



Reducing the indoor exposure to traffic emissions

Welcome



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Graduation goal



Problem statement

Objective

Focus

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Preview solution

Structure thesis

Problem statement



de Volkskrant

ANALYSE STIKSTOFKRISIS

De stikstofcrisis, bijna vergeten: miljarden lossen het conflict niet op

Onder al het coronageweld kreeg het niet veel aandacht, maar minister Schouten mag de komende tien jaar 5 miljard euro extra spenderen om het stikstofprobleem aan te pakken. Goed nieuws – behalve dat de betrokken belangengroepen meteen alweer boos zijn: het geld wordt volgens iedereen verkeerd besteed.

Yvonne Hofs 27 april 2020, 20:07

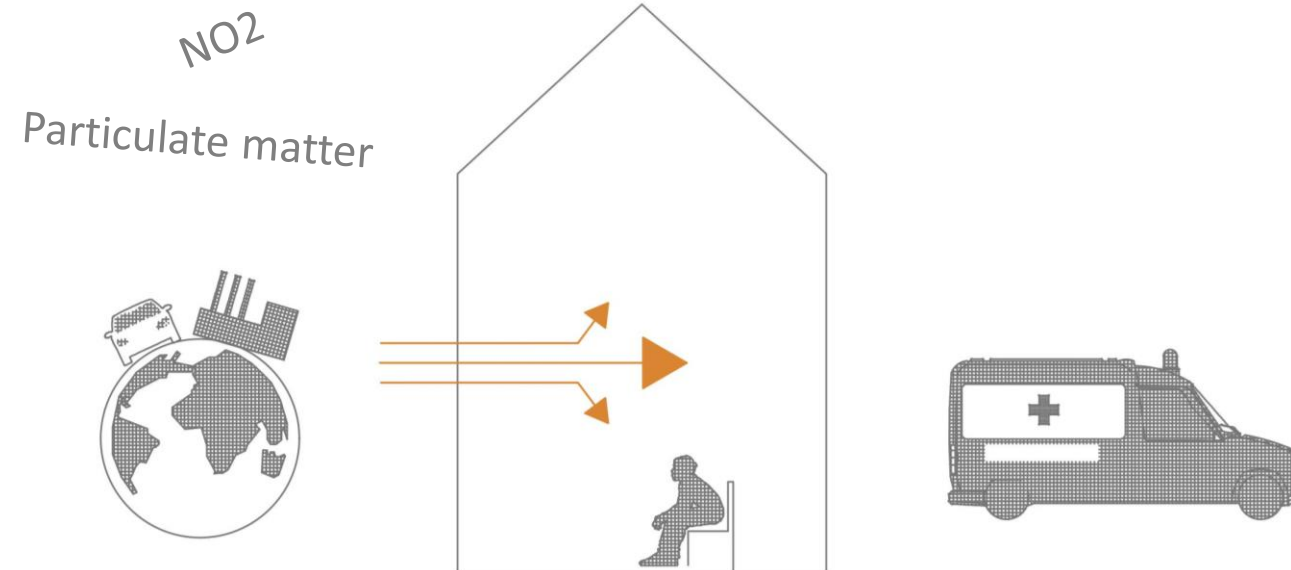


Urban populations in south-east at greatest risk from air pollution

More than one in 10 deaths in UK's largest towns and cities linked to exposure to toxic air



Problem statement



Problem statement



Health risks due to ambient concentrations of particulate matter and nitrogen dioxide in urban areas that exceed the norms worldwide.

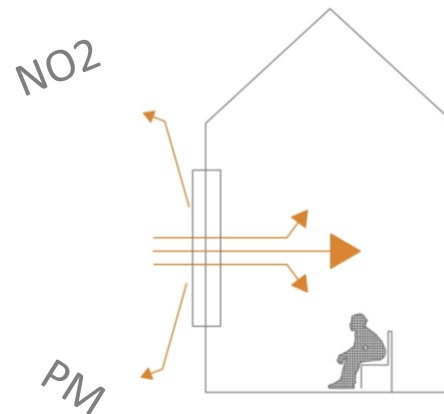
Objective



Starting point research: solutions in the building industry

Distinguish from existing solutions: solutions that use the natural air flow

Adding new solution to the facade: existing air purification technologies



Objective



Making new solutions that reduce the indoor exposure to air pollution, by making use of existing air purification technologies and the natural air flow

Focus

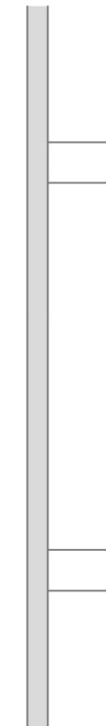


Location: urban areas in developed regions

Building type: high-rise buildings

Facade type: closed or partly closed

Ventilation type: ventilation type C



closed



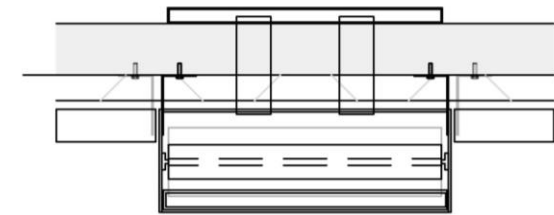
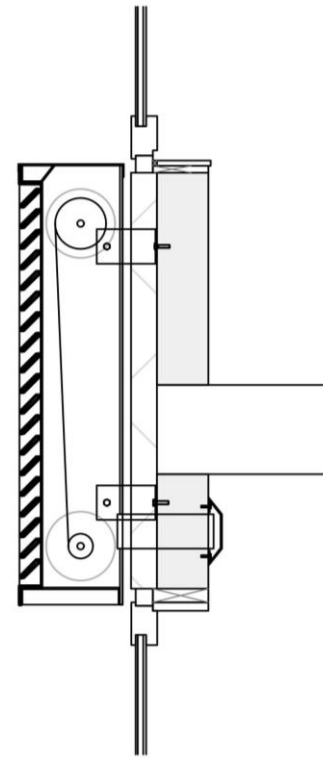
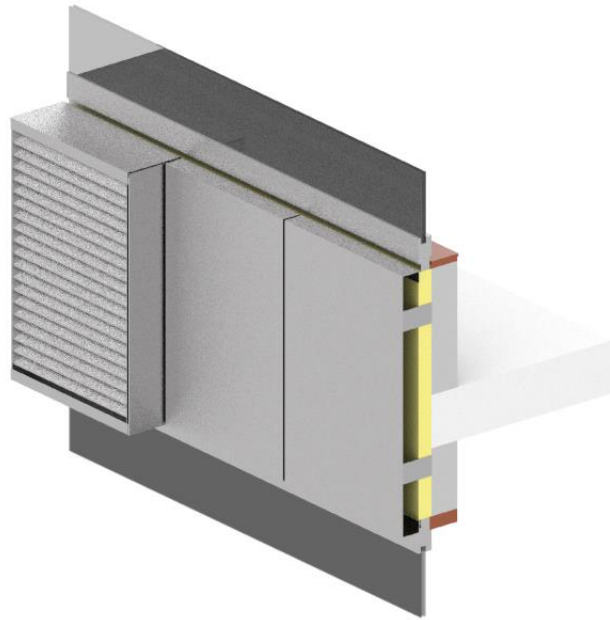
partly closed

Research question

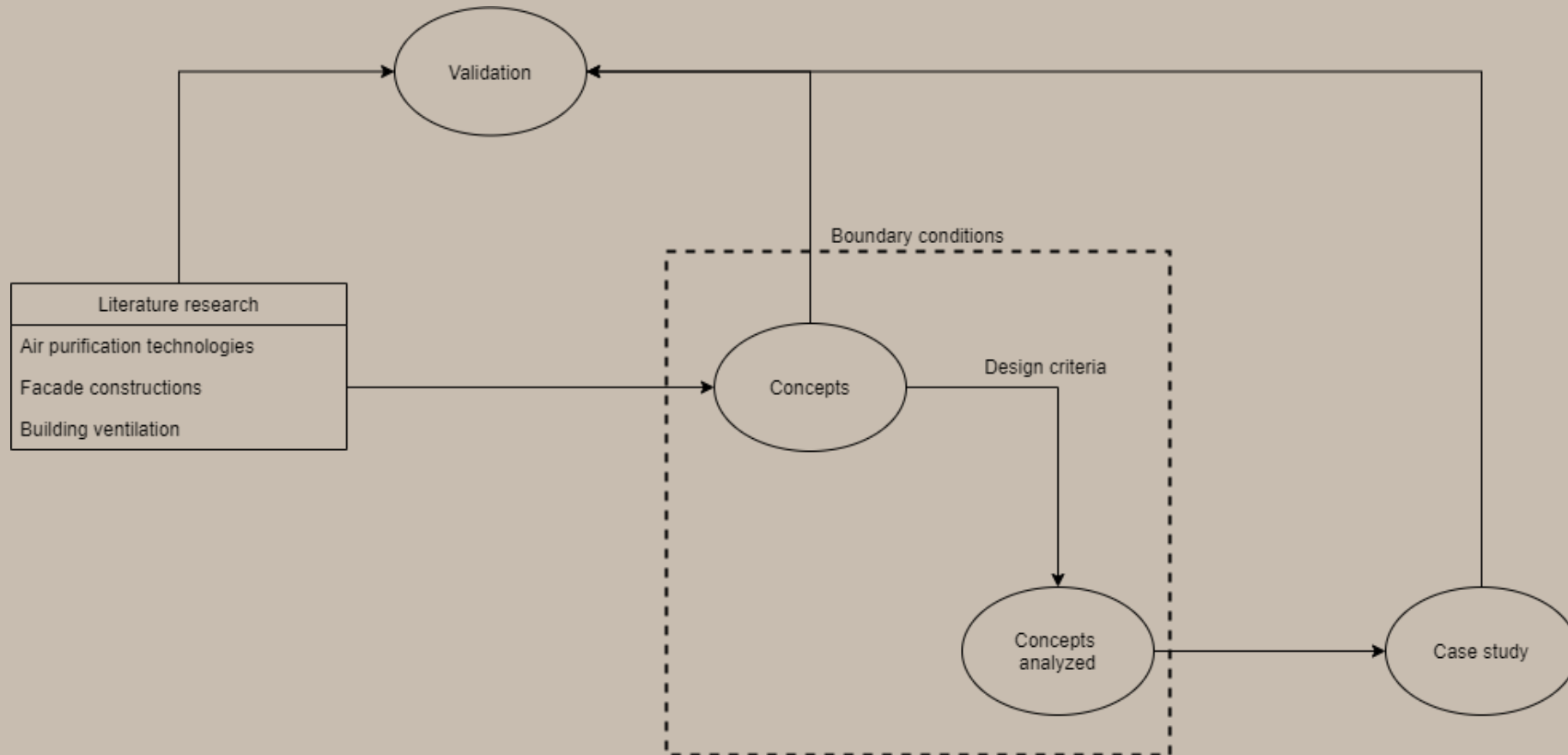


‘How can the façade of a high-rise building in an industrialized region be designed to improve the indoor air quality by using ventilation type C?’

Preview solution



Structure thesis



Literature research



Air purification technologies

Which air purification technologies form the basis of this research?

How can the different technologies be compared to each other?

Building ventilation

Which ventilation openings are relevant for this research?

How can the different ventilation openings be compared to each other?

Air purification technologies



Which air purification technologies form the basis of this research?

Selection criteria:

Size: must fit in facade

Pressure drop: max 20 Pa

Pollutant: NO₂ and particulate matter

Air purification technologies



Which air purification technologies form the basis of this research?

Answer:

Photocatalytic oxidation with TiO₂

Bio-facade: Living Wall System

Bio-facade: Active Green Wall

Cyclone separator

Fibrous filter

Air purification technologies



Photocatalytic oxidation with TiO₂

Bio-facade: Living Wall System

Bio-facade: Active Green Wall

Cyclone separator

Fibrous filter



Air purification technologies



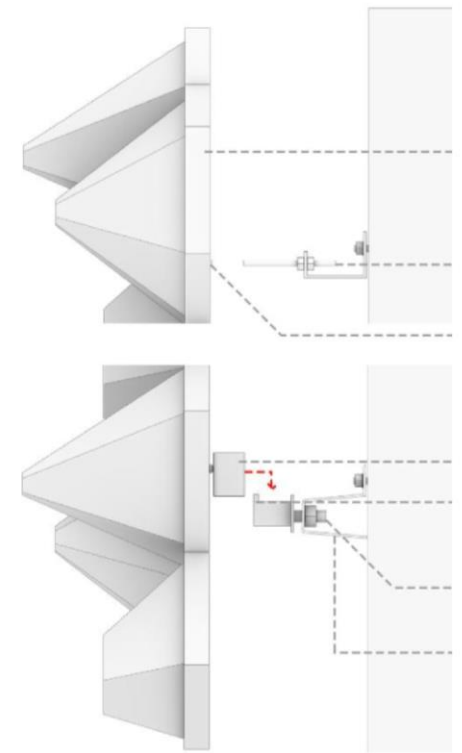
Photocatalytic oxidation with TiO₂

Bio-facade: Living Wall System

Bio-facade: Active Green Wall

Cyclone separator

Fibrous filter



Air purification technologies



Photocatalytic oxidation with TiO_2

Bio-facade: Living Wall System

Bio-facade: Active Green Wall

Cyclone separator

Fibrous filter



Air purification technologies



How can the different technologies be compared to each other?

Criteria:

Filter quality NO₂

Filter quality PM

Maintenance frequency

Air purification technologies



How can the different technologies be compared to each other?

Technology	Filter quality NO ₂	Filter quality PM	Maintenance frequency
PCO with TiO ₂	2	-	3
Living Wall System	1	1	1
Active Green Wall	2	2	1
Cyclone separator	-	1	3
Electret filter	-	2	2

Building ventilation



Which ventilation openings are relevant for this research?

Answer:

Operable window

Double facade

Operable vent

Ventilation grille

Wall ventilation opening

Mashrabiya

Building ventilation



Which ventilation openings are relevant for this research?

Answer:

Operable window

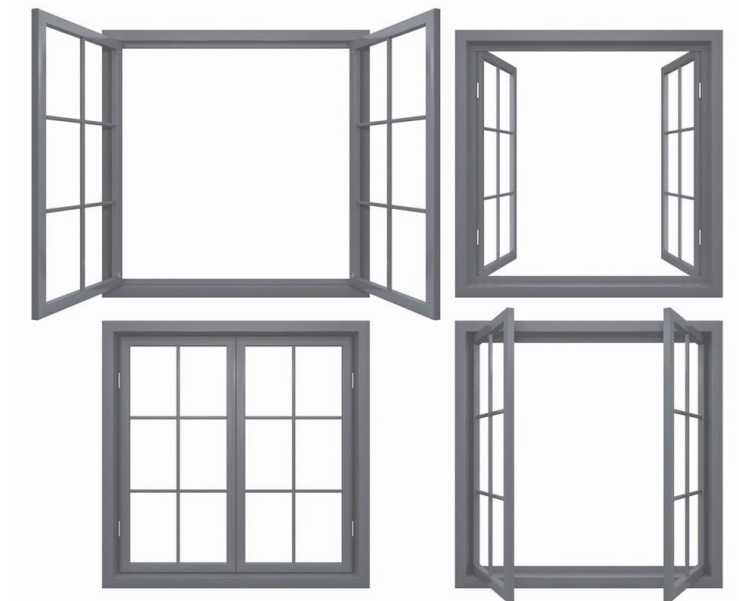
Double facade

Operable vent

Ventilation grille

Wall ventilation opening

Mashrabiya



Building ventilation



Which ventilation openings are relevant for this research?

Answer:

Operable window

Double facade

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Ventilation grille

Wall ventilation opening

Mashrabiya



Building ventilation



Operable window

Double facade

Operable vent

Ventilation grille

Wall ventilation opening

Mashrabiya



Building ventilation



How can the different ventilation openings be compared to each other?

Criteria:

Air circulation

Thermal comfort

Acoustics

Building ventilation



How can the different ventilation openings be compared to each other?

	Air circulation	Thermal comfort	Acoustics
Operable window	1	1	1
Double facade	2	2	3
Operable vent	3	3	3
Ventilation grille	1	1	3
Wall ventilation	1	1	3
Mashrabiya	1	1	1

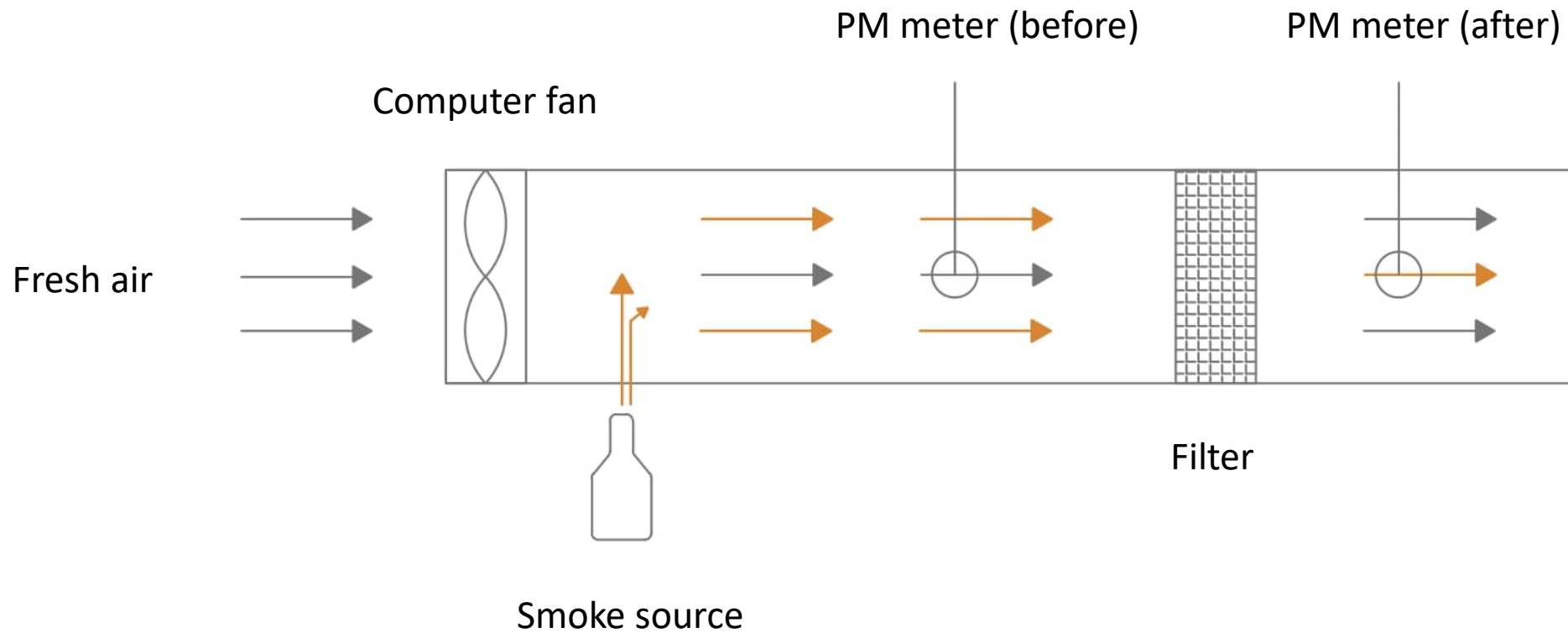
Validation



LIVE test

Interpretation of the results

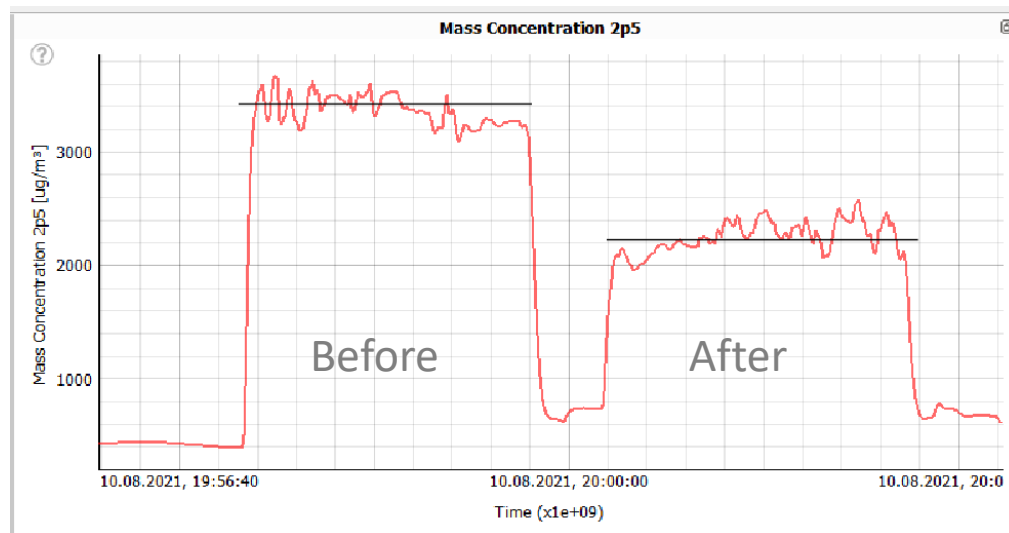
Testing



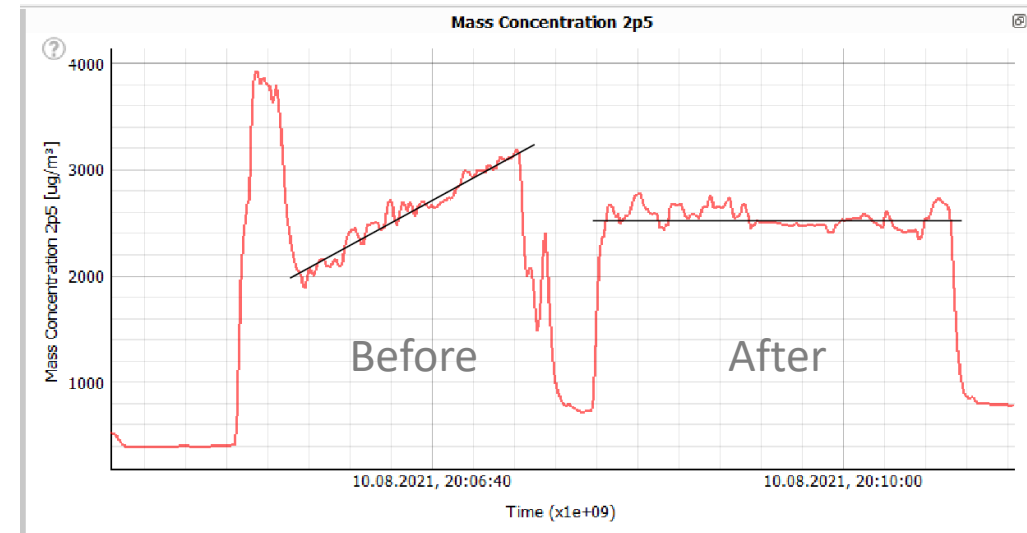
Interpretation of the results



Reliable test result



Unreliable test result



Concept design



How did the concepts develop?

How do the different concepts relate to each other?

Concept development



How did the concepts develop?

Design choices:

Air purification technologies

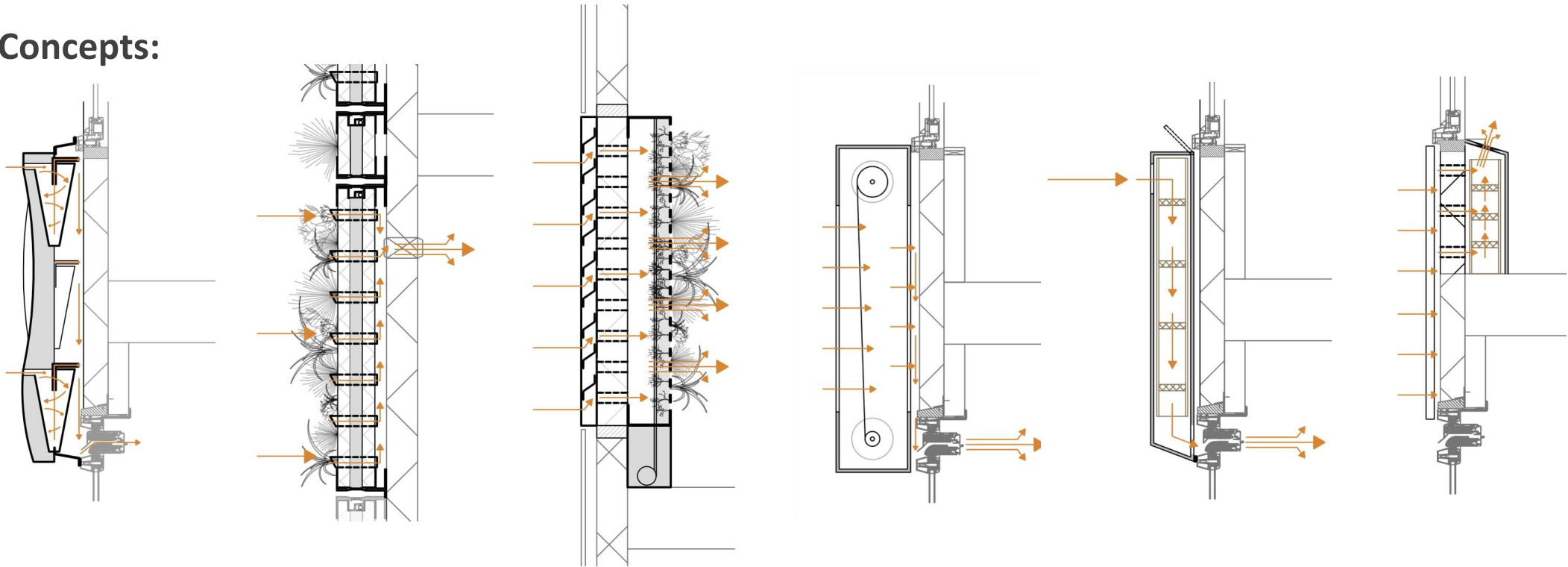
Ventilation opening

Concept development



How did the concepts develop?

Concepts:



Concept development



How did the concepts develop?

Concept example:

Cyclone separator with PCO

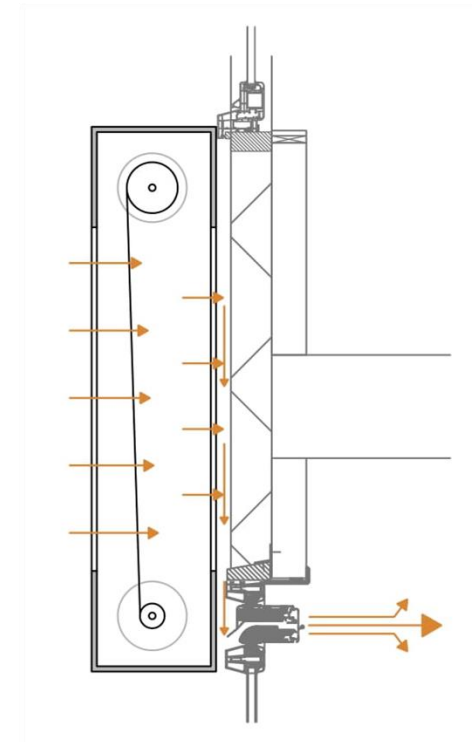
Bio-facade: Living Wall System

Bio-facade: Active Green Wall

Outside filter box: variant I

Outside filter box: variant II

Inside filter box



Concept development



How did the concepts develop?

Selected air purification technology

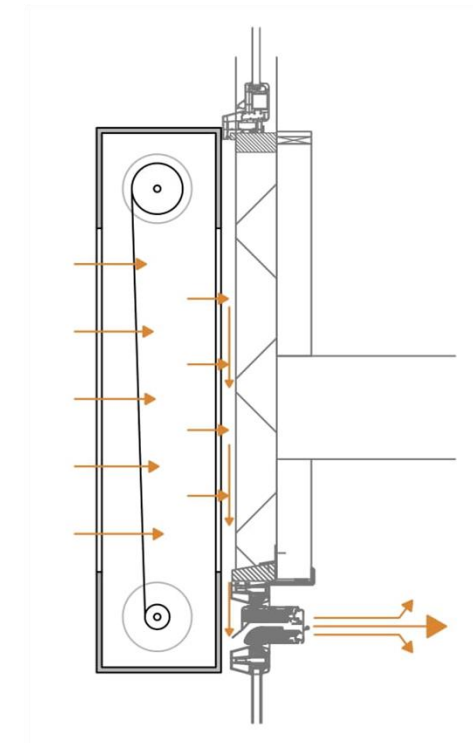
Photocatalytic oxidation with TiO₂

Bio-facade: Living Wall System

Bio-facade: Active Green Wall

Cyclone separator

Fibrous filter



Concept development



How did the concepts develop?

Selected air purification technology

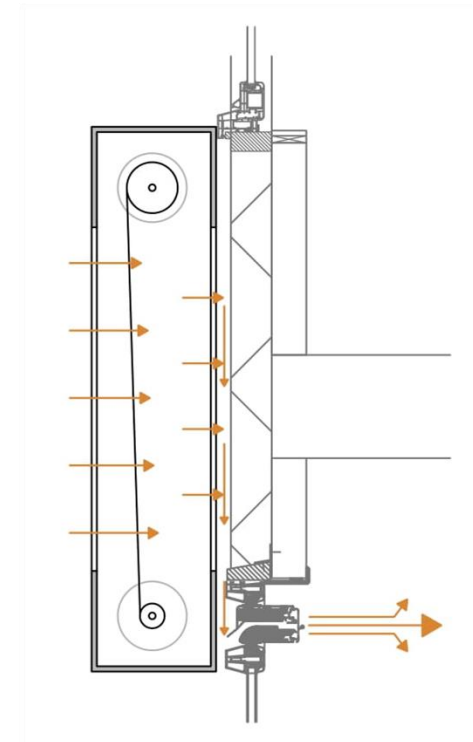
Photocatalytic oxidation with TiO_2

Bio-facade: Living Wall System

Bio-facade: Active Green Wall

Cyclone separator

Fibrous filter



Concept development



How did the concepts develop?

Selected ventilation opening

Operable window

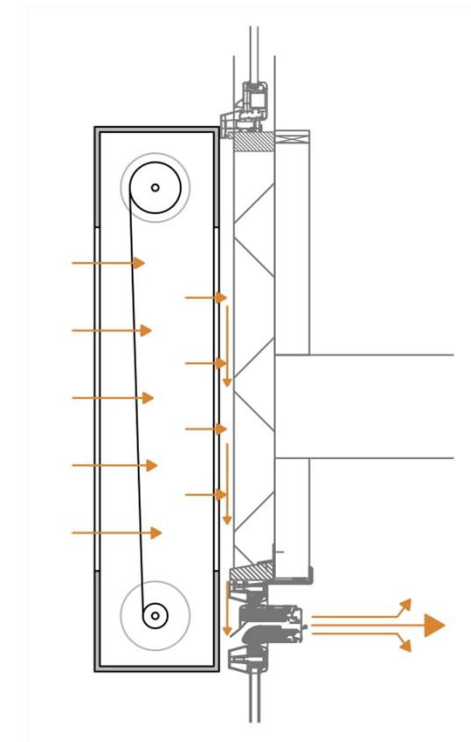
Double facade

Operable vent

Ventilation grille

Wall ventilation opening

Mashrabiya

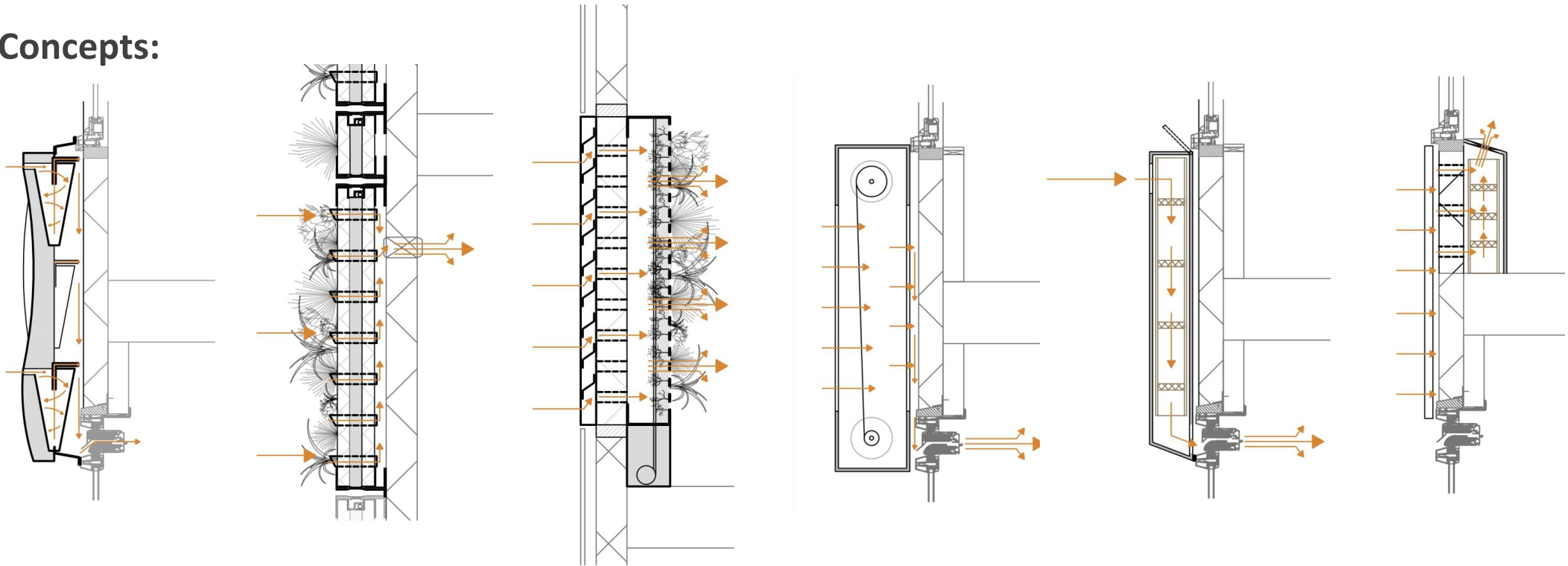


Concept analysis



How do the different concepts relate to each other?

Concepts:



Concept analysis



How do the different concepts relate to each other?

Hard criteria:

Pressure drop

Dimensions

Hard criteria	
Pressure drop	<ul style="list-style-type: none">● < 20 Pa, most likely● Close to 20 Pa, or not sure if it is below● Very little chance that it is below 20 Pa
Dimensions	<ul style="list-style-type: none">● Height: fit between floors Width: 1,2m / 1,5m According to commonly used sizes● It fits, but unusual sizes● Doesn't fit in a facade

Concept analysis



How do the different concepts relate to each other?

Soft criteria:

Filter quality NO₂ / PM

Thermal comfort

Acoustic damping

Design flexibility

Suitability for renovation project

Building speed on site

Maintenance effort

Maintenance frequency

Concept analysis



How do the different concepts relate to each other?

Soft criteria:

Filter quality NO2 / PM

Thermal comfort

Acoustic damping

Design flexibility

Suitability for renovation project

Building speed on site

Maintenance effort

Maintenance frequency

Maintenance	
Maintenance frequency	<ol style="list-style-type: none">1. Multiple times a year2. No more than once a year3. No maintenance during lifetime only accidentally
Maintenance effort	<ol style="list-style-type: none">1. Parts can only be replaced from outside the building and cost a lot of time.2. Parts can be replaced from inside, but cost a lot of time to replace or parts can be replaced from outside very fast3. Parts can be replaced from inside very fast

Concept analysis



How do the different concepts relate to each other?

	Hard criteria		Air treatment			Design qualities		Construct-ability		Mainte-nance		Total score:
	Dimensions	Pressure drop	Filter quality NO ₂	Filter quality PM	Thermal comfort	Acoustic damping	Design flexibility	Suitability for renovation project	Building speed on site	Maintenance effort	Maintenance frequency	
CYCLONE SEPARATOR with PCO	●	●	2	1	1	1	2	3	3	2	3	18
BIOFACADE Living Wall System	●	●	1	1	2	2	2	2	2	1	1	14
BIOFACADE Active Green Wall	●	●	3	2	3	2	2	1	1	2	1	17
Outside filter box: variant I	●	●	2	2	2	3	2	3	3	1	2	20
Outside filter box: variant II	●	●	2	2	2	3	2	3	3	2	2	21
Inside filter box	●	●	2	2	3	3	3	1	1	3	2	20

Case study I: Renovation



The case

Concept selection

Design plan

Design development

The Case: Montevideo



The Case: Montevideo



The Case: Montevideo



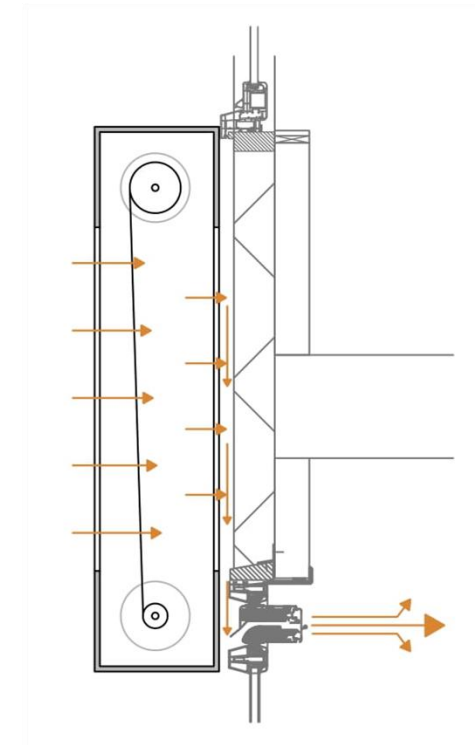
Renovate a part of the facade of the Montevideo using one of the concepts

Concept selection



Which concept should I choose?

	Hard criteria		Air treatment			Design qualities		Constructability		Maintenance		Total score:
	Dimensions	Pressure drop	Filter quality NO ₂	Filter quality PM	Thermal comfort	Acoustic damping	Design flexibility	Suitability for renovation project	Building speed on site	Maintenance effort	Maintenance frequency	
CYCLONE SEPARATOR with PCO	●	●	2	1	1	1	2	3	3	2	3	18
BIOFACADE Living Wall System	●	●	1	1	2	2	2	2	2	1	1	14
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Inside filter box	●	●	2	2	3	3	3	1	1	3	2	20



Design plan

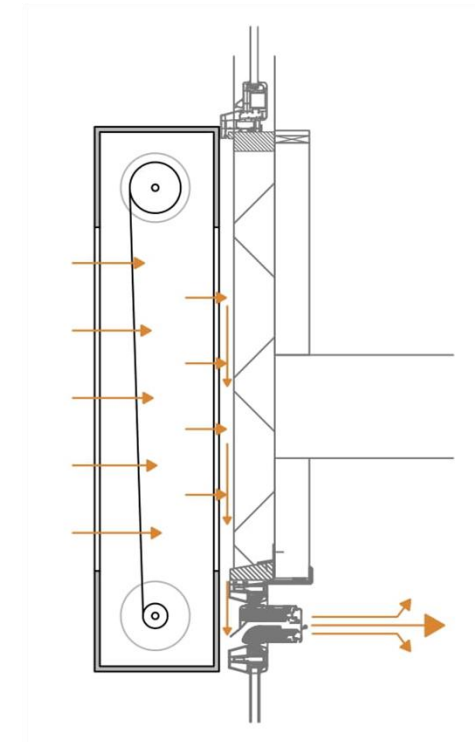


How can this concept be worked out in more detail?

Working out the following design parameters

Design parameter → Goal → Method

Box properties	PCO friendly materials
	Surface roughness
	Shape and dimensions
	Mechanism to open box
Filter properties	Performance
	Pressure drop
	Thickness
	Material
	Mechanism to change filter fabric
Fixing system	Box aan achterliggende gevelconstructie
	Boxen aan elkaar (luchtdicht)
Ventilation openings	Frontside panel
	Backside panel
	Into the room
Thermal comfort	Measures to cool air
	Measures to preheat air
Acoustics	Measures to dampen noise



Design plan



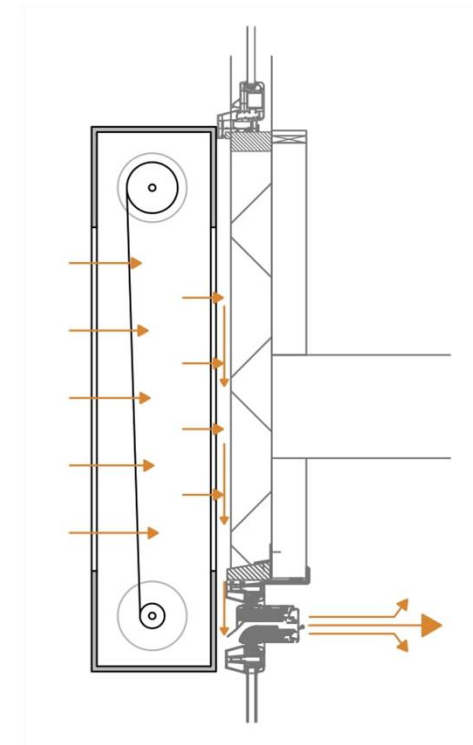
How can this concept be worked out in more detail?

Working out the following design parameters

Design parameter → Goal → Method

Dimensions box → Fit in existing facade structure → Analyze building

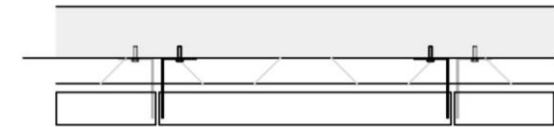
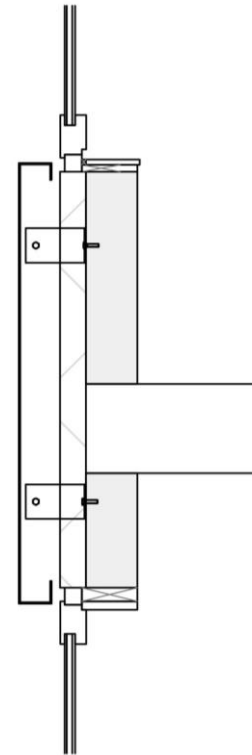
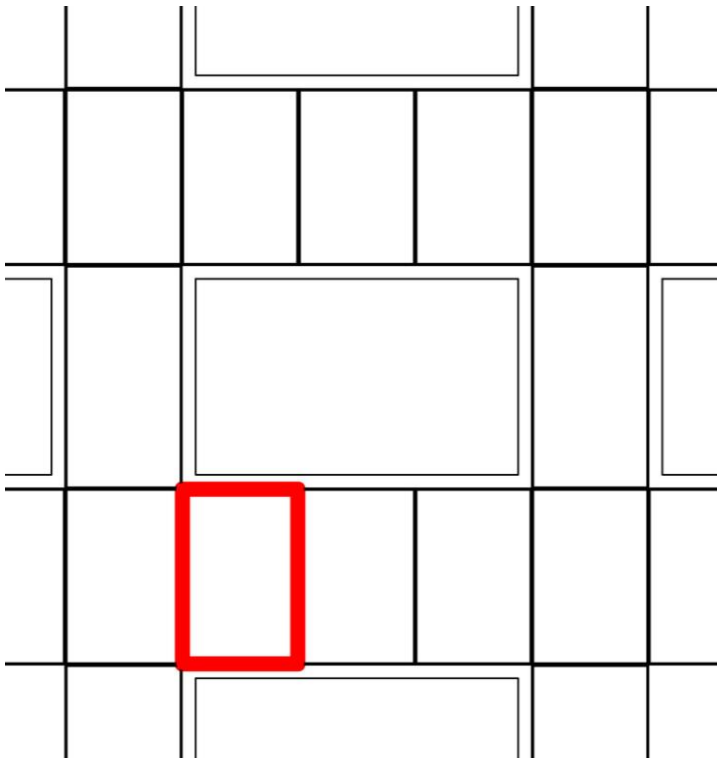
Result: dimensions box: 850 x 1280 mm



Design development



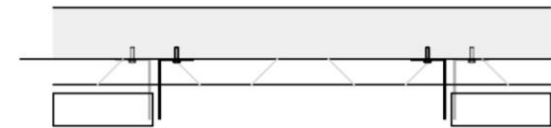
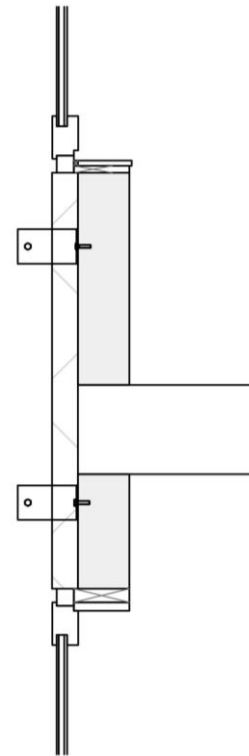
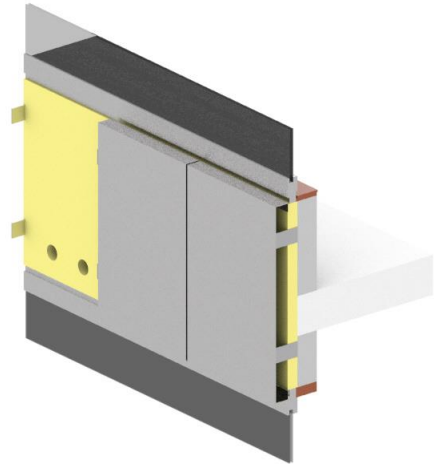
Front view existing facade



Design development



Existing panels are removed

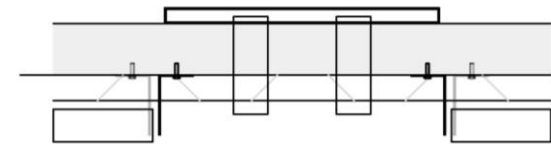
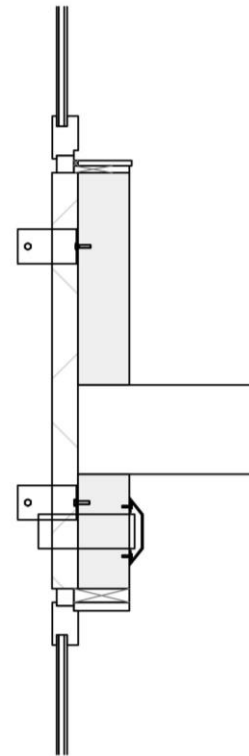
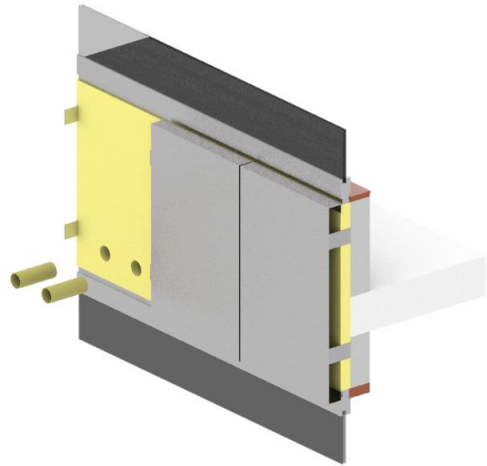


Ventilation openings



Holes are drilled

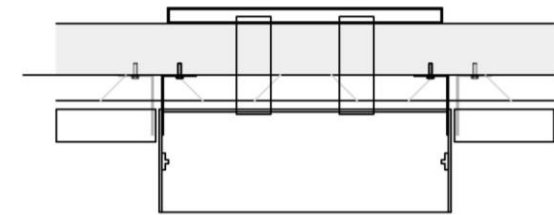
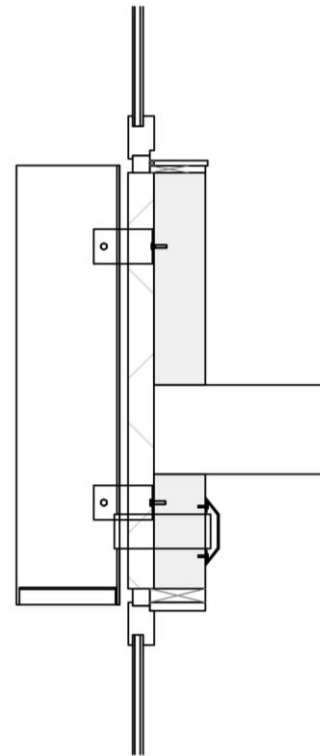
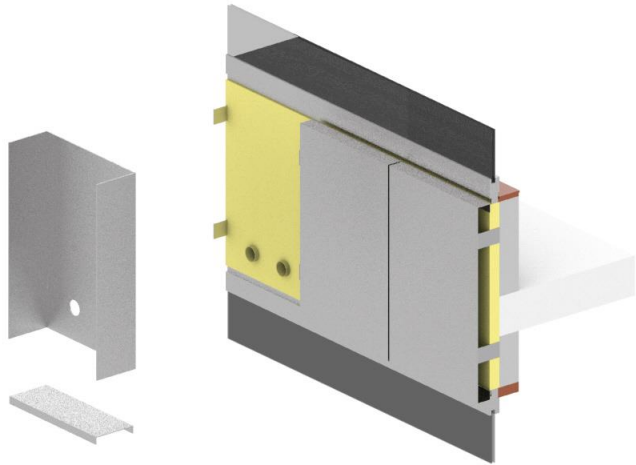
Ventilation tubes are placed



Design development



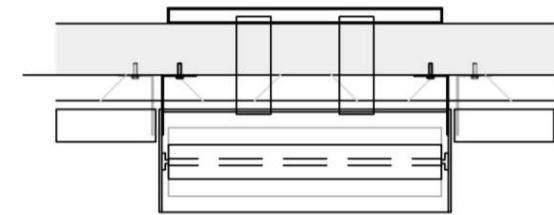
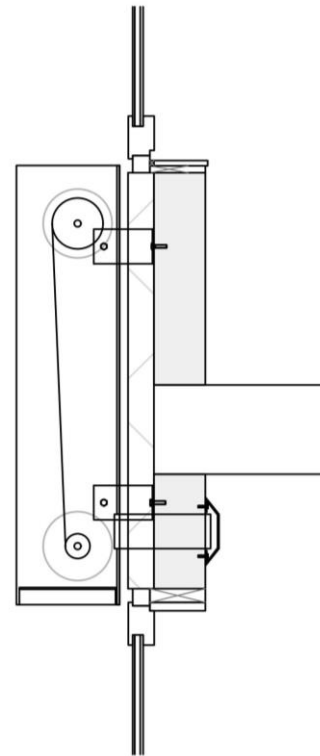
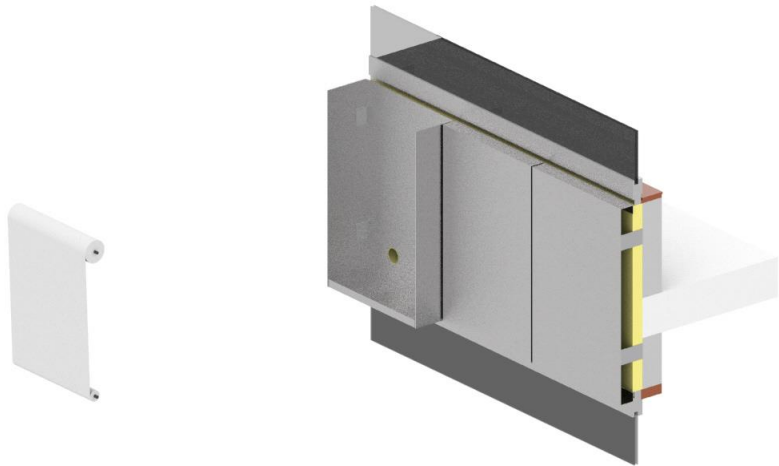
The casing for the filter box is placed



Design development



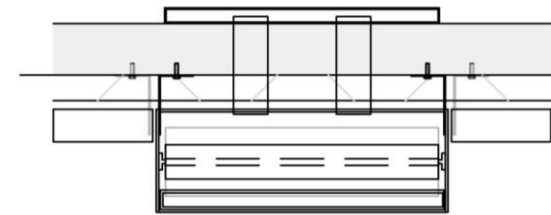
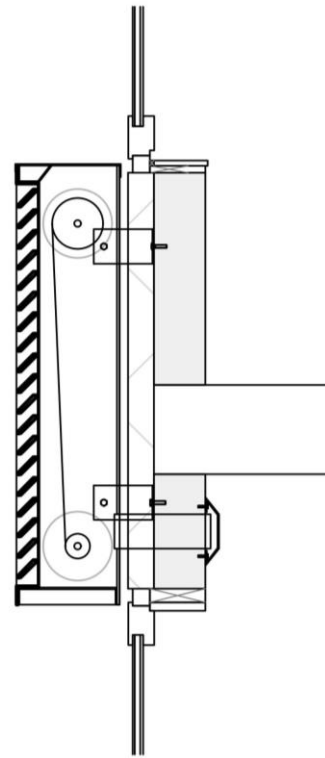
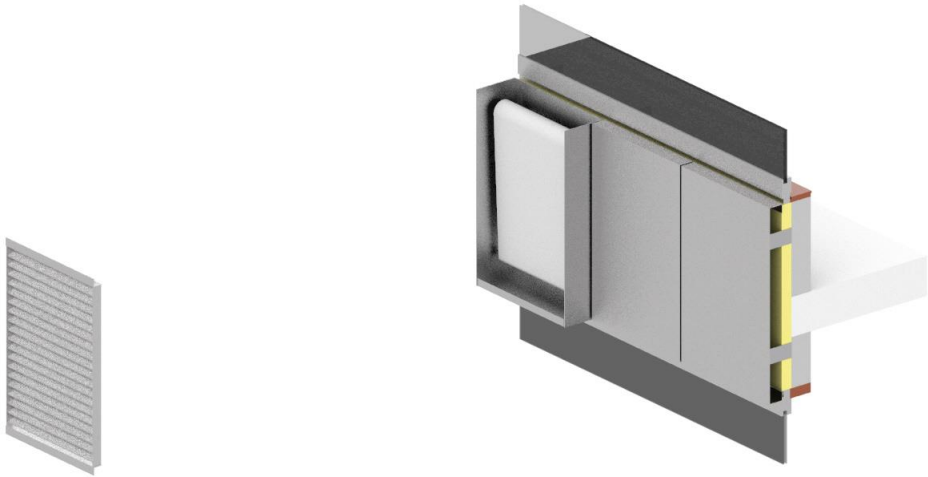
The filter roll is placed inside the casing



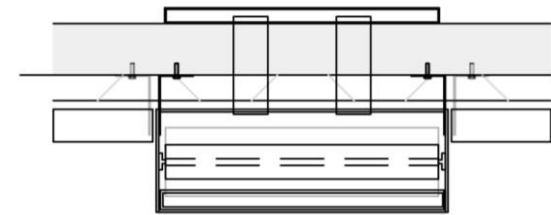
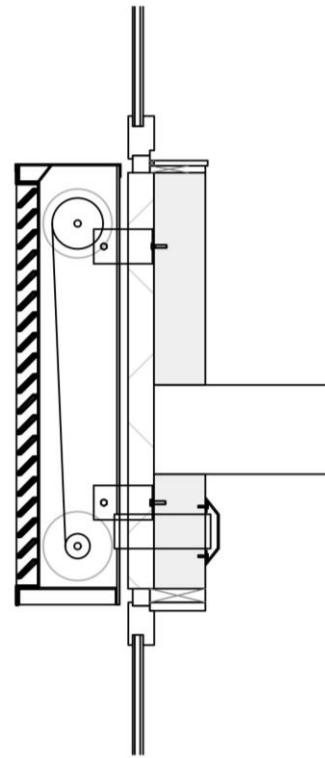
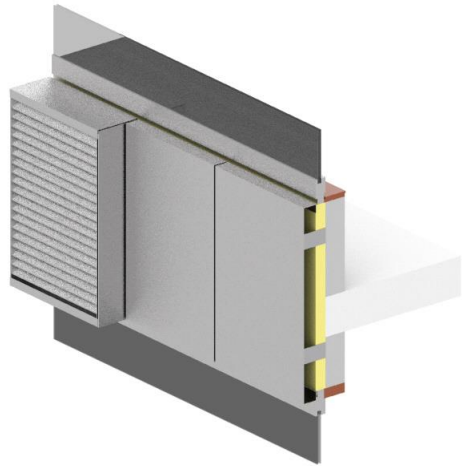
Design development



The ventilation grille and the top lid are placed



Design development



Conclusion



Research question

Concepts

Concepts analyzed in quality table

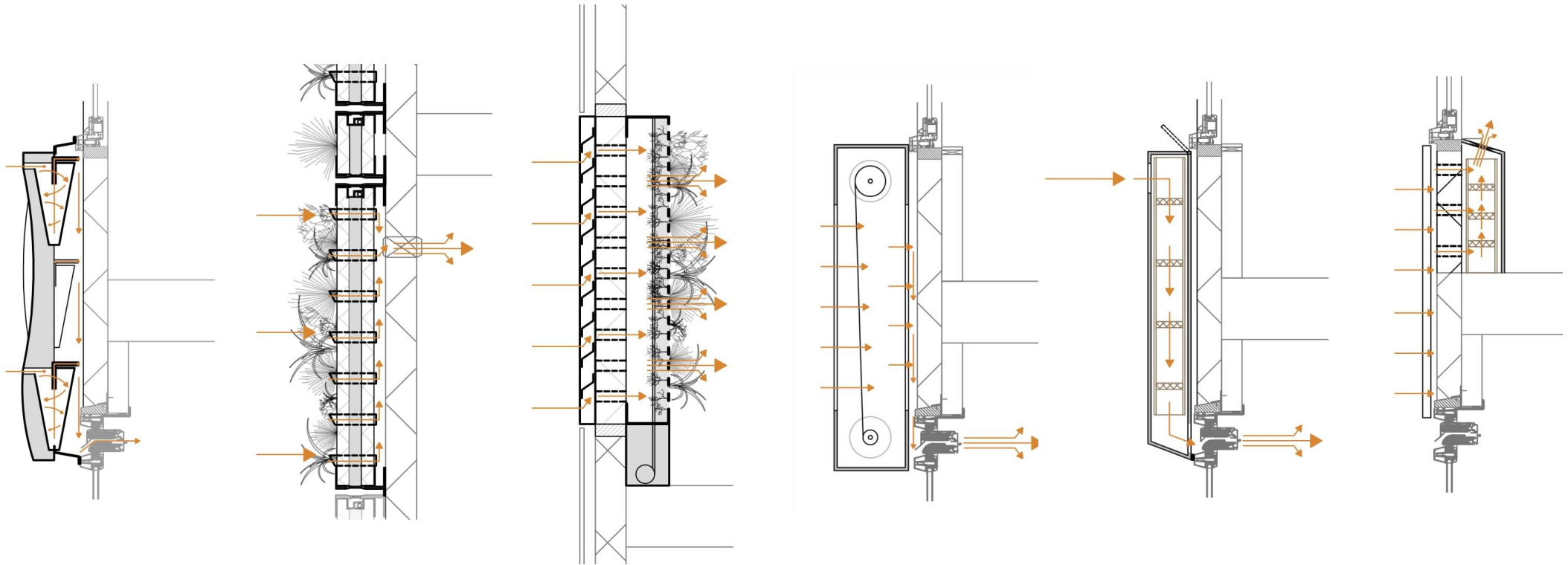
Concepts worked out in case study

Research question



‘How can the façade of a high-rise building in an industrialized region be designed to improve the indoor air quality by using ventilation type C?’

Result: concepts



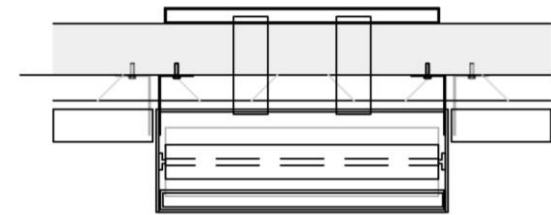
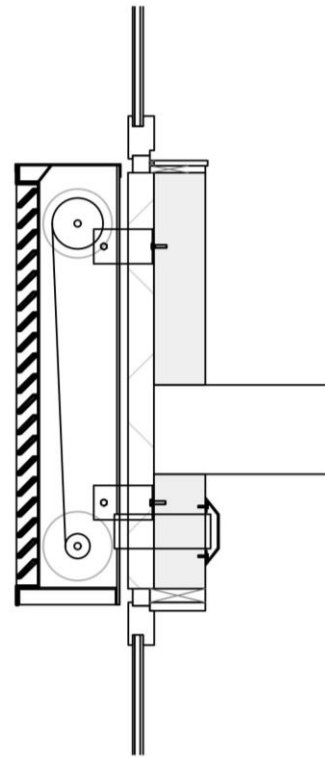
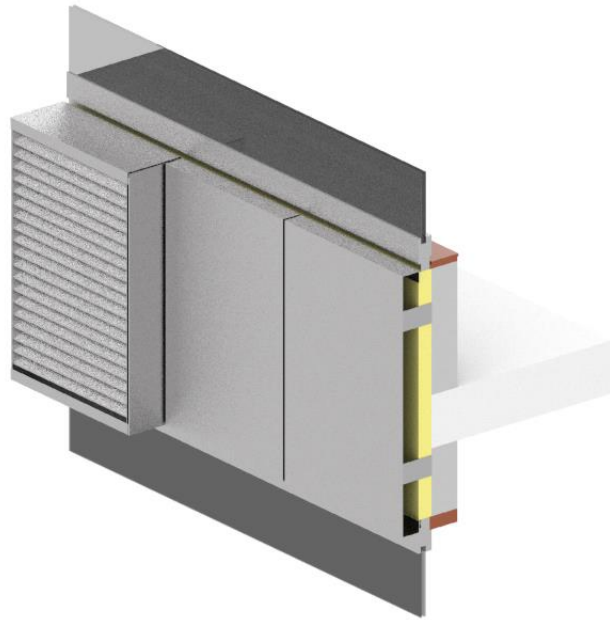
Result: concepts



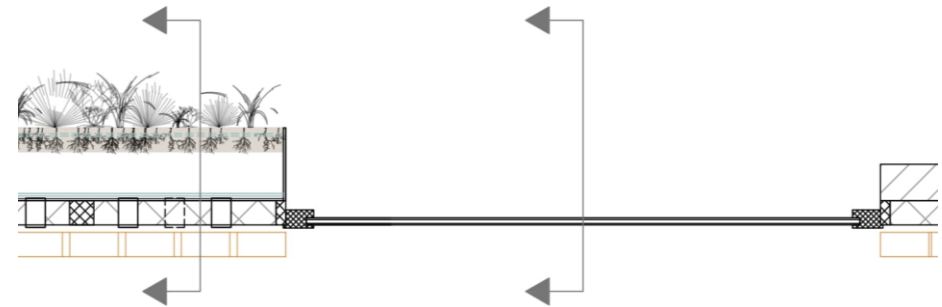
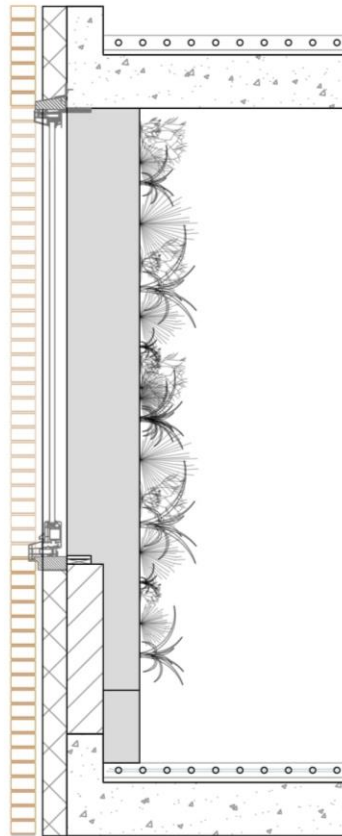
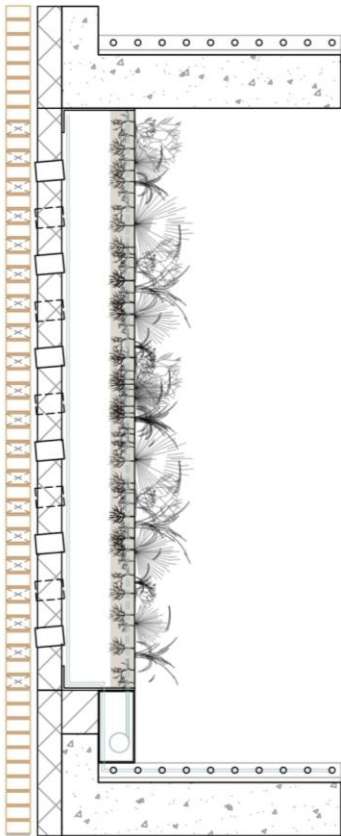
Quality table

	Hard criteria		Air treatment			Design qualities		Construct-ability		Mainte-nance		Total score:
	Dimensions	Pressure drop	Filter quality NO ₂	Filter quality PM	Thermal comfort	Acoustic damping	Design flexibility	Suitability for renovation project	Building speed on site	Maintenance effort	Maintenance frequency	
CYCLONE SEPARATOR with PCO	●	●	2	1	1	1	2	3	3	2	3	18
BIOFACADE Living Wall System	●	●	1	1	2	2	2	2	2	1	1	14
BIOFACADE Active Green Wall	●	●	3	2	3	2	2	1	1	2	1	17
Outside filter box: variant I	●	●	2	2	2	3	2	3	3	1	2	20
Outside filter box: variant II	●	●	2	2	2	3	2	3	3	2	2	21
Inside filter box	●	●	2	2	3	3	3	1	1	3	2	20

Result: Case study I

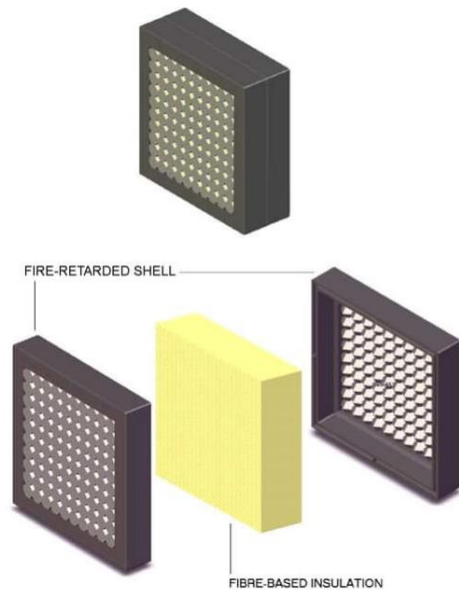


Result: Case study II

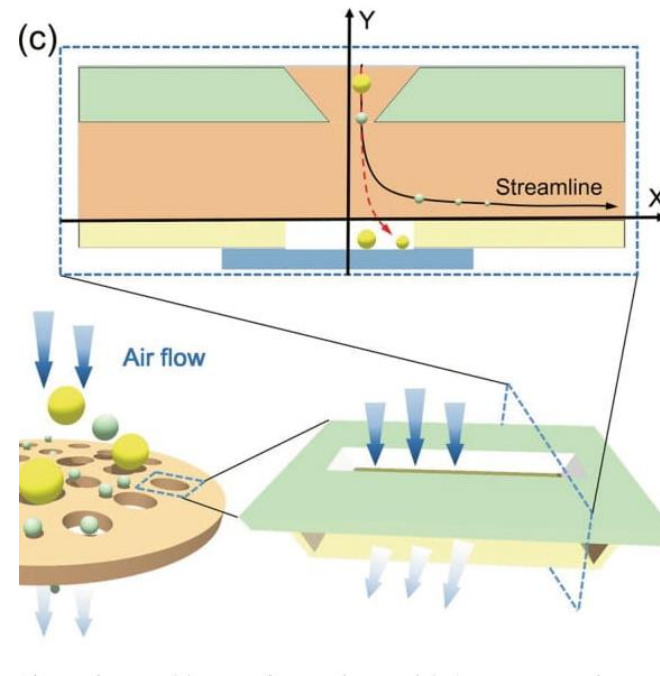


Recommendations

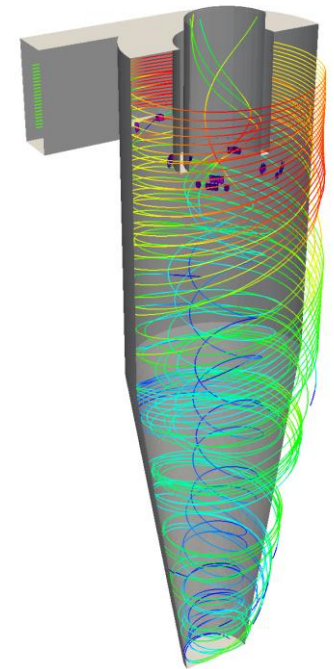
Dynamic insulation



Inertial impaction filter



CFD analysis



Thank you!

Questions?

Appendix

Hard criteria

Hard criteria	
Pressure drop	<ul style="list-style-type: none">● < 20 Pa, most likely● Close to 20 Pa, or not sure if it is below● Very little chance that it is below 20 Pa
Dimensions	<ul style="list-style-type: none">● Height: fit between floors Width: 1,2m / 1,5m According to commonly used sizes● It fits, but unusual sizes● Doesn't fit in a facade

Appendix

Soft criteria

Air treatment	
Filter quality NO ₂	<ol style="list-style-type: none"> 1. Performance: < 50% 2. Performance: >>50% 3. Performance: >> 50%
Filter quality PM	<ol style="list-style-type: none"> 1. Classification: ISO ePM10 / coarse Pressure drop: > 20 Pa 2. Classification: ISO ePM2,5 Pressure drop: around 20 Pa 3. Classification: ISO ePM1 Pressure drop: < 20 Pa
Thermal comfort	<ol style="list-style-type: none"> 1. No measures taken to cool or heat air 2. Can only cool or only heat air 3. Can both cool and heat air
Air circulation	<ol style="list-style-type: none"> 1. Location: wrong regarding climate conditions Opening type: too big or too low pressure drop 2. Location is good but opening type is not good or the other way around 3. Location: right spot regarding climate conditions Opening type: smaller openings with enough pressure drop to prevent draft

Design qualities	
Acoustics	<ol style="list-style-type: none"> 1. No possibilities for improving sound attenuation / Risk that air flow in system causes noise 2. Some possibilities for improving sound attenuation 3. A lot of possibilities for improving sound attenuation
Design flexibility	<ol style="list-style-type: none"> 1. The design contains little or no freedom to be adapted to the user's wishes 2. Parts of the design can be adapted to the wishes of the user 3. The design can be adapted almost entirely to the wishes of the user
Constructability	
Suitability for renovation project	<ol style="list-style-type: none"> 1. All existing parts have to be removed or adapted 2. Parts of the existing façade have to be removed and adapted 3. Only one part is replaced or adapted
Building speed on site	<ol style="list-style-type: none"> 1. The structure has to be build part by part on site 2. Parts of the structure are prefabricated and can be installed immediately on site 3. The whole structure is prefabricated and can be installed on site
Maintenance	
Maintenance frequency	<ol style="list-style-type: none"> 1. Multiple times a year 2. No more than once a year 3. No maintenance during lifetime only accidentally
Maintenance effort	<ol style="list-style-type: none"> 1. Parts can only be replaced from outside the building and cost a lot of time. 2. Parts can be replaced from inside, but cost a lot of time to replace or parts can be replaced from outside very fast 3. Parts can be replaced from inside very fast