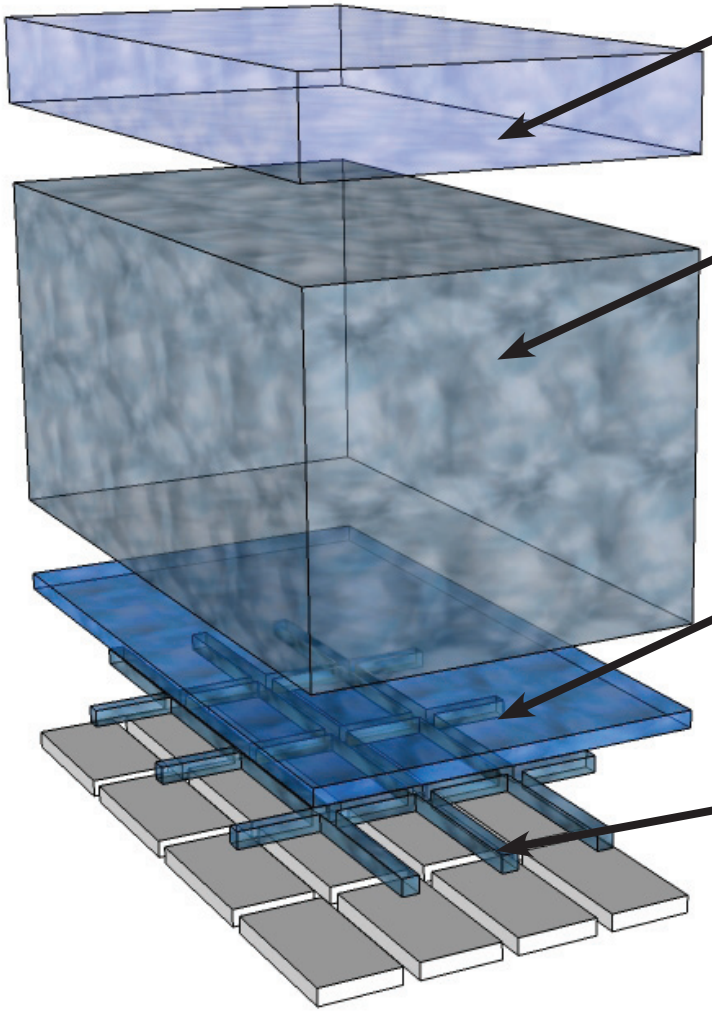
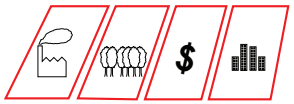
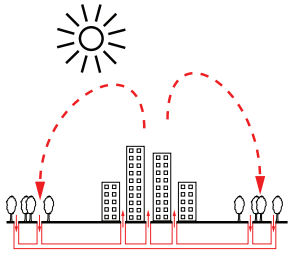
Prevent	Filter	Ventilate	Shift
		- Funneling towers	- New mountains
- Exodus of industry - Industry emission cut		- $1 billion vaccum cleaner	- Extreme zoning - Exodus of industry
	- Tree filters - Algae lakes - Falling water	- Fresh air tubes	
- Electric cars - Behavioural restrictions	- Gas masks - Façade filters - Car exhaust filters - Road roof - Crowdsourcing	- Street ventilators - Special street profiles - New mountains	- Behavioural restrictions



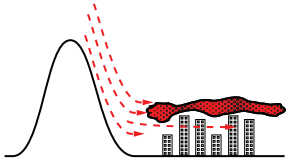
2. Catalogue



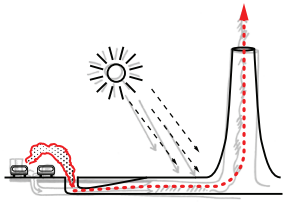
Extreme zoning



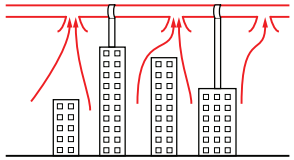
Fresh air tubes



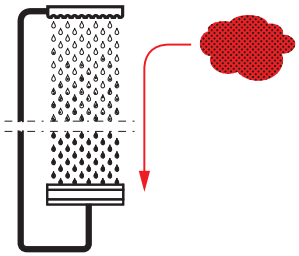
New mountains



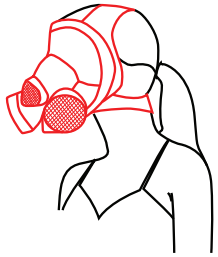
Funneling towers



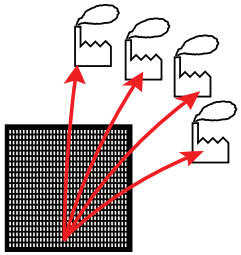
$1 billion vacuum cleaner



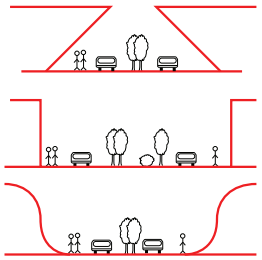
Falling water



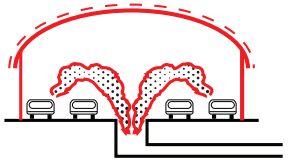
Gasmasks



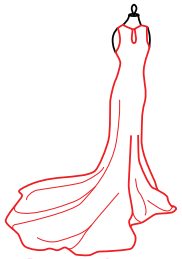
Exodus of industry



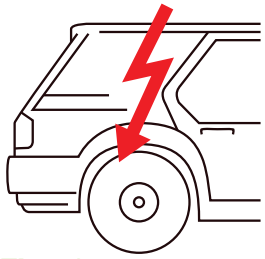
Special street profiles



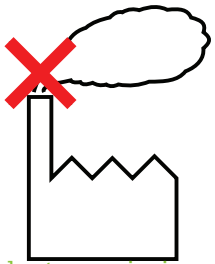
Road roof



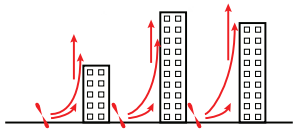
Crowdsourcing



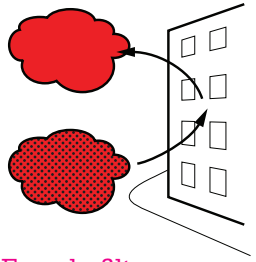
Electric cars



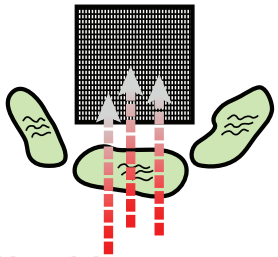
Industry emission cuts



Street ventilators

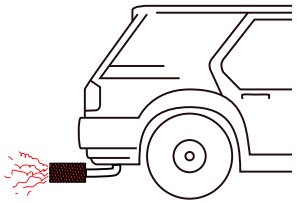


Façade filter

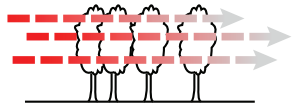


Algae lakes

Behavioural restrictions



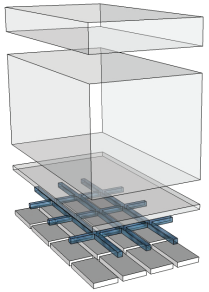
Car exhaust filters



Tree filters

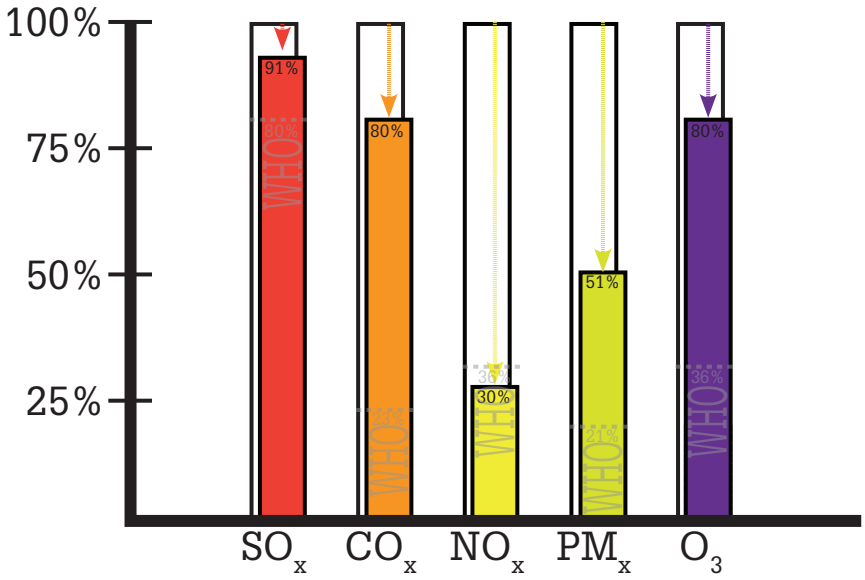
2. Electric Cars

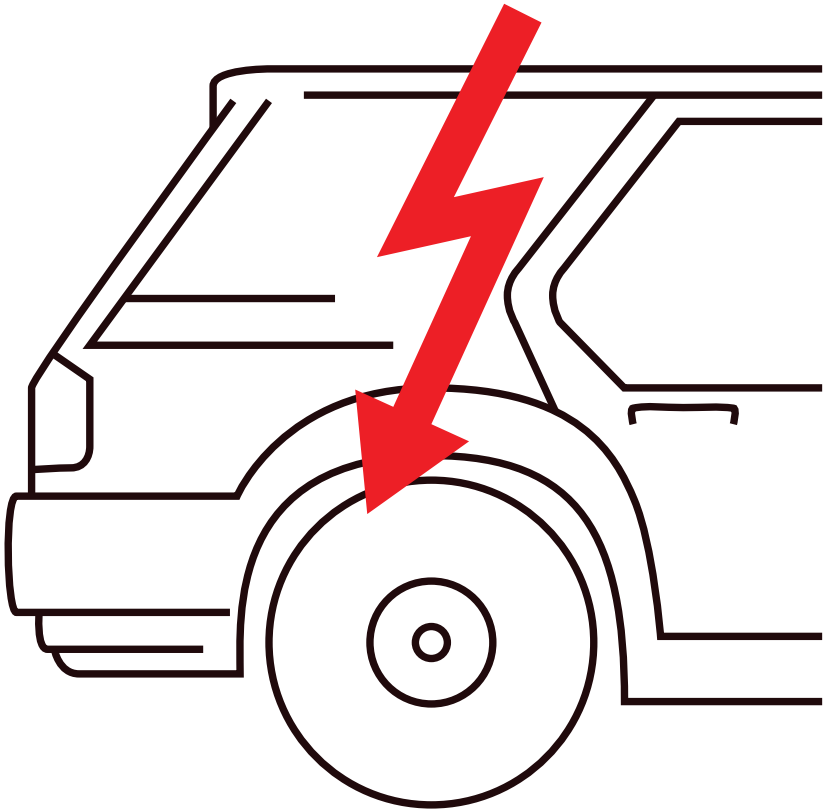
Category:	Prevent
Strategy/Product:	Electric cars
Price per capita:	€ 5.700
Program added:	0 m³



0-21m

- Generic city
- Technical information
- Existing projects





06.04.2011 1153250 Sjoerd Hoogewerf

http://www.iav.com/de/index.php?we_objectID=15760&pid=227
http://www.drive-ec1.nl/images/PDF/Prijslijst%20eC1%202010%20resize.pdf
http://www.fhwa.dot.gov/environment/air_quality/publications/fact_book/page16.cfm
http://www.epa.gov/otaq/consumer/f00013.htm
http://www.worldometers.info/cars/
http://en.wikipedia.org/wiki/Motor_vehicle_emissions
http://rainforests.mongabay.com/08-carbon_emissions.htm
http://www.columbia.edu/~xsp1/About.html

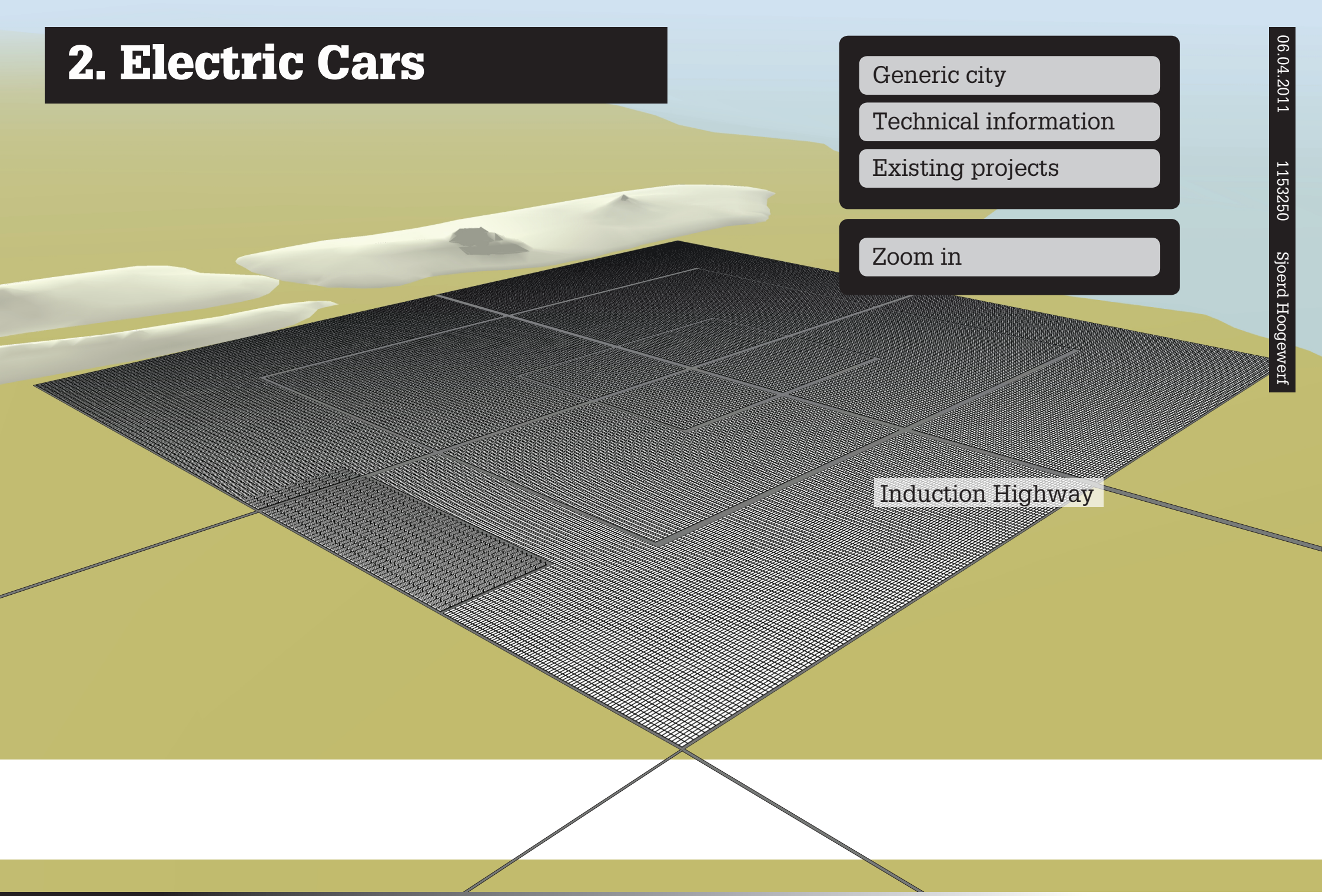
2. Electric Cars

Generic city

Technical information

Existing projects

Zoom in



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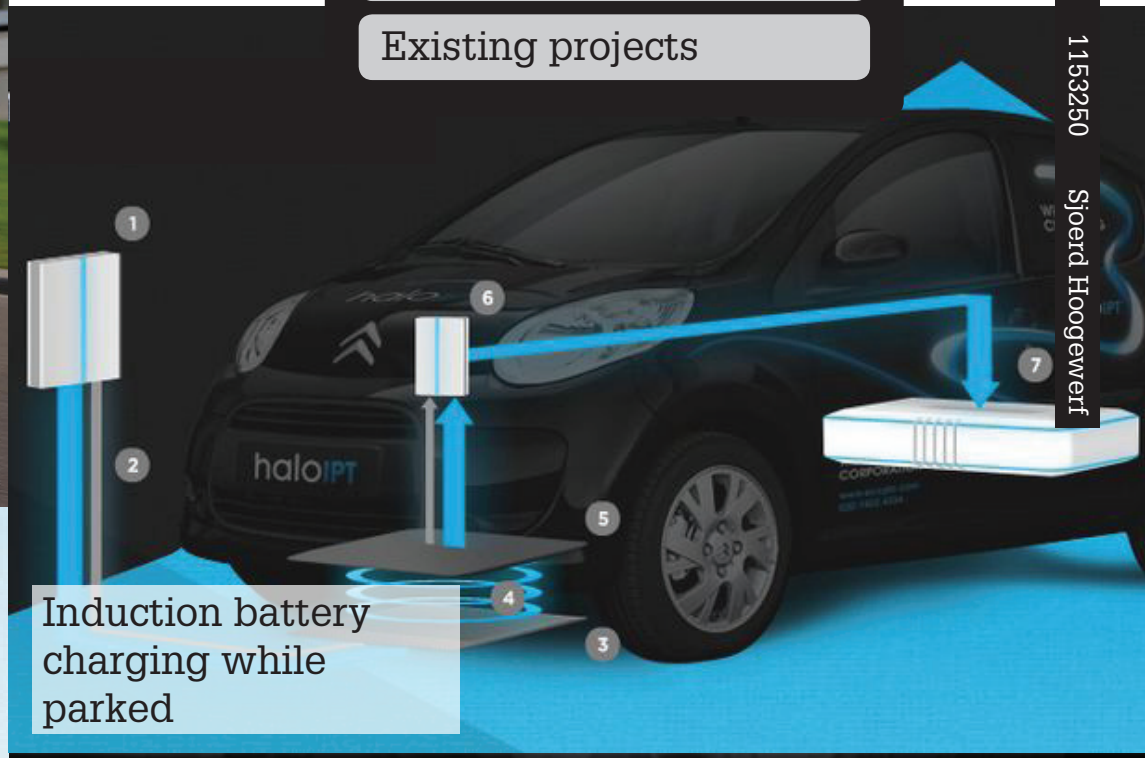
2. Electric Cars

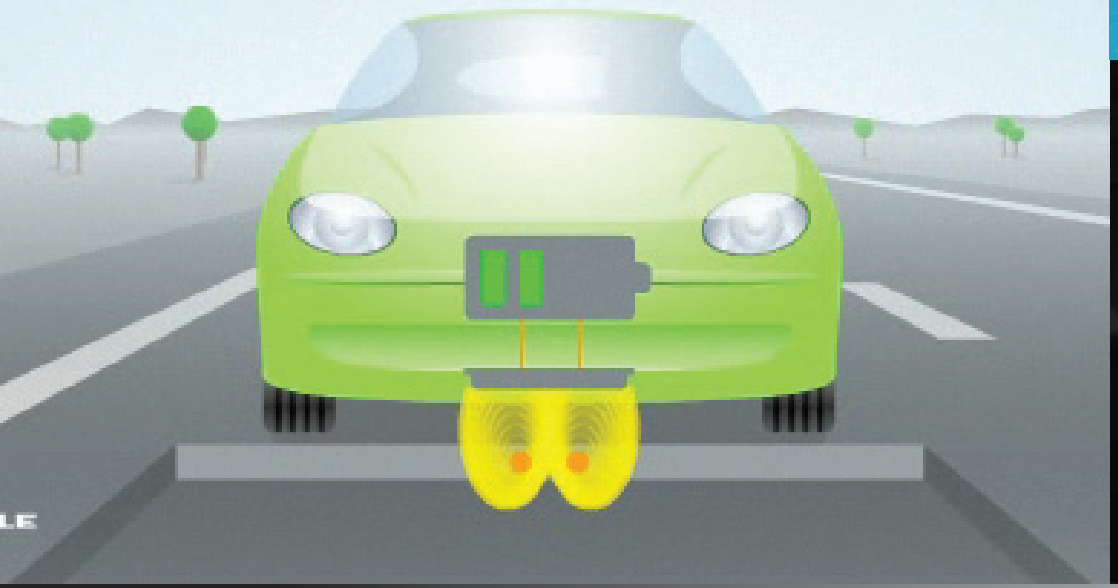
- Generic city
- Technical information
- Existing projects

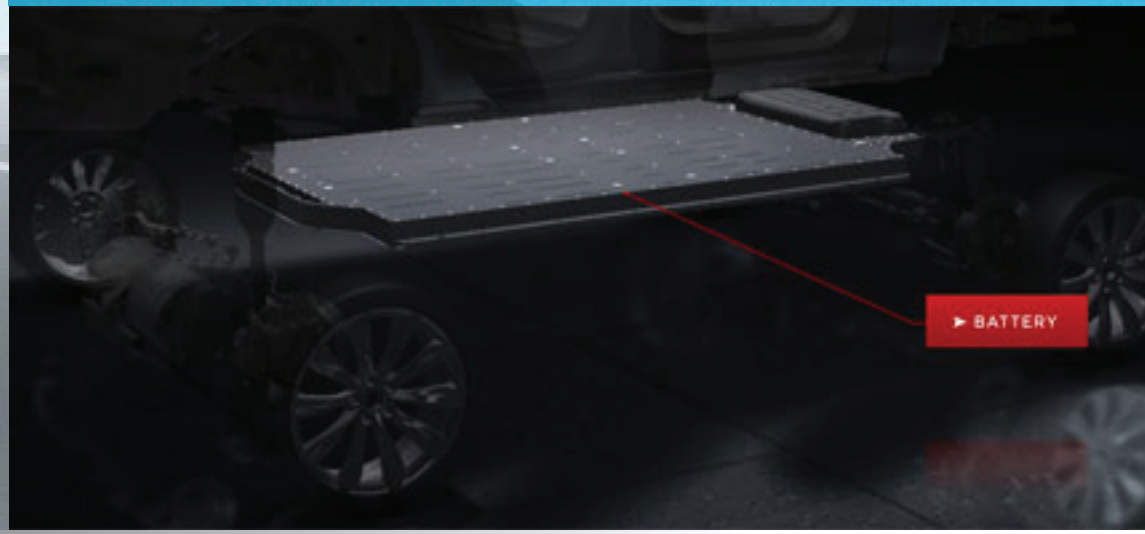
EC1 5-door Séduction
100% electric car
€35.995



Induction battery charging while parked

Induction highway charging the battery





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http://www.drive-ec1.nl/images/PDF/Prijslijst%20eC1%202010%20resize.pdf
http://www.fhwa.dot.gov/environment/air_quality/publications/fact_book/page16.cfm
http://www.epa.gov/otaq/consumer/f00013.htm
http://www.worldometers.info/cars/
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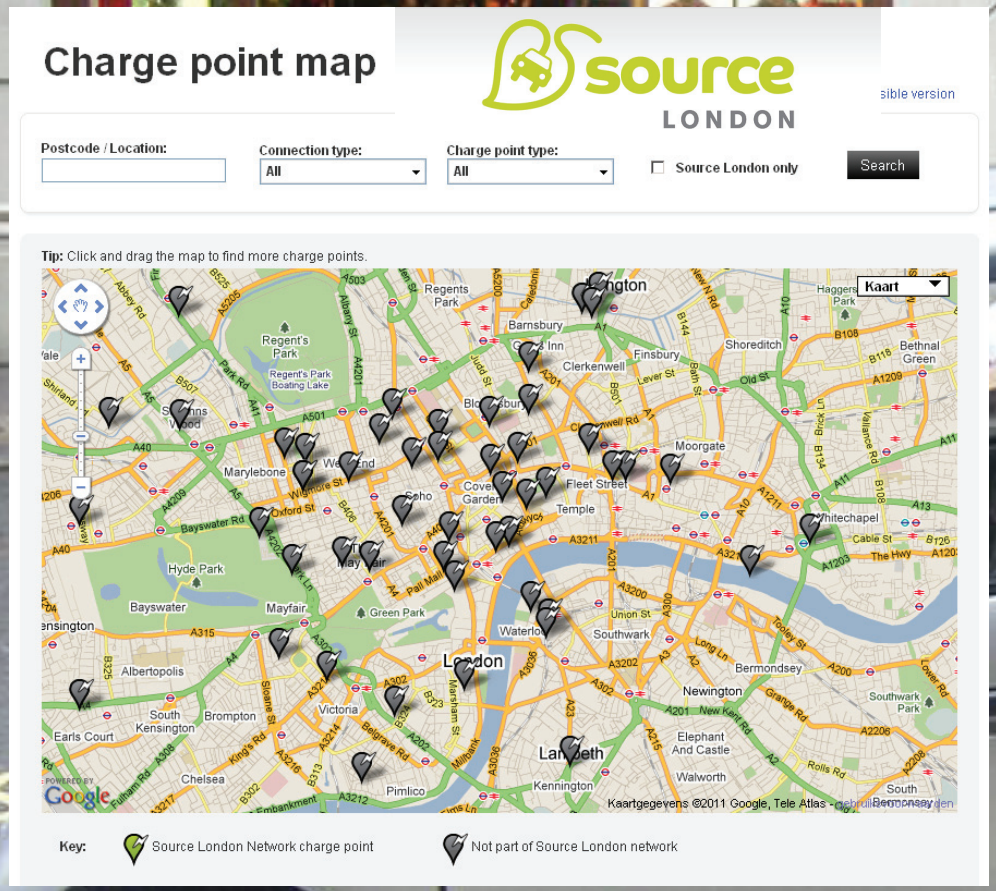
2. Electric Cars



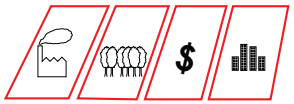
- Generic city
- Technical information
- Existing projects

- Catalogue

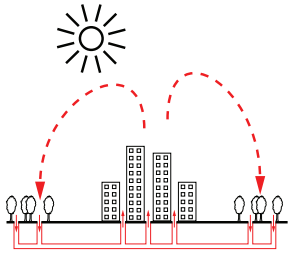
£5.000 subsidy
discount parking
2011: 50 charging points, 1.700 vehicles
2013: 1.300 charging points. 100.000 vehicles
£400/year(electric 10.000 miles) vs £1.300/year (petrol)

06.04.2011 1153250 Sjoerd Hoogewerf

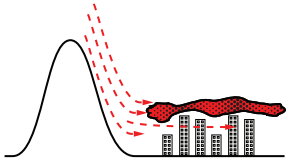
2. Catalogue



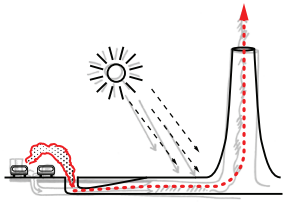
Extreme zoning



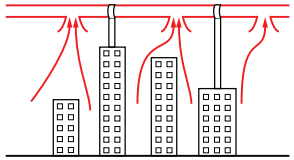
Fresh air tubes



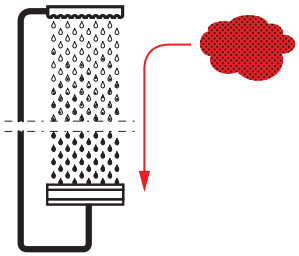
New mountains



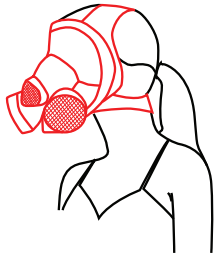
Funneling towers



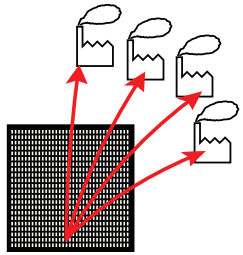
$1 billion vacuum cleaner



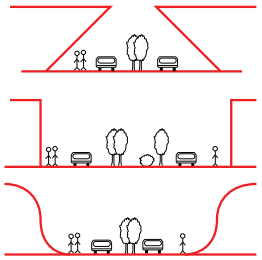
Falling water



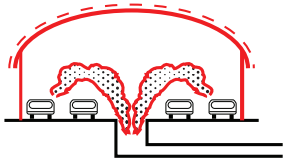
Gasmasks



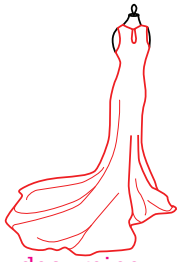
Exodus of industry



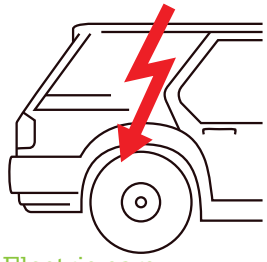
Special street profiles



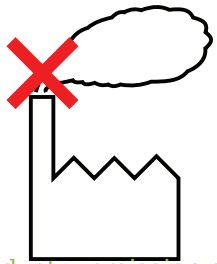
Road roof



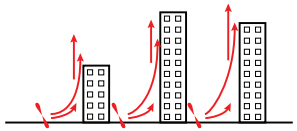
Crowdsourcing



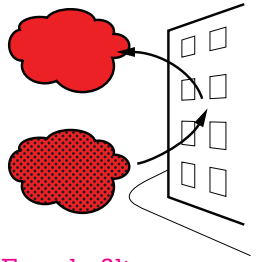
Electric cars



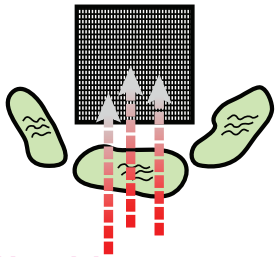
Industry emission cuts



Street ventilators

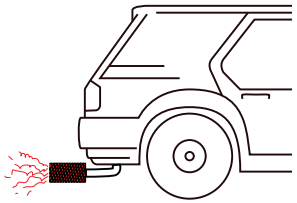


Façade filter

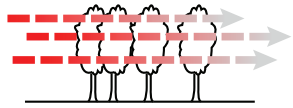


Algae lakes

Behavioural restrictions



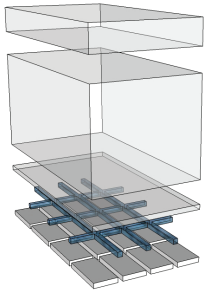
Car exhaust filters



Tree filters

2. Street Ventilators

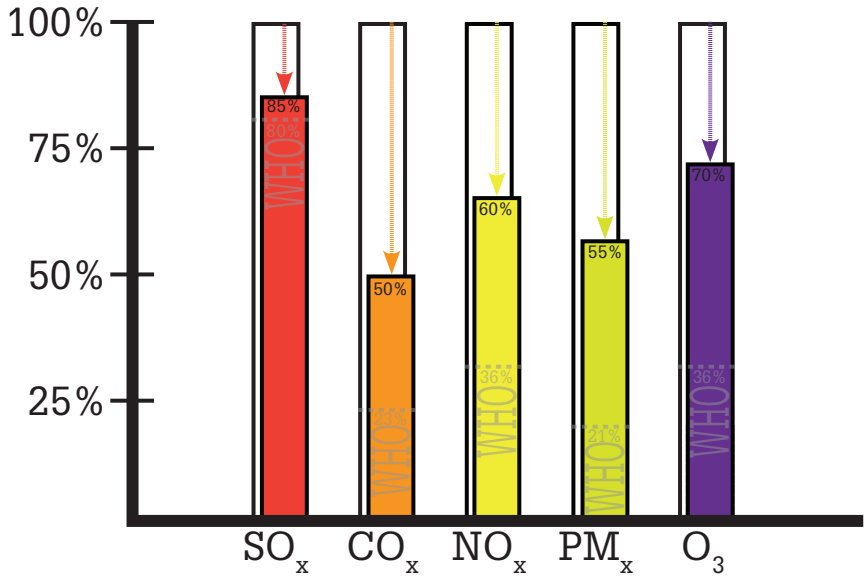
Category:	Ventilate
Strategy/Product:	Street ventilators
Price per capita:	€ 4.000
Program added:	1.600 m^3

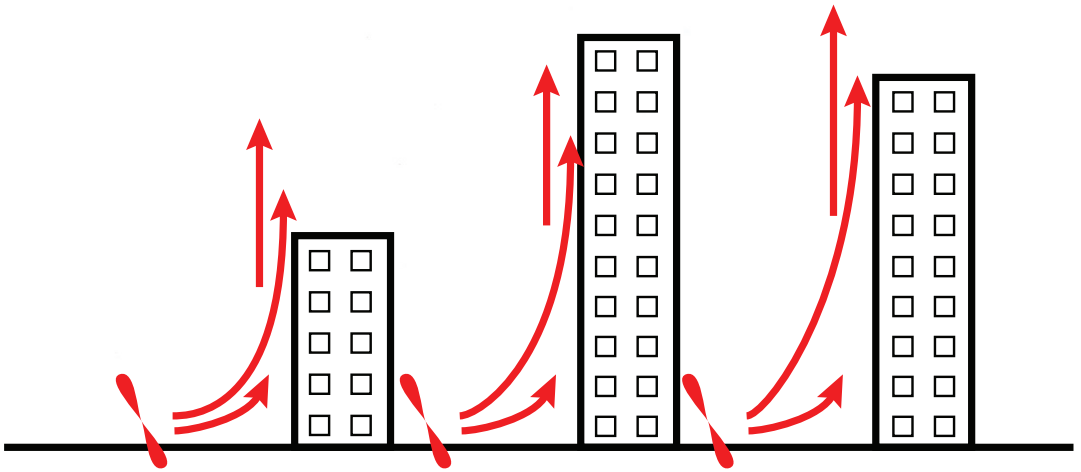


Generic city

Technical information

Existing projects





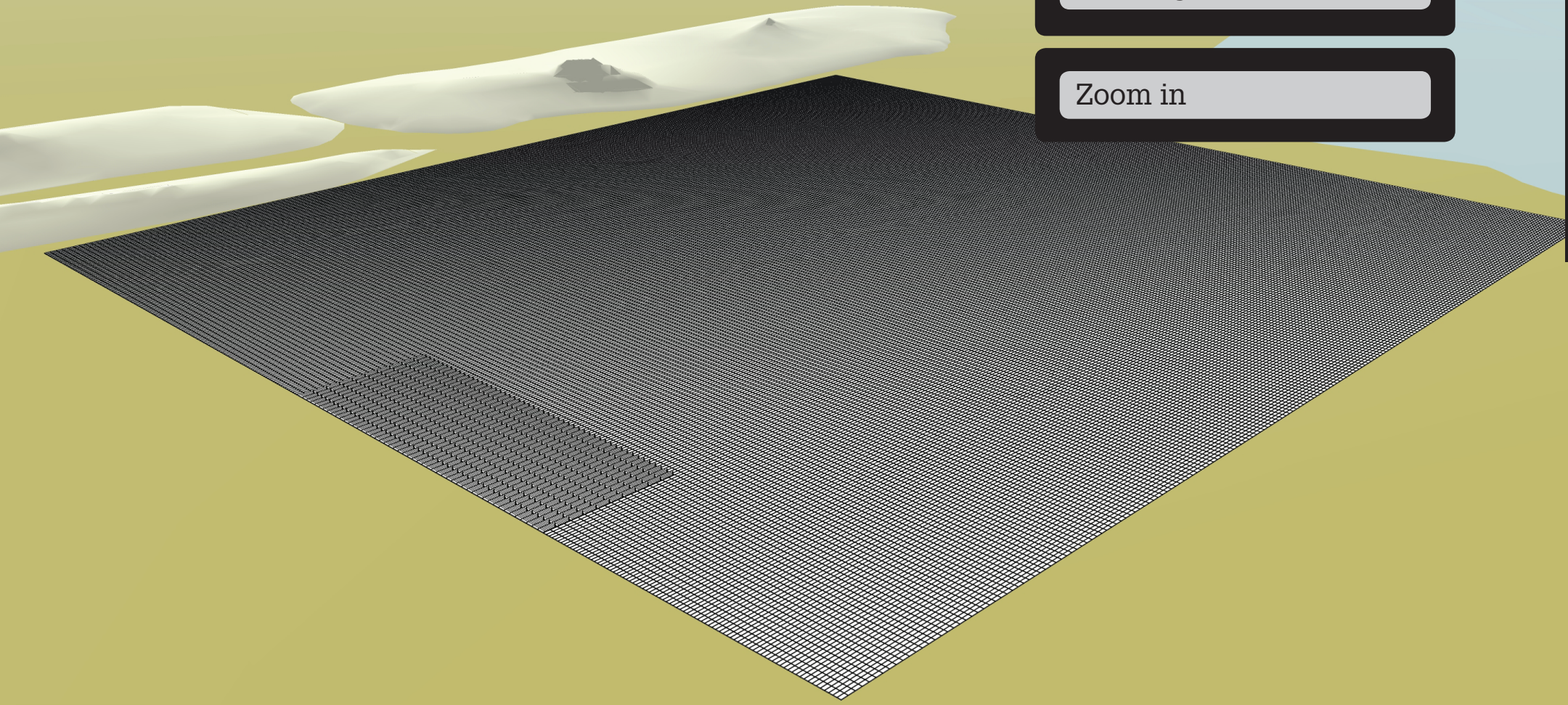
2. Street Ventilators

Generic city

Technical information

Existing projects

Zoom in



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2. Street Ventilators

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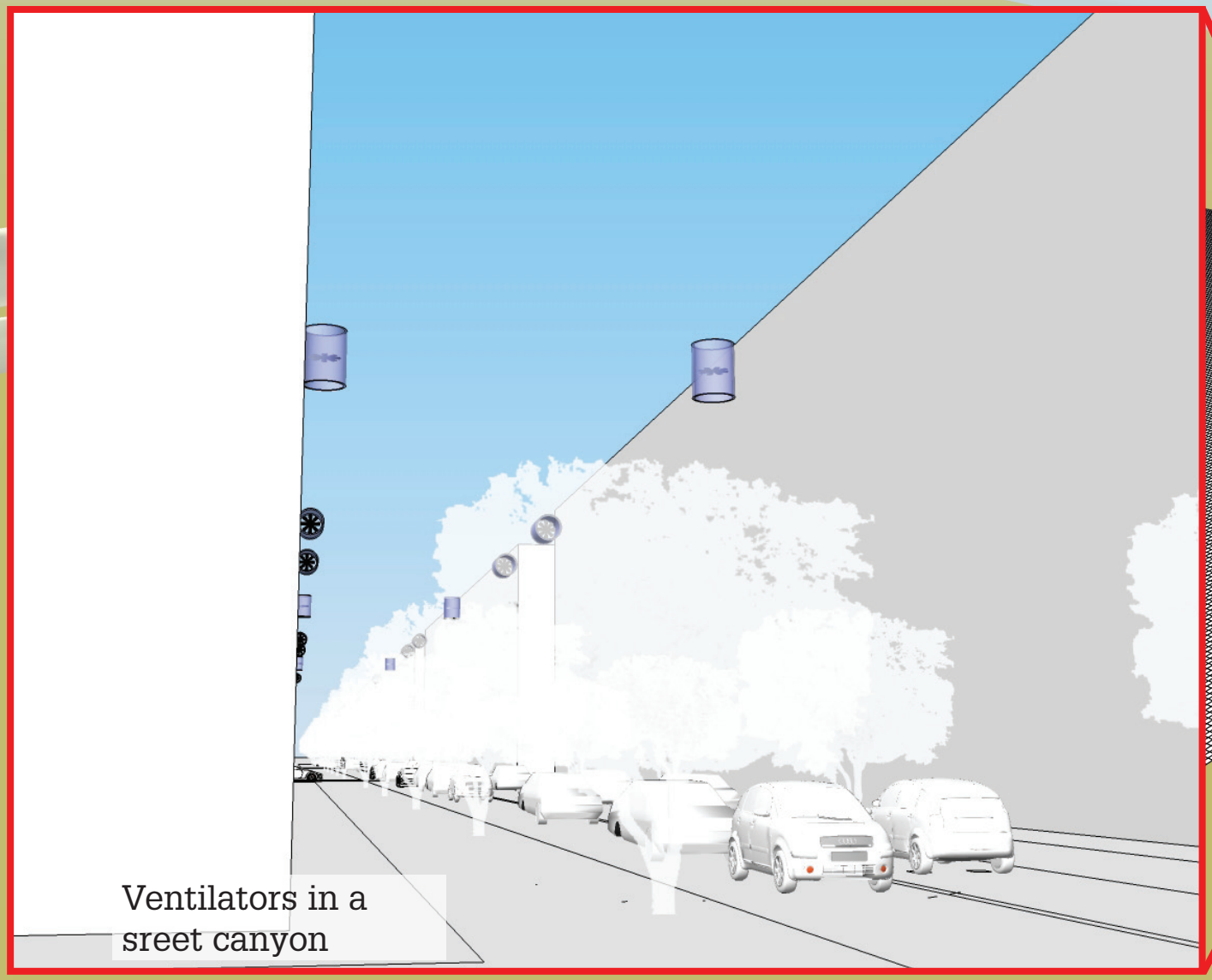
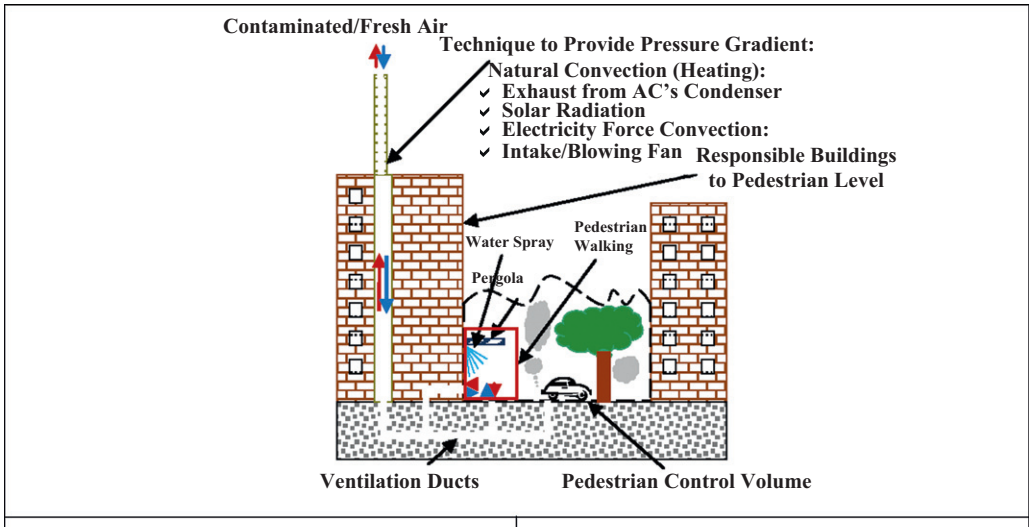
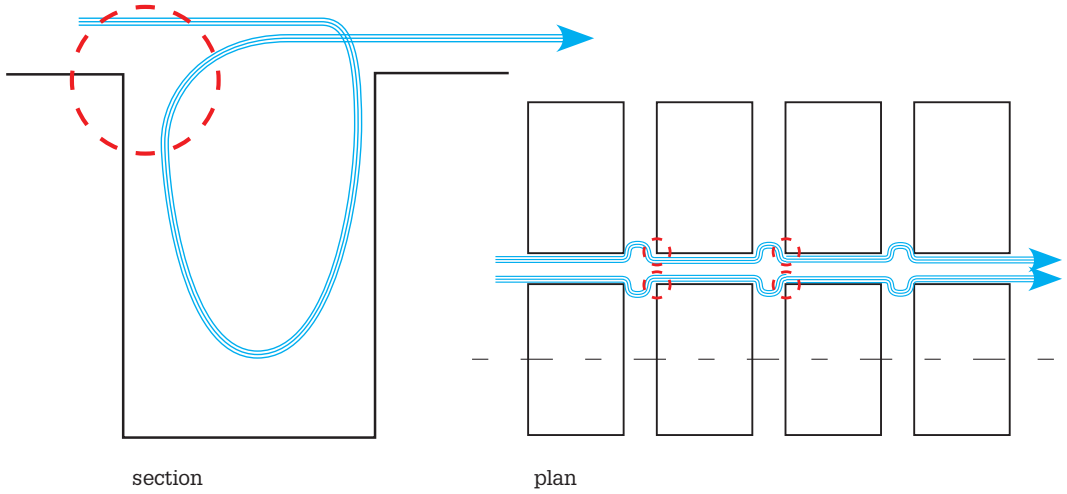


Ventilators in a sreet canyon

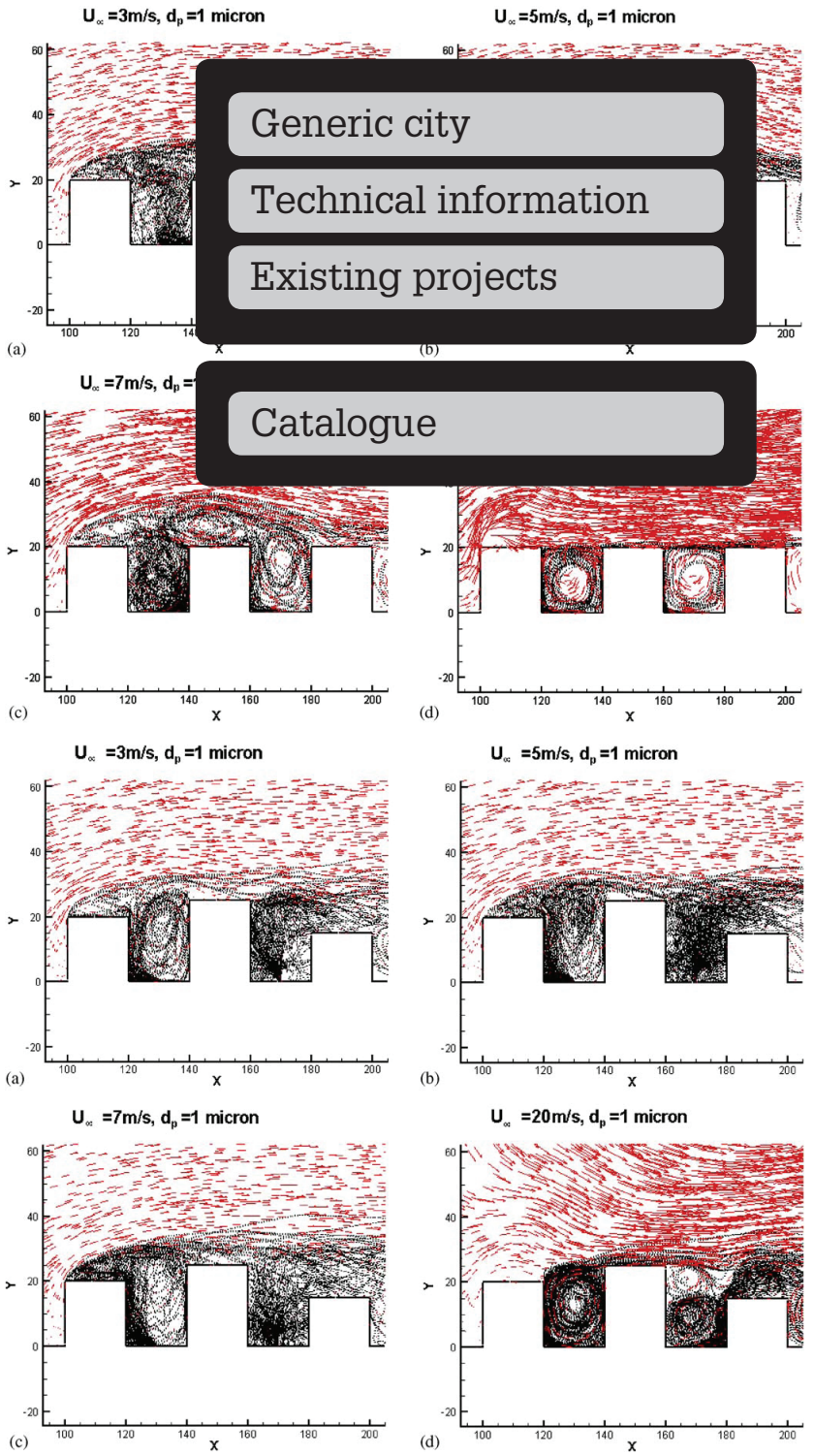
2. Street Ventilators



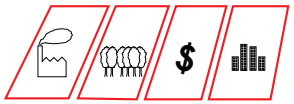


section plan

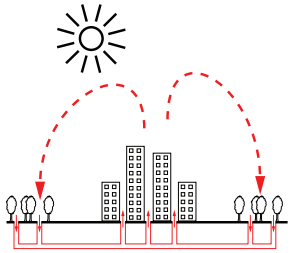
- Generic city
- Technical information
- Existing projects
- Catalogue



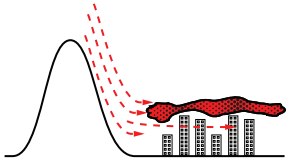
2. Catalogue



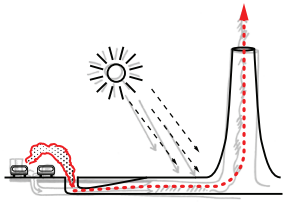
Extreme zoning



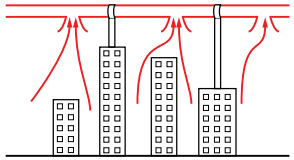
Fresh air tubes



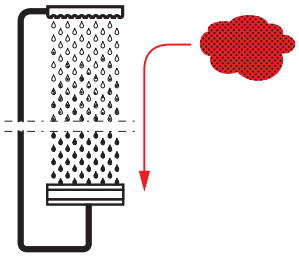
New mountains



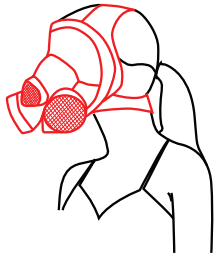
Funneling towers



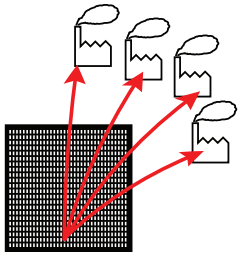
$1 billion vacuum cleaner



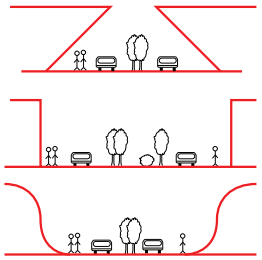
Falling water



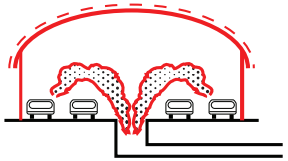
Gasmasks



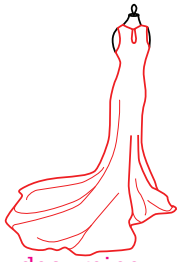
Exodus of industry



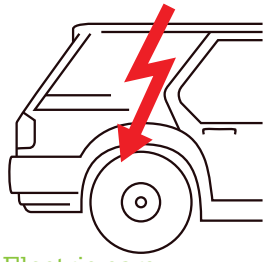
Special street profiles



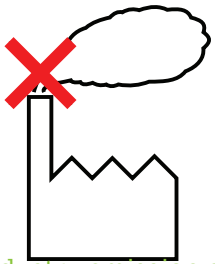
Road roof



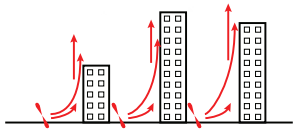
Crowdsourcing



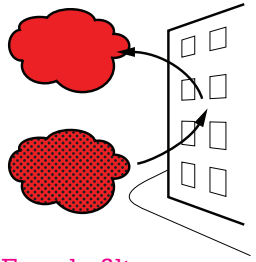
Electric cars



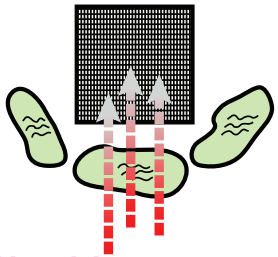
Industry emission cuts



Street ventilators

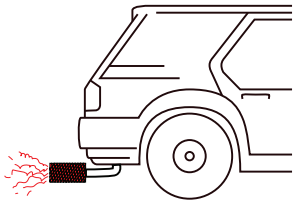


Façade filter

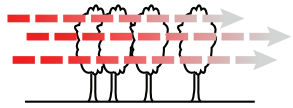


Algae lakes

Behavioural restrictions



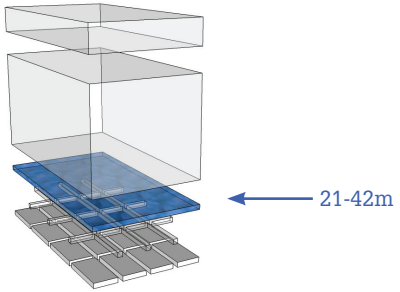
Car exhaust filters



Tree filters

2. Tree Filters

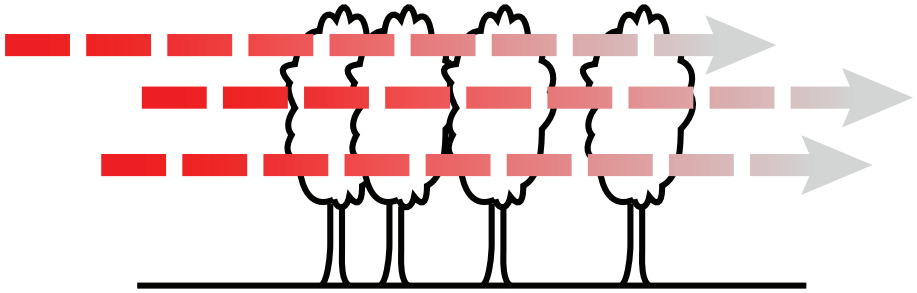
Category:	Filter
Strategy/Product:	Tree filter
Price per capita:	€ 9.180 (1 tree = € 20)
Program added:	38.407.504.320.000 m^3

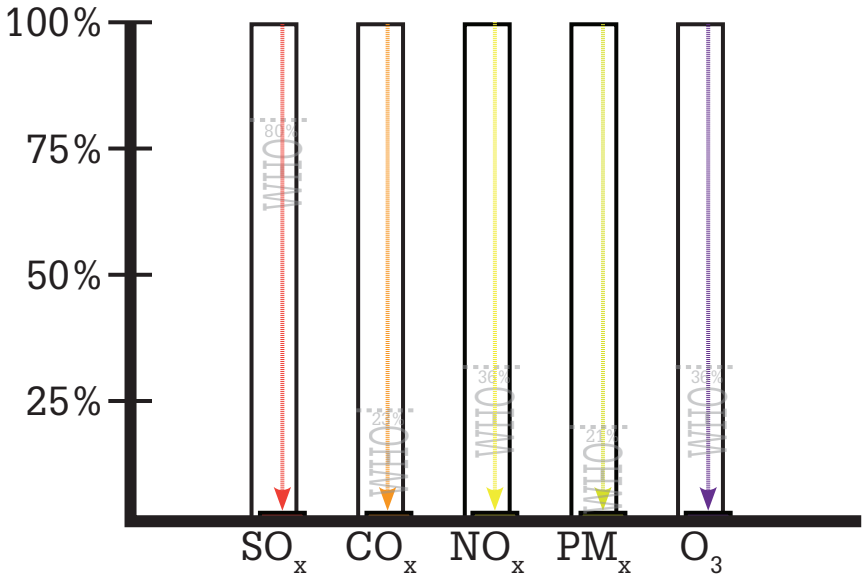


Generic city

Technical information

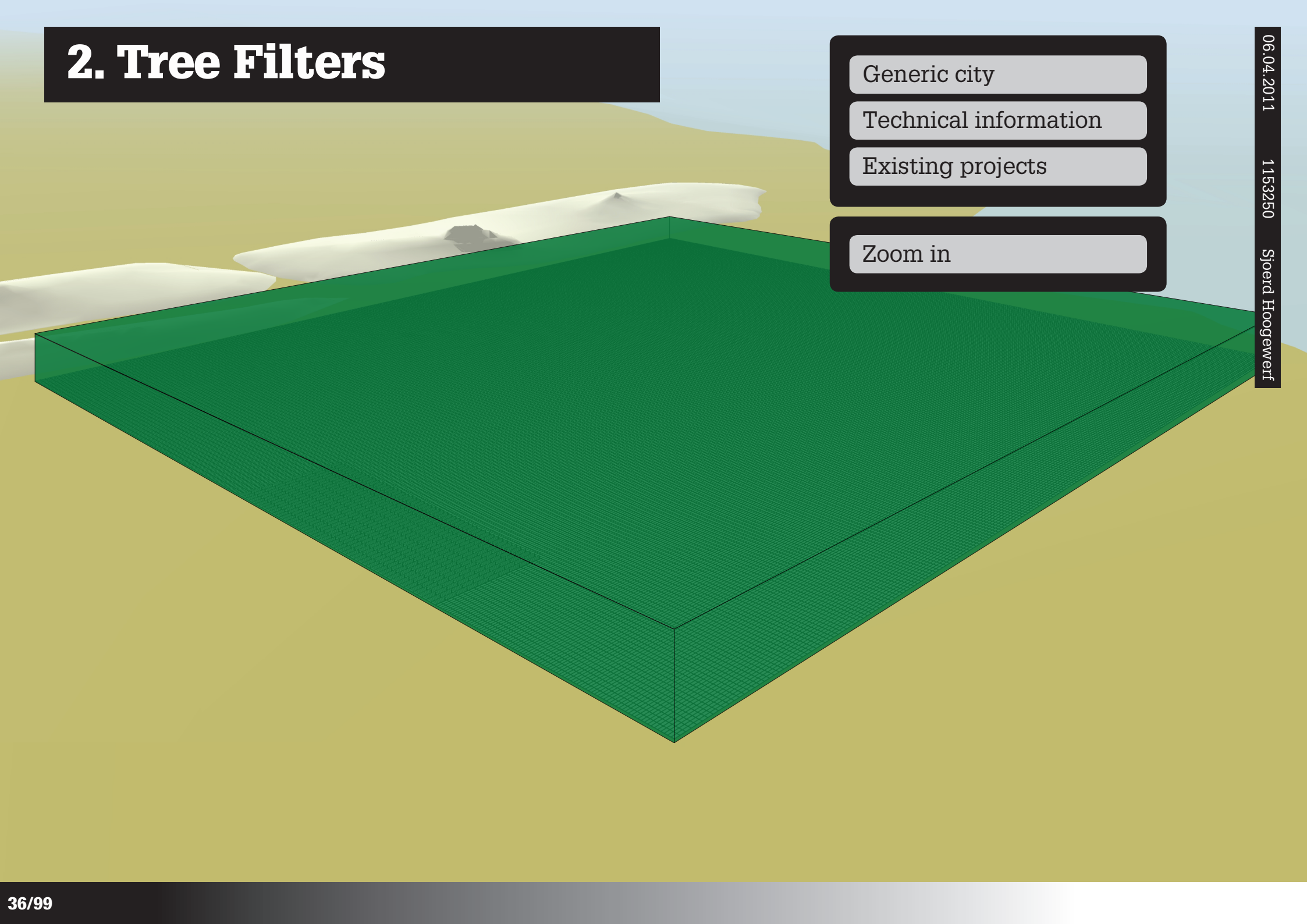
Existing projects





Dr J. Wesseling | R. Beijk | N. van Kuijeren; Effecten van groen op de luchtkwaliteit; RIVM, 2008
A. T. Vermeulen et al.; Vegetatie voor een betere luchtkwaliteit; ECN/TNO/PRI(Innovatie Programma Luchtkwaliteit), 2009

2. Tree Filters



Generic city

Technical information

Existing projects

Zoom in

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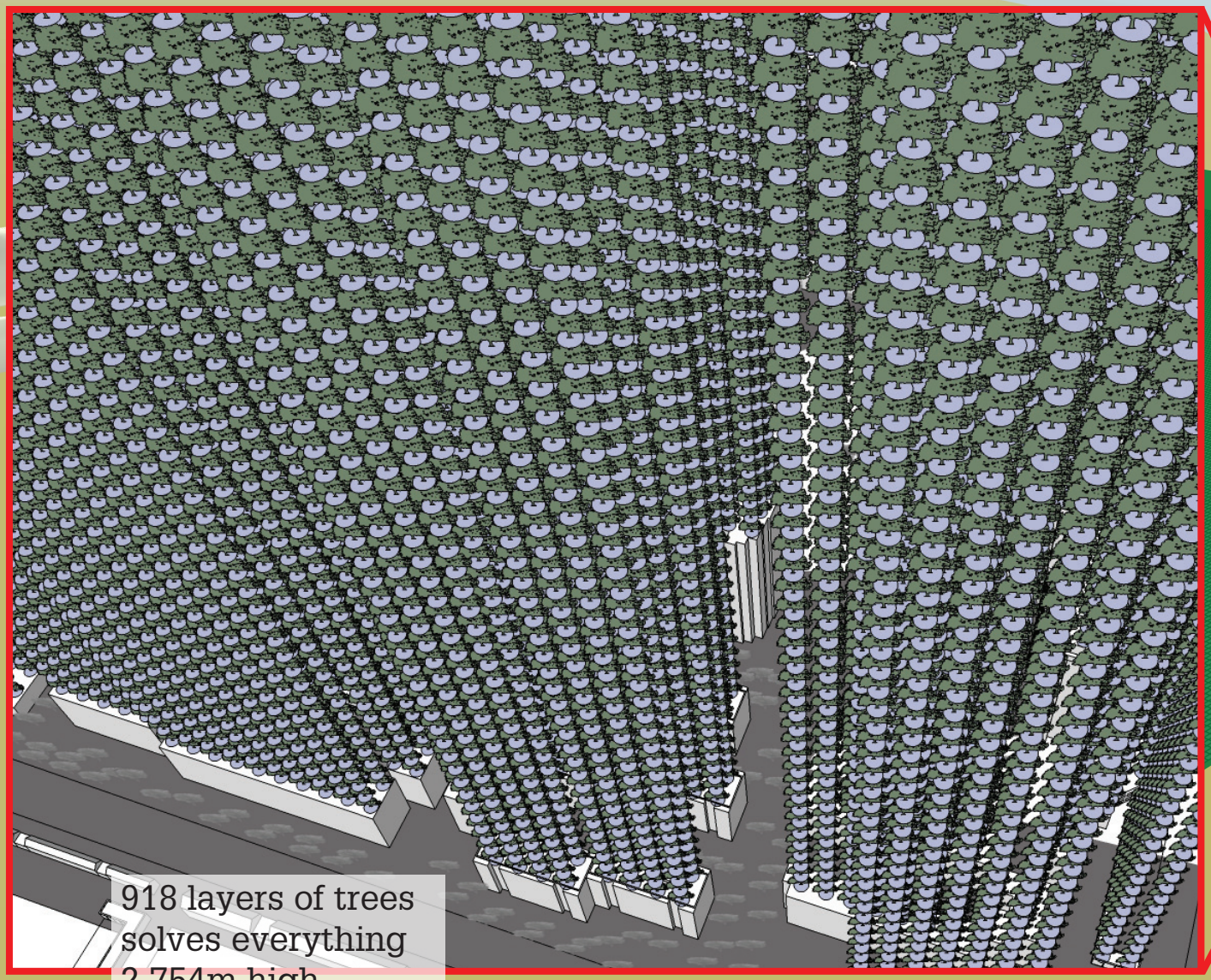
2. Tree Filters



918 layers of trees
solves everything
2.754m high

Generic city

Technical information

Existing projects

Zoom in

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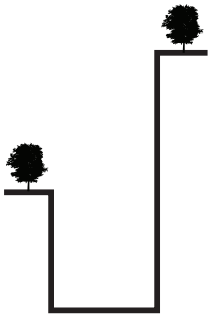
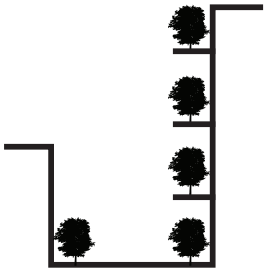
2. Tree Filters

06.04.2011 1153250 Sjoerd Hoogewerf



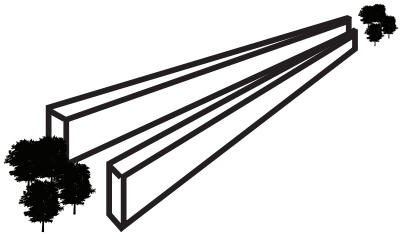
Trees on roofs:
++

No speed reduction.
+ Filters larger particles.



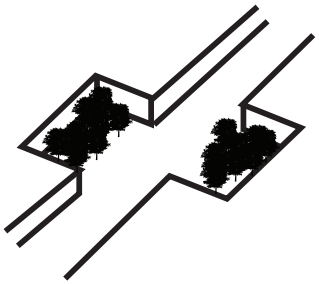
Trees in street:
-

+ Slows down wind in streets
+ Filters larger particles.
- higher concentration of PMx.



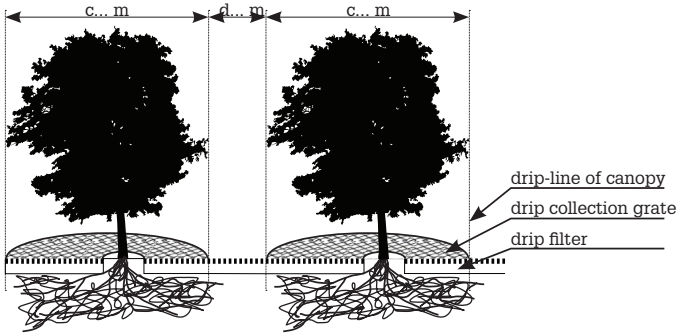
Trees in start/en of street:
+

No speed reduction.
+ Filters larger particles.



Trees in 'pockets':
+

No speed reduction.
+ Filters larger particles.




Euonymus


Pyracantha

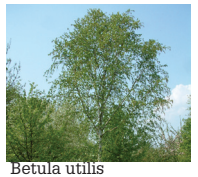

Ginkgo biloba


Fagus


Ligustrum


Alnus x spaethii


Betula pendula mus


Betula utilis


Malus


Pinus nigra

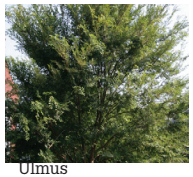

Carpinus betulus


Betula ermanii


Prunus


Betula nigra


Sorbus

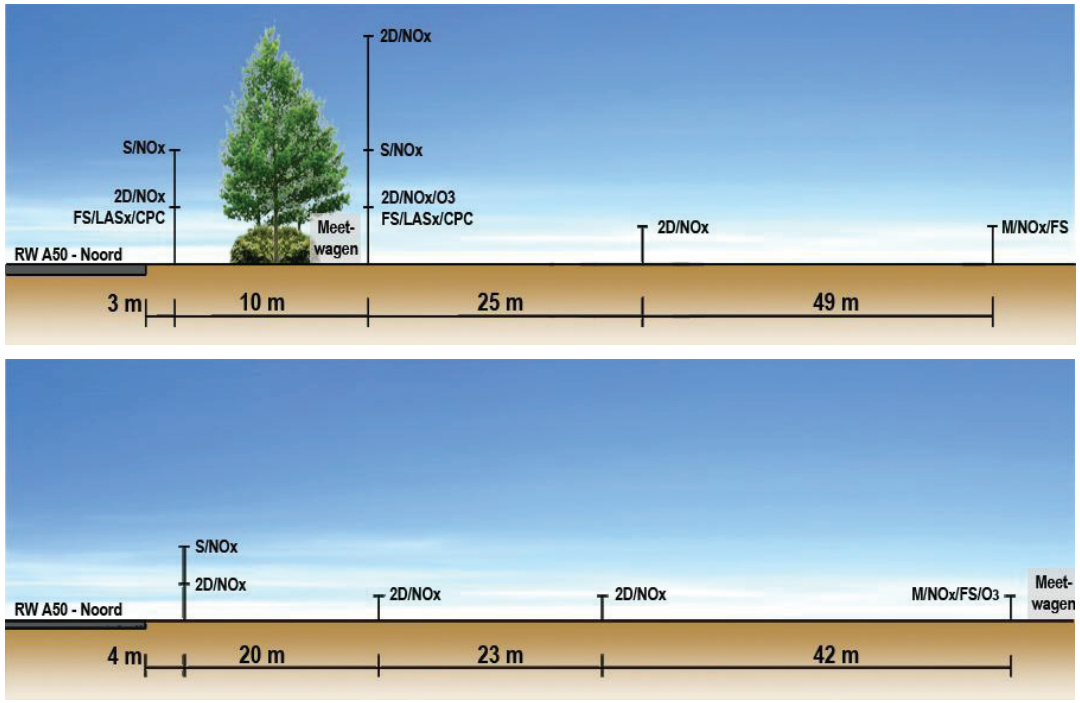

Ulmus

http://www.chicagotrees.net/our-urban-forest/
http://websearch.mep.gov.cn/was40/detail?record=2&channelid=24398&searchword=ozone
Jun Yang et al.; The urban forest in Beijing and its role in air pollution reduction; University of California at Berkeley and Chinese Academy of Forestry Science, Beijing, 2005
http://www.greenfacts.com/GreenfactsGuides/Plant-a-Tree-at-Home.html

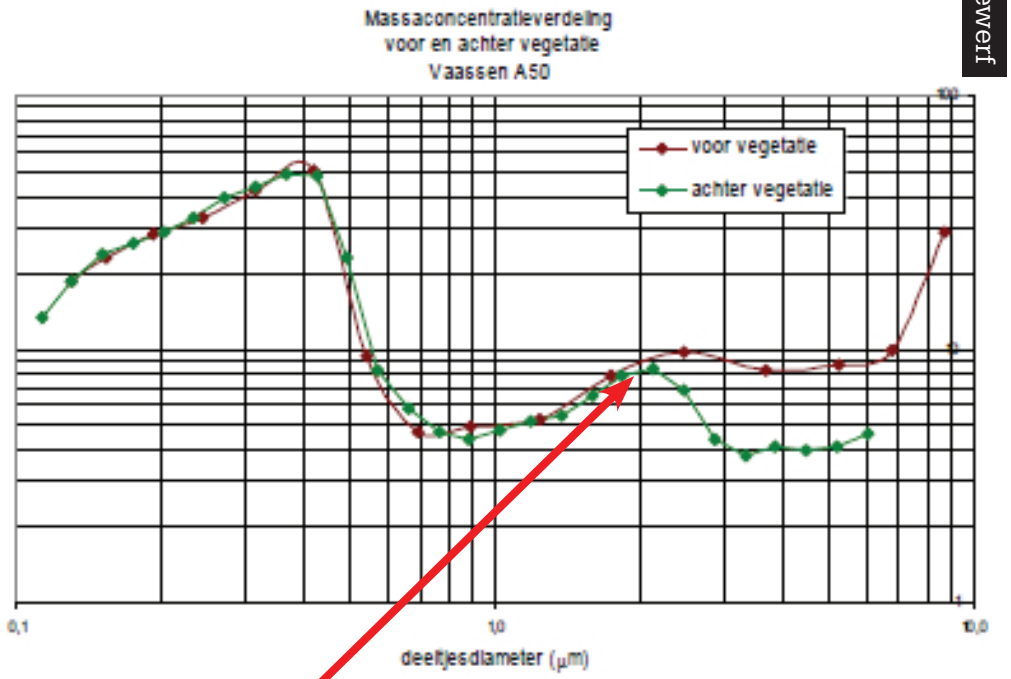
2. Tree Filters

- Generic city
- Technical information
- Existing projects

- Catalogue

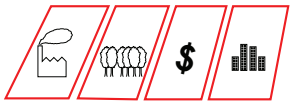


Schematische opstelling van strook met vegetatie(boven) en zonder vegetatie(onder). (codering: S=3d-sonic, 2D=2d-windsonic, M=mierij, NO_x=NO + NO_2, FS=fijn stof met TEOM en Osiris, LASx en CPC=fijn stof met betreffende apparatuur)

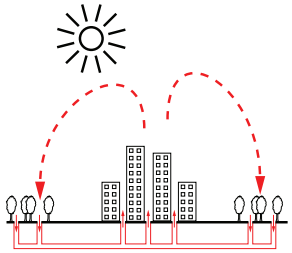


From 3µm (=PM_3) 50% of particles is sunk

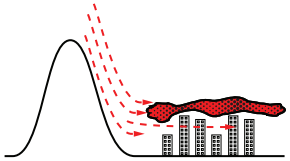
2. Catalogue



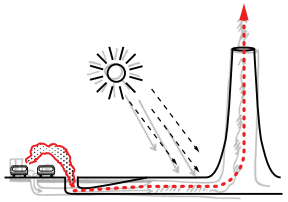
Extreme zoning



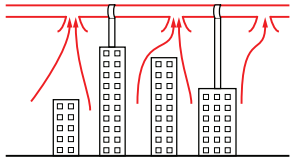
Fresh air tubes



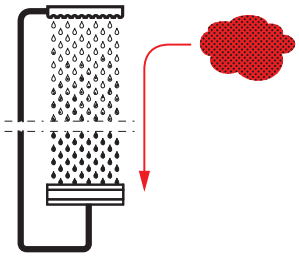
New mountains



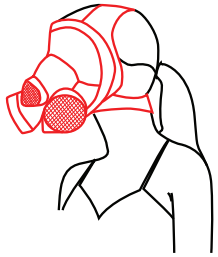
Funneling towers



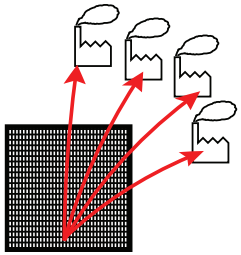
$1 billion vacuum cleaner



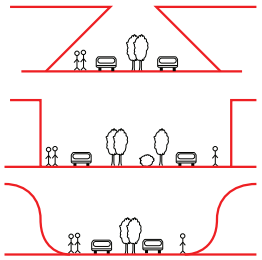
Falling water



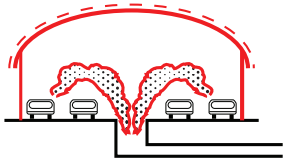
Gasmasks



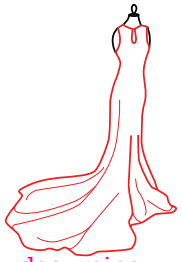
Exodus of industry



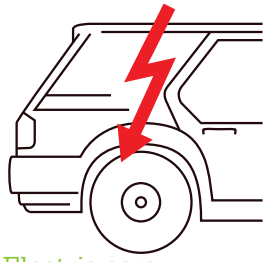
Special street profiles



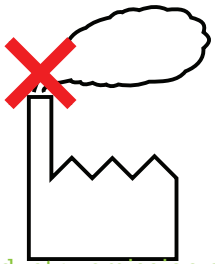
Road roof



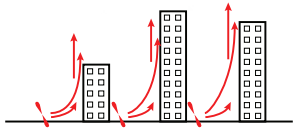
Crowdsourcing



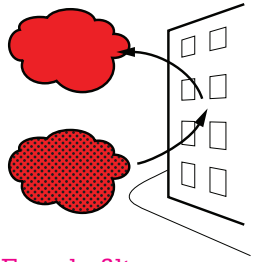
Electric cars



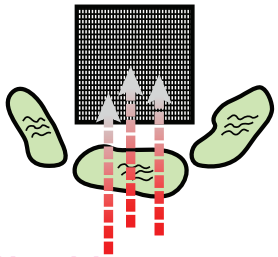
Industry emission cuts



Street ventilators

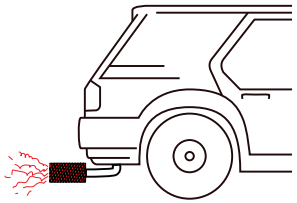


Façade filter

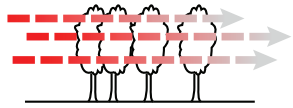


Algae lakes

Behavioural restrictions



Car exhaust filters



Tree filters

2. Comparison

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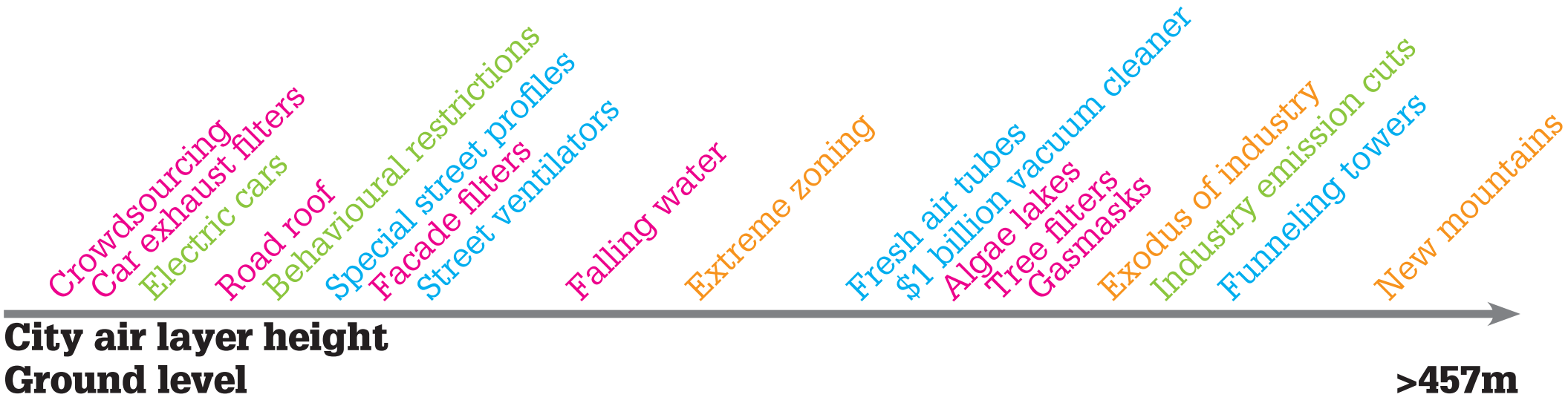

2. Comparison

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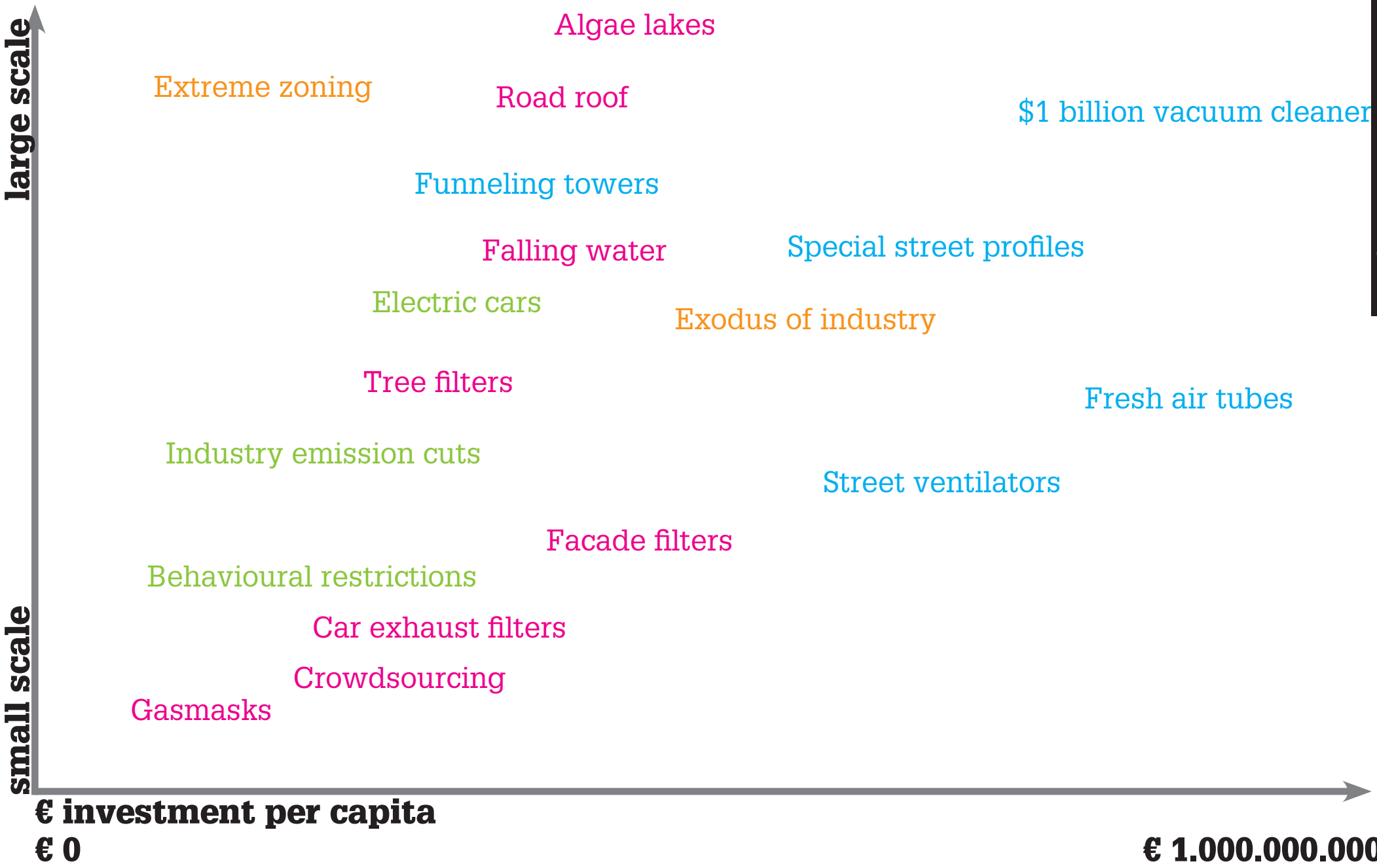

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2. Comparison

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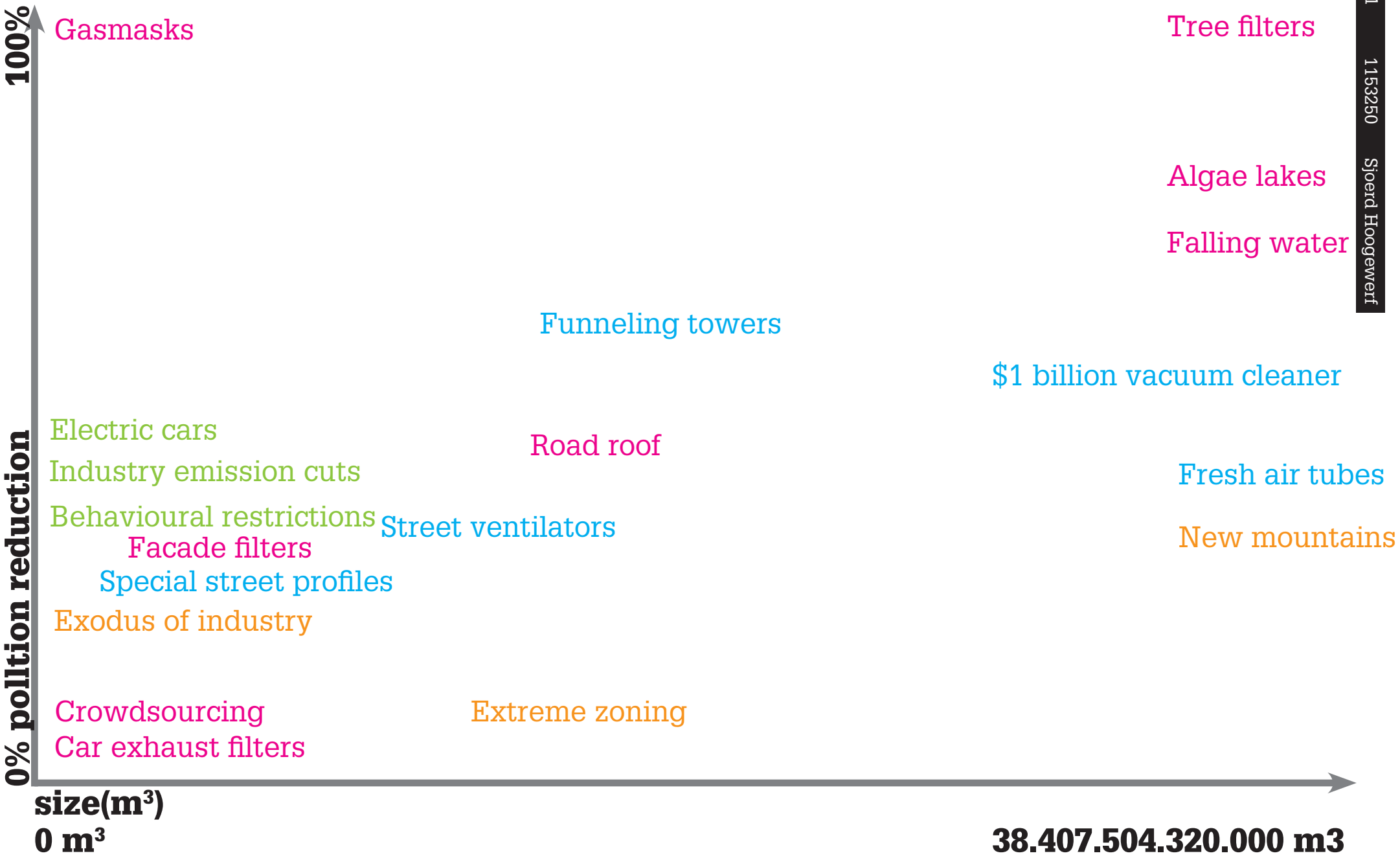

2. Comparison

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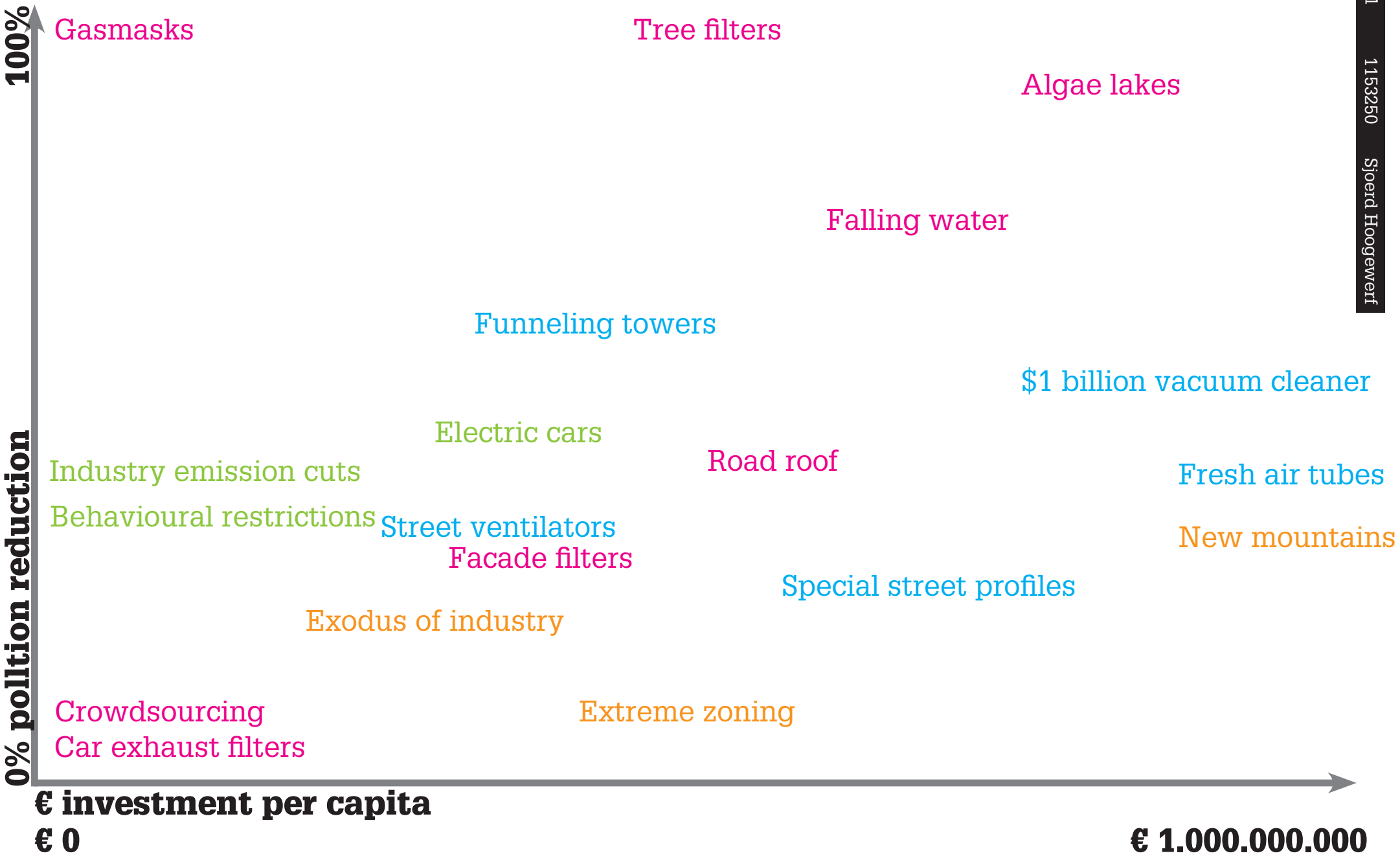
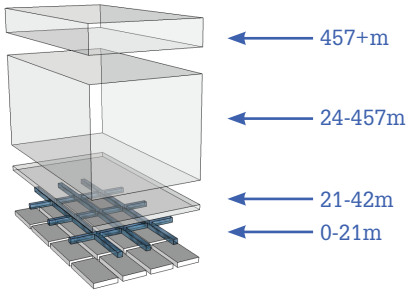
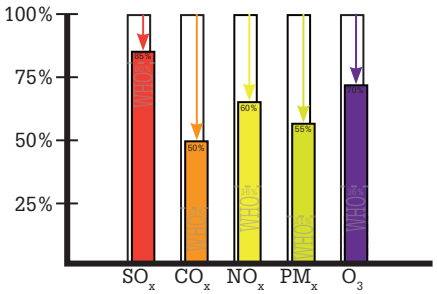


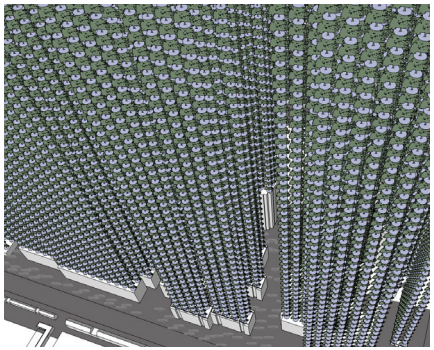
2. Subconclusion



Different heights



Different pollution reduction



A single strategy cannot solve everything

3. Application

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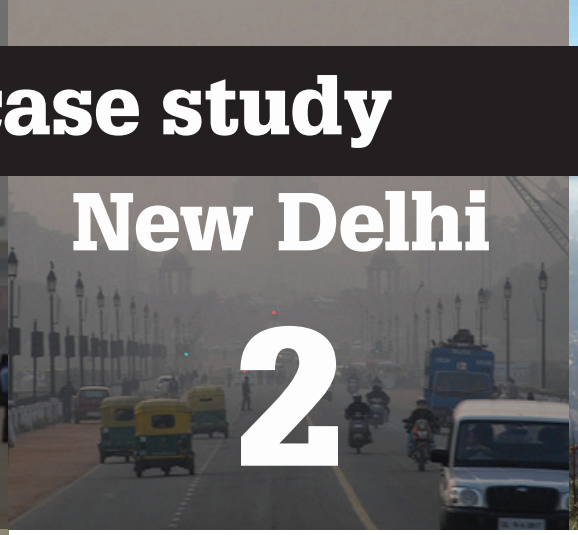
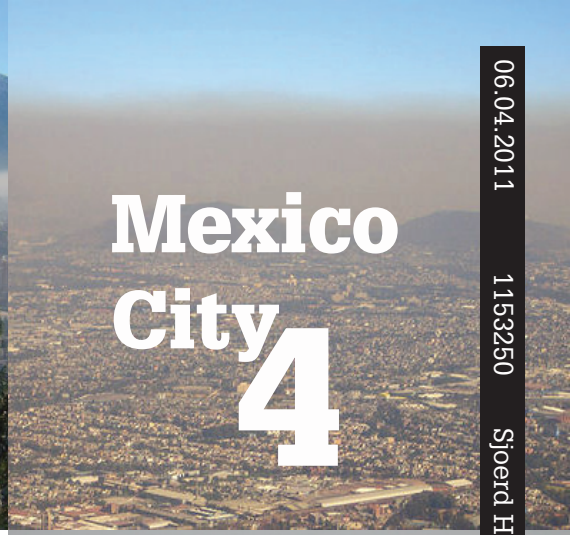
3. Beijing case study





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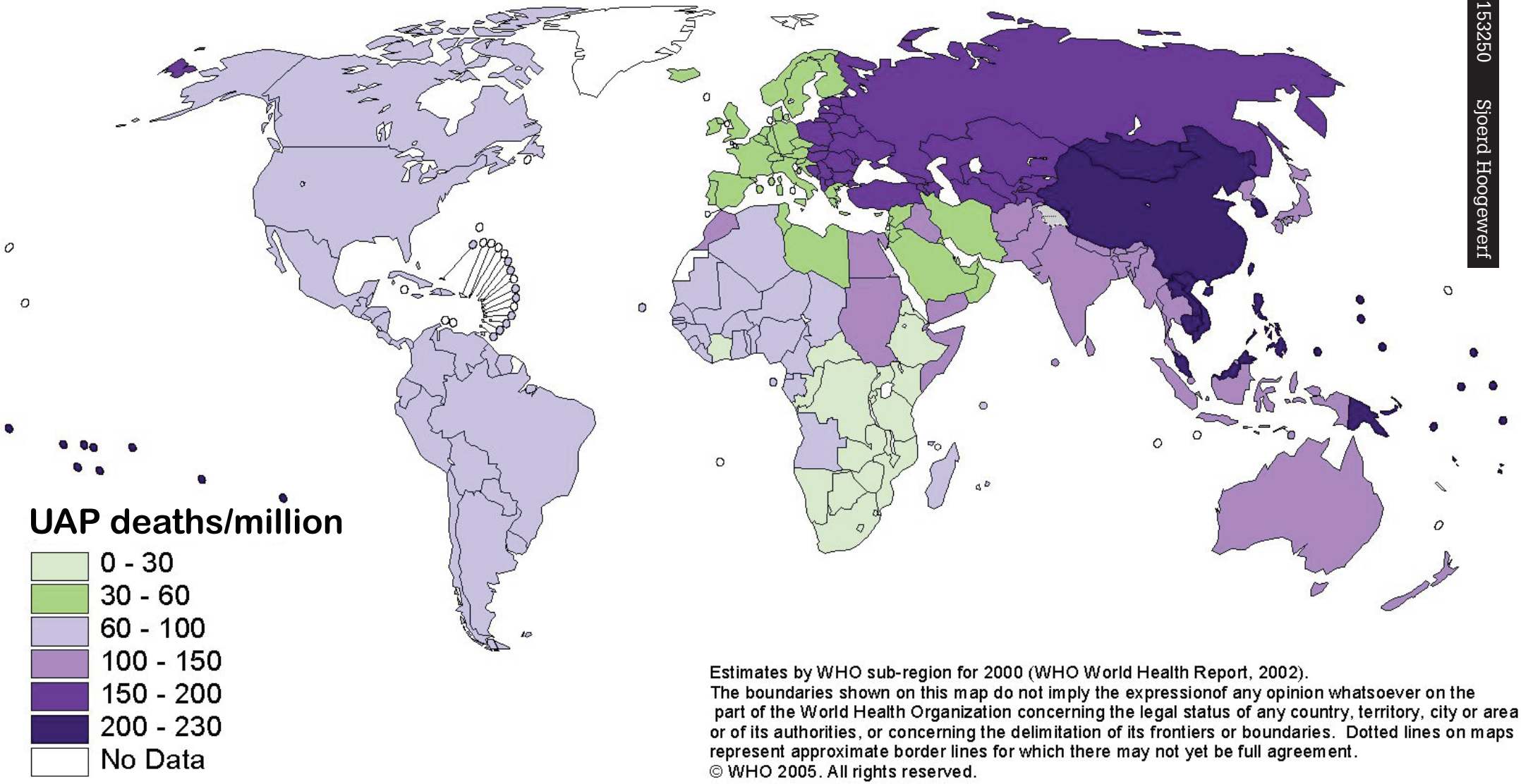
Top 10
worst air quality

3. Beijing case study

Deaths from urban air pollution



Estimates by WHO sub-region for 2000 (WHO World Health Report, 2002).
The boundaries shown on this map do not imply the expressionof any opinion whatsoever on the part of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted lines on maps represent approximate border lines for which there may not yet be full agreement.

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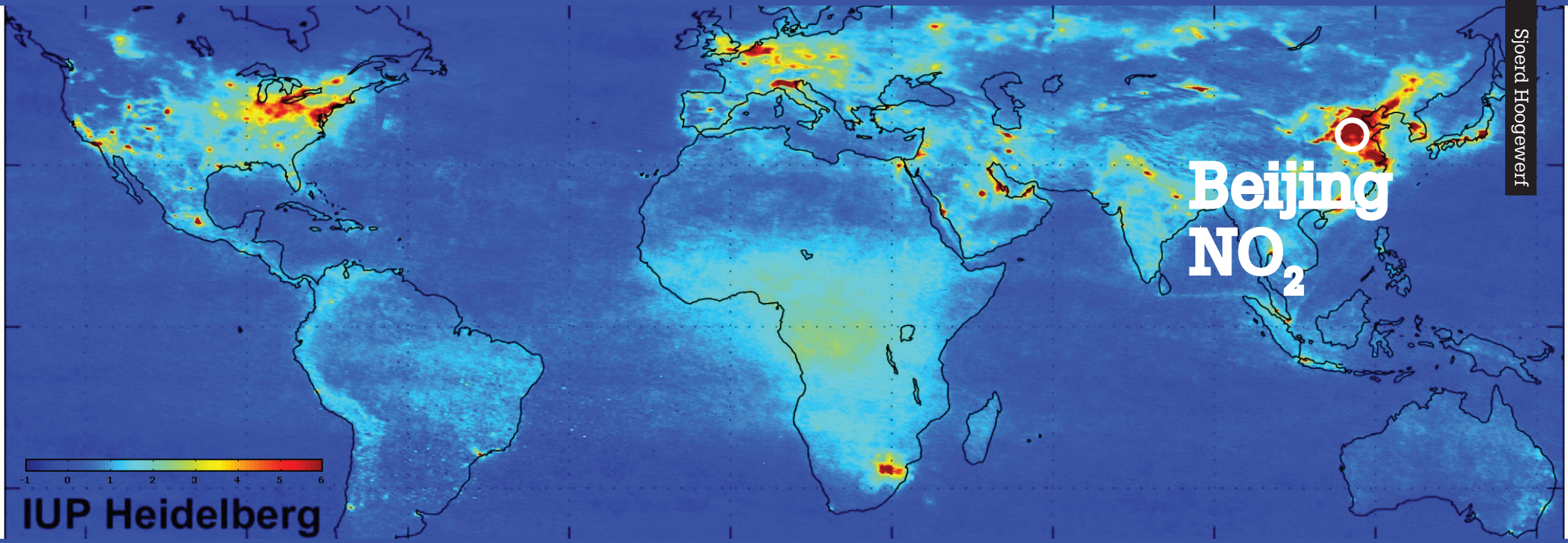
http://timetocleartheair.com/wp-content/uploads/2009/01/air_pollution_map-a.jpg

3. Global NO_2



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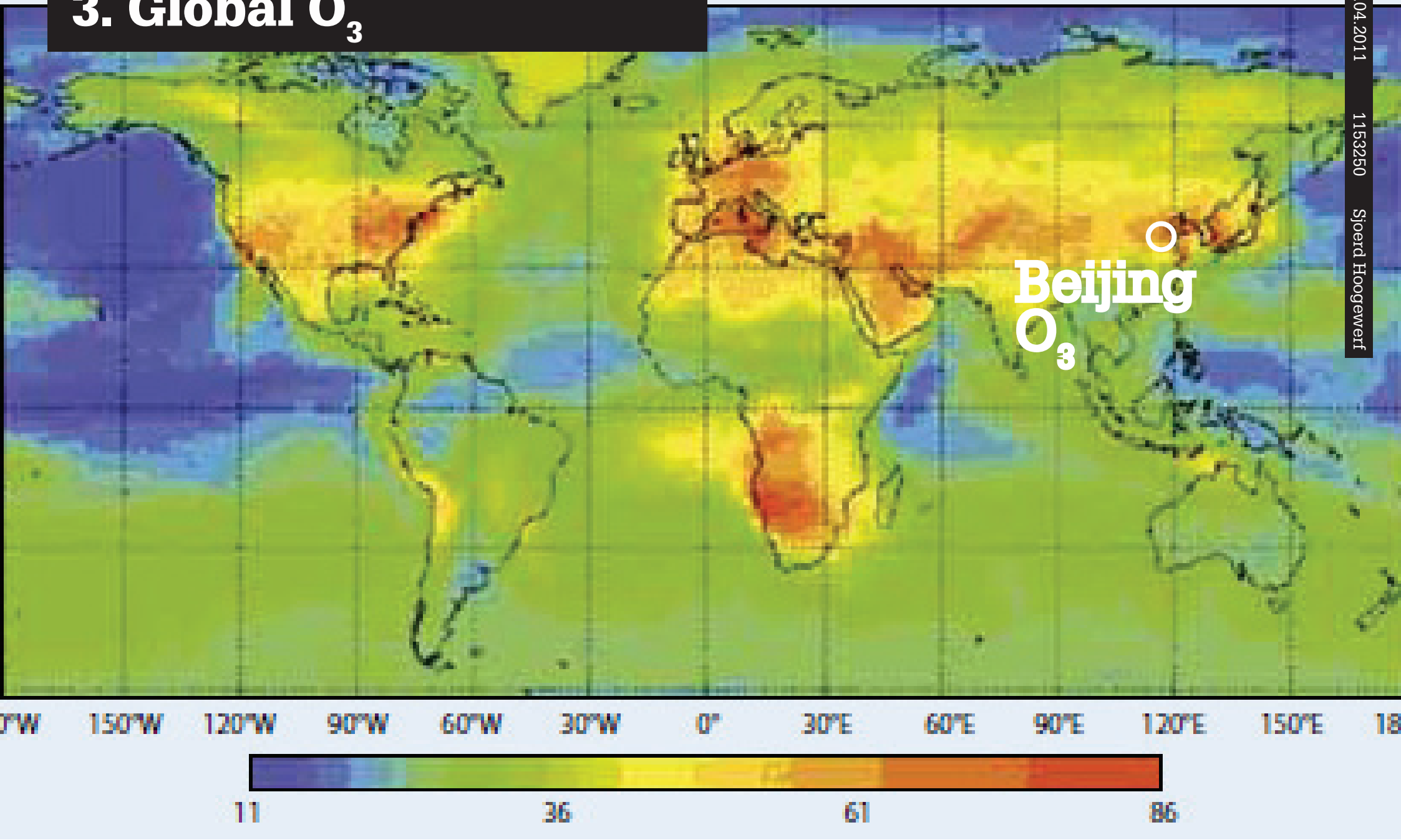
3. Global O_3



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3. Aim for Beijing

To bring the air quality of the city(within the fifth ringroad) to within the WHO guidelines.

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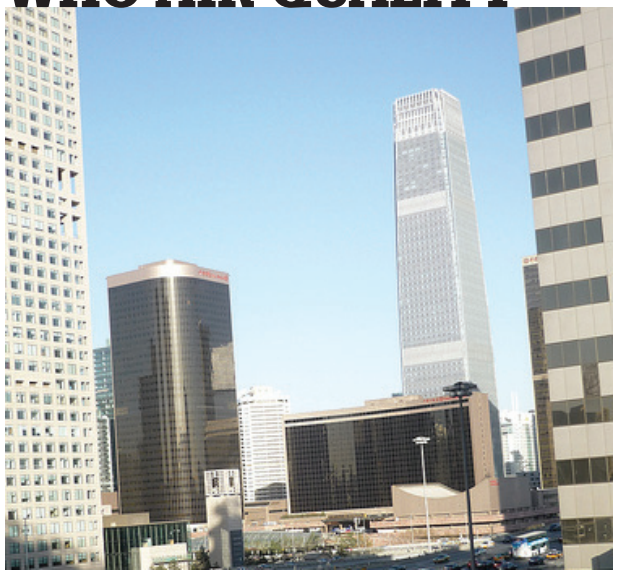
BEIJING AIR QUALITY

URBAN STRATEGY

WHO AIR QUALITY



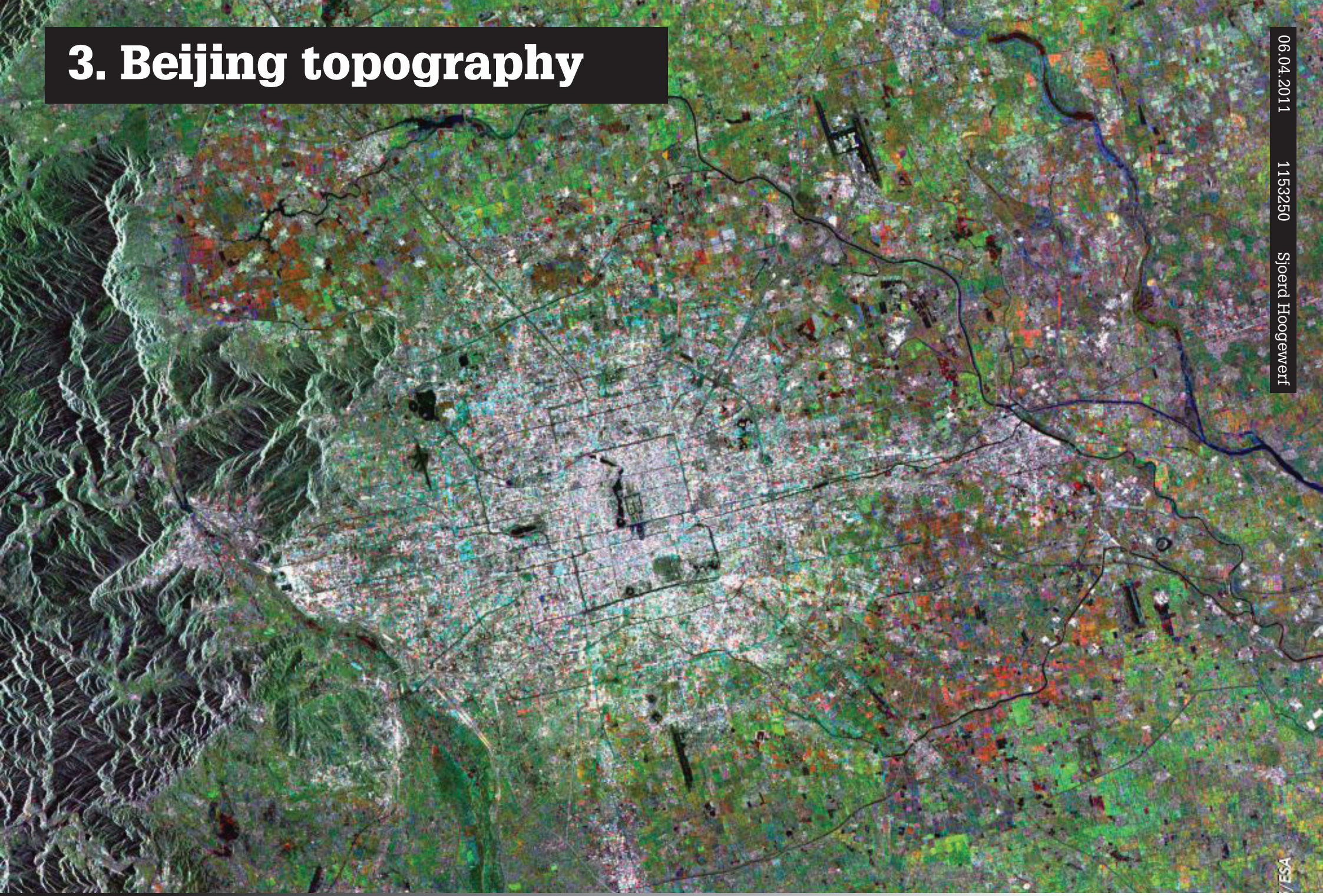
3. Beijing data

BEIJING

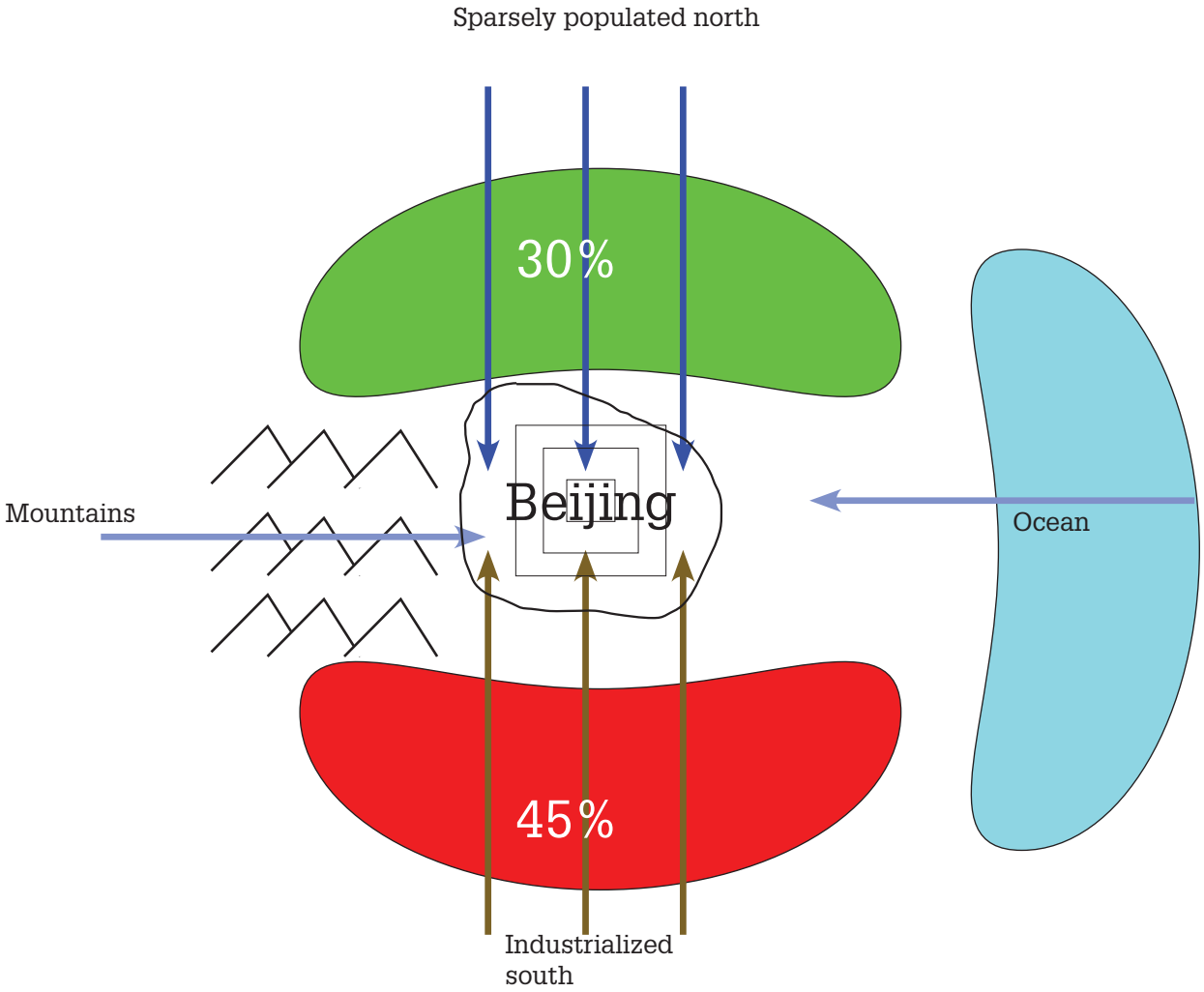
Population(City): 13,14 million
Area: 87 km^2
Density: 782 people/km^2
Population(Metropolitan): 16,95 million
Elevation 43 m
Roadlength: 4.460 km
of whichmain+expressways: 236 km

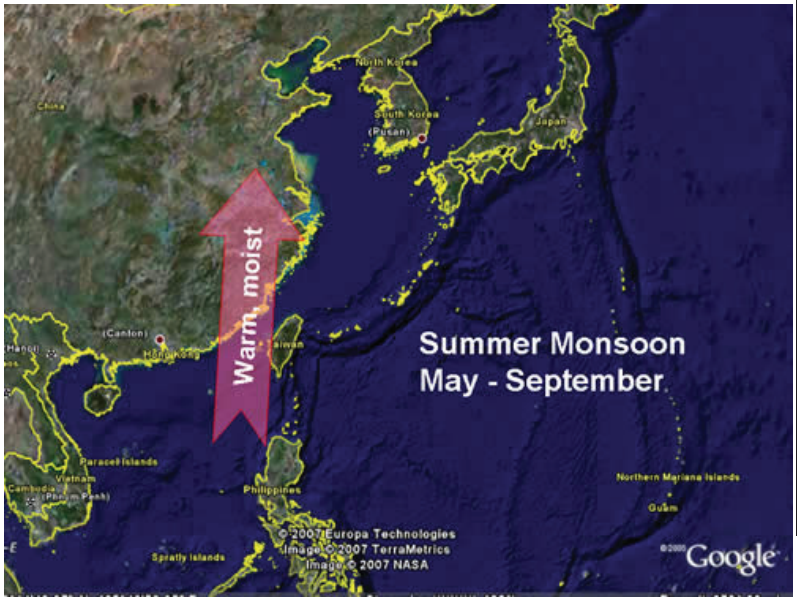
Population(Metr):16.95 million
Area: 16807.8 km^2
urban population: 77.54%
Density: 805 inh/km^2
Average Household Size: 3.21
GDP: US$ 34.07 billion
Per capita GDP: US$ 3060

3. Beijing topography



3. Outside of the city





Summer
vs
Winter

http://www.livescience.com/environment/080806-beijing-air-pollution.html
http://disc.sci.gsfc.nasa.gov/oceancolor/additional/science-focus/locus/USNA_project_1.shtml

3. Inside of the city

Mobility within Beijing

SO_x 60%

CO_x 90%

NO_x 70%

PM_x 60%

O_3 80%

remaining =
powerplants
household heating/cooking
waste processing
small factories

http://www.livescience.com/environment/080806-beijing-air-pollution.html
http://disc.sci.gsfc.nasa.gov/oceancolor/additional/science-focus/locus/USNA_project_1.shtml
Jonathan Telkamp

3. Beijing pollution

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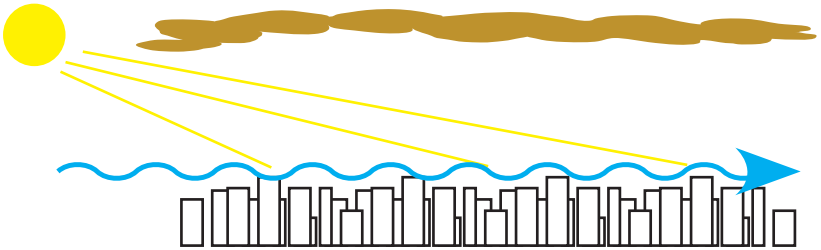
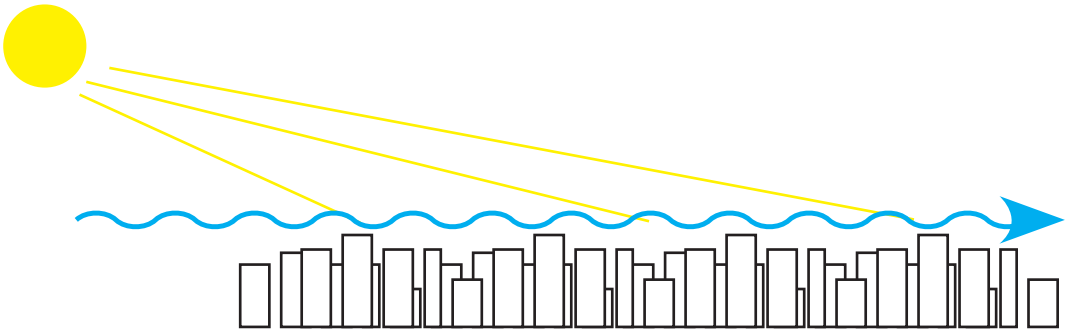
Pollution from outide of the city

Pollution from within the city

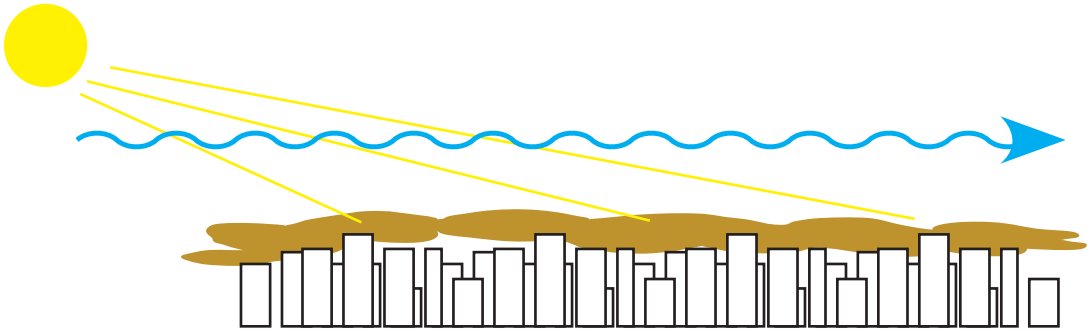
Urban climate(UHI, wind, pollution layers, rain, topography)



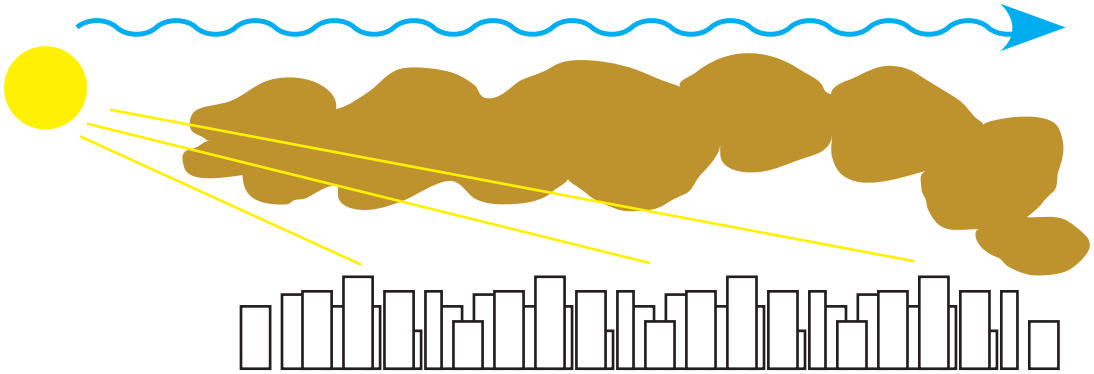
3. UHI & pollution layers



Sun heats buildings => UHI



City pollutes the air



A polluted warm air layer forms over the city creating a buffer between ventilating winds and the city

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3. Beijing -> WHO

Beijing now

	PM10	SO2	NO2	O3	CO
tons	3.368,5	191.000	139.369	1.593	45.520
	-2.913	-114.600	-54.903	-683	-44.700
concentration(µg/m3)	148	50	66	70	2.000
	-128	-30	-26	-30	-1.960
WHO(µg/m3)	20	20	40	40	40
China I	40	50	40	120	-

	PM10	
	24hours	annual
WHO	50	20
China I	50	40
China II	100	60
China III	150	120

	SO2		
	10min	1hour	24hours
WHO	500		20
China I	150	50	20
China II	250	150	50
China III	700	500	150

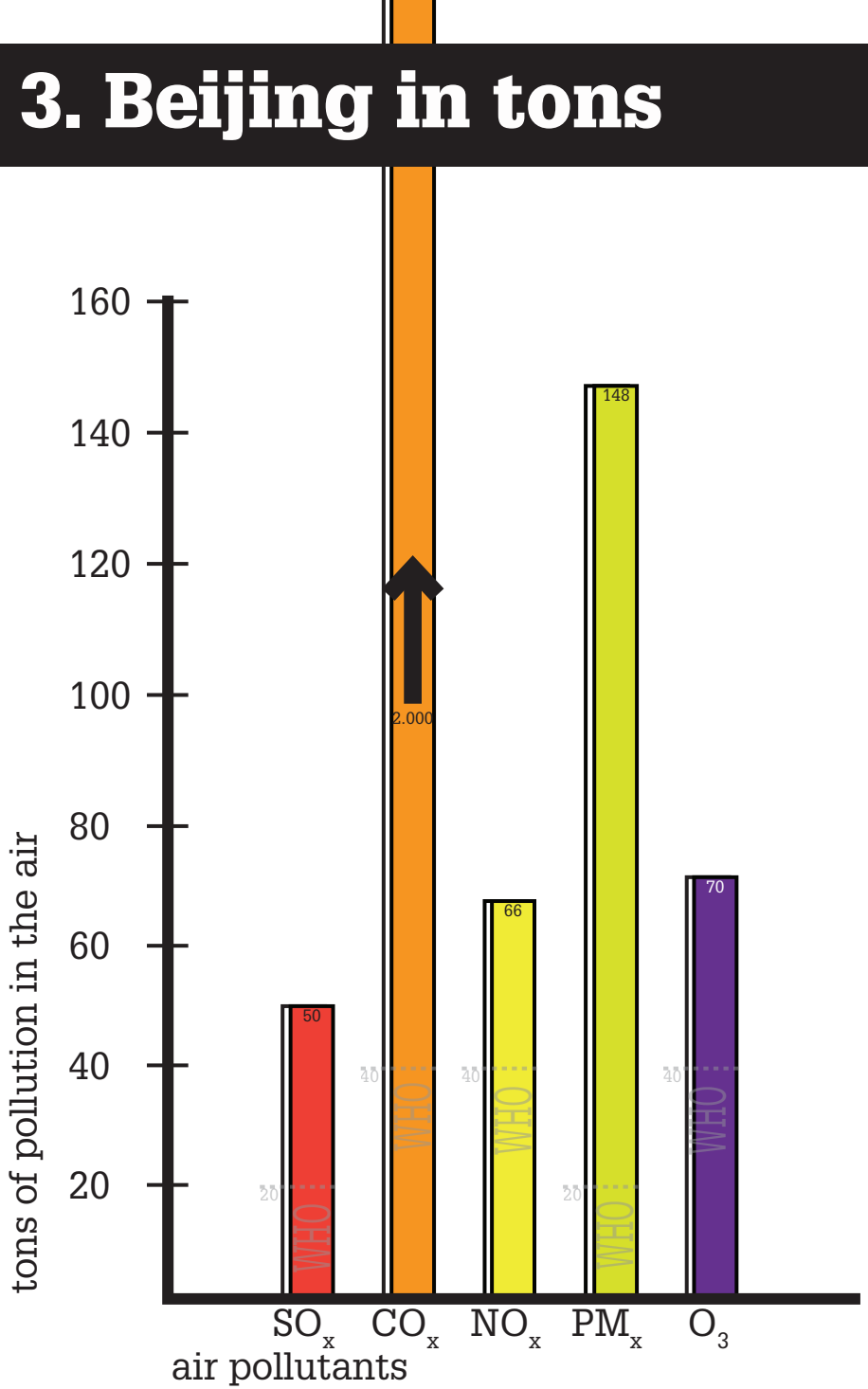
	NO2		
	1hour	24hours	annual
WHO		200	40
China I	120	80	40
China II	120	80	40
China III	240	120	80

	O3			
	1hour	8hours	24hours	annual
WHO		100	200	40
China I	120			
China II	160			
China III	200			

	CO	
	1hour	annual
WHO	200	40
China I		
China II		
China III		

Class I: tourist, historical and conservation areas;
Class II: residential urban and rural areas;
Class III: industrial and heavy traffic areas.

3. Beijing in tons



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3. Cleaning Beijing's air in 5 steps

1. Prevent polluted air from outside of the city
    - Algae filters
    - Cost?
    - How much will it clean?

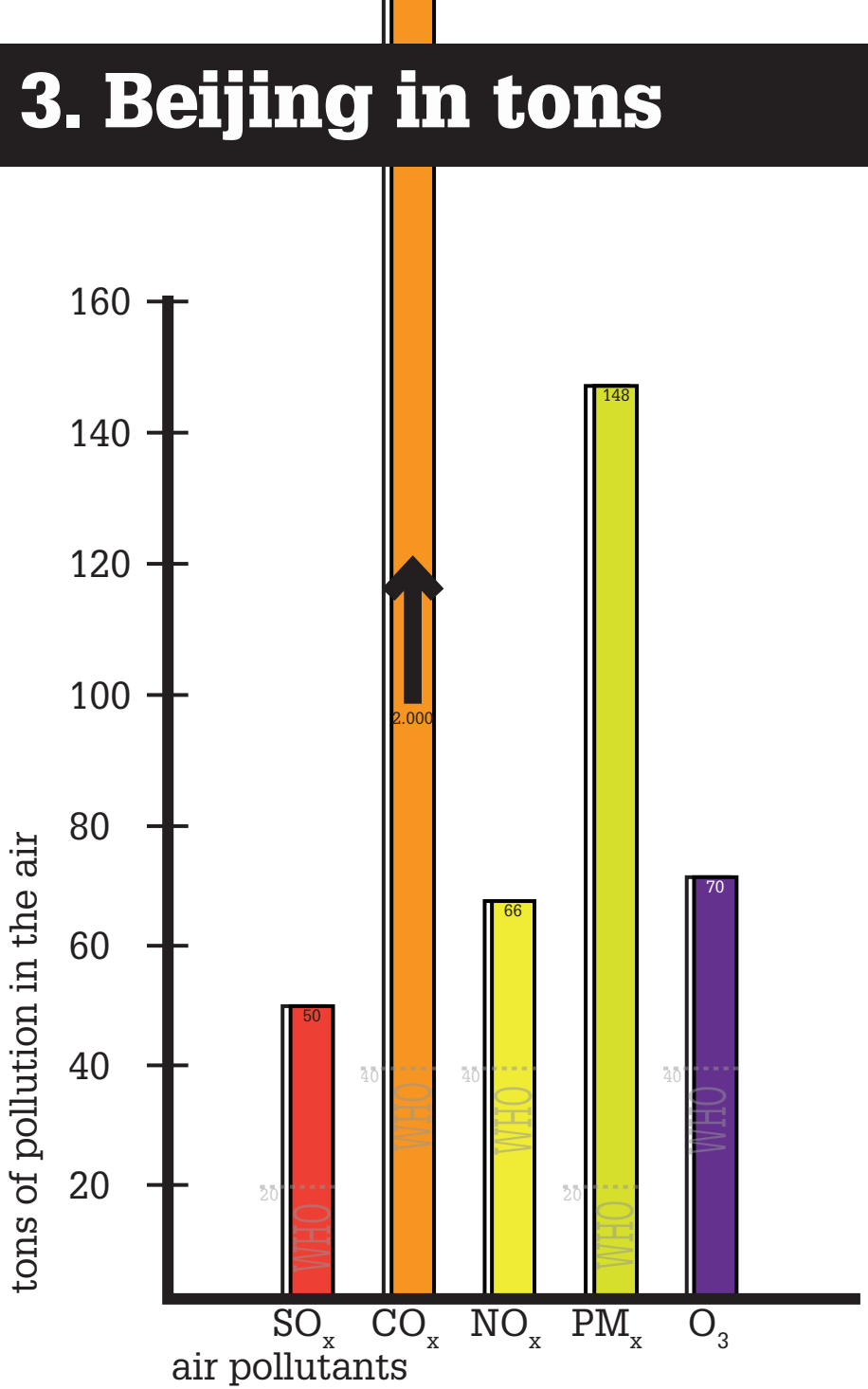
2. Prevent UHI(lower urban wind layer) and filter air
    - Tree filters; 2 layers of trees on every building in Beijing
    - Cost?
    - How much will it clean?

3. Suck away air from mobile sources and penetrate UHI air layer
    - Solar towers(Jonathan) grid over the city
    - Cost?
    - How much will it clean?

4. Clean last bits of pollution from the air
    - Falling water filter
    - Cost?
    - How much will it clean?

5. Beijng air = CLEAN! => What is the reduction in death toll?

3. Beijing in tons



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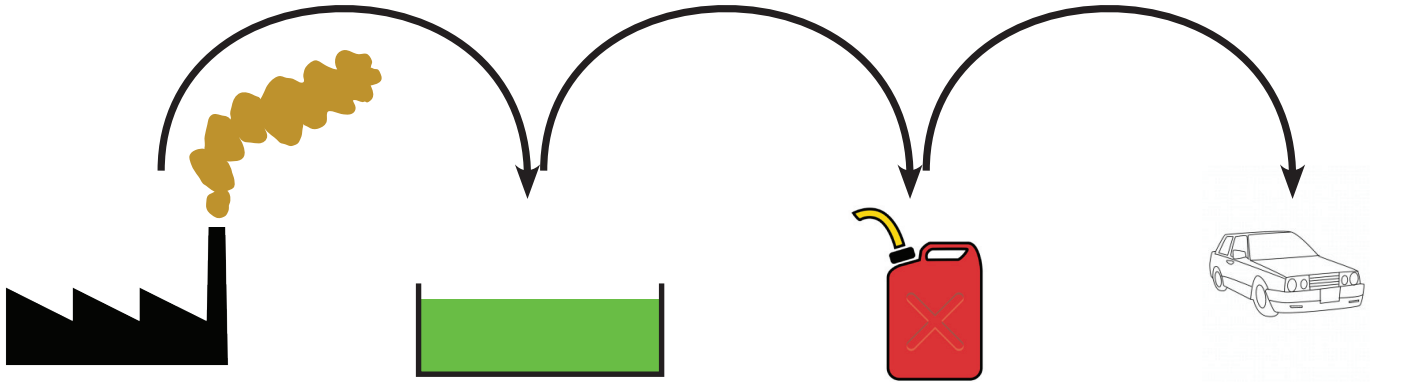
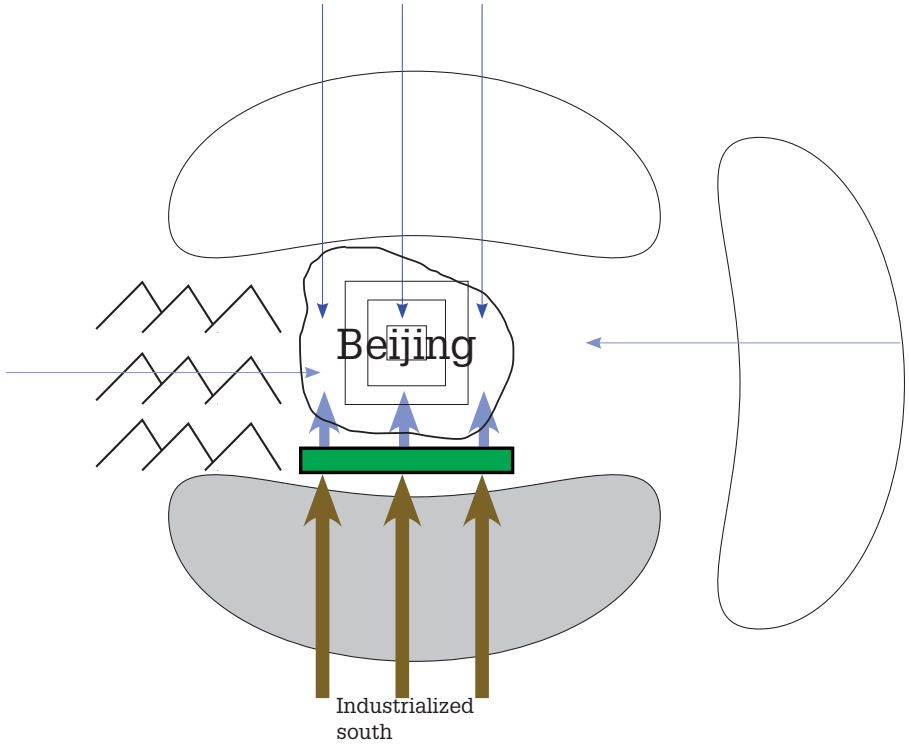
3.1 Algae Filters



factory smoke | algae reactor | fuel production | fuel combustion



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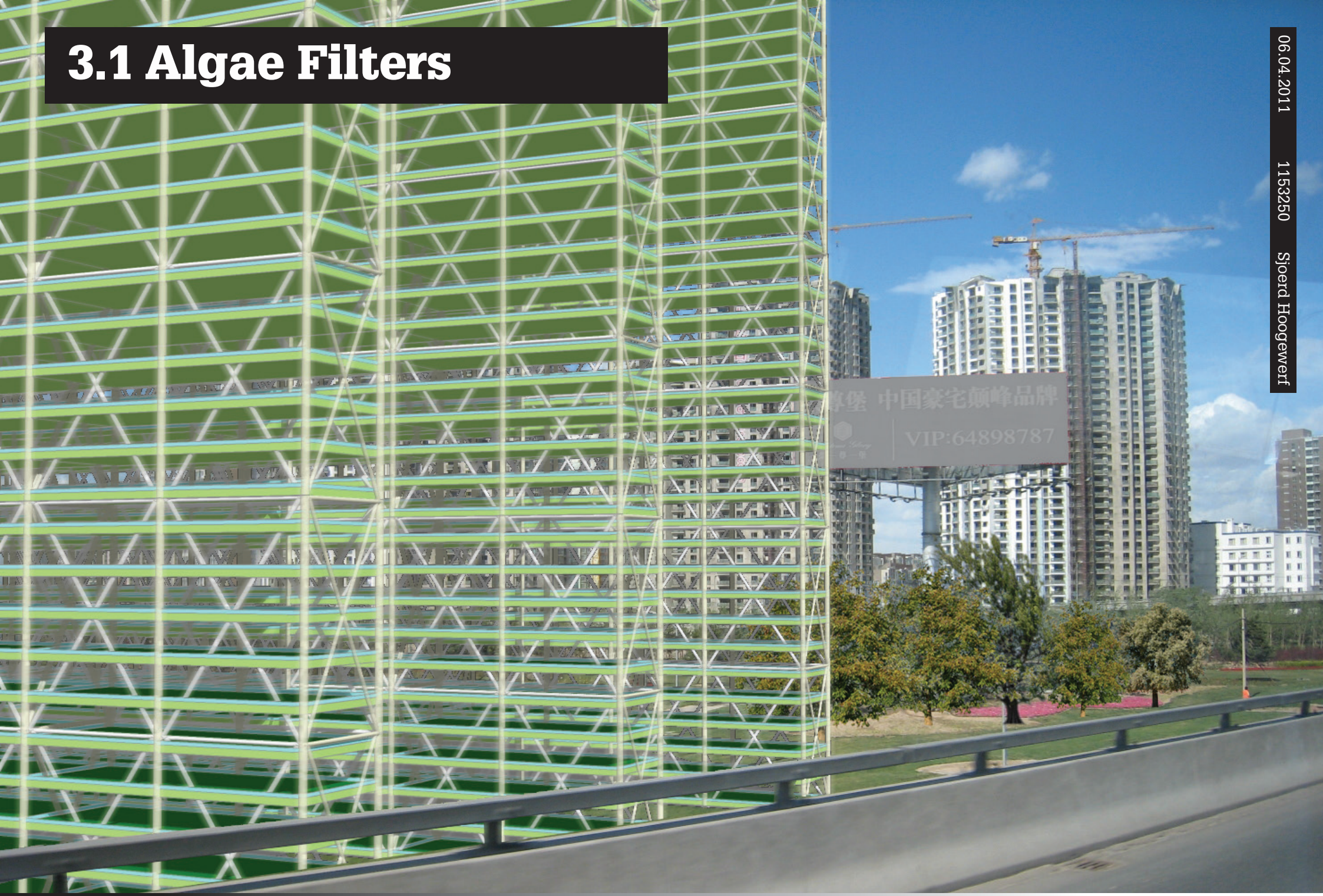

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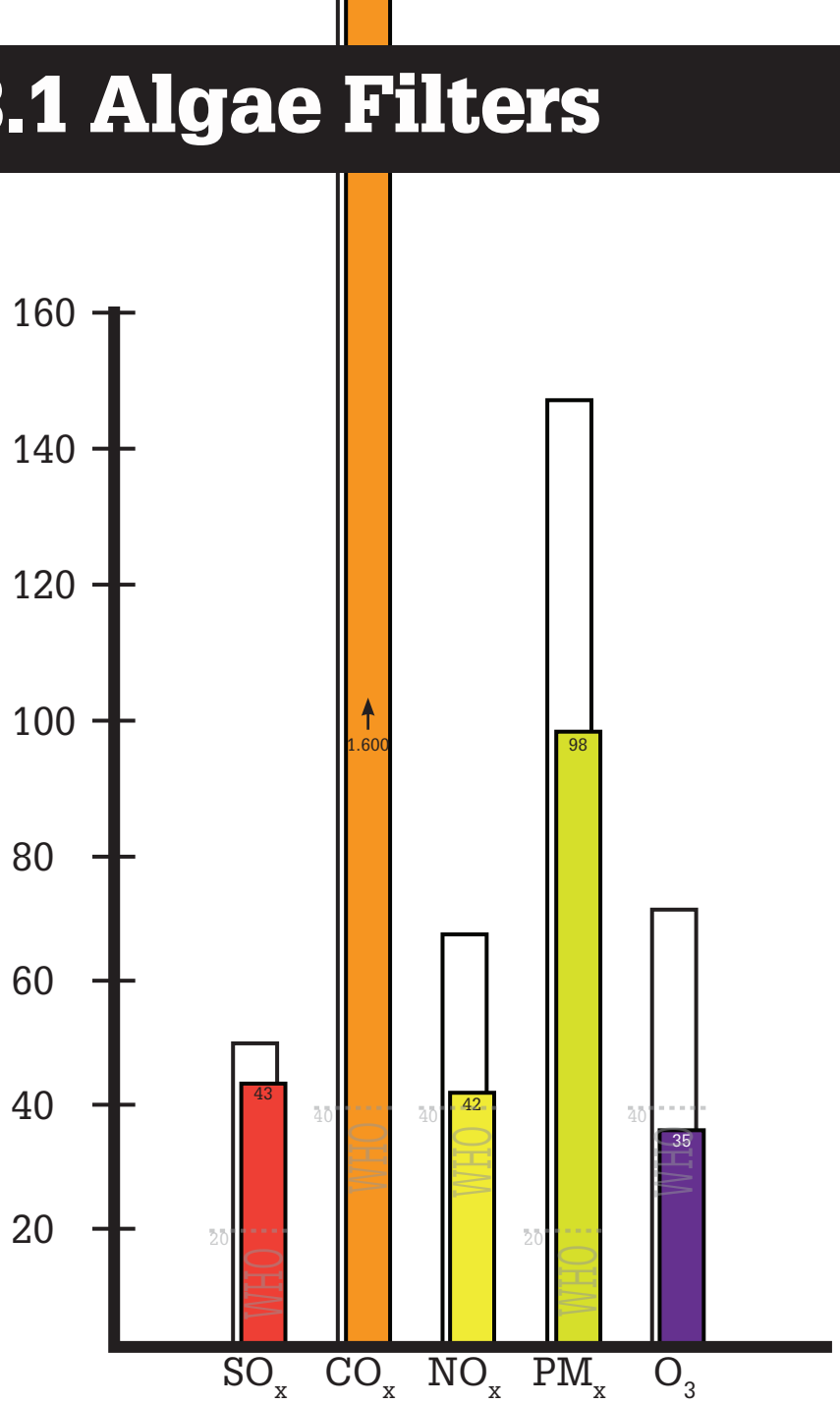

14.500 m^3 algae pond

€5.800.000 (or €0,44/capita)

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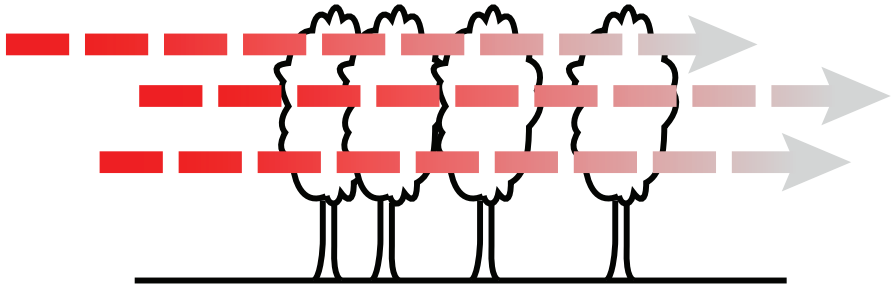
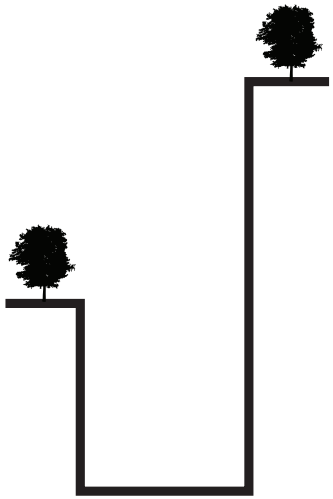
http://www.livescience.com/environment/080806-beijing-air-pollution.html
Carbon monoxide and aerosols contents, boundary layer parameters and estimation of the CO sources intensity in Moscow city.; V. Rakitin et al.; Obukhov Institute of Atmospheric Physics, RAS, Moscow, 119017
China Daily, http://chinathetimes.com/forum/index.php?topic=1574.0
Pollution management;
A modeling analysis of a heavy air; X. An et al.; Atmos. Chem. Phys. Discuss., 6, 8215–8240, 2006
Air quality during the 2008 BeijingOlympics: secondary pollutants and regional impact; T. Wang et al.; Copernicus Publications, 2010

3.2 Tree Filters



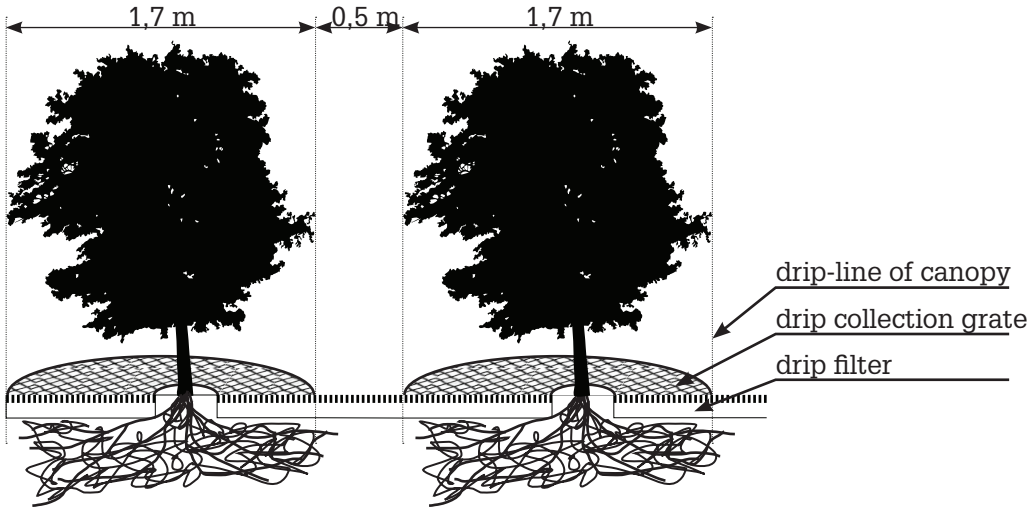
Category: Filter
Strategy/Product: Tree Filter

Specs:
- Filters PM_x, aerosols and $CO_{2(1\ tree=20kg/year)}$ from air flowing through the canopies



Trees on roofs:
++

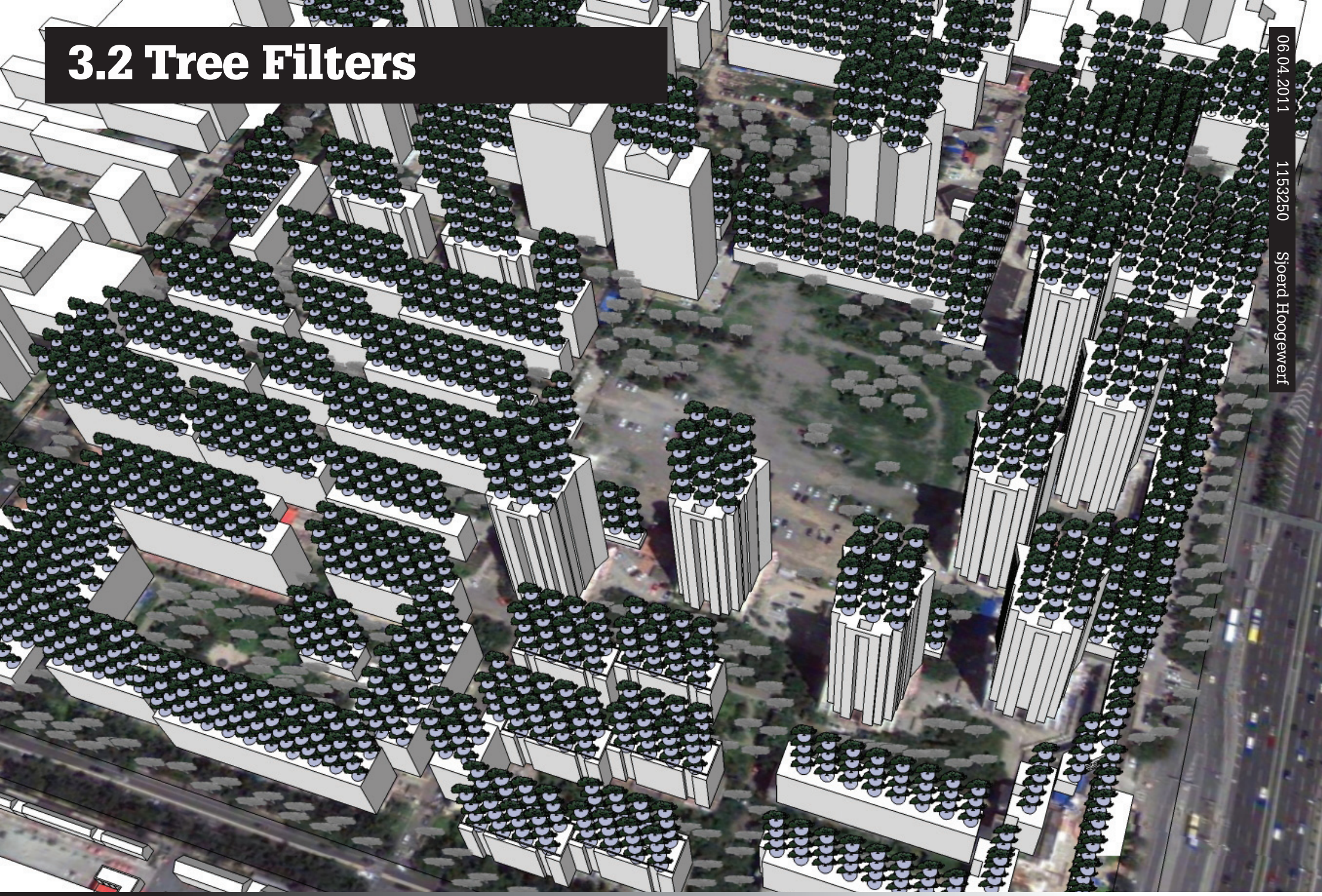
No speed reduction.
+ Filters larger particles.



3.2 Tree Filters

	NO2	O3	SO2	PM10	CO			
tons filtered by trees	132,3000	256,4000	100,7000	772,0000	275,9496			
total tons in city	139396	1593	191000	3368,5	45520			
percentage of tons filtered	0,09%	16,10%	0,05%	22,92%	0,61%			
							area1 trees now (m2)	44.508
times more trees needed	1054	6	1897	4	165		area2 trees now (m2)	36.504
area1 extra trees (m2)	46.895.217		84.419.345	194.204	7.341.935		area1 built now (m2)	56.990
area2 extra trees (m2)	38.461.917		69.237.974	159.279	6.021.614		area2 built now (m2)	41.885
area1 extra layers on top of built	823		1.481	3	129			
area2 extra layers on top of built	918		1.653	4	144			

3.2 Tree Filters



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area1 extra layers on top of built	823		1.481	3	129			
area2 extra layers on top of built	918		1.653	4	144			
tons reduction with 2 layers trees	264,6	512,8	201,4	1544,0	551,9			

3.2 Tree Filters

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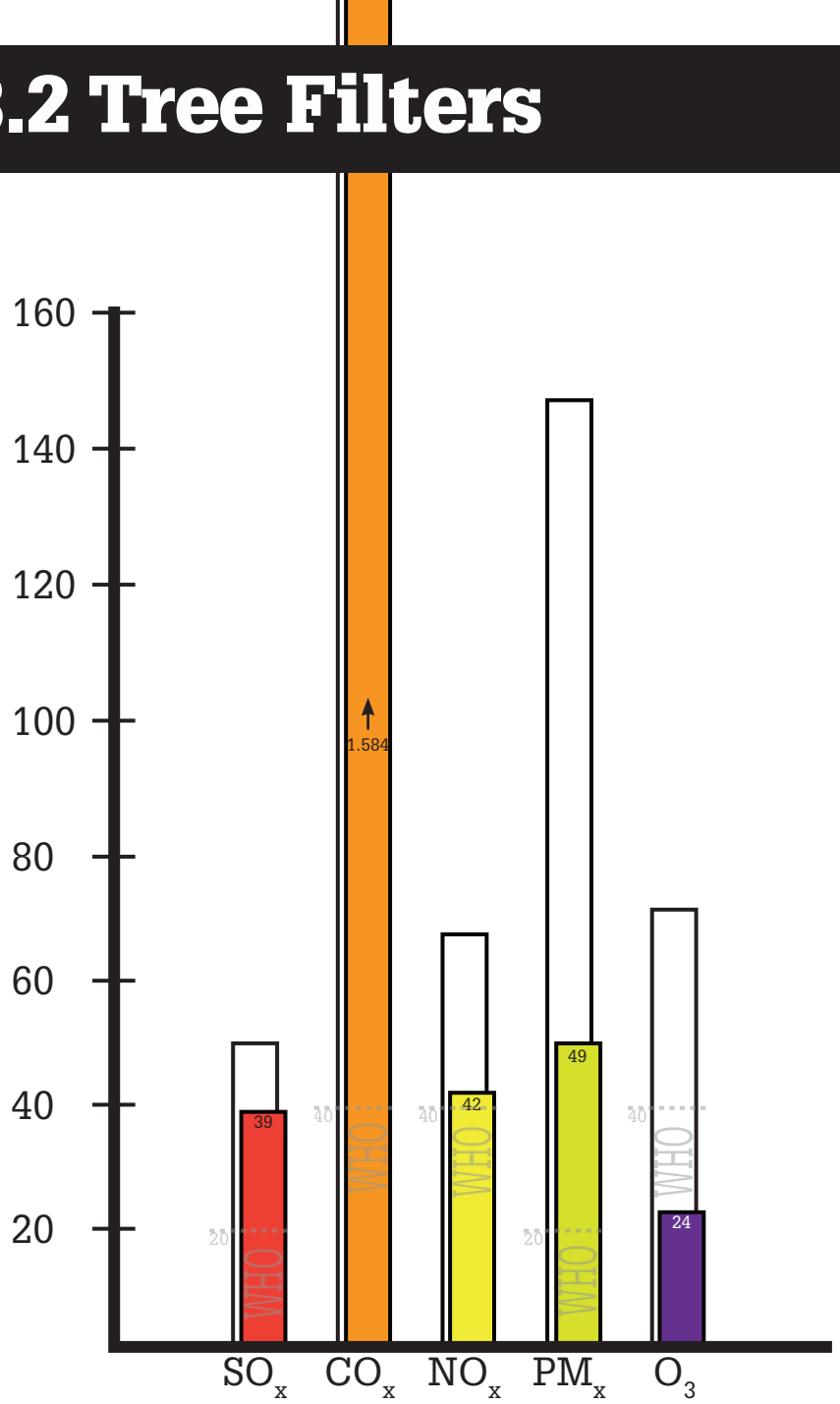
3.2 Tree Filters



15.170.625 extra trees

€1.896.328.125 (or €144/capita)

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http://www.livescience.com/environment/080806-beijing-air-pollution.html
Carbon monoxide and aerosols contents, boundary layer parameters and estimation of the CO sources intensity in Moscow city.; V. Rakitin et al.; Obukhov Institute of Atmospheric Physics, RAS, Moscow, 119017
China Daily, http://chinathetimes.com/forum/index.php?topic=1574.0
Pollution management;
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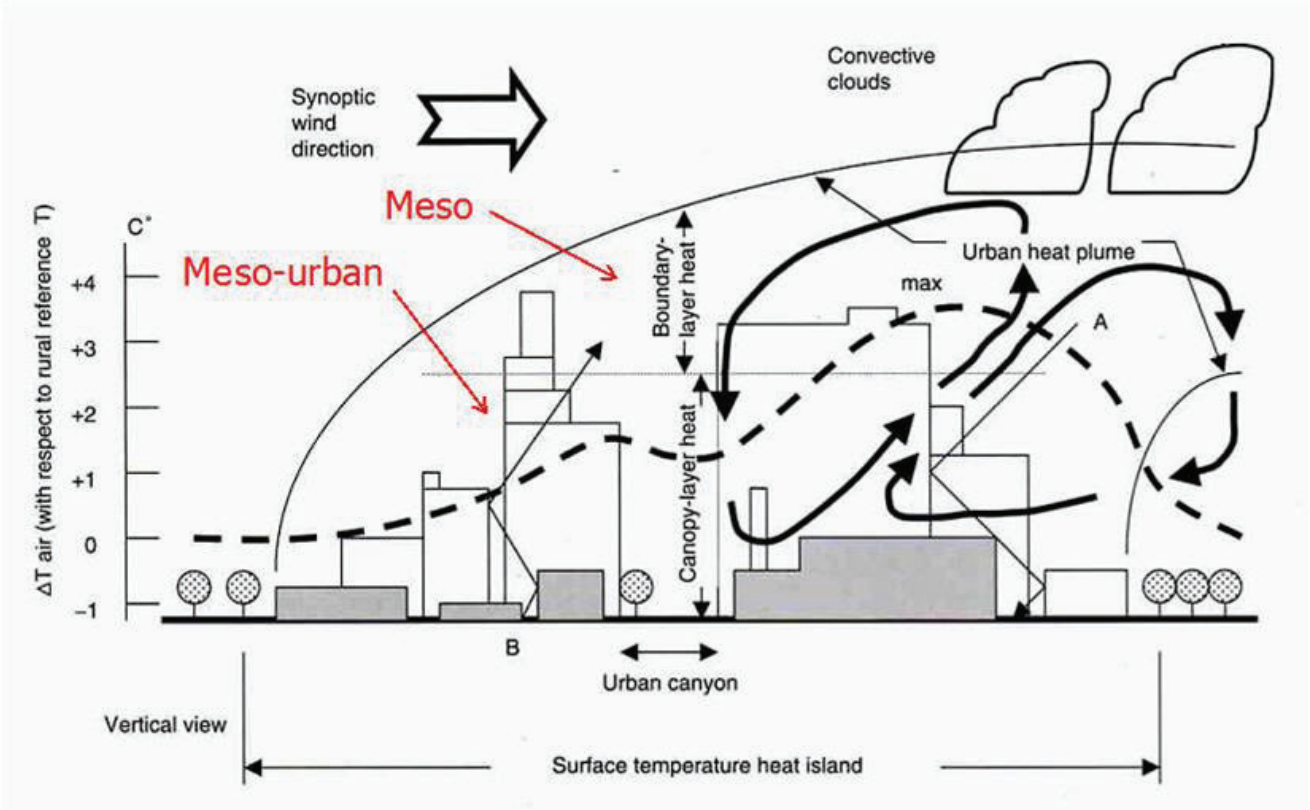
Air quality during the 2008 BeijingOlympics: secondary pollutants and regional impact; T. Wang et al.; Copernicus Publications, 2010

3.2 Tree Filters

summer:

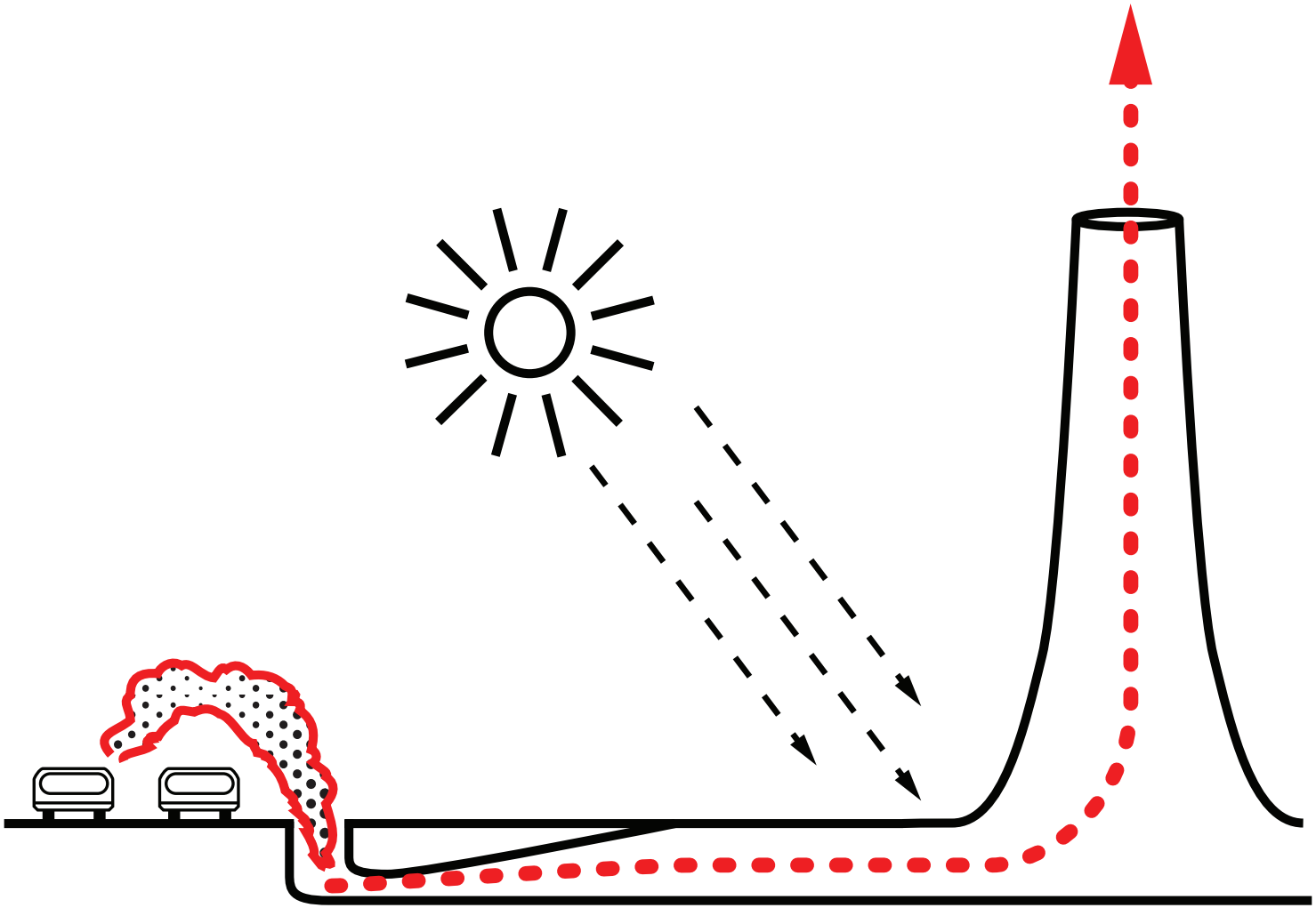
1460kg of water

860MJ = 5 air conditioners



Mitigating the Urban Heat Island Effect: Some Points without Altering Existing City Planning; A.I. Che-Ani et al.; European Journal of Scientific Research, Vol.35 No.2 (2009), pp.204-216
Rotach et al.;2004

3.3 Solar Towers



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3.3 Solar Towers

1 tower = 33,5 MW

use in Beijing = 4.735 MW

-**All energy** by Solar Towers: **141 towers** (=13km^2 towers/87km^2 Beijing)

-All **cars electric** and powered by Solar Towers: **4 towers** (=0,36km^2 towers/87km^2 Beijing)

-All energy formerly from **coal** produced by Solar Towers: **81 towers** (=7,5km^2 towers/87km^2 Beijing)

-All energy in THE WHOLE OF CHINA by Solar Towers: 25.216 towers

http://www.btmbeijing.com/contents/en/facts/2004/economy/infra
Jonathan Tolkamp
Current Status of Beijing Energy Use & the Future Development Goals; Tong Qing 3E Research Institute, Tsinghua University, 2005

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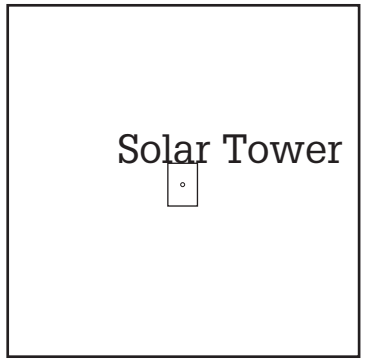
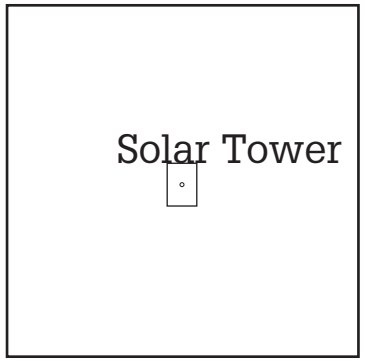


x 73

+



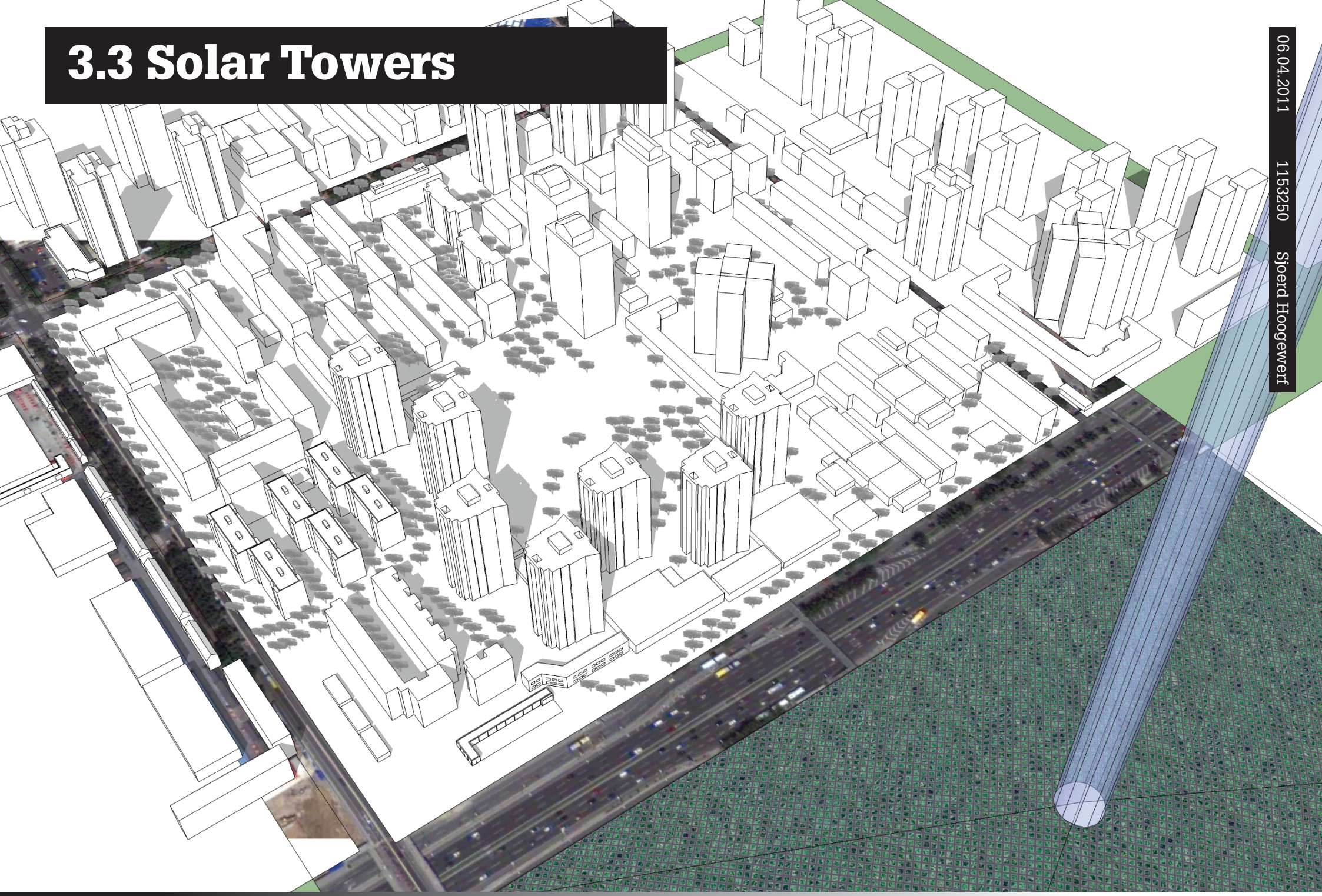
x 8

11 km² Beijing

3 km² Beijing

http://www.btmbeijing.com/contents/en/facts/2004/economy/infra
Jonathan Telkamp
Current Status of Beijing Energy Use & the Future Development Goals; Tong Qing 3E Research Institute, Tsinghua University, 2005

3.3 Solar Towers



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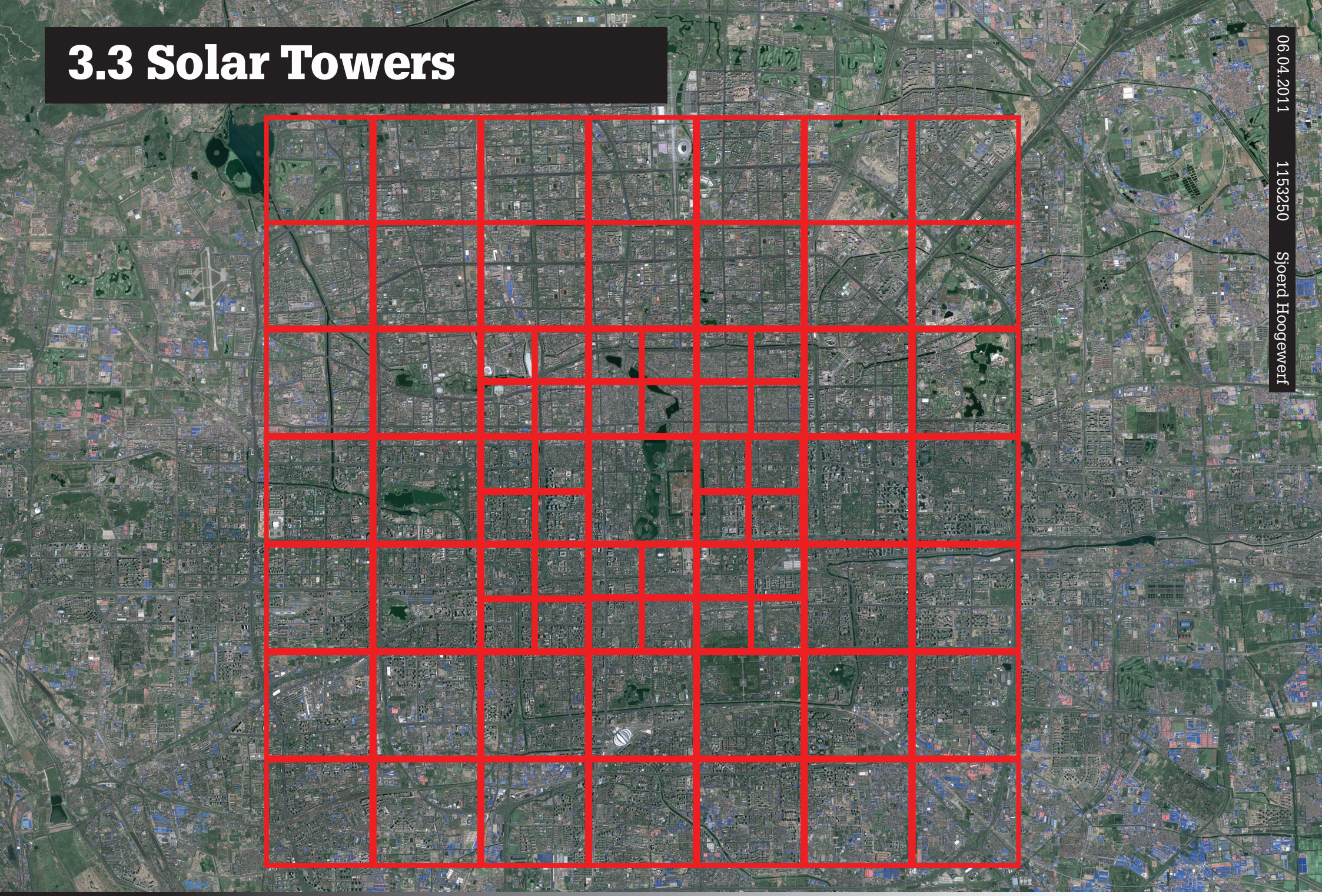
3.3 Solar Towers



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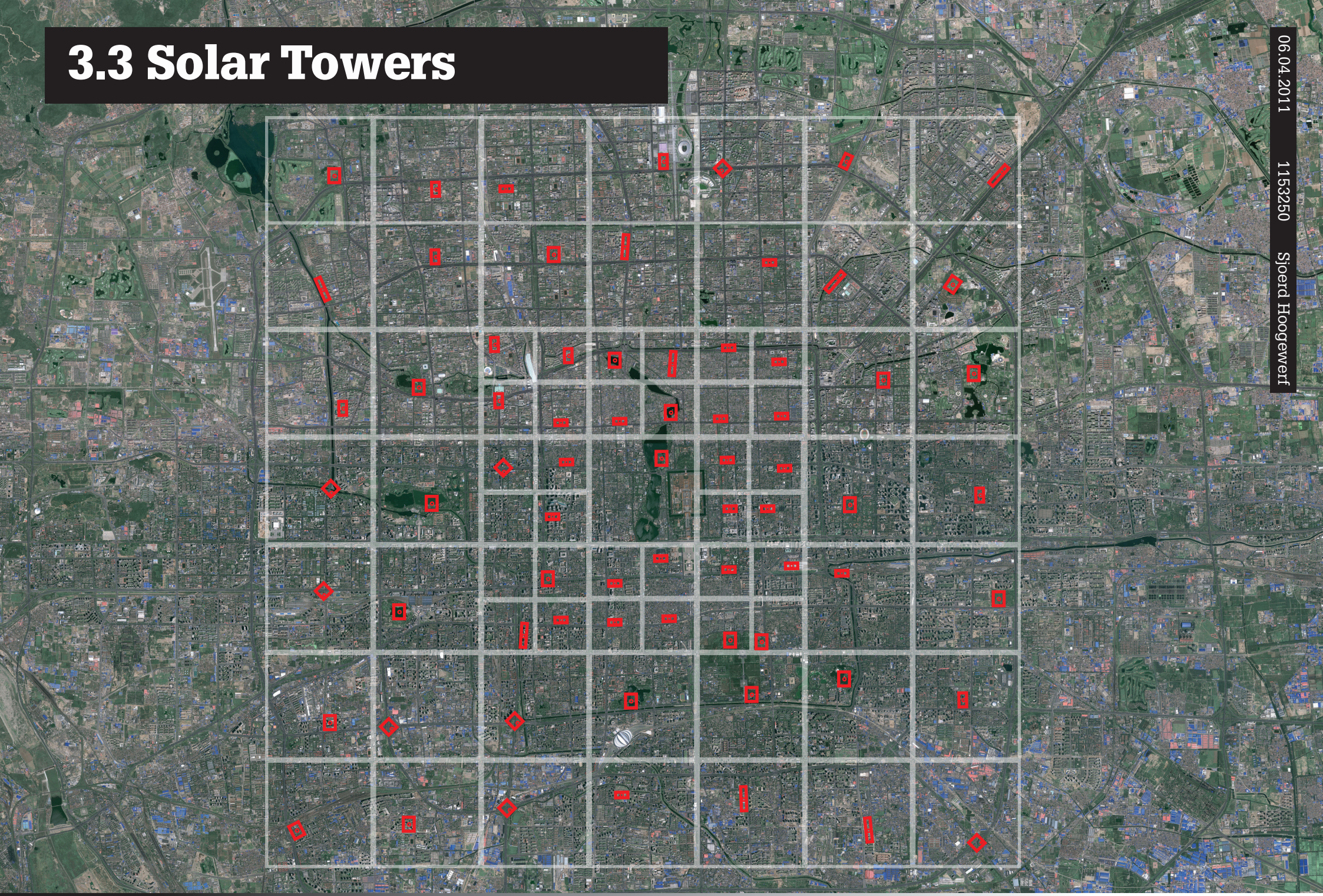
3.3 Solar Towers



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3.3 Solar Towers

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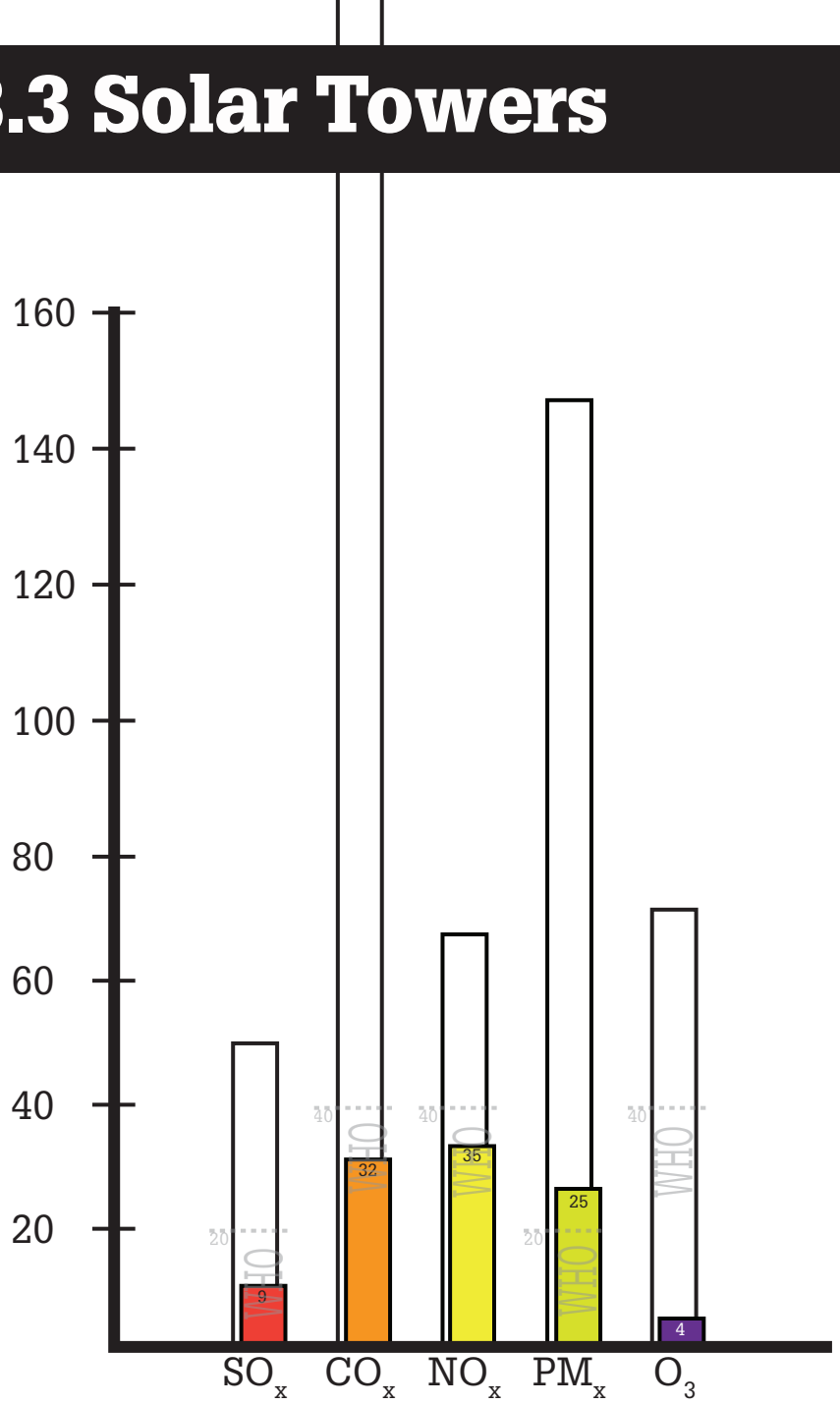

81 towers or 7,5km^2

€404.311.500 (or €30/capita)

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http://www.livescience.com/environment/080806-beijing-air-pollution.html
Carbon monoxide and aerosols contents, boundary layer parameters and estimation of the CO sources intensity in Moscow city.; V. Rakitin et al.; Obukhov Institute of Atmospheric Physics, RAS, Moscow, 119017
China Daily, http://chinathetimes.com/forum/index.php?topic=1574.0
Pollution management;
A modeling analysis of a heavy air; X. An et al.; Atmos. Chem. Phys. Discuss., 6, 8215–8240, 2006
Air quality during the 2008 BeijingOlympics: secondary pollutants and regional impact; T. Wang et al.; Copernicus Publications, 2010

3.4 Falling Water Filters

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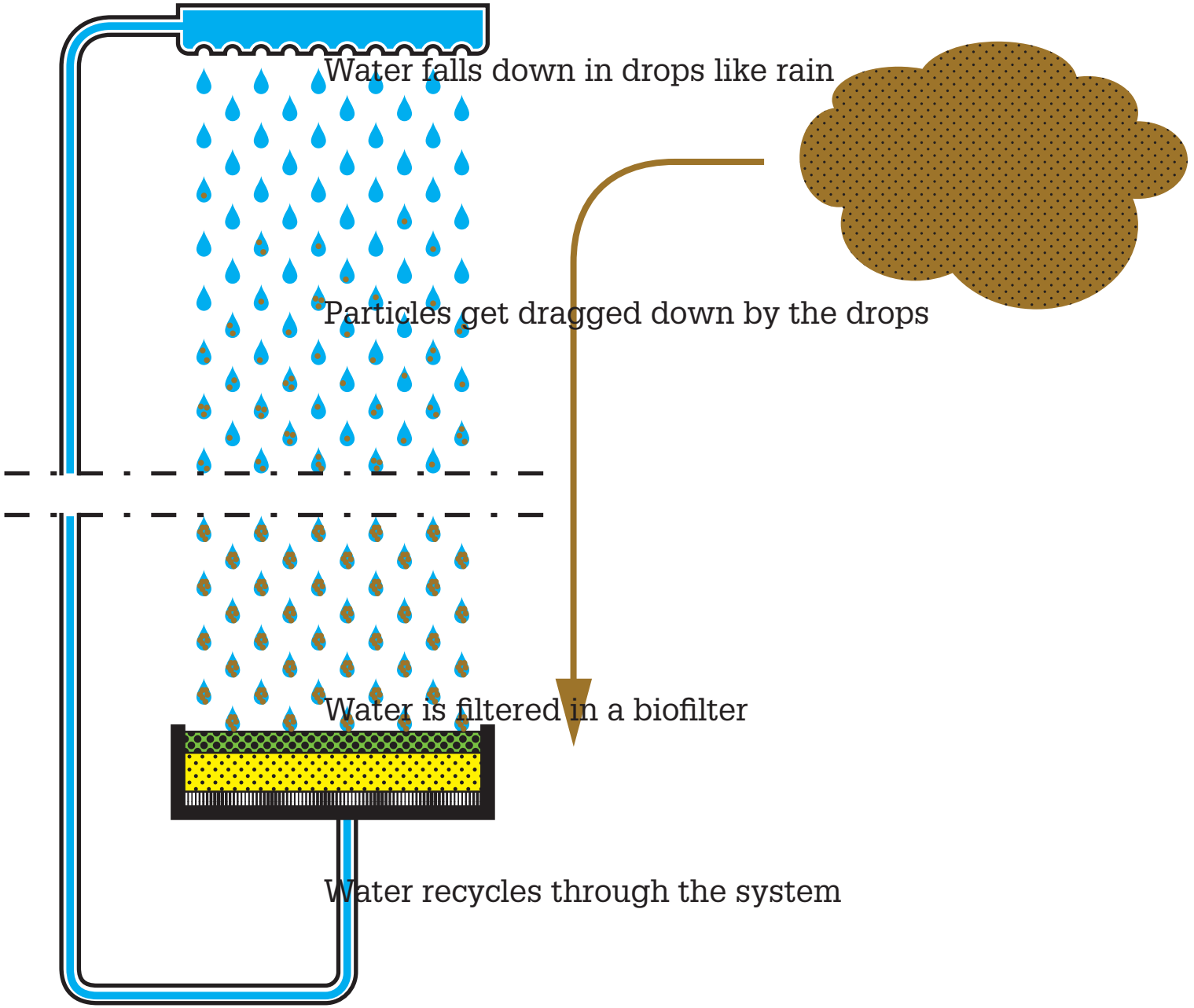
3.4 Falling Water Filters



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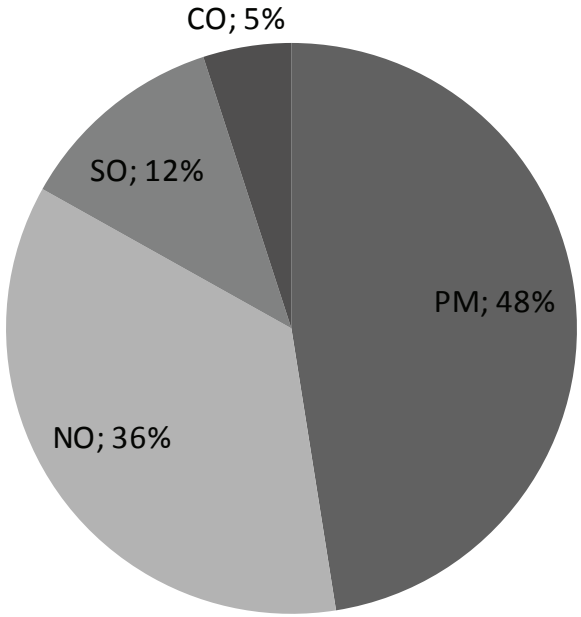
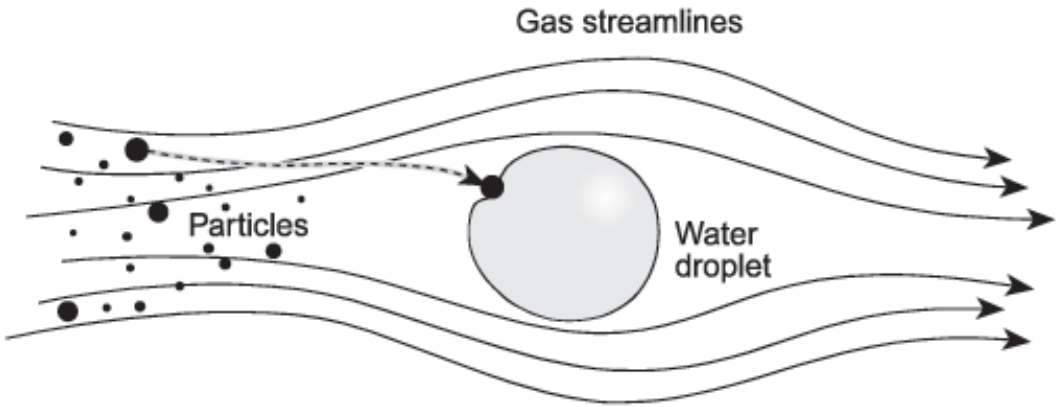
3.4 Falling Water Filters





Making rain through artificial means

Cloud seeding is a weather modification system that aims to boost precipitation or rain by introducing condensation nuclei such as salt or dry ice.

1 Aircraft drop flares or artillery/rockets are shot from the ground to introduce artificial nuclei into cloud systems that have the right conditions.

2 The artificial nuclei then attracts water vapour within the cloud system to become larger droplets. Once it becomes heavy, the droplets fall as rain. Hygroscopic seeding, which involves using salts such as sodium chloride or potassium chloride, are larger nuclei resulting in very big cloud droplets.

3 Once seeded, it could take less than an hour to rain. In case of warm cloud systems, wherein the temperature is not colder than 0C, salt is preferred for seeding. Silver iodide or dry ice is generally used for clouds colder than 0C

Neng-Huei Lin and Chi-Ming Peng; Estimates of the Contribution of Below-cloud Scavenging to the Pollutant Loadings of Rain in Taipei, Taiwan; TAO, Vol. 10, No. 4, 683-704, 1999
Peter A. Tanner and Christopher W. F. Tam; In-Cloud Concentrations and Below-Cloud Scavenging Processes in Hong Kong, China; Environ. Chem. 2006, 3, 142–148

3.4 Falling Water Filters

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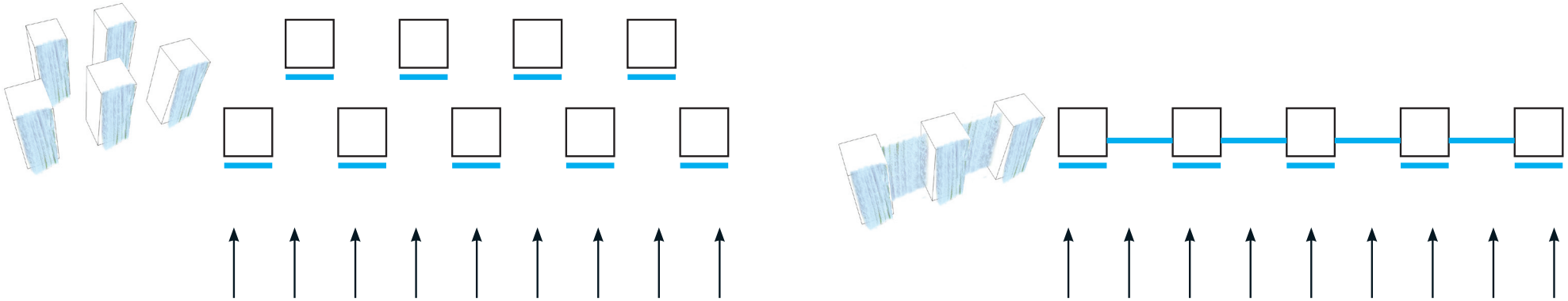

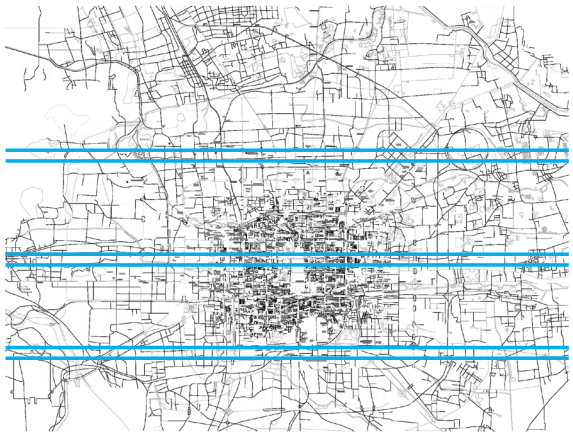

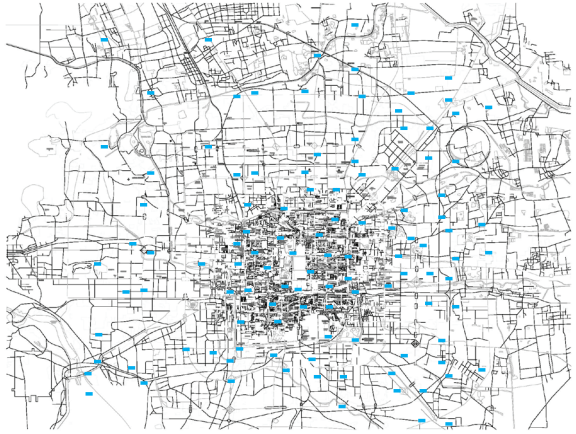

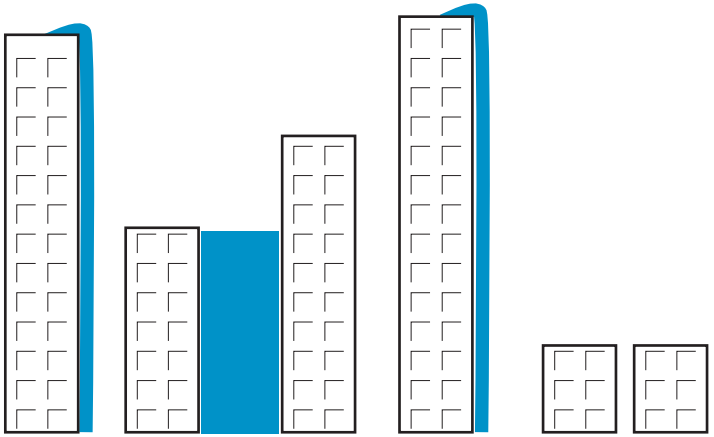

3.4 Falling Water Filters

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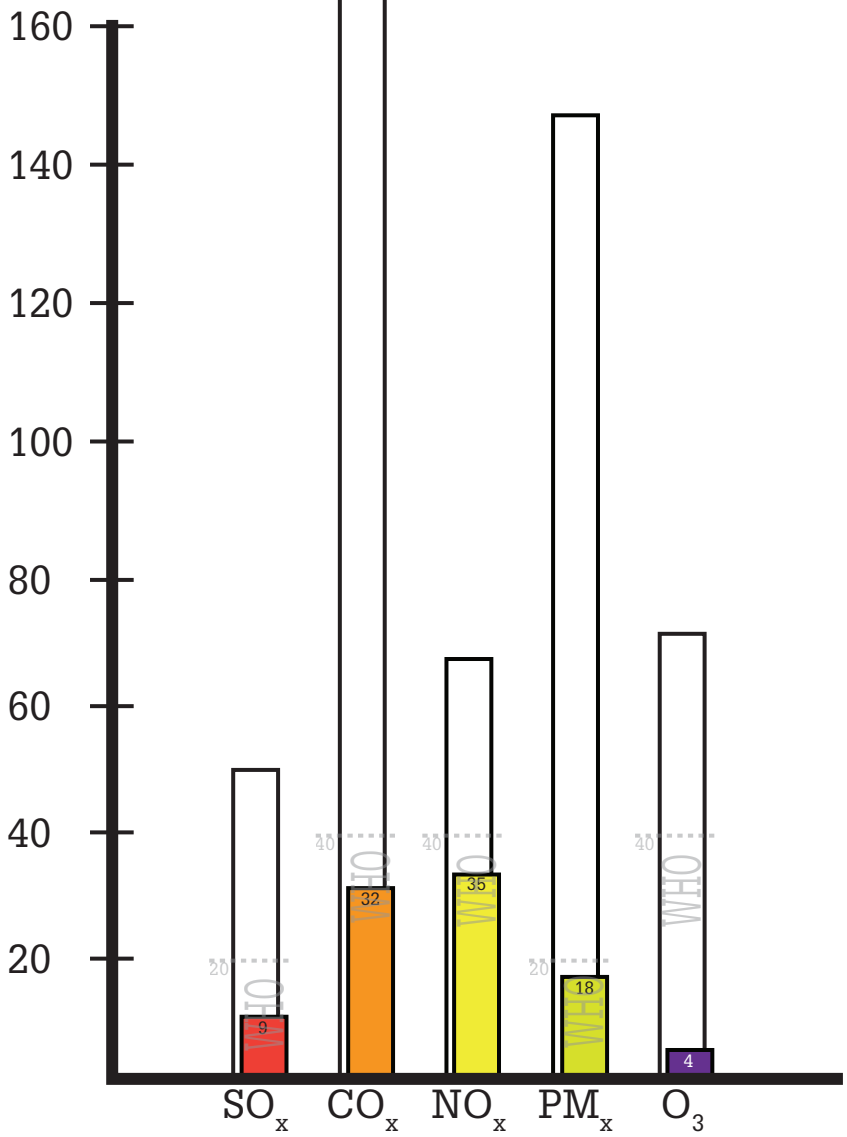

600 waterfalls

€600.000.000 (or €45,66/capita)

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3. Result

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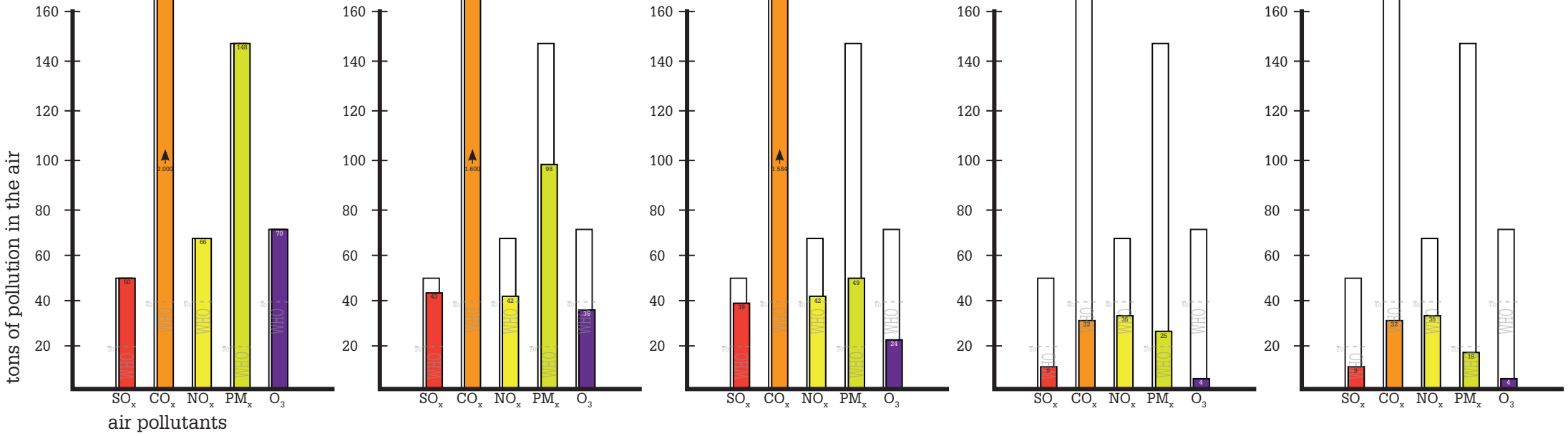
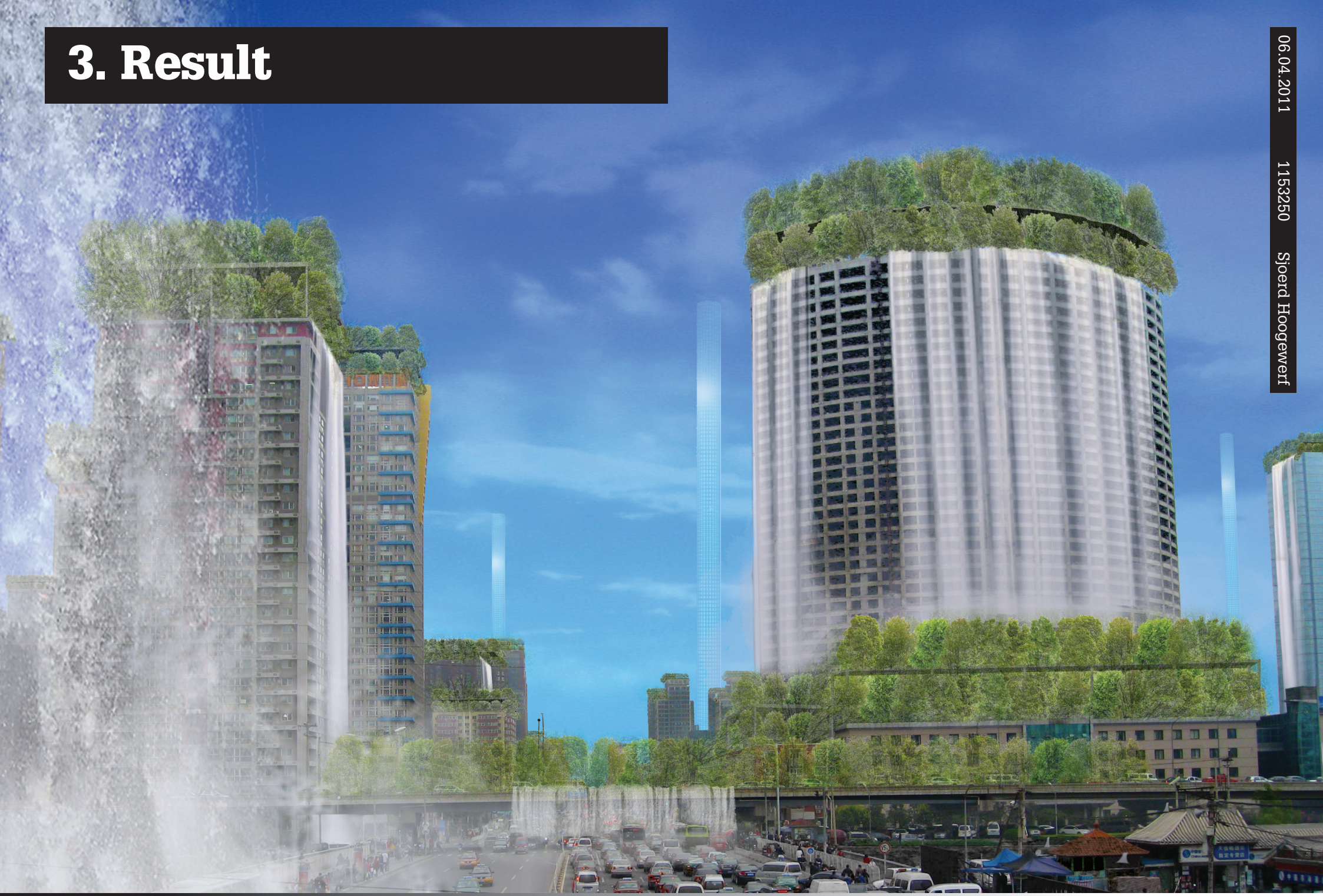


Beijing now + Algae filters + Tree filters + Solar towers + Waterfalls

3. Result



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4. Conclusion

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4. Reduced death toll

To calculate the expected number of deaths due to air pollution (E), we take the product of:

$$E = beta \times B \times P \times C$$

where:
E = expected number of premature deaths due to short-term exposure
beta = percentage change in mortality per 10-µg/m3 change in PM10
B = incidence of the given health effect (deaths per 1000 people)
P = relevant exposed population for the health effect
C = change in PM10 concentration (µg/m3 × 0.1).

$$E = 0.15 \times (?/13.140.000) \times 13.140.000 \times 1,28 = ???$$

http://news.nationalgeographic.com/news/2007/07/070709-china-pollution.html
http://airnow.gov/index.cfm?action=resources.conc_aqi_calc
http://www.gasdetection.com/TECH/calculator/micrograms_per_cubic_meter_to_ppm.html

4. Reduced death toll

Research indicates that when the air pollution index (AQI) in Beijing rose by 10%, the daily number of deaths caused by respiratory disease increased by 3.52% (Zhang et al., 2003).

6.631 deaths/year AQI 500

2.707 deaths/year AQI 34

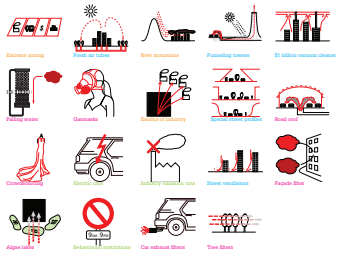
€2.892.141.600
or
€220,10/capita

http://news.nationalgeographic.com/news/2007/07/070709-china-pollution.html
http://airnow.gov/index.cfm?action=resources.conc_aqi_calc
http://www.gasdetection.com/TECH/calculator/micrograms_per_cubic_meter_to_ppm.html

4. Being realistic?

€1.838.960.200.000

- €2.664/capita globally/year



+ €220/capita globally/year

+

+ €2.444/capita globally/year

4. Other cities

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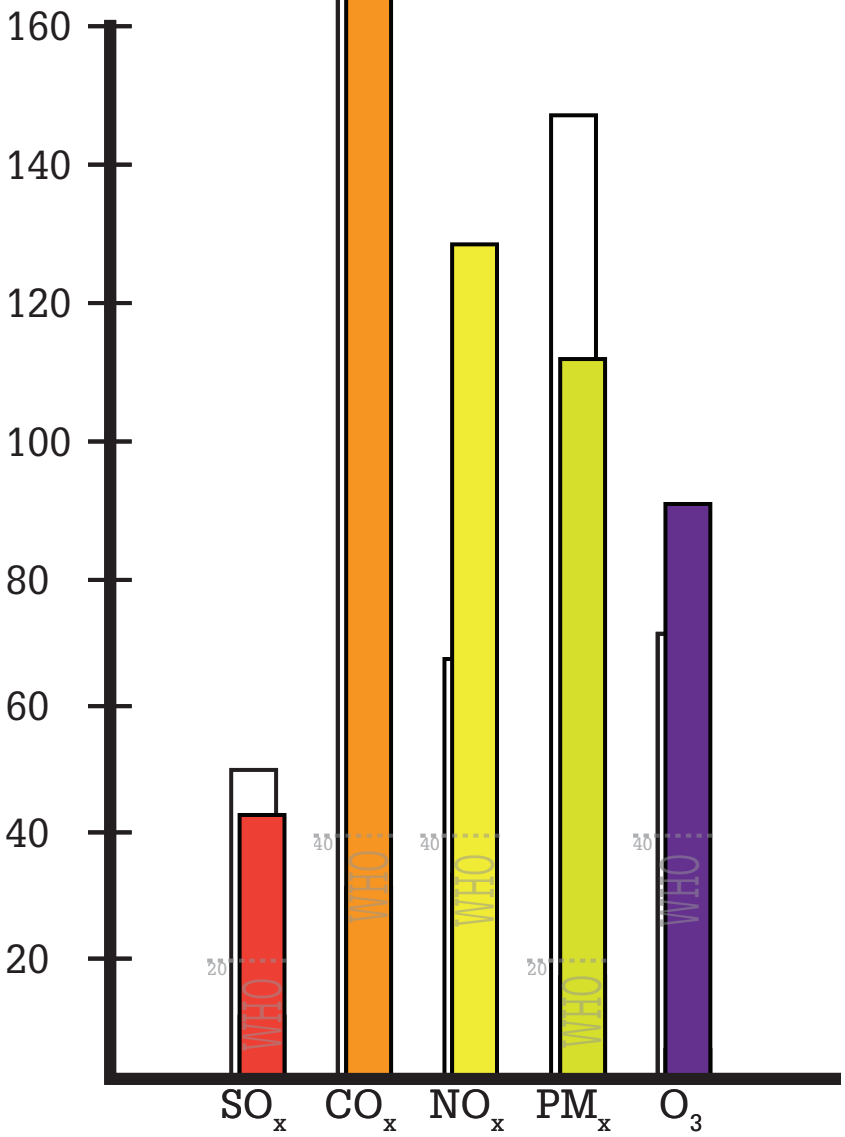
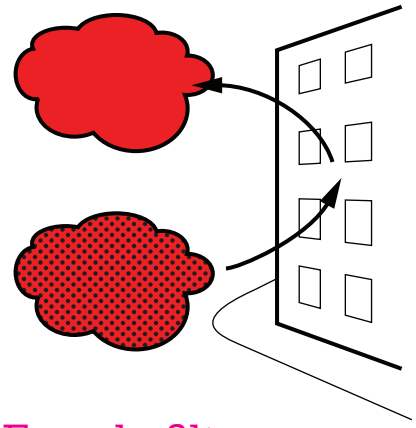
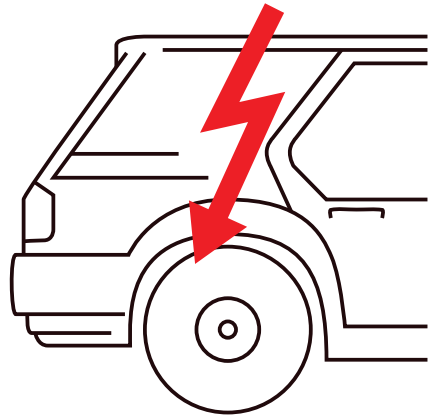
4. Mexico City perfect mix

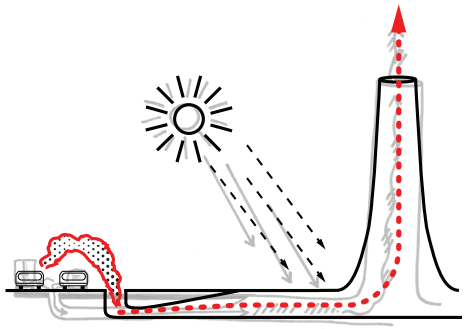




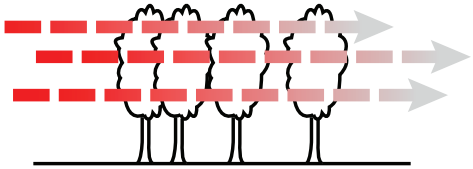
Façade filter



Electric cars



Funneling towers



Tree filters

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4. Recommendations

Choose a mix of different strategies to adress different types of pollutants at different heights.

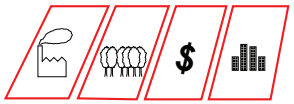
Mix strategies that complement each other.

New designs should consider UC, street profiles and surrounding sources of pollution.

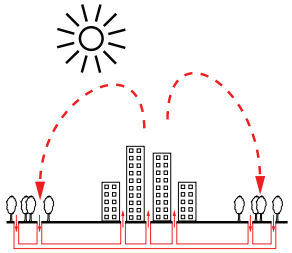
Take three steps:

1. prevent pollution from outside
2. prevent pollution from staying in or above the city(e.g. UHI)
3. remove pollution

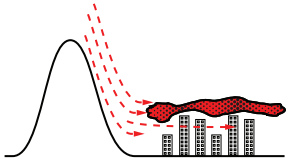
Questions?



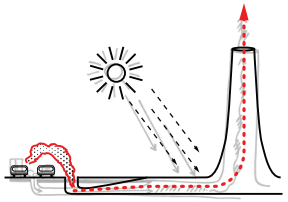
Extreme zoning



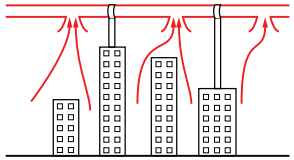
Fresh air tubes



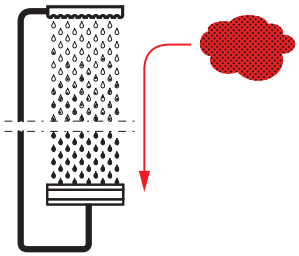
New mountains



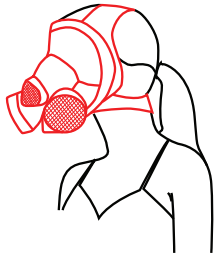
Funneling towers



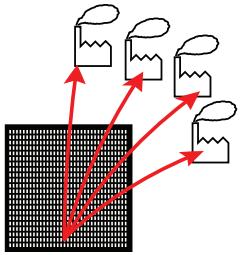
$1 billion vacuum cleaner



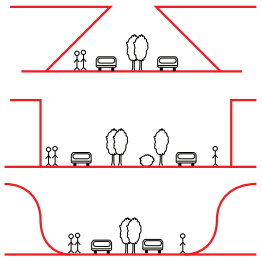
Falling water



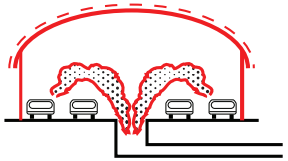
Gasmasks



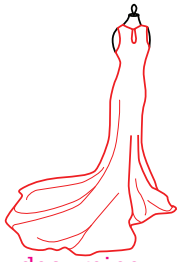
Exodus of industry



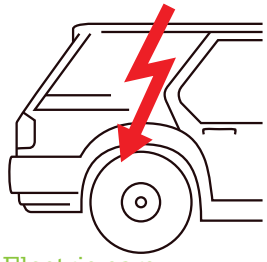
Special street profiles



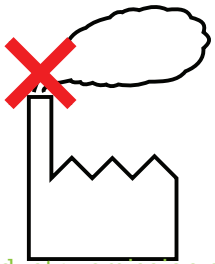
Road roof



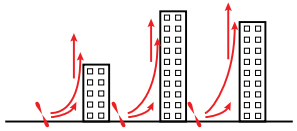
Crowdsourcing



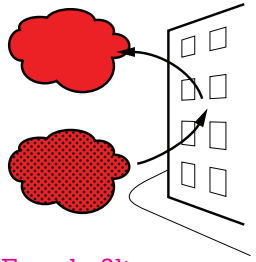
Electric cars



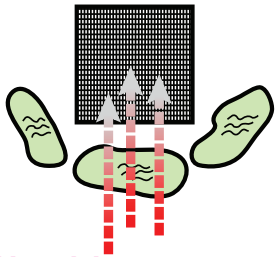
Industry emission cuts



Street ventilators

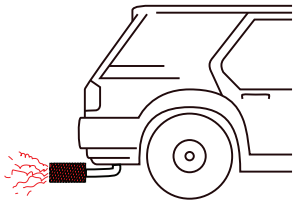


Façade filter

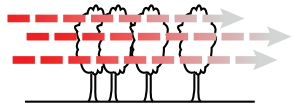


Algae lakes

Behavioural restrictions



Car exhaust filters



Tree filters

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