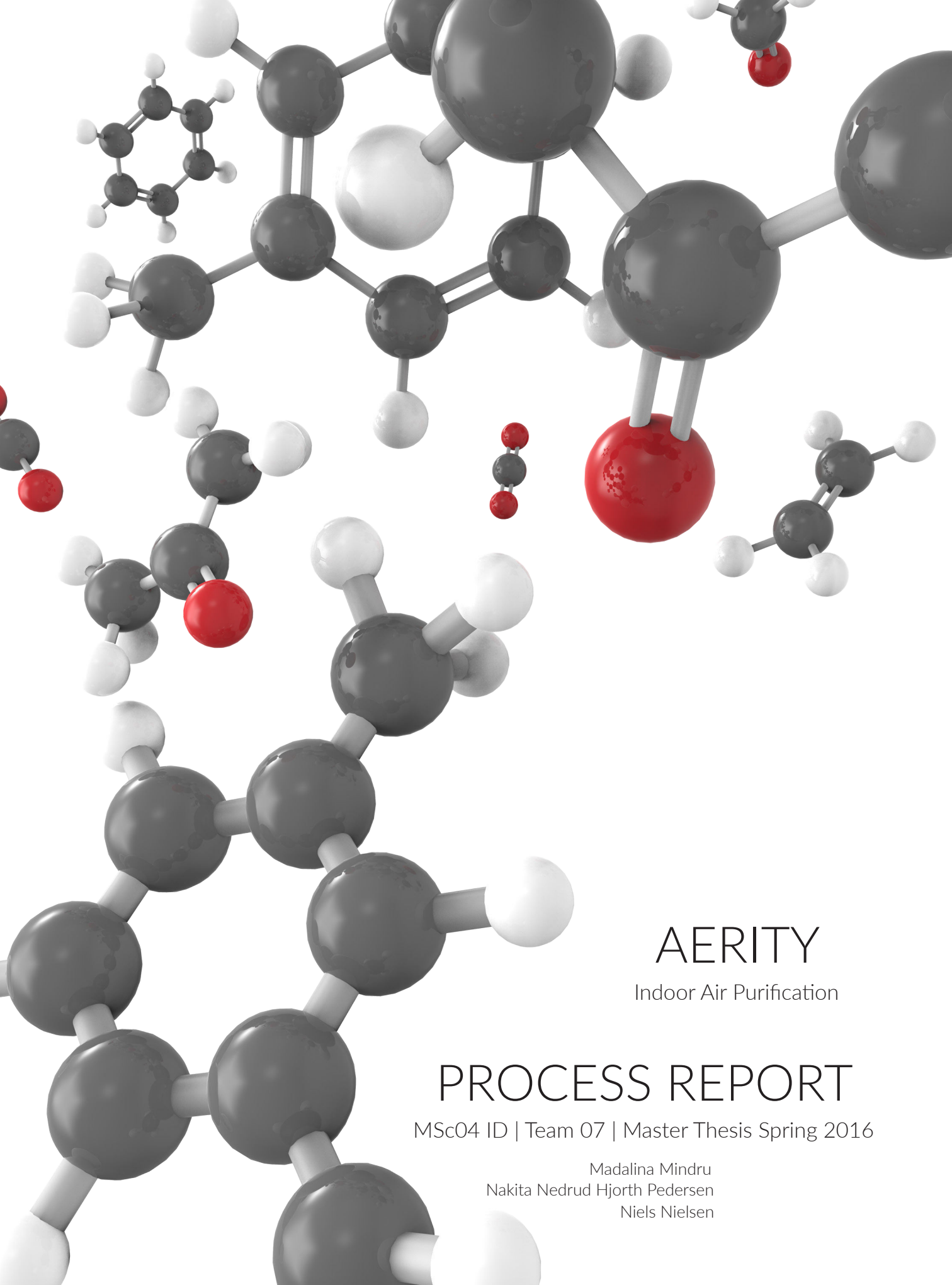

AERITY

Indoor Air Purification

PROCESS REPORT

MSc04 ID | Team 07 | Master Thesis Spring 2016

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TITLE PAGE

Aalborg University
Architecture & Design
MSc04 Industrial Design
Team 7

Project title	AERITY
Area of interest	Indoor Air Quality
Project period	01.02.2016 - 25.05.2016
Supervisor	Finn Kehlet Schou
Technical supervisor	Mikael Larsen
Total no. of pages	91
Editions	7

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ABSTRACT

Dette projekt er udarbejdet af et team afgangsstuderende på linjen Industriel Design på Aalborg Universitet i løbet af foråret 2016.

Fokus under dette projekt har været på indeklima samt luftkvalitet. Projektet udsprang i fugt komplikationer men ændrede retning, da teamet blev bevidste om usynlige og alvorligere parametre som flygtige organiske stoffer, kuldioxid samt fine partikler. Disse parametre er alle usynlige og det er utroligt svært at afgøre hvorvidt niveauet af de pågældende er indenfor den humane komfort zone eller forhøjet, hvilket kan lede til alvorlig forringelse af den individuelles helbred.

Projektet er baseret på ekspert viden, tests foretaget af teamets medlemmer, mock-ups, interviews, undersøgelser samt begrundet data fra anerkendte forskere.

Resultatet er et multifunktionelt møbel, der renser luften ved at anvende naturlige elementer som planter og aktivt bambus kul. Produktet henvender sig til enhver der er interesseret i at forbedre indeklimaet i hjemmet – til brug i det private samt det offentlige.

Denne rapport giver læseren det komprimerede men dog detaljerede indhold der understøtter udviklingen af det endelige produkt.

READING GUIDE

The Process Report consist of different process phases: Introduction, Pre-Phase, Research, User Insight, Market Insight, Vision and Mission, Concept Development, Detailing and Manufacturing and Business Case. The report content contains the most condensed and relevant material of the project work, while the complete research, interviews, explanations, experiments conditions and interpretations are presented in detail in the corresponding worksheets.

The worksheets [*WS. XX*] are being referred to along the report.

Due to a simultaneous work in chapters Research, Concept Development and Market Insight, it is recommended to consult the Process Tracking if in doubt of the order in different project stages.
The Process Tracking is to be found on pp. 8-9.
A complete list of used scientific terminology and abbreviations is to be found in *[WS. 01]*

PREFACE

Current paper serves as Master Thesis Project of Industrial Design, Architecture & Design Department at Aalborg University. The project theme is natural methods for improving indoor air quality, taken as departure point from private homes in Denmark.

The final product has its main focus on actions on indoor climate rather than simply indicating the problem.

The project progress was evaluated during two Status Seminars and multiple supportive supervision meetings.

In this sense, during the project period, Finn Kehlet Schou and Mikael Larsen offered careful guidance as the main and respectively technical supervisor.

The written material contains three main sections. The Process report takes the reader through the stages from research to development and implementation of the physical product. The Product Report presents user guidance and interaction, features and characteristics of the product. The Worksheet compendium contains all detailed research and testing supporting the Process Report.

LEARNING GOALS

In the Semester Description for this Master Thesis project, Aalborg University has set up some requirements for the students to achieve, in order to demonstrate the high level of skills, competencies and knowledge behind the project. Below there will be an excerpt of the requirements the team finds most relevant. *[Semester Description MSc04 ID Spring 2016]*

Skills

The students must demonstrate that they are able to

Design by integrating a desired expression and experience through form and function.

Frame the design and develop a design proposal, which is based of clearly defined values, user needs and or business plan.

Select, use and reflect on the appropriate methods for analyzing important areas relevant for the design process as on the developed product.

Navigate a design process, drive the design process forward and at the same time focus on the relevant part of the project in order to stay on track.

Use the appropriate methods, techniques and tools in order to carry out experiments and synthesizing design based product or solution proposals.

Communicate complex problems and solutions to both peers as well as non-specialists.

AERITY

The story behind the name and logo of AERITY:

AERITY is a combination of the Latin word, *AER* meaning "*air*", means taking care of the air we breath in our homes and *purity*.

The graphical signature symbolizes the various parameters air quality consists of, which are vital to take in consideration for a balanced indoor climate. *[WS. 02]*

Illu. 1.01 - AERITY graphical signature

Competencies

During the project the team members must achieve a high degree of integration of selected appropriate aspects of the subject of choice within the field of design engineering.

The team members are able to independently and professionally manage and facilitate a design process that integrates engineering disciplines in order to design innovative solutions.

Furthermore it is important that the team members are able to review the final proposal considering engineering, design and business perspectives.

Knowledge

The team members must account for relevant design related knowledge and identify design relevant problems within the chosen subject.

The team members must also account for research-based knowledge in the design process and the scientific validity of test, investigations and other type of data used in the design process.

The team members must demonstrate a high degree of awareness regarding experiments, test, concept proposals, evaluations affecting the decision making during the design process, the main critical issues and also how these can be amended.

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METHODOLOGY

The scheme below describes the methods used during the different project stages. This is divided into four categories: Method, Activity, Approach and Purpose, to give the reader a full understanding of the chosen method, their purpose and expected outcome of the process.

METHOD	ACTIVITY	APPROACH	PURPOSE
SCRUM Board *Ovesen, N. (2012)*	Process navigation	Write tasks on post-its and categorize these as "To do", "Doing" and "Done"	To create an overview of the tasks in order to achieve process of the process and project
Timeline	Planning	Make a wall hung calendar and put in important dates, meetings and deadlines	Not to forget any thing of importance during the project period
Desk Research *David Travis. (2016)*	Gaining knowledge	Research on the Internet and physical literature consulting	To achieve a higher level of understanding
Moodboards *Creative Bloq (2016)*	Inspiration	Appealing pictures related to the chosen area of interest are printed and hung on the wall to be visible for all team members at all times	To be inspired and get an understanding of what the team members subconscious reveals of thought on the area
Expert Interviewing *Design Kit (2016)*	Gaining knowledge	Taking contact with and interviewing experts in the chosen field	Get high quality of knowledge in the chosen area of interest
CAWI *Daniel Sims (2016)*	Gaining knowledge	Creating an online questionnaire by using Google Forms and send out	Determine if the chosen area is valid as project topic and find behavior patterns regarding indoor climate
Design Brief *Philips, Peter L. (2004)*	Expectation agreement and get an overview of the current status of the project	Creating a design brief and send this to supervisors	To update supervisors on current status of the project and achieve relevant feedback
Brainstorming *(Osterwalder, A., 2010. pp. 144)*	Idea- and concept generation	Drawings, sketches, conversations and keywords for generation phase	To get the creative mind going and begin on the design process
Forced Relationship *Striim, O. (2002)*	Idea generation	Drawings and sketches from the brainstorm is placed in a pile and is paired	To bring ideas and concepts the team would not have though of by themselves

METHOD	ACTIVITY	APPROACH	PURPOSE
CAD modelling	Development and detailing of chosen concept	The chosen concept is drawn into the CAD program Solid Works, where the final detailing process is happening.	To fully understand all aspects of the integrated design
Point Value	Evaluation of concepts	Establish important parameters and rate the concepts according to these. The concepts with the highest no. of points is chosen for further development.	To secure that the chosen concept is the one most likely to succeed
Market analysis *Marketing Donut (2016)*	Documented investigation	Compare existing products available on the market on relevant parameters	Identify the most competitive product on the market
Interviewing of target group	Gaining knowledge	Interviews with the chosen target group face to face	To understand who the target group is and their thought
Persona *Smashing Magazine (2016)*	Mapping gained knowledge	Map gained knowledge and information from previous research, interviews and questionnaires	To illustrate and map the actions that effects the indoor climate during a day
Tests and experiments	Tests on living indoor plants	Placing the plants in test chambers and observe they behavior on basis of relevant parameters	Compare obtained results with literature ones and develop own biological models.
Business Canvas *(Osterwalder, A., 2010. pp. 14)*	Business understanding	Plot the "Business Canvas Model" developed by Osterwalder	Understand the involvement of different actors and the possible scenarios for their network and interactions between them
Mock ups	Model creation	Simple and affordable models are made to use for testing	To understand the product size, functions, form, placement of parts and assembly
Hypothetical deductive method *Hypothetico-Deductive Method (2016)*	Gaining knowledge	Hypothesis based on theoretical research is tested by simplified experiments	Confirmation or invalidate the hypothesis tested
SWOT *(Osterwalder, A., 2010. pp. 216)*	Understanding the product	A chart is made and contains the Strengths, Weaknesses, Opportunities and Threats of the product developed	Understanding the products placement in the market

PROCESS TRACKING

ALIGNMENT

Project Starts
01.02

Predefined Theme
Home dehumidification

Company
Initial Visit

NORDIC LINE
- en direkte handel

Ventilation &
Indoor Climate
Products

Broaden Project Focus

Indoor Climate
Private Rented Homes

RESEARCH 01

Indoor Climate
Define Context

- *Air Quality*
- *Thermal Comfort*

Target Context
Rented Housing

Indoor Climate
Define Parameters

- *Volatile Organic Compounds*
- *Carbon Dioxide*
- *Airborne Particulate Matter*
- *Relative Humidity*

MARKET INSIGHT

Smart Monitors
Indoor Climate

RH %
T [oC]
PM
VOCs
CO2
CO

EVALUATION

Design Brief
17.02

USER INSIGHT

Online Survey
Behavioural Patterns &
Acknowledgement on
Indoor Climate

Interviews
Health problems from
bad Indoor Climate

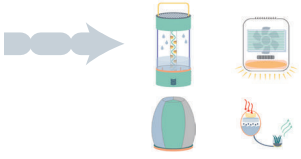
Street Survey
Manual Ventilation

Effects
Inhabitants & Building

Breathable Air

CONCEPT DEVELOPMENT

Concept Session 01
Forced Relations



EVALUATION

Milestone 01
01.03

RESEARCH 03

Air Quality Index
Worldwide

World impact
Energy consumption

REVISED FOCUS

Requirement Revision
Values & Functions

- *PM, Odor & VOCs removal*
- *Oxygen release*
- *Integrated home function*
- *Decorative*
- *Natural Elements*

CONCEPT DEVELOPMENT

Shape Development
Requirements revision

- *Sitting furniture*
- *Table Convertable*
- *Mobile*
- *All age design*
- *Cleaning facility*

MARKET INSIGHT

Competitor Analysis
Air purification with plants

Limited function
& efficiency

CONCEPT DEVELOPMENT

Plants Efficiency
CO_2 reducing Tests

Night & Day
Plants CO_2 efficiency

VOCs Removal test
Plant efficiency

DETAILING & MANUFACTURING

Power
Consumption
Dimensioning

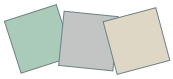
Mobility at
home
Variants

Ventilation
Principle
Chamber Air flow

Filters
HEPA
Activated Bamboo

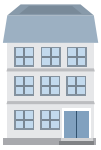
Injection
Moulding
Dimensioning

Color
Customization
Top & Bottom



RESEARCH 01

Centralize Problems
Indoor Climate at Home



- *Relative Humidity (RH%)*
- *Particulate Matter (PM)*
- *Volatile Organic Compounds (VOCs)*
- *Carbon Dioxide (CO_2)*

Correspondence
Home Rental Agencies
Offen Indoor Climate issues

Retailers
Climate & Ventilation

Initial Tests & Observations
At own homes

MARKET INSIGHT

Market Research
Products - Indoor Climate
16.02

- *Dehumidifier*
- *Humidifier*
- *Air Purifier*
- *Odor Removal*
- *Ventilator*

RESEARCH 02

Real Problem
Aknowledged publically

Air Cleaning
- Airborne Particles Size
- Removal filters

Natural Methods
Dehumidifying
Humidifying
Air Purifying
Odor Removal

Environmental Engineering
AAU

CO_2 VOCs

Most dangerous Parameters

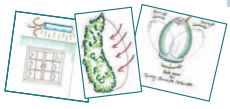
INITIAL STATEMENT

Missing Links

Action Products	*Home Interior*
Home Needs	*Limited Function*
Monitor	*Solution*

CONCEPT

Sketching Session 1
All Parameters



EVALUATION

Concept Evaluation
09.03

Air purification with indoor plants

RESEARCH 04

Natural Photosynthesis
Benefits

Human Response
- *Green color*
- *Indoor Plants*
- *Biophilic Interior*

CONCEPT DEVELOPMENT

6 Effective Plants
CO_2 & VOCs reducing

Home design Integrate
Sketching Session 02

- ✓ *Furniture*
- ✗ *Mobile GreenWall*
- ✗ *Coat Hanger*

Modern Home
Styleboard

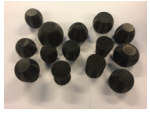
REVISED TARGET

Redefine Target Group
All types of private homes
Families - Couples - Elderly

DETAILING & MANUFACTURING

PM Removal test
Height placement

Shape Closing
Human Dimensions



Mock-Up Building
Dimensions Evaluation

Glass Dome
Dimensioning

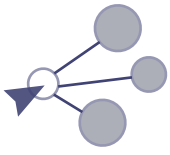
Dehumidification Technique
Plant Sef Watering system

Moist Technique
Lechuza Pon

BUSINESS CASE

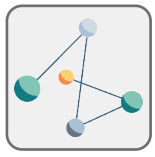
Product Pricing
Components Price
Selling Price

Distribution Channels
Denmark



Business Expansion
Worldwide

Added Value
Dedicated App



Project Delivery
25.05

Illu. 1.02

Illu. 2.01

PRE-PHASE

The Pre-Phase section presents the background of this semesters team composition and topic selection, various collaboration the team have had during the project phases and design limitations for the developed product. The Collaboration sections is a gratitude expression for all the guidance, resources, interest and help received from various teachers and companies.

TEAM COMPOSITION

This semesters teaming was of free choice.
Group 7 has formed out based on previous satisfactory work experience on academic projects, personal interests and competencies, which are seen as an optimal combination for covering the different project stages.

TOPIC SELECTION

Topic selection for the Master Thesis Project was also free of choice with submission of a preliminary description of project scope, which focused on dehumidifiers and relevant technology.
The project phase started with a company visit at Nordic Line ApS, it was concluded the need of better products and usability in all areas concerning the indoor air quality. *[WS. 03]*
It was at this point unanimously decided to broaden the focus on all what concerns the indoor climate and find most relevant problems to work further with.

An additional thanks goes to

Tommy V. Schmidt - CEO of Nordic Line, for providing the team with a dehumidifier and great knowledge
Alexander Alsing - Medicine Student AAU, for expert knowledge on health impacts caused by bad air quality
Theophanis Psomas - Department of Civil Engineering AAU (PhD Fellow), for data on invisible parameters
Pia Larsen - Plantoram, for sharing her experiences and knowledge on various effective plants
Rasmus Lund Jensen - Institut for Byggeri og Anlæg, for providing the team a CO_2 measurement
Palle Berggreen - DUOTEC A/S (CO_2 + VOCs) for lending a VOC measurement to the team
Janni Laursen - House of Coal ApS , for sending a batch of activated bamboo charcoal to use during tests
Preben Johannsen - MiritGlas A/S for giving a price on the glass globe and needed moulds
Johan Stenfeldt -CEO at MiritGlas A/S, for guidance on material dimensions
Jens Nørgaard - Hans Thyge & Co ApS for guidance on safety factors used for sitting furniture
Louise Hede Sørensen - InGarden Hegn & Haveartikler, for sending Lechuza Pon stones for testing

DESIGN LIMITATIONS

The following topics were not included in the project scope

Radon
Measurement of concentration, health impacts and efficient methods of removal

Bathrooms
Due to significantly high humidity level and particularities of construction, the proposed product will not have high influence in moist removal.
Measuring sensors
There are none placed on the product to serve as monitoring/indicating of the local air quality. It is assumed that the air quality index around the product is automatically better, therefore no need of recording data on the environment condition.

RESEARCH

Illu. 3.01

The following chapter presents detailed information on health impacts of poor indoor air quality in domestic environments, values at which these symptoms usually occur and case studies reflecting the daily routine and impact on inhabitants.

INDOOR CLIMATE

The current project focuses on air quality and thermal comfort as part of the indoor environment. Following section describes the main parameters, how it became a modern increasing problem and where is AERITY expecting to intervene for reconnecting the inhabitants with their state of well-being at home.

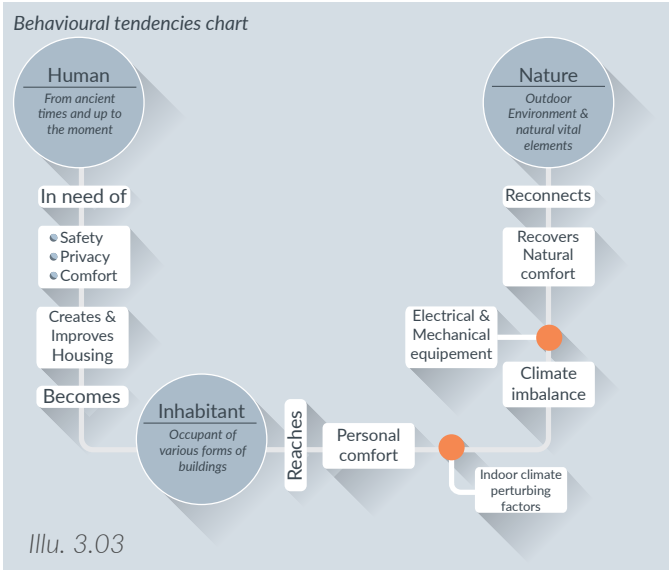
What is indoor climate?

Indoor climate relates to the overall conditions inside buildings and the health impact on their occupants. It is a part of the general category of Indoor environment and refers to the thermal, audible, visual comfort, mechanical comfort and air quality.

Indoor climate conditions are in continuous degradation on worldwide level, mainly as consequence of the human actions.

All parameters related to indoor climate are equally important, however some are easier to detect by the human body when exceeding the comfort level.

Illustration below presents the basic behavioral pattern regarding indoor climate along the time. The orange dots are the areas AERITY considers to be important to take action on.



Illu. 3.03

Illu. 3.02

Indoor climate parameters Focus

- Air quality
  - *Volatile Organic Compounds (VOCs)*
  - *Carbon Dioxide (CO_2)*
  - *Particulate Matter (PM)*
  - *Odors*
- Thermal comfort
  - *Relative humidity (RH%)*
  - *Indoor temperature (not in project scope)*
  - *Velocity of air (not in project scope)*

The main reasons for a poor indoor air quality are the followings:

- Old accommodations and buildings which does not meet the current living standards
- New housing which encapsulates people in air tight constructions: highly insulated. Natural air exchange is prohibited.
- Simple, daily actions inside the home with high repercussions on human health

TARGET GROUP

The project work will have the same theme as the Domestic Indoor Climate, since it is the environment which is controlled by the inhabitant only, in comparison to the public spaces, ventilated on an industrial scale. There will be taken as point departure the rented accommodations, where the tenant has minimum freedom on changing the interior of the home.

Domestic indoor climate

Danes spend in average approximately 16h per day in their homes during workdays. *[CISBO, (2016)]* Whereas the climate conditions in institutions are automatically controlled belonging to the industrial ventilation topic, the ones at home can only be established by occupant themselves.
Therefore, acknowledging, creating and maintaining optimal air quality becomes the occupants own concern.

Rented housing

Moreover, the project focus will be on the indoor climate in the private rented housing. Here it is common that people are constrained by the signed contracts to minimal construction changes in their homes. Additionally, there is a significantly less interest in financial investment in climate systems in a rented accommodation. These two main arguments conduct to a worth to investigate the topic further.

Population acc. to home ownership (DK)
[WS. 04]
62% - People living in owned places
38% - People living in rented places

Illu. 3.04

Housing acc. to ownership (DK)
[WS. 04]
50.12% - Private owned housing
49.88% - Rented accommodation

App. 38% of Denmark's population, represented by 2.323.948 people, lives in rented places, while the remaining of 3.272.501 (62%) own their home.

There are 1.302.233 occupied rented forms of accommodation and 1.308.023 private homes in entire Denmark, leading to an almost equal ownership distribution.

Targeted accommodation

New flat complex
Build in 2001

Illu. 3.05-a

Flat complex
Build in 1943

Illu. 3.05-b

Old house building
Build in 1897

Illu. 3.05-c

Renovated House
Build in 1905

Illu. 3.05-d

Targeted context

The apartment or house is often small, with large windows, a tendency of white, plain wall finish. Scandinavian interior design stands out through the clean, simple lines, elegance and carefully crafted decoration items. Materials are inspired from nature, earthy tones and there is a minimal ornamentations.

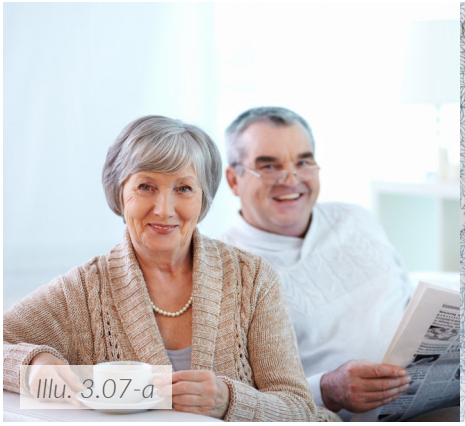

Illu. 3.06-a


Illu. 3.06-b


Illu. 3.06-c

Inhabitants

The target group for the product could be beneficial to, is the human in any age category, from infant to elderly, since it is of very high importance having proper indoor environmental conditions.


Illu. 3.07-a


Illu. 3.07-b


Illu. 3.07-c

The target group is following the tendency of renting rather than to owning an accommodation. However, it should be kept in mind if the proposed solution could accommodate both situations. The age of the building and the size should not be considered as a limitation but more as a challenge to solve. The inhabitants are of all ages, genders and number of people since everyone shall have a good indoor climate without compromising.

DECISIVE FACTORS & PROVENIENCE

It is important to know which actions and products at home are main responsible for each of the four indoor air quality parameters. Following section presents the most natural and most encountered causes, applicable for most homes scenarios. [WS. 05] [WS. 06] [WS. 07] [WS. 08] [WS. 09] [WS. 10]

Volatile Organic Compounds (VOCs)

Illu. 3.08-a

Illu. 3.08-b

Acetone: Nail & furniture polish, wallpapers, varnishes
Benzene: Glue, gasoline, detergents, combustion
Formaldehyde: Clothes and other treated fabrics, polyester, cigarettes, stoves & fireplaces, cleaning products, resins, fragrances, carpets, leather, wood
Dichloromethan: Paint solvent, paint, medicines, electronics coating, insects spray
Toluene: Tobacco smoke, adhesives, paints, vehicle exhaust
Xylene: Solvent, rubber, ink, adhesives, leather

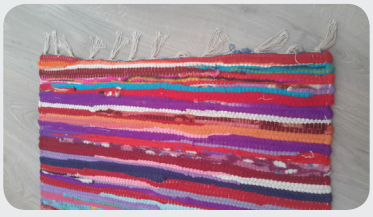
Carbon Dioxide (CO_2)

Illu. 3.08-c

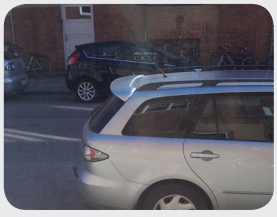
Illu. 3.08-d

Human breathing together with possible pets at home contributes the most to the excess CO_2.
The concentration of a breath is 48000ppm.
Cooking and baking are the second most important source of CO_2. In general any combustion process, even a lighting candle increases the CO_2 level at home.

Airborne Particulate Matter (PM 2.5)



Illu. 3.08-e



Illu. 3.08-f

PM 2.5 refers to 'fine' particles, with diameter less than 2.5 microns. There are considered as being the most dangerous for the human health.
Their provenience varies from: bacteria, viruses, vehicles exhaust, combustion processes, dust mites, pollen, mould, cooking smoke, spores, fumes, pet dander, fabrics particles, human skin, while also the ones from outside enter when opening the windows.

Relative humidity (RH%)

Illu. 3.08-g

Illu. 3.08-h

RH = pressure of water vapors/pressure of saturated water vapor.
The indoor relative humidity increases as a result of activities such as showering, taking a bath, washing and drying clothes inside or cooking and boiling food.
However, human breath, along with the ones of pets is a significant continuous releaser of moist.

DECISIVE FACTORS & QUANTIFICATION

In order to understand how indoor air quality is perceived by the inhabitants, the most important four parameters are evaluated. Presented limits are the ones at which personal comfort is perturbed or becomes a health threat. [WS. 05] [WS. 11]

Volatile Organic Compounds (VOCs)

Total Volatile Organic Compounds (TVOCs)

Toxic exposure - Severe health effects

25 mg/m³ (ppm)

Discomfort range

- *Headache*
- *Tiredness*
- *Allergies*
- *Lack of concentration & attention*

3 mg/m³ (ppm)

Multi-functional exposure range

0.2 mg/m³ (ppm)

Comfort range

Illu. 3.09-a

Carbon Dioxide (CO_2)

40.000 ppm

Coma, Death
Paralysia, Brain damage

Over 5000 ppm

Time exposure of max. 8 hours

- *Headaches*
- *Sleepiness*
- *Stuffy air*
- *Lack of concentration & attention*

2500 ppm

General drowsiness

1000 ppm

Complaints of stiffness & Odor

700 ppm

Acceptable indoor level

400 ppm

Healthy, normal outdoor level

350 ppm

Illu. 3.09-b

Airborne Particulate Matter (PM 2.5)

35 µg/m³/ 24 h. mean[IT-1]

Associated with app. 15% higher mortality risks to Air Quality Guideline (AOG) level

25 µg/m³/ 24 h. mean[IT-2]

Reduced pre-mortality risks with 6% than IT-1 level

15 µg/m³ /24 h. mean[IT-3]

Reduced mortality risks with 6% than IT-2 level

10 µg/m³ /24 h. mean

Reduced cardiopulmonary & lung cancer mortality with 95%

Illu. 3.09-c

Relative humidity (RH%)

100% RH

- *Fungi /Mould (70-100% RH)*
- *Dust Mites (60-100% RH)*
- *Allergic Rhinitis & Asthma (60-100% RH)*

45% Winter / 65% Summer

Comfort level for people with no serious health affections

40% Winter / 60% Summer

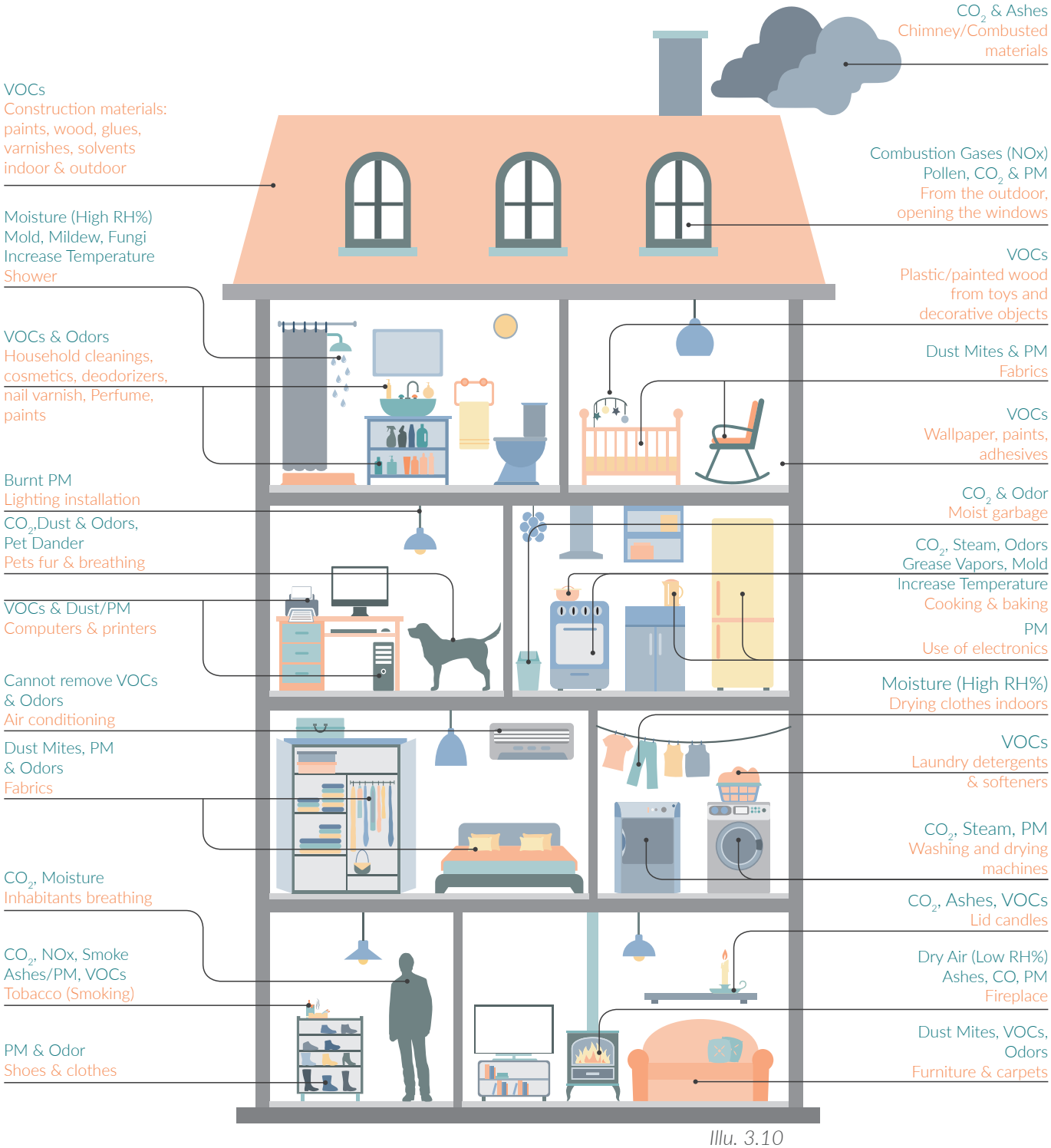
- *Viruses/Bacteria (0-30% RH)*
- *Respiratory Infections (0-40% RH)*
- *Allergic Rhinitis & Asthma (0-40% RH)*
- *Ozone Production*

0% RH

Illu. 3.09-d

LOCATION - ACTION - EFFECT

The following illustration presents a condensed conclusion of the most common causes for unhealthy indoor climate and its source, the scenario being valid for all types of accommodation. It is noticeable that all the belongings in private homes and most simple actions over the day have influence on the quality of air. All the presented parameters are scientifically identified as 'Sick Building Syndrome'. [WS. 12]



Illu. 3.10

STANDARD EQUIPMENT

For taking a fast and cost effective action regarding indoor climate, it is important to know which is the standard equipment found in most homes with the purpose of purifying and balancing the indoor environment. This takes as offspring the rented Danish homes and it is most often in built installations which are meant to help ventilate, keep optimal humidity level and temperature. [WS. 13]

Kitchen

An exhaust or cooker hood is the equipment mounted usually on top of the stove and contains a mechanical fan. When turned on, the moist air from cooking is absorbed and ran through a filter, usually of carbon, to remove the airborne grease, combustion resultants, smoke, odors, excess heat and steam. Most hoods exhaust the air outside the building, while some only recirculate it back in the room after cleaning it. The carbon filter shall be replaced approximately every half of a year and the grates shall be cleaned from grease continuously.

Illu. 3.11 Cooker Hood

Bathroom

Following are the most common bathroom ventilations:

- Mechanical, where a fan placed on the building roof extracts air constantly from all homes
- Electrical, which either start when the light switch is pressed or it has a timer for certain run cycle or a humidity sensor which triggers the start.
- Natural channel through which steam comes out, due to self rising to the ceiling level
- Window, by manual opening

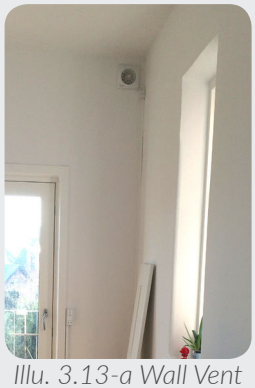
Illu. 3.12-a Mechanical Vent

Illu. 3.12-b Electrical Vent

Sleeping Rooms/Living room

Most common ventilation for these room are:

- Window opening - manual ventilation
- Fresh Air Vents mounted in the window frame
- Mechanical or electrical vent mounted in the wall
- Natural channel for fresh air exchange - wall mounted



Illu. 3.13-a Wall Vent

Illu. 3.13-b Window Fresh Air vent

For all the above name standard equipment, it is assumed to be common sense in using it both in rented and private owned accommodation. The manual ventilation through window opening is the most complementary one for CO_2 and VOCs. There is no season dependent adjust-ability regarding humidity level or fresh air exchange rate. A next step in research will be interviewing rental agencies on what type of equipment their properties have installed.

INTERVIEWS & STATEMENTS

In order to understand where precisely is it important to intervene for improving indoor climate, a series of interviews have been carried out. It was of high need the opinion of home rental agencies and retailers for all purpose ventilation and indoor climate systems. Moreover, an important role is played by one of the designers of tomorrow's housing: Department of Civil Engineering - AAU. [WS. 14] [WS. 15]

Accommodation organizations

"We receive most of the complaints about bad indoor air during the autumn and winter months. We suspect that it is because inhabitants do not air out often in this period of time."

Jesper Futtrup - Project leader
Hasseris Boligselskab Aalborg

"Generally there are complaints about bad or missing ventilation...There are multiple places were the inhabitants are clogging the ventilation system...Often they only need a simple explanation, nothing very technical"

Kasper Nielsen - Operating staff
Viva Bolig Aalborg

"Our old buildings have only mechanical ventilation in the kitchen and bathrooms. The fresh air exchange is naturally made ie. by opening the windows."

Jesper Weng - Inspector
Alabu Bolig Aalborg

"The most often reasons for complaints are due to improper use of the home by renters: drying clothes inside, having large size pets, not airing out enough through the windows, long showers or too less heating the place."

Kim Bech Hillgren - Janitor
Himmerland Boligforenig Aalborg

"8 out of 10 renters do not follow our advice on airing out regularly, since it has high importance. Drying clothes indoors and apparition of thermal bridges are also on of the three reasons for bad indoor climate."

Jacob Klit Christensen - Building inspector
Plus Bolig Aalborg

"We often experience the renters drying their clothes inside the accommodation, slit valves in windows are closed or the needed airing out is missing in the accommodations."

Jesper Futtrup - Project leader
Hasseris Boligselskab Aalborg

Retailers for indoor climate systems

"Here at Bygma, the products we sell the most are by far the bathrooms ventilators, for bathrooms with too high humidity level. On Bygma.dk we mostly just sell the products so the advisement-part is very limited."

Rune Petersen - Customer service and sales
Bygma

"Our costumers are very focused when they shop in our store, they have searched they assortment from home. We do not advise our costumers about the products, and they do not ask for our knowledge."

Michel
Hjem og Fix - Aalborg

Department of Civil Engineering AAU

Illu. 3.14

Theofanis Ch. Psomas
PhD Fellow

Theofanis Ch. Psomas is PhD Fellow at the Department of Civil Engineering of AAU.
The overall experience shows that the most important perturbs are CO_2 and VOCs emissions, while people simply cannot see them. He confirmed as well that inhabitants are simply not aware of the air condition at home and what could be dangerous for their health.
He is currently working on developing an actuator system which will open the windows automatically when the air quality inside reaches uncomfortable levels. *[WS. 16]*

"If I would be you, I'd focus more on the CO_2 and VOCs. Humidity level is not the most concerning matter, mostly because people can still see the condense drops and feel the increase in humidity."

"As you can see even from the research papers, people only air out when they feel the need, not knowing that an intake of fresh air should be made more often."

General problems of poor indoor climate

Rental agencies focus on informing their tenants on the bad consequences of not airing out enough, drying clothes indoors and having too low temperature in their rooms. All these have consequences on apparition of mould and fungi spores on the inner walls, further on with damaging health effect on inhabitants. None of the agencies informs about reactions on excess levels of CO_2 or VOCs. These last two are acknowledged as being high importance factors only by people with expertise in indoor air quality.

Visible indications

- Fungus spores
- Condense on windows
- Expansion of wood parts
- Wet outer walls

Invisible indications

- CO_2 level
- VOCs level
- Particulate Matter
- Germs and Bacteria

INITIAL TESTS & OBSERVATIONS

Followings observations and tests were performed at group members homes related to the five main air quality parameters: CO_2 level, TVOCs concentrations, particulate matter absorption, relative humidity, grease and odors. The observations are aiming for a fast validation of a real problem of indoor air quality and opportunity for further work in area.

TVOCs concentration

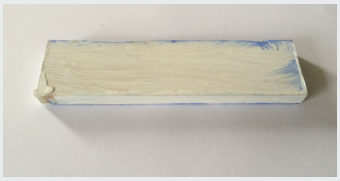
Initial testing consisted in measuring the VOCs release from different materials. The samples collected are from the most encountered ones at home. Each of these was kept in a glass container for 30 minutes. Glass is assumed to not release VOCs. The start and end values were noted down. *[WS. 17]*. Spray and wall paint on wooden surface and perfume had the highest VOCs release.

Illu. 3.15 a

Medium-density fiberboard with spray paint

End level: 34 ppm

Illu. 3.15 b



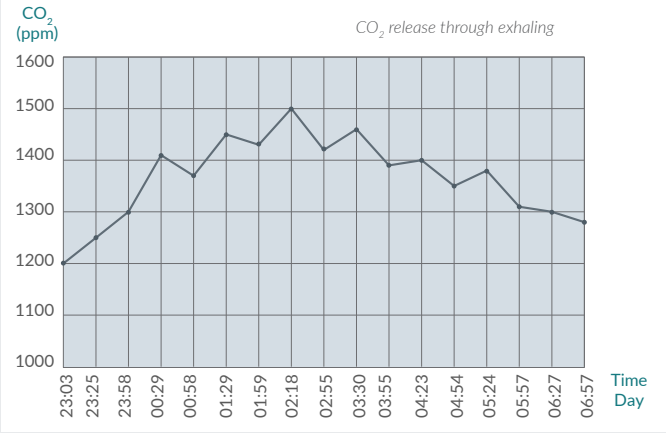
Medium-density fiberboard with wall paint

End level: 7.8 ppm

Perfume: End level: 25 ppm

CO_2 level

The experiment consisted in monitoring the CO_2 level during the entire night, in a bedroom where two adults were sleeping. The door and windows were closed at all time during the testing. The aim of the test is to observe the achieved concentrations and behavior during the night.
The start concentration was of 1200ppm and it had a sinusoidal behavior, with a peak concentration of 1500ppm at 02:18. It is assumable that some materials in the room absorb CO2 or humans have a various breathing concentration during the sleep. *[WS, 18]*

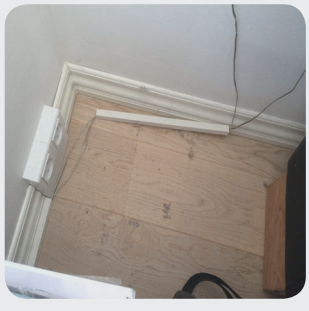


Illu. 3.16

Particulate Matter

Dust accumulation on electronics
Illu. 3.17 a

Dust accumulation on lighting objects
Illu. 3.17 b



Dust accumulation behind furniture
Illu. 3.17 c

Major dust accumulations were found on the floor, under the furniture or on the electrical equipment such as television and lamps. Gravitational force determines the fall of the airborne particles on the floor, while the electrostatic effect determines the particles to lay on the surface of electronic equipment.

Humidity & Dehumidifier

Window condense
Bedroom - Temp.: 19C
Illu. 3.18 a

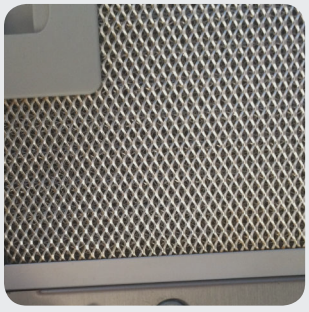
High RH in the bathroom
dehumidifier is needed
Illu. 3.18 b

A dehumidifier has been used for testing if there can be collected any excess moist in a 49 m^2 apartment, with two people living inside, while drying clothes indoor.
A Bright dehumidifier was used. *[WS. 8] [WS. 9] [WS. 19]*

Day 1 successive results
0.6 L collected in 4 h, from a RH of 64% down to 53%
0.25 L collected in 2.5 h, from RH of 53% down to 48%
0.13 L collected in 2 h, from RH 48% to 44%
Day 1 successive results
0.35 L collected in 3 h, from a RH of 54% down to 51%
0.55 L collected in 3.5 h, from a RH of 57% down to 54%

Grease & Odors

Cooker hood
before being cleaned
Illu. 3.19-a



Cooker hood
after being cleaned
Illu. 3.19-b

Internal fabric filter
soaked in grease
Illu. 3.19-c

Cooking was the activity with major release of odors and grease vapors.
The exhaust hood has been dismounted and fabric filter was replaced with a new one.
Grease accumulations were visible on both metallic grate and filter.
Other odor common sources are the human body itself and personal care products.

Mould & Fungus spores

Fungi spores
Door & Window frames
Illu. 3.20

Mould and fungi spores have been identified on the window and door frames made of wood.
The wooden parts present cracks also, most expected cause being the high humidity from rain water, which has infiltrated in the frames.

Tests & Observations Subset
Work Opportunity

There is a clear potential for working further with any of the five parameters, while the most simple tests and observations confirmed their presence at home.
Next step in the process work will be to find out whether there is a common knowledge about these factors for other people, what is their perception on them and if they consider them to be health threatening.

Illu. 4.01

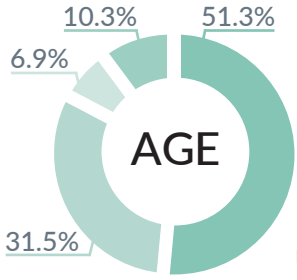
USER INSIGHT

Current chapter begins with the most relevant results of an online survey on indoor climate, followed by two interviews of subjects experiencing with poor air quality due to certain conditions.
A newspaper article, a street survey, illustrated persona and their daily life, as well as general health affections are also part of better understanding the potential users.

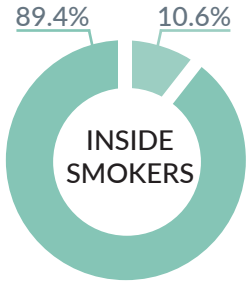
ONLINE SURVEY

The survey contained series of carefully selected questions for getting an understanding on the behavioral patterns of subjects regarding their acknowledgment and actions on indoor climate. The total number of respondents was 273 persons. Beneath the most interesting findings will be presented as donut charts while the full report made upon the Online Survey can be found as a worksheet. [WS. 20]

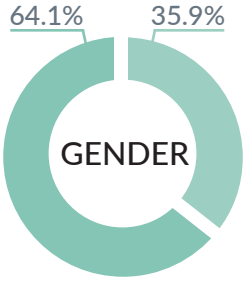
Essential Results



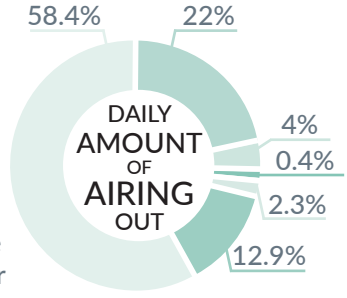
51.3% of the respondents are 18-25 years old



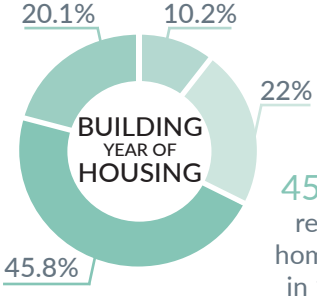
10.6% of the respondents accepts smoking indoor



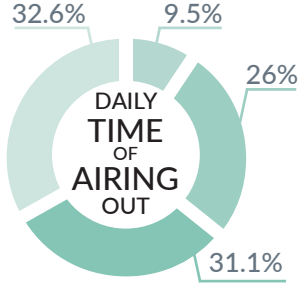
64.1% of the respondents are women



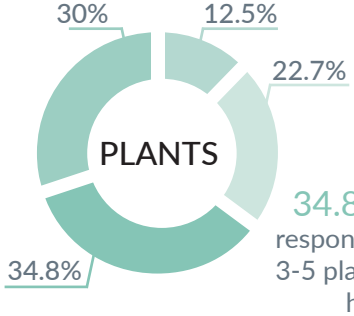
58.4% of the respondents air out 1 time a day



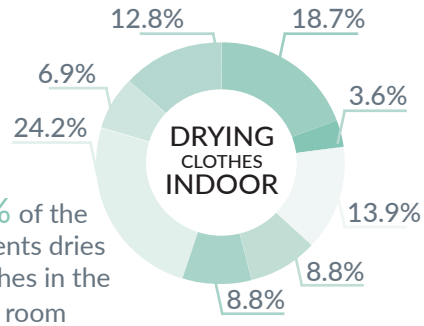
45.8% of the respondents homes are build in 1951-2000



32.6% of the respondents air out min. 11 minutes a day



34.8% of the respondents have 3-5 plants in their home

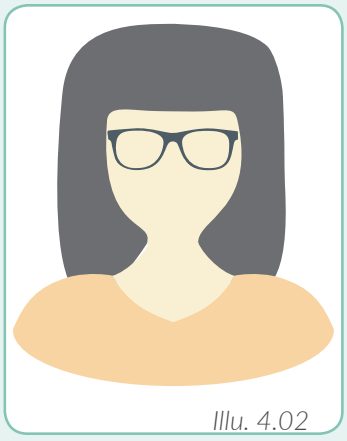


24.2% of the respondents dries their clothes in the living room

INTERVIEWS

The interview is made with persons living in an accommodation with a bad indoor climate to get to know their story regarding the indoor climate, to find out how the conditions have developed over time and the bad indoor climate has effected the interviewed person. The full interviews can be found as worksheets [WS. 21] [WS. 22]

Smoking at home



Illu. 4.02

Käte
North Jytland, Denmark

Käte is female, 57 years old, very positive and optimistic and she lives in a house from 1857, which is very badly isolated.

Käte had been smoking cigarettes for the last 40 years, and over time she became an emotional smoker. Käte smokes 10-15 cigarettes each day.

Käte is aware that smoking has a bad impact on her health, and she has tried to stop twice but without luck.

Käte has health problems, which has resulted in her smoking less than she did earlier.

"I only smoke in the living room and I do not open the windows while I smoke. I air out app. 5-10 minutes each day during winter"

"I am a bit unsure exactly what actions I need to do in order to achieve a great indoor climate"

"When the weather is hot outside, I just leave my windows open all hours a day - I like the fresh air"

Acknowledging the problem

On February the 22nd, the local newspaper MetroExpress has published an article related to the bad indoor climate: "Bad indoor climate is a cause of death".
Jørn Toftum, university lecturer and researcher in health and indoor climate, gave his opinion and results of research to public. He mentioned how the inoffensive everyday actions at home contribute to chronic allergies and affections and are especially harmful for children and elderly.

[MetroExpress, (2016)]

"Firstly I would like to point that it is the things inside out houses which give a bad indoor climate here in Denmark. It is the ultra fine particles from the lit candles, flame retardants from electronics and furniture, nitrogen oxides from our stoves. All these are elements which affect our health in a negative way."

"Children's rooms are especially the ones to keep an eye on. Treated tree furniture imported from outside EU is a main release of formaldehyde. Plasticizes found in toys and chemicals from different paints and solvent are just as harmful. It can cause them allergies and asthma."

Humidity at home

Illu. 4.03

Lone Kragelund Andersen
Gistrup - North Jutland

Lone is living with her son Martin in a terraced house with the size of 70 square meters and noticed problems with the indoor climate after only 2-3 months. It came in form of dew on the windows. She did not react in any way but just wiping off the water drops every morning. She and her son lived in these conditions for 1 year before taking action. During this time she developed a skin disease and Martin made an allergy on its eyes causing them to be read and itchy.
She borrowed a dehumidifier and it did not take long before the dew stopped appearing. During this time, both her and Martin's symptoms disappeared.

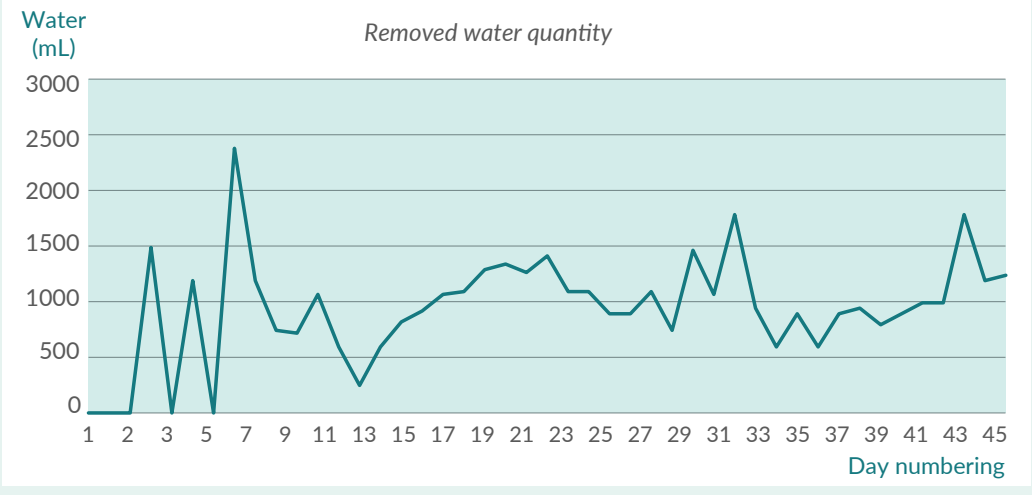
"In the mornings there was a lot of dew on the windows. Eventually I just got used to clean it everyday, but I was still thinking that this situation cannot be a normal one."

"During the one year of high humidity I have developed a skin rash, my skin was simply peeling off. My son has been also more sick than usually and he felt tired all the time."

Quantifying the humidity problem

The test was performed during 45 days and it included using a dehumidifier at Lone's place. Relative humidity at the beginning of the test was on 65%, while the end value when the test finished was 40%.

The chart below present the amounts of water (mL) removed during each day. During the weekends, the removed moist quantity was higher, since both Lone and her son Martin were at home for more hours.



Illu. 4.04

STREET SURVEY

Earlier it has been detected that people do not open their windows at home in order to get exchanged the air. For the team to understand why this is not done, a street survey was performed.
The outcome of the survey is presented beneath and the full survey report can be found as a worksheet [WS. 28].

Street Survey Details

For the street survey 50 unfamiliar citizens of Aalborg was asked on the street, about the habits regarding airing out in the home.

58% of the respondents were women

42% of the respondents were men

36% of the respondents owns their own home

64% of the respondents rents their home

52% of the respondents air out 1-2 times a day

78% of the respondents said they have ventilation

Conclusion - Street survey

From the answers received it can be noticed that it is very different in what amount people air out in their home.
None of the interviewed persons mentioned terms as particulate matter, volatile organic compounds and CO_2 as reasons for airing out, only the relative humidity.
One of the interviewed has a good ventilation system installed in the home and thereby assumed to have a good indoor climate by default.
Two persons had their windows open at all times, because they smoke indoor.
The most mentioned reasons for people to air out their home is that they like the fresh air from outside.
It can be concluded that the biggest reasons for people not doing it is because they are not aware of the fact that it is a need in order to keep a good indoor climate, they do not like the cold exchange air and lack in knowledge on how to secure a good indoor air quality.

Often

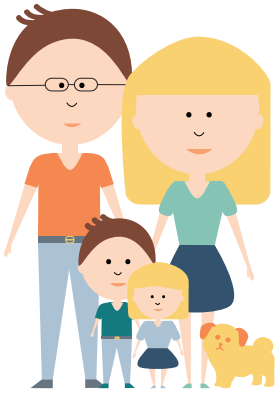
- High RH% after bathing
- Cooking makes the home steamy
- Allergies
- Smoking indoor
- Likes to sleep in a cold bedroom
- Fresh air
- Birds singing
- Natural light
- Health impact
- To lower indoor RH%
- To prevent/remove heavy air

Rarely

- Dislikes cold air
- Keep warm air out during summer
- The air seems fine
- Convinced once a day is enough
- Do not spend time at home
- Being forgetful
- Dislikes the cold draft
- Laziness
- Owns a good ventilation system
- Believes good indoor climate is present
- Ignorance

PERSONAS / CASES

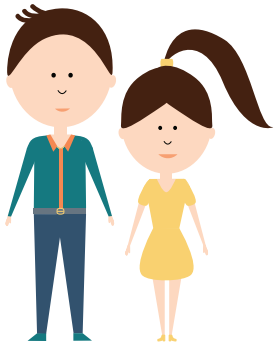
The following three personas illustrate different living situations which have been developed based on the gathered information from the Online Survey [WS. 20]. The cases include information about family members, common activities, habits and other relevant actions regarding their indoor climate. The current section is an excerpt and the integral texts can be found in the Worksheet Compendium [WS. 24]



Illu. 4.05

The young family

This is John and Lise and their beautiful children, Lucas and Ann. John and Lise both work as social workers in the municipality. Lucas plays football on Mondays and Ann receives dance lessons for small children on Thursdays. The young family cooks dinner every day. The 5th member of the family is the small cotton dog Holger, which loves to play ball outdoor and sleep in Lucas' bed when no one is home during the day. The family has no plants since Holger cannot leave them alone. The young family lives in an old apartment where there is draft from the windows. Because of the draft the young family does not air out in fear of getting an even colder apartment. They aways have a lot of laundry which is always being dried in the corner of the living room. Lise is spending an extreme amount of hair spray each morning, which irritates John, but he loves her anyways.



Illu. 4.06

The middle-age couple

Freja and Benjamin are young, trendy, always following new tendencies and love to discover the newest gadgets on the market. They have no children yet and they fell in love with each other on a online dating app. They live in a beautiful and modern decorated apartment and it is always extremely clean because Freja is a cleaning fanatic. Freja washes the floors twice a week, cleans the windows inside and outside once a week and is wiping of dust every second day. Her favorite cleaning liquid has the smell of lavender. Every evening at eight they pour a glass of wine, light up some candles and put on a movie to relax.

Illu. 4.07

The elderly couple

Gunnar and Kirsten have been happily married for 47 years and lives just outside the city on a old farm with their cat Romeo. They have been working hard their entire life and Kirsten's health is beginning to be a bit problematic due to this hard work prior in her life. She has breathing difficulties and Gunnar is now only smoking in the kitchen and not in the entire house as he used to. Kirsten cooks food for her and Gunnar every evening on her beloved and old gas stove. They are both fond of nature, but because of Gunnar's bad hip, they have decided to bring the nature into their home so Gunnar will not fall and risk his hip getting worse. All of the plants has resulted in a very humid indoor climate which is visible as dew on the inside of the windows.

HEALTH IMPACTS

The following illustration presents the most common symptoms and illnesses related to the quality of indoor air and the influencing parameters, also named as Sick Building Syndrome. A syndrome is based on a serie of symptoms. An obstacle in the diagnostics of SBS consists in the missing or inadequate objective examination methods that are available to the doctors. [WS. 05] [WS. 07] [WS. 25]

Headaches - CO, CO_2
Dizziness - VOCs
Lack of concentration
Cognitive issues - VOCs
Fatigue - CO_2, CO
Central Nervous System Damage - CO_2, VOCs
Drowsiness - CO_2

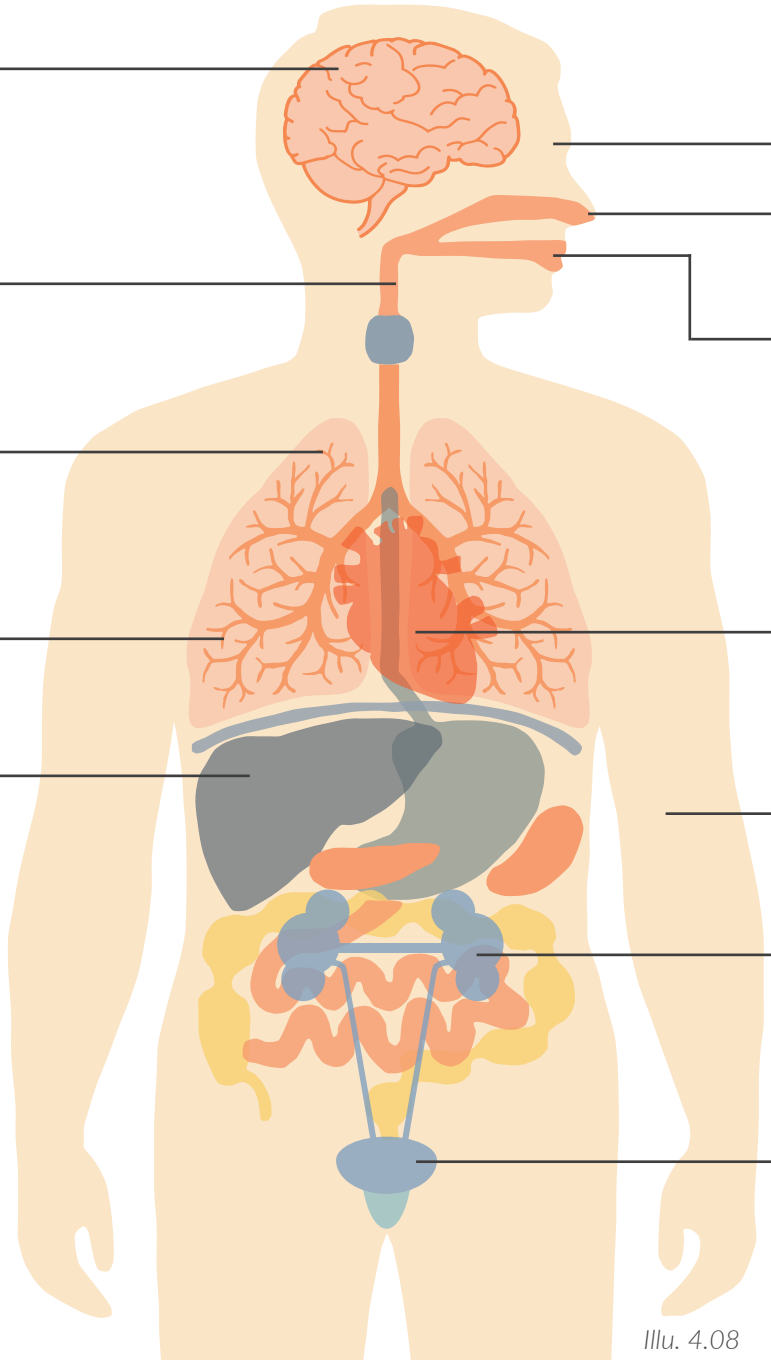
Throat irritation (VOCs)

Chest tightness
Drowning sensation
Wheezing
Dry cough
Bronchitis – (irritation of the lung bronchi) (PM, mould, fungus)
Toxic alveolitis

Chronic Obstructive Pulmonary Disease (PM)
Reduced Lung functions
Lung Cancer (PM)

Liver Damage (VOCs)

Other General Affections
Leukemia
Nausea
Weakness
Lethargy
Anxiety



Eye irritation - Dryness, itching, tearing, redness , conjunctivitis (VOCs, high RH%)

Sneezing (PM)
Irritated mucous membranes (VOCs)
Congestion

Coughing (VOCs)
Asthma (PM)
Breathing difficulties
Humidifier fever-Influenza alike symptoms (too high RH%)

Cardiovascular diseases (PM, O_3, SO_2)
Increased heart rate & blood pressure (CO_2)
Stroke

Skin irritation, rashes, redness, general & localized itchiness (VOCs, CO_2, too high or too low RH%)

Kidney damage (VOCs)

Reproductive system affections (VOCs)
Increased risk of fetal mortality or affections (VOCs, CO_2, PM)

Illu. 4.08

All the listed Sick Building symptoms can lead to severe affections after long exposure.
They are most often hard to connect to their real causes: the recurrent poor quality of indoor climate.
Moreover, inhabitants react differently to air conditions, leading to difficulty of finding the right cause and diagnose.

BREATHABLE AIR

Breathing in general plays a high role in creating excess CO_2 at home. Here there are included all the organisms which have influence: inhabitants, their children and the pets. Based on the previously identified recommended values for indoor air quality constituents, basic calculations are made for different scenarios and presented in the following section. [WS. 06]

Air composition

The air humans inhale is composed out of approximately:
78.62% nitrogen
20.84% oxygen
0.96% argon
0.04% carbon dioxide
0.5% water vapor

Exhaled air contains about 4% CO_2 and only 16% Oxygen. The CO_2 concentration of each breath exhaled is 100% higher than the inhaled one.

A normal breath produces a CO_2 concentration of around 48000 ppm.

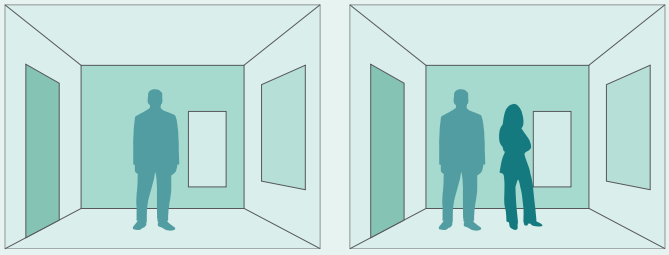
In average, a human exhales app. 0.075 m^3/min or 4,5 m^3/h air volume. It gives an exhales CO_2 concentration of 0.003m^3/h or 0,18 m^3/h.

Variables
Indoor Breath Air

- Inhabitant's age
  Determines lung capacity
- Number of pets and their size
  Determines lung capacity
- Room surface and height
  Available initial air volume
- Type of walls/air draft
  Wall absorption of CO_2
- Air Exchange rate
  Fresh air intake for given initial volume

Assumption for extrapolation

It is assumed that a person is placed in an airtight room and breaths normally. No other materials in the room release or absorb from the exhaled CO_2 concentration. There is no air exchange during the experiment, nor air draft. The room has a random given volume of 62.5 m^3, WxLxH = 5x5x5m. A child or pet breath counts as half of average human, in the absence of other values.



Illu. 4.09

Initial CO_2 level in room = 1300 ppm

Final CO_2 concentrations (ppm)

	1 Adult	2 Adults	2 Adults +child/pet
After 1 hour	1438	1576	1645
After 12 hours	2959	4618	5447
After 24 hours	4618	7935	9594

It is noticeable that humans breath does have a high impact on CO_2 level when no proper ventilation is available. The most costless action for reducing the CO_2 excess is the manual ventilation by opening the window. This is recommended to be done several times each day, for a few minutes and especially when cooking or after taking a shower.

MARKET INSIGHT

Illu. 5.01

Current chapter begins with a presentation of additional purchased home equipment for balancing indoor climate and latest trends in smart monitors. When reaching the final product specifications, a research is made on the current indoor air purifier using the power of indoor plants. Other available types of air purifiers are also investigates.

SUPPLEMENTARY HOME EQUIPMENT

Often people realize that the air quality is not optimal for their well-being at home and therefore buy an additional product as an intended solution to their problem. Following section presents the available products and their price range in the most known Danish supply chains. [WS. 26]

Air Cleaners/Purifiers

Illu. 5.02-a Honeywell

Illu. 5.02-b Woods

Illu. 5.02-c Wilfa

Price range:
899-5595 DKK

Illu. 4.01 a
HEPA filter - 99.97% efficiency
Illu. 4.01 b
ION HEPA - filter, 99.98% efficiency
Illu. 4.01 c
UV light filter for bacteria removal

Ventilators

Illu. 5.02-d Quine

Illu. 5.02-e DUKA

Illu. 5.02-f DUKA

Price range:
899-5595 DKK

Illu. 4.01 d
Supply: 230 V | dB: < 35
Illu. 4.01 e
Supply: 230 V | dB: 17
Illu. 4.01 f
Supply: 230 V | dB: 25

Dehumidifier

Illu. 5.02-g Teclime

Illu. 5.02-h Woods

Illu. 5.02-i Zibro

Price range:
1.795-6.595 DKK

Illu. 4.01 g
3 L reservoir | 220 -240 V supply
Illu. 4.01 h
2.7 L reservoir | 220 V supply
Illu. 4.01 i
1.5 L reservoir | 220-240 V supply

There is a generally higher interest in acquisition from the people which rent a home, since it is the minimum investment and does not require changes in house structure or appearance.
But in fact it does not seem that the inhabitant's needs are met in the available products. The air purifiers have focus on collecting airborne particles only, while organic compounds and carbon dioxide concentrations are not reduced.
Most common found ventilators are intended to be mounted on the ceiling and have the air extraction principle.
The available dehumidifiers on online shops only inform about the maximum room surface for optimal operation, where is in fact the room volume, which makes a difference in product efficiency. Most shops do not inform what is the dehumidification principle: compressor or desiccant wheel.
Regarding the product design, these are running on color variants: white and black, with simple shape and very visible and large grates for air circulation.

Smart Monitors for Indoor Air Quality

Illu. 5.03 a

Illu. 5.03 b

Illu. 5.03 c

Illu. 5.03 d

The products in this category can be defined as remotely equipment which has the ability to sense one or multiple parameters of air quality at home, store and process data and make it available for the users to see through the dedicated mobile application. *[WS. 27]*

Recorded parameters are often:

- Relative Humidity
- Temperature
- Particulate Matter 2.5 or 10
- Total Volatile Organic Compounds
- or single compound only
- Carbon Dioxide level
- Carbon Monoxyde level
- Smoke (smoke alarm function)
- Gas leakage detection

Air quality is usually indicated through color code on the monitor or directly on mobile interface.

Price range: 650-3900 DKK

The monitors work as sensors, indicators and/ or alarms only and do not have any influencing action in recover the recommended air quality index.

MISSING LINK

The following missing links have been identified between current action products on the market, the smart monitors available, home interior trends and functionality and the various needs in the same home. The links will be referred to during the upcoming design stages.

1

Action Product

Available products on the market have a bulky shape, is in a plastic casing and are seen as emergency solution than integrated at home.

DESIGN

The home is the nest of the family, carefully decorated, with attention on materials, colors and fabrics. Inspired well-being & comfort.

Home Interior

2

Home Needs

There are various needs for indoor air quality: excess CO_2, VOCs level, airborne particles and humidity balancing.

FUNCTION

Current products on the market help improving in on only one parameter of indoor air.

Limited Function

3

Monitoring Product

Smart Indicators play highly on design and user interface. Unfortunately these do not have a corresponding action product.

DESIGN COMPATIBLE

Action products lack in design and have integrated display and sensor for monitoring only the surrounding conditions.

Action Product

AIR PURIFICATION BY INDOOR PLANTS

The product in development is incorporating the benefit of indoor plants in daily functionality of furniture. The following section presents the main competitors using the same principle of plants, their product characteristics and aspects where improvement is considered needed. [WS. 28]

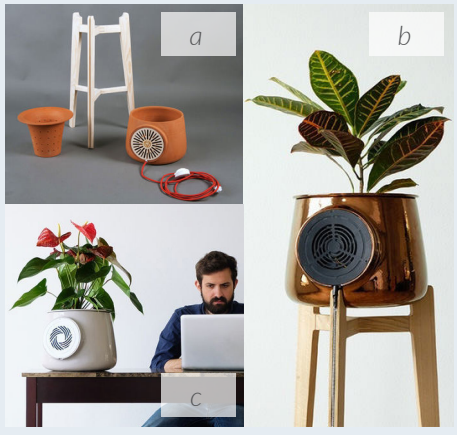
Illu. 5.04 a-d

ANDREA

Principle

A living indoor plant is placed inside the plastic capsule. Room air is continuously fed through the top slots. It runs through natural filtering from leaves, roots and the water container before is released back to the room through an electrical fan. The product aims for speeding air purification from airborne toxins and VOCs.

✗ No inlet & outlet filters
Pollen, smoke and odor are not retained
Airborne is actually not retained
Small grow area for the plant
Manual watering



Illu. 5.05 a-c

CLAIRY

Principle

Clairy consists of two handmade clay pots: outer with inbuilt fan and the inner one has holes for the plant to absorb water. It is assumed to purify the room air by the roots and soil and release it back through the fan. The smart sensors indicate the level of toxins and can send data to the mobile phone by the dedicated app.
Activated carbon are the recommended potting mix.

✗ Concept of hand made pots: Expensive, time consuming and increased delivery time for large orders.
No filter along with the fan: possible to expel soil particles in the room.
Manual watering of the plant

Illu. 5.06 a-c

AIRY

Principle

It is a plastic injected plant pot which has an internal pattern of holes. These permit air circulation in contact with the soil and roots for a higher surface than regular pots. The product aims for a natural air flow through the pot and air purification by plant roots. The pot can retain 2.4 L water and as a water level indicator.

✗ No inlet & outlet filters
Pollen, smoke and odors are not retained.
Air circulation based on stack effect only. No method of forcing the ambiental air thgrough the plant pot.
Manual watering of the plant (approx. each 6 weeks)

OTHER AIR PURIFIERS

Beside the small variety of air purifiers with living indoor plants, there other products on the market which aim for improving the indoor air quality. In their case, a more complex technology is used and no plant is involved. The following section present some of the most popular product reveled from the Internet research. [WS. 29]

Photo-Catalytic Oxidation and Ionizer

Sunpentown AC-7013 Magic Clean Air Cleaner

Illu. 5.07-a

Combines UV light and TiO_2 to form activated oxygen. Oxidizes and decomposes organic materials or smelling gas and kills bacteria.

Price: 450 DKK

Ultraviolet germicide irradiation

Honeywell UV100E3007 - Single Bulb

Short-wave length ultraviolet (UV-C) light is used for killing or inactivate microorganisms. Their nucleic acids are destroyed and the DNA is disrupted, leaving them unable to have cellular functions.
It kills airborne and surface bacteria.

Price: 2,284.36 DKK

Illu. 5.07-b

Polarized media electronic air cleaner

Rheem / Protect

Illu. 5.07-c

Polar Ionic charges are sent to the particles that pass the charged media.
The polarization facilitates the particle agglomeration. These are removed mechanically by multiple passes through the device.

Price: 450 DKK

Titanium dioxide

Airpura P600 Air Purifier

UV light shines on TiO_2 and release electrons, which react with water molecules in the air breaking them into hydroxyls (OH-). The hydroxyls attack larger pollutant molecules, break their bounds and turn them into molecules of water and CO_2.

Price: 7833 DKK

Illu. 5.07-d

HEPA (High-efficiency particulate arrestance)

Dyson Pure Cool Link Air Purifier

Illu. 5.07-e

360° Glass HEPA filter captures remove 99.97% of allergens and pollutants as small as 0.3 microns
Available on tower and desk versions.

Price: 3.200 DKK

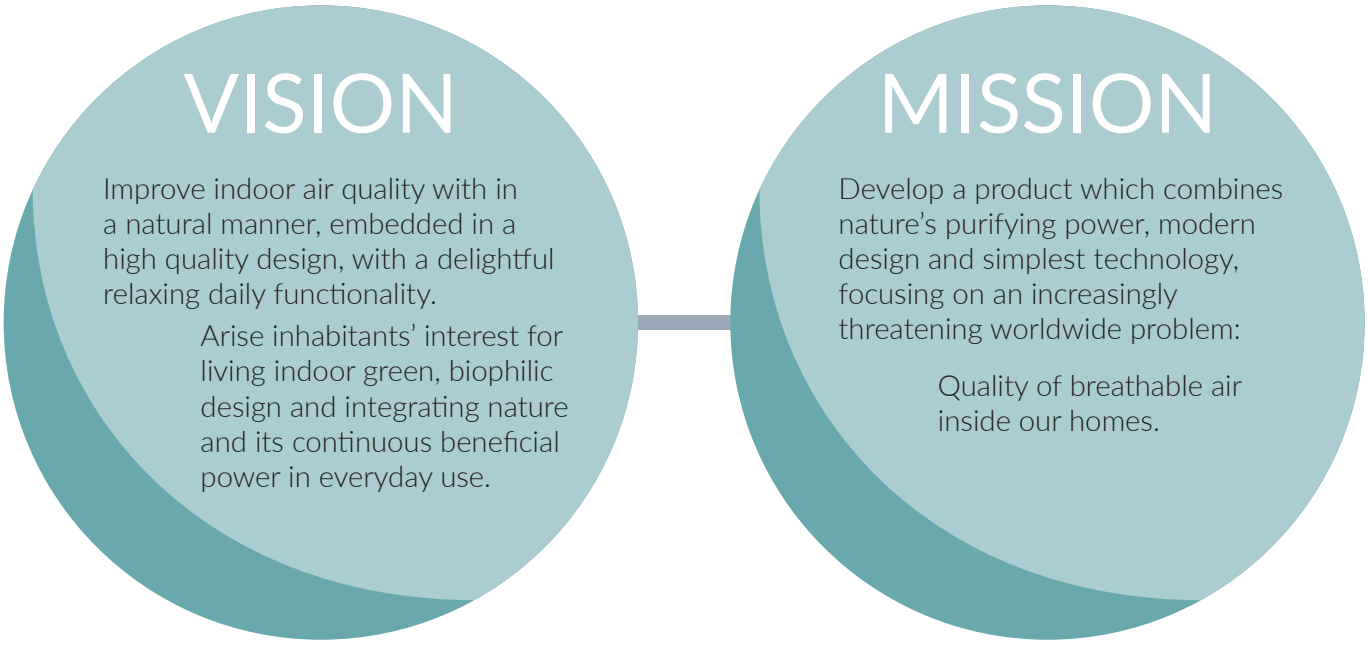
Conclusion

None of the air purifiers using living plants informs about which plants are recommended for the day time and nigh time. None of them informs about the ability of the plant to remove the excess CO_2.
On the other hand, all the air purifiers presented on page 29 only have the ability of removing airborne particles.
For the product in development it is desired to combine removal functions for both VOCs and CO_2 and airborne particles.

VISION & MISSION

Illu. 6.01

The chapter presents the chosen direction, general wishes for the further product development and main guidelines for the final product design.



PROBLEM STATEMENT

How can indoor air quality be improved by mean of living plants in the most efficient manner, with minimum maintenance, while adding functionality to the decorative symbol of plants?

Illu. 7.01

CONCEPT DEVELOPMENT

Following chapter presents the initial problem statement, sketching sessions and first concept development. The revised and prioritized requirements are conducted to a rigorous concept evaluation and the aim of using indoor plants integrated in the functionality of a daily used home object. Various tests and experiments are also important contribution to the concept development stage.

PROBLEM LISTING - INITIAL

In order to start the concept development stage, a list with problems to take in consideration has been gathered. These reflect the four main issues for indoor air quality and serve as an initial departure point for the first sketching and concept generation sessions.

Carbon Dioxide

A high concentration of CO_2 becomes dangerous for humans, especially at home. It is released by breathing, cooking, combustion, from pets or washing and drying clothes.

Volatile Organic Compounds often cause allergies, rashes and respiratory problems. These are released by cosmetics and cleaning products most often, as well as painted or treated surfaces.

VOCs

Humidity

Too high humidity at home leads to damages on the interior walls and allergic reactions for humans. Too low humidity can harm eyes, sinuses and throat, give a feeling of fever and flue-like symptoms.

Particulate Matter irritates the respiratory system (nose, throat, lungs). It often comes from outdoor pollution, fabrics, combustion processes, use of electronics.

Particulate Matter

PM

SKETCHING SESSION 1

For the first sketching session, the above mentioned four parameters are combined with a list of terms. These notions are the basis for brainstorming on various solutions for indoor air quality. *[WS. 30]*

Humidity	Adherent to multiple surfaces
Aesthetics	Multiple functions
Light	Natural material
Reuse	

Illu. 7.02 a-i

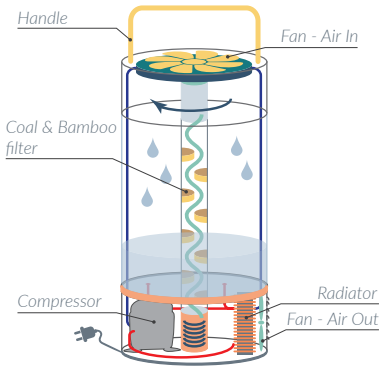
CONCEPT GENERATION 1

The four following concepts are the result of a sketching brainstorming sessions based on the serie of relevant word from initial problem formulation. The concepts are associations of the sketches with similar content and functionality of ideas, based on the Creative Technique method of Ole Striim. [WS. 30]

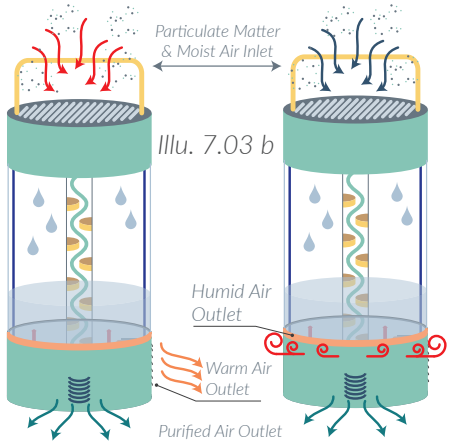
Natural Rotation

Principle

A cylindrical transparent body is serving as a triple function product: dehumidifying, humidifying using collected water and air purification during any of the other processes.
It contains a compressor and cooled pipes for obtaining condensation of moist air and a radiator for cooling the output air. The inner rotative cylinder with bamboo and active coal *[WS. 31]* serves for airborne collecting, while air suction takes place through the top placed fan.



Illu. 7.03 a



Illu. 7.03 b

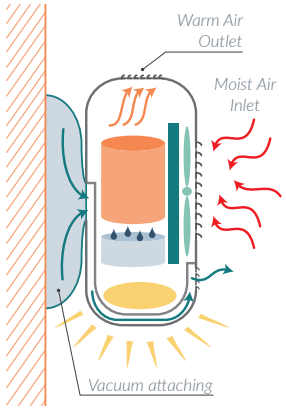
✓ Triple function
Dehumidifying
Humidifying
Air Purifying
Natural Element
Transparency

✗ Expensive
Heavy
Increased power consumption

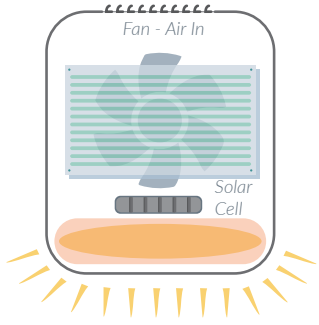
The flying source

Principle

This unit is suitable for most surfaces due to vacuum installation. It contains desiccant material absorbing moist air and releasing the condense in a water tank. As a supplementary function, a dimmed light is powered with the help of the solar chargeable light.



Illu. 7.04 a



Illu. 7.04 b

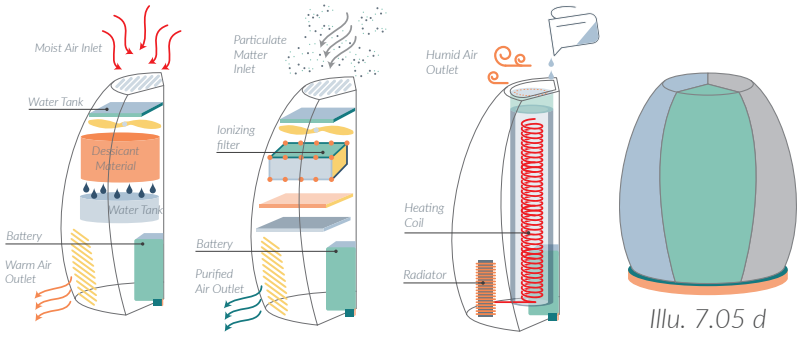
✓ Double function
Dehumidifying
Dimmed Light
Most Surfaces Suitable
Mobile

✗ Heavy for suspended placing
Low moist absorption
Low efficiency

Care & Aware

Principle

Three separable units with a common power charging base perform individual functions of: dehumidifying, humidifying and air purifying. Dehumidification is obtained with help of desiccant material, collecting the condense in a water tank. Humidification unit contains a heating coil for warming up water and release vapors. The purifying unit works based on replaceable ionizing filter.



Illu. 7.05 a-c

Illu. 7.05 d

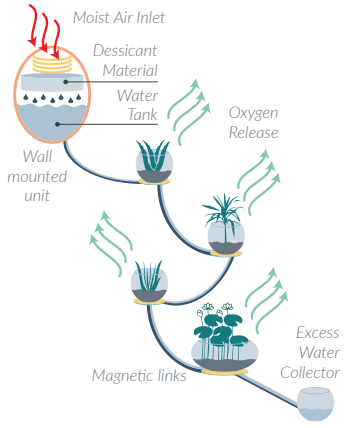
✓ Triple function	✗ High total weight
Dehumidifying	Increased power consumption
Humidifying	High daily maintenance
Air Purifying	Low efficiency
One/more units/room	Reduced run time
Remote use / Mobile	

Plantastic

Principle

The dehumidifying unit is intended for wall mounting, while the combination of indoor plants are linked through metallic connectors. It is working on a basic principle of natural air purifying. *[WS. 32]*

Dehumidification is obtained with help of desiccant material and collecting condense in a water tank. On the metallic connectors, water drops travel from the main unit to each plant pot.



Illu. 7.06

✓ Double function	✗ Heavy for suspended placing
Releasing Oxygen	Low moist absorption
Dehumidifying	Low efficiency
Decorative	
Highly customizable	

REQUIREMENTS REVISION

Environmental well-being describes humans living in harmony with the nature by understanding the impact of our actions to nature. The current product development is aiming to reconnect inhabitants to a natural state of good in their own homes. Therefore, the overall requirement have been revised with respect to both world impact from home level and crucial human needs indoors. [WS. 33]

World Impact

Illu. 7.07 Human impact on overall air quality

It is highly important to decrease the energy cost and consumption for the personal heating, cooling and ventilating systems, obviously without affecting nor compromising the indoor air quality and comfort conditions.
Burning fossil fuel has a clearly noticeable damaging effect on nature. While the population is increasing is also increases the energy use on personal and thermal comfort.
The energy required to provide this comfort (temperature, relative humidity, air purification) is estimated to be about 50% of the building total energy consumption, in most cases being in form of electrical energy.
Further on, the process of revising the product requirements will be done bearing in mind the effects on nature at individual level, highly increasing CO_2 level and finding alternatives for improving indoor air quality. The real need lays in integrating a natural solution, rather than persuade in changing the habits at home.

Requirements Revision

VALUES

- Natural (Inspired) Elements
- Decorative (Aesthetics)
- Minimal daily human maintenance
- Reduced noise level (<30 dB)
  sleeping area recommendation
- Mobile inside the home
- Reusable or recyclable parts and materials

FUNCTIONS

- Particulate Matter and VOCs removal
- Excess indoor CO_2 removal
- Oxygen release
- One person installation
  no advanced tools
- Dehumidification function
- Additional daily use integrated function

CONCEPT EVALUATION

Point Value Scheme is used for evaluating the four concepts following the parameters from the Requirement Revision. The VP-Scheme is weighting the parameters on a scale from 1 to 5. The Concepts are evaluated from 0 to 5, where value 0 is given when the action is impossible to be performed and 5 where the action is achieved at its highest.

FUNCTIONS	IMPORTANCE	C1 Natural Rotation	C2 The flying Source	C3 Care & Aware	C4 Plantastic	C1 Imp. Val.	C2 Imp. Val.	C3 Imp. Val.	C4 Imp. Val.
Dehumidify	4	5	3	5	3	20	12	20	12
Humidify	3	5	0	5	2	15	0	15	6
High CO_2/VOCs/ PM Removal	5	4	2	5	2	20	10	25	10
Portable at home	3	3	5	5	0	9	15	15	0
Low energy consumption	4	1	5	1	5	4	20	4	20
One personal installation (no advanced tools)	4	4	5	5	5	16	20	20	20
Any surface adherent	2	1	5	1	5	2	10	2	10
Additional/ second function	4	4	5	5	5	16	20	20	20
Oxygen release	5	0	0	0	5	0	0	0	25
Static electricity removal	1	1	1	5	1	1	1	5	1
VALUES									
Transparency/ Show process	2	5	2	1	5	10	4	2	10
Natural Elements	5	4	0	0	5	20	0	0	25
Production cost: <400DKK	3	2	5	0	4	6	15	0	12
Weight: < 5 kg/ entire product	3	0	5	0	3	0	15	0	9
Min. daily human maintainance	5	3	0	2	3	15	0	10	15
Decorative/ Aesthetic	5	4	3	3	5	20	15	15	25
Modular system	3	0	1	0	3	0	3	0	15
High market scalability	4	3	4	3	5	12	16	12	16
Reduced noise level: <30dB (sleeping area recomm.)	5	2	4	2	5	10	20	10	25
Recyclable/ Reusable Parts	5	2	3	2	4	10	15	10	20
Remoted run time (min. 3 days)	3	0	5	4	4	0	15	12	12
					Total	206	226	197	308

Extracted guidelines for direction

The concept with the highest score from the PV-Scheme was Concept 4, Plantastic. It have therefore been chosen as basis for the further development of concept, with possibility of incorporating additional functions. Additionally, 34.8% of the online survey respondents have stated to own 3 to 5 plants in their homes, being a clear sign of enjoying living indoor plants in their daily environment.

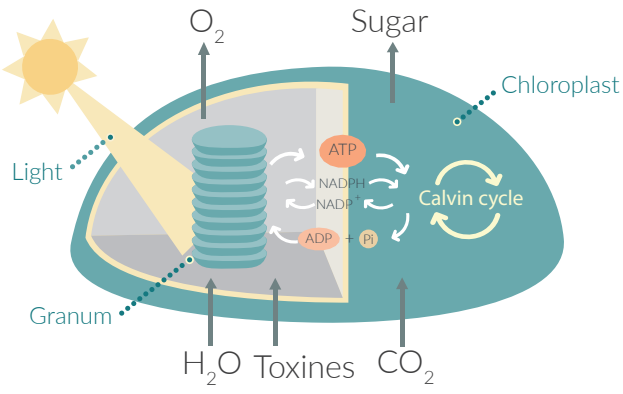
The factors with highest ponder in evaluation were:

- Excess CO_2/ VOCs/ PM Removal
- Oxygen release
- Natural Element incorporated in the product
- Reduced noise level (under 30 dB-sleeping room recommendations)
- Decorative/ Aesthetic property
- Recyclable/ Reusable parts

NATURAL BENEFITS

For obtaining the highest output from using indoor plants in the concept development, it is important to understand the natural processes which take place in these organisms and how do humans benefit from them. [WS. 34] [WS. 35]

Photosynthesis

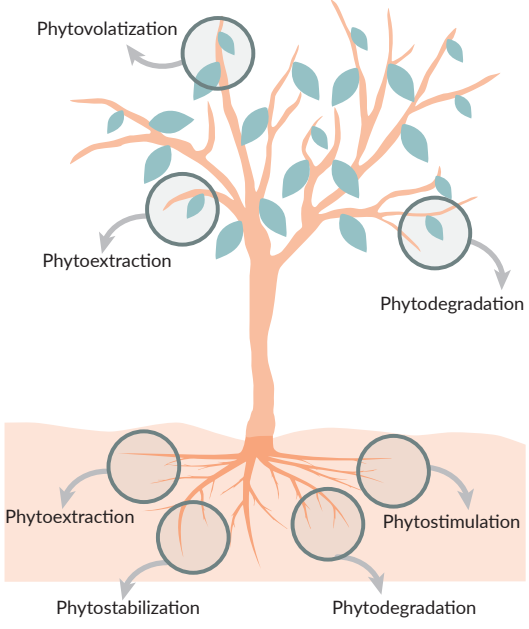


Illu. 7.08 Natural Photosynthesis Principle

Principle

All growing plants are using excess CO_2 found in the atmosphere and release O_2 during the process of photosynthesis.
The main function of photosynthesis is to ensure the growth of the plant in presence of sunlight, air and water containing nutrient salts.
A regular leaf consists of the blade, veins and epidermis. The majority of the chloroplasts is found in the blade, being the place where the photosynthesis occurs.
During their photosynthesis plants release a small amount of vapors through their pores, equivalent of human transpiration, which keeps the leaves constantly moist. The ambiental relative humidity is also increasing a few percentage due to the transpiration.

Phytoremediation



Illu. 7.09 Total mechanism of phytoremediation

Principle

Phytoremediation is the natural process using green living plants to detoxify and remove organic and inorganic air pollutants. The mechanism of phytoremediation includes degradation, stabilization, stimulation and extraction of toxins from soil, with the help of roots and rhyzosphere (fine area of soil in direct contact with the roots).

Second part of the mechanism consists of extraction, degradation and volatilization of air pollutants and takes place in the plant leaves. Most removed indoor pollutants are the VOCs.

Plants act also as a small biological filter by collecting dust and other airborne particles on their constant moist leaves.

Human response

Human brain reacts without the person even realizing it to different stimulus from the surroundings. Colors and textures are among the most common indoor stimulus. The following section explains human response to green color, indoor plants and tendency of bringing nature into work and living place. [WS. 36]

Green Color

It is automatically associated to nature and clean, pure outdoor environment. It has a calming effect during the day, while being see in the mornings boosts people us with energy.
The word is for the last decade strongly related to recycling, clean and renewable energy and a general positive effect on world condition.

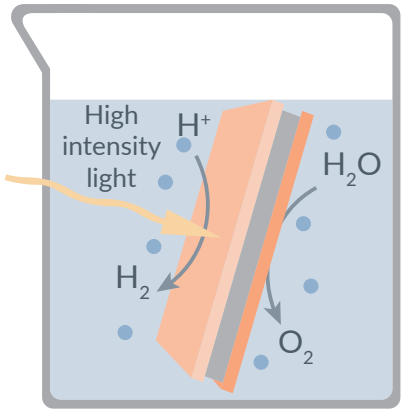
Indoor Plants

Various studies have shown that being in presence of indoor plants increase concentration ability and task performing by at least 20%, both at home or workplace.
Natural aesthetics lowers stress and anxiety by offering tranquility and positive energy. They offer pleasing visual stimulation which as well increases creativity and concentration abilities.

Biophilic Design

Biophilic design means "love of life and living systems". Interior design with accent on biophilia focuses on establishing natural elements in work and living spaces. It includes colors, textures and sounds from the nature brought indoors. It is proven to have the same beneficial effect on creativity, wellbeing and productivity.

Artificial Photosynthesis



Illu. 7.10 Principle of artificial photosynthesis

Principle

Artificial photosynthesis can be a viable alternative for reducing ambiental CO_2 at home. It is the electronic replica of the natural process with the same principle of converting CO_2 with the help of light and water into carbohydrates and oxygen. *[Illu. 7.09]*
It is necessary to have a photosynthetic cell made out of silicon and titanium oxide plates which is submerged in water. In the presence of an intense light source, the water is split into hydrogen ions and oxygen. *[WS. 37]*

Disadvantages

Does not remove: VOCs and particulate matter
Working only in presence of intense light source
Not available at small scale/ indoor purpose

Living indoor plants qualify as one harmless, low cost and self maintaining method for reducing excess CO_2 and volatile toxins from ambiental air. The natural processes of photosynthesis and phytoremediation are interdependent and require few resources in form of light, water and organic nutrients. Artificial photosynthesis is not a viable method mainly due to not removing VOCs and airborne particles. Next step in development is finding the most suitable species of indoor plants in CO_2 and VOCs removal, their particularities and efficiency rate in indoor air purification.

6 effective plants *[WS. 38] [WS. 39] [WS. 40] [WS. 41]*

For the next stage in development, six indoor plants with benefits on the humans have been analyzed based on VOCs removal ability and lights, water, fertilizer and soil needs, division method and toxicity at home.

Illu. 7.11

English Ivy
Hedera Helix

Average leaf surf.: 13 cm²

- Thricholoethylene, Formaldehyde, Benzene, Toluene and Xylene
- Bright light, but no direct sun
- Soilless potting mix or any that provides good drainage
- Soil shall be kept evenly moist spring to fall and a bit drier in the winther
- Feed monthly from spring through fall with a high-nitrogen liquid fertilizer
- A 8-10 cm cut stem tip in spring shall be placed to root in moist soil
- Can remove air borne mold
- Leaves are poisonous if eaten and it can cause skin irritation

Red Edged Dracaena
Dracaena marginata

Average leaf surf.: 16 cm²

- Trichloroethylene, Formaldehyde, Benzene, Xylene
- constant low-intensity light and no sun direct exposure during hot days.
- Good-quality, well drained potting mix, Feces, Biofilm
- Medium amount of water
- In spring and summer with 10-10-10 liquid fertilizer diluted by half.
- By cutting off the cane at any height and root them like stem cuttings.
- Toxic to cats and dogs

Peace Lily
Spathiphyllum Mauna Loa

Average leaf surf.: 16.5 cm²

- Trichloroethylene, Formaldehyde, Benzene, Xylene and Ammonia
- Bright light, but no direct sun. Will tolerate low light, but may bloom poorly.
- Peat moss based potting mix
- Evenly moist soil, but preventing from being soaked which causes root rot.
- Monthly in spring and summer with a balanced liquid fertilizer diluted by half
- Plant prefers to be pot bounded. Shall be divided each 5 years if needed.
- Toxic for cats and dogs and children. Shall not be eaten.

Varigated Snake Plant
Sansevieria trifasciata

Average leaf surf.: 33.5 cm²

- Alcohol, Acetone, Trichloroethylene, Formaldehyde, Benzene, Xylene
- Low to full (direct) sun/ Tolerant to low sunlight
- Free draining soil/ Succulent plant soil
- Soil must be dry before watering
- Feed monthly spring through fall with this fertilizer for succulent plants
- Is easy to divide due to shallow roots. Leaves shall be potted separately.
- Mildly toxic to dogs and cats Causes indigestia if consumed

Florist's Chrysanthemum
Chrysanthemum Morifolium

Average leaf surf.: 9.5 cm²

- Trichloroethylene, Formaldehyde, Benzene, Xylene, Toluene and Ammonia
- Direct sun with half shadow of minimum 4 hours of dark per day
- Peat moss based potting mix
- Medium amount of water
- Pothasium fertilizer during growth season
- Division though stem cutting and potting them.
- Leaves are poisonous for cats & dogs. Children should not touch the plant.

Aloe Vera
Aloe Barbadensis Miller

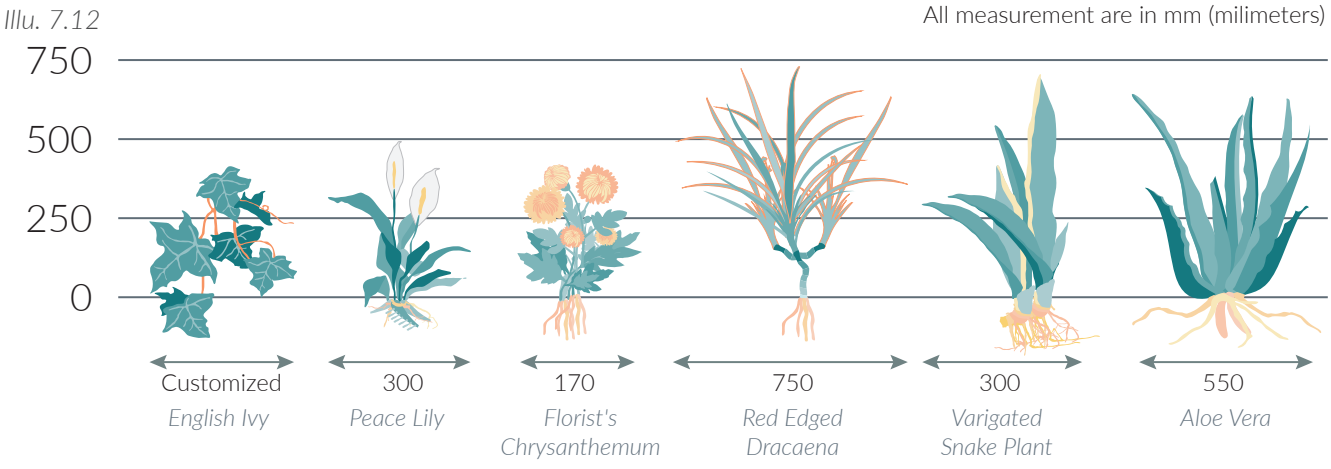
Average leaf surf.: 64 cm²

- Formaldehyde, Benzene
- Direct sun as much as possible
- Cactus potting soil mix or a regular potting soil
- Soil must be dry before watering. Leaves have water storing property.
- Usually it does not need fertilizer. If needed, phosphorus one can be used
- By removing the offsets, which are the child plants and plant them separately
- Toxic for cats and dogs

Average adult plant

A very important parameter of the six plants is the average dimension. The illustration below presents height and width for an average adult plant specimen. Plants' heights are measured above roots level, considering that roots have no constrain in vertical growth. The plants sizes may have influence on the product further development when reaching shaping stage. [Illu. 7.11] [WS. 42]

Illu. 7.12



Potting Mix

One of the most important conditions for all the identified plants is the growth media. As seen from the investigation on each plant, the two recommended type of soils are: peat moss based potting mix and succulent plant soil mix. Illustrations 7.12 a and 7.12 b present the two types. It is noticeable that the two soils have a light consistency which permits air flow to easily pass through.

Illu. 7.13 a - Peat moss potting mix

Illu. 7.13 b - Succulent plant soil mix

The next step in conceptualizing should be integrating the indoor plants in the home functionality and design. This will include brainstorming on which physical product would accommodate them best and offer an additional daily use.
The consistency of the soil was important to investigate for developing a system which will permit air flow through it. This will ensure air circulation for phytoremediation by roots area.

SKETCHING SESSION 02

Second sketching session had as output integrating the indoor plants in the indoor environment for giving an additional home functionality to the product in the development. [Illu. 7.27 to 7.35]
Three categories of the brainstorming have been chosen based on points from 1 to 3 given by group members. These have been the basis for the actual sketches. [WS. 43]

Furniture

Illu. 7.14 a

Illu. 7.14 b


Illu. 7.14 c

Clothes Hangers


Illu. 7.14 d

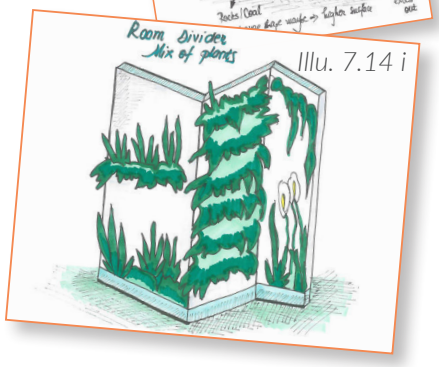

Illu. 7.14 e

Illu. 7.14 f

Mobile Green Walls


Illu. 7.14 g

Illu. 7.14 h



Illu. 7.14 i

Category evaluation

Furniture

✓
- Daily utilization for additional function
- Modern interior design

✗
- Low height for moist extraction from the air

Clothes Hangers

✓
- Bionic Design - New trend
- Highly innovative

✗
- Difficult implementation and ventilation

Mobile Green Walls

✓
- One in each room
- Easy ventilation for implementation and production

✗
- Difficult to get additional functionality at home

Functionality at home
Furniture has been chosen for the additional product functionality and shape where the indoor plants shall be integrated in. Additional styleboards have served as inspiration for shape development. [Illu. 7.16] *[WS. 44] [WS. 45]*

Current product requirements: [Illu. 7.14]

- Sitting furniture
- Convertable to small table
- Mobile inside the house
- Easy replacement / cleaning of plants
- Easy cleaning of relevant parts

Current product functions:
Main: *VOC removal*
CO_2 level reducing
Additional: *Airborne (PM) removal*
Odor reducing
Moist removal for self watering

Illu.7.15 Initial sketching on product shape

Illu.7.16 Styleboard

Revised Target Group

At the this stage it was identified the opportunity of developing a products which can be used in any home, disregarding the housing tenure.

It is important to have an integrated solution for improving indoor air quality of which people can find out about from other channels than the ones for ventilation systems e.g. by having the power of plant inside of a unique design sitting furniture, the distance to the user's home becomes shorter. This requirement meets the needs expressed in Missing Link No. 1 (Market Insight) Decorating a home is often seen as a relaxing activity by creating a nest, a comfortable and intimate place, while buying an air purifier is seen as solving a task or problem.

Further development will focus on reducing the excess of the truly invisible indoor perturbations for health and well-being: CO_2 and VOCs.
The six identified plants will be procured and subjected to own tests on observing and understanding their CO_2 and VOCs removal rates at the room given conditions.

The following list of demands and wishes has been compiled as guideline for further work. [WS. 46]

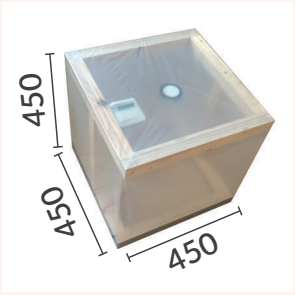
	DEMANDS	WISHES	
QUANTITATIVE	Must decrease TVOCs, CO_2 and PM2.5 level in time frame of 7 days	Must contain necessary water for 2 plants during 7 days	
	Mush release oxygen in the room ambiental air	Must run on power supply of 220~240 V	
	Must not exceed a 30 dB level noise, sleeping room recommended limit	Must have at least one customizable component	
	Must withstand a maximum human load of 250 kg uniformly top applied	Must permit ergonomic sitting position for humans	
QUALITATIVE	Must fit into rented as well as owned homes	Must be mobile in within indoor home area	
	Must fit in fit a modern dynamic home design	Internal part must be recyclable through common methods	
	Must be easy to clean with home common detergents	Must permit easy access for replacing the living plants	
	Must contain environmentally friendly materials	Must be possible to mount and dismount by two persons without any additional tooling	

CO_2 REMOVAL TESTS

The 6 analyzed plants were subjected to CO_2 removal tests. These were performed with one plant at a time, placed in airtight chambers of 0.1/ 0.2m³ volume at the ambiental room CO_2 level, equipped with a CO_2 transmitter. The plants were observed time dependent until reaching and passing their saturation point. Collected data will be used in developing a biological model for each plant and its CO_2 removal rate. [WS. 47] [WS. 48]

Experiment setup

Chambers



Illu. 7.17-a Small Chamber

Illu. 7.17-b Large Chamber

Test chambers have been built out of wooden frames and wrapped in translucent plastic foil. One face of each chamber is open for inserting the test plants.

Measurement Equipment

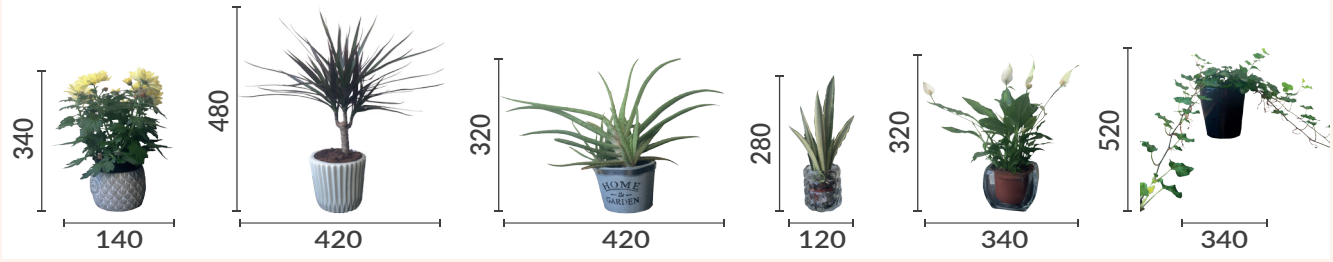
Illu. 7.18-a CO_2 measurer

Illu. 7.18-b Weather station

A CO_2 transmitter equipped with a display has been positioned for reading current concentration. The weather station informs about the relative humidity and temperature.

Subjects

Illu. 7.19 a-f Test Subjects



Florist's Chrysanthemum | *Red Edged Dracaena* | *Aloe Vera* | *Variegated Snake Plant* | *Peace Lilly* | *English Ivy*

All plants have been purchased from Plantorama Aalborg 9000 as small size specimens and have been acclimatized with the indoor conditions for 5 days before commencing the experiment.

Plants have been watered sufficiently before being placed in the chamber and the inside air conditions have not been interfered during the individual experiments.

Exposure and Records

Each plant has been placed in the chambers at the ambiental CO_2 concentration level and monitored until reaching and passing its saturation point in absorbing the CO_2. Results were plotted afterwards in Excel files.

Output data - Small Chamber

Illu. 7.20

English Ivy

Hedera Helix

Saturation Point: 560 ppm

Date (dd-mm)	Time (hh-mm)	CO_2 (ppm)	RH (%)	Temp (°C)
12-04	07:37	830	55	22.3
12-04	15:45	560	75	22.8
12-04	17:22	620	76	22.5
12-04	18:14	660	75	22.4
12-04	19:09	680	72	22.6
12-04	21:20	770	70	22.9
13-04	07:26	1080	70	22.1

The specimen had a day activity of 9 h, with a removal rate of 30 ppm/h and a night one of 15 h with release of 34,7 ppm/h.

Red Edged Dracaena

Dracaena marginata

Saturation Point: 970 ppm

Date (dd-mm)	Time (hh-mm)	CO_2 (ppm)	RH (%)	Temp (°C)
10-04	07:18	1170	66	21.7
10-04	15:58	970	69	22
10-04	19:29	1000	68	22
10-04	22:00	1200	67	22,5
11-04	07:21	1510	69	21,9

The specimen had a day activity of 8.5 h, with a removal rate of 23,5 ppm/h and a night one of 15,5 h with release of 34,8 ppm/h.

Peace Lily

Spathiphyllum Mauna Loa

Saturation Point: 890 ppm

Date (dd-mm)	Time (hh-mm)	CO_2 (ppm)	RH (%)	Temp (°C)
11-04	07:27	1440	68	21,9
11-04	08:05	1230	68	21,9
11-04	16:37	900	69	23,1
11-04	18:35	890	68	23,3
11-04	21:58	1000	66	23,3
12-04	07:19	1180	68	22,2

The specimen had a day activity of 11 h, with a removal rate of 50 ppm/h and a night one of 9,5 h with release of 18,95 ppm/h.

Varigated Snake Plant

Sansevieria trifasciata

Saturation Point: 1370 ppm

Date (dd-mm)	Time (hh-mm)	CO_2 (ppm)	RH (%)	Temp (°C)
13-04	11:02	1710	56	20,9
13-04	11:46	1590	57	21,0
13-04	14:30	1570	54	21,4
13-04	20:30	1540	56	21,5
13-04	22:30	1530	50	22,0
13-04	00:00	1500	55	23,5
14-04	09:30	1390	56	22,4
14-04	11:30	1370	56	23,5
14-04	14:00	1450	57	24,1

The specimen had a day activity of 9.5 h, with a removal rate of 14,7 ppm/h and a night one of 11 h with release of 14.5 ppm/h.

Florist's Chrysanthemum

Chrysanthemum morifolium

Saturation Point: 300 ppm

Date (dd-mm)	Time (hh-mm)	CO_2 (ppm)	RH (%)	Temp (°C)
07-04	21:20	990	55	22,3
07-04	22:45	960	58	22,2
08-04	07:38	710	67	21,5
08-04	12:43	600	70	22
08-04	16:06	520	70	22,3
08-04	23:30	460	71	21,5
09-04	08:55	420	72	21,4
09-04	13:03	300	73	23,3
09-04	16:32	330	75	22,9

The specimen had a continuous CO_2 reducing activity during 40 h with a reduction rate of 17,25 ppm/h.

Aloe Vera

Aloe Barbadensis Miller

Saturation Point: 1050 ppm

Date (dd-mm)	Time (hh-mm)	CO_2 (ppm)	RH (%)	Temp (°C)
15-04	08:30	1910	51	18,7
15-04	10:30	1830	51	19,2
15-04	12:30	1760	51	20,8
15-04	14:00	1700	47	23,7
15-04	16:30	1570	49	26,4
15-04	20:30	1440	52	20,9
15-04	23:00	1360	55	20,1
16-04	07:30	1050	55	19,1
16-04	11:00	1070	55	19,3

The specimen had a continuous CO_2 reducing activity during 23 h on a rate of 39,1 ppm/h in first 12 h and 28,1 ppm/h the last 11h

Output data - Large Chamber

Illu. 7.21

English Ivy

Hedera Helix

Saturation Point: 970 ppm

Day (No.)	Time (hh-mm)	CO_2 (ppm)	RH (%)	Temp (°C)
01	11:00	1020	56	20.6
01	12:00	1010	61	20.9
01	14:00	1010	63	20.9
01	17:00	990	66	21.3
01	18:30	980	64	20.3
01	22:00	970	64	20.4
02	07:00	1080	62	19.8

The specimen had a day activity of 11 h, with a removal rate of 4.5 ppm/h and a night one of 9 h with release of 12.2 ppm/h.

Red Edged Dracaena

Dracaena marginata

Saturation Point: 740 ppm

Day (No.)	Time (hh-mm)	CO_2 (ppm)	RH (%)	Temp (°C)
01	01:00	1420	44	22.1
01	11:00	1340	53	20.6
01	16:00	1040	58	25.5
01	20:00	990	62	22.1
01	22:00	1000	61	21.8
02	12:00	1150	66	22.3
02	14:00	1000	65	23.5
02	18:00	740	68	22.9
02	21:00	810	66	21.1

The specimen had a removal activity during 31 h at a rate of 19,3 ppm/h and a release one of 3 h with rate of 23,3 ppm/h.

Peace Lily

Spathiphyllum Mauna Loa

Saturation Point: 1130 ppm

Day (No.)	Time (hh-mm)	CO_2 (ppm)	RH (%)	Temp (°C)
01	10:00	1250	48	20.6
01	12:30	1170	54	22.6
01	14:00	1130	56	23.2
01	16:00	1140	58	22.0
01	19:00	1210	58	21.3

The specimen had a very short removal activity during 4 hours, with a rate of 30 ppm/h.

Varigated Snake Plant

Sansevieria trifasciata

Saturation Point: 1190 ppm

Day (No.)	Time (hh-mm)	CO_2 (ppm)	RH (%)	Temp (°C)
01	07:00	1410	53	18.8
01	17:00	1260	54	20.9
01	22:00	1240	53	20.2
02	07:00	1240	52	19.8
02	12:00	1230	53	21.9
02	16:00	1200	53	22.0
02	18:00	1190	56	22.8
02	21:00	1210	56	21.4

The specimen had a continuous removal activity during 35 h, at a rate of 6,28 ppm/h.

Florist's Chrysanthemum

Chrysanthemum morifolium

Saturation Point: 850 ppm

Day (No.)	Time (hh-mm)	CO_2 (ppm)	RH (%)	Temp (°C)
01	20:00	1800	49	24.6
01	22:00	1780	48	24.1
01	06:00	1690	57	22.9
02	12:00	1250	59	23.4
02	18:00	950	61	21.8
02	20:00	850	61	22.0
02	22:00	1000	63	22.5
03	07:00	1050	67	23.4

The specimen had a continuous CO_2 reducing activity during 24 h with a reduction rate of 39,6 ppm/h.

Aloe Vera

Aloe Barbadensis Miller

Saturation Point: 890 ppm

Day (No.)	Time (hh-mm)	CO_2 (ppm)	RH (%)	Temp (°C)
01	09:00	1590	53	23.6
01	13:00	1420	54	26.1
01	17:00	1340	47	29.1
01	22:00	1260	52	27.0
02	07:00	1110	51	23.5
02	12:00	1080	52	24.7
02	14:00	1060	52	26.7
02	20:00	890	50	25.7
02	07:00	900	51	23.9

The specimen had a continuous CO_2 reducing activity during 35 h on a rate of 20 ppm/h

CO_2 Removal Experiment conclusion

The more intense the photosynthetic process is, the higher the relative humidity becomes inside the test chamber.
Plants release humidity during their activity, the human equivalent of transpiration. This moist amount adds in most cases to the moist released by humans' breathing and other activities at home.
It is therefore important to collect the moist from the plant and possibly re-use it as water self supply for it.
Performing own experiments have provided a better understanding of the relevant specialty literature and similar results to these ones. *[WS. 49]*

Day and Night efficiency

As observed in the two CO_2 removal tests, some plants are more active in removal action during the day time (sunlight period) and the rest during the night (dark period). The day plants begin producing CO_2 when the light source is removed, while the night plants pass their saturation and begin producing CO_2 when the source light is appearing.

The six tested plants are presented below according to their day-night cycles. The respiration is based on combined information from own testing and relevant literature, while some of the tested plants had abnormal behavior regarding day-night cycle. The behavior might be caused by extended testing in short time and reduced plant size in some cases such as Snake plant.

DAY

- English Ivy
- Florist's Chrysanthemum
- Peace Lily
- Red Edged Dracaena

NIGHT

- Variegated Snake Plant
- Aloe Vera

For obtaining the highest efficiency of plants and avoid canceling each-other's night and day photosynthetic processes, it was established to implement a separator in the middle of the product. This will ensure separate rooms and running cycles for day plant and night ones.

Illu. 7.22

CO_2 Removal - Biological model

Having already data on CO_2 quantity humans produce in average hourly and the CO_2 removal rate for the six plants, biological models can be computed where room volume, number of inhabitants and foliage surface are adjustable parameters for reaching a satisfactory CO_2 concentration for given number of people.

	Reduction	Reduction	Reduction	Reduction
	Small Chamber	Small Chamber	Large Chamber	Large Chamber
Plant	ppm/ h	ppm*m³/ h	ppm/ h	ppm*m³/ h
English Ivy	30	3	4,4	0,88
Peace Lily	50	5	39,6	7,92
Florist's Chrysanthemum	17,25	1,725	30	6
Red Edged Dracaena	23,5	2,35	19,3	3,86
Varigated Snake Plant	14,7	1,47	6,28	1,256
Aloe Vera	37,4	3,74	20	4

In ideal test conditions, the reduction rate (ppm*m³/h) would have probably been the same for both chambers. This would mean that each plant has a constant removal rate of CO_2.
Given the fact that the test subjects are living organism, with individual and personalized biorhythm, the registered values are not identical. This shows that each plant has a different behavior depending on the give conditions during the test period. For obtaining a relevant removal rate in this case, an average of the both columns would can be a relevant value to use for each plant.

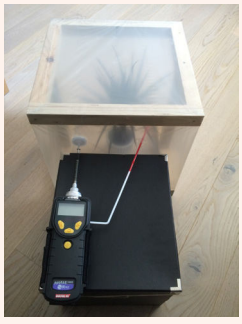
VOCs REMOVAL RATE

VOCs removal is an important part of the natural phytoremediation process. Following section presents own tests on removal rate with the six chosen plants, at the room VOCs concentration. Experiments were carried out at the normal daily conditions, since the specialty literature only presents plants subjected to high VOCs induced levels. [WS. 50] VOCs measuring equipment was borrowed from DUOTEC.

Experiment Setup

Measurement Equipment

Illu. 7.23-a VOCs measurer Type ppbRAE 3000



Illu. 7.23-b Experiment Setup

The portable VOCs measurer has been attached to the test chamber by inserting the reception nozzle through the plastic foil which covers the chamber. The transmitter identifies the mean value of all identified VOCs compounds and not individual substances.
Each of the six test plants has been monitored during six hours.

The setup required to be installed in a place with shadow, since direct sun light triggers the plastic foil to release a high amount of VOCs.

English Ivy	*Florist's Chrysanthemum*	*Peace Lilly*
Without fan Chamber VOCs level increased from 0,479 to 1,232 ppm.	Without fan Chamber VOCs level increased from 0,288 to 4,632 ppm.	Without fan Chamber VOCs level increased from 0,268 to 0,704 ppm.
With fan Chamber VOCs level increased from 0,241 to 3,793 ppm.	With fan Chamber VOCs level increased from 0,382 to 5,025 ppm.	With fan Chamber VOCs level increased from 0,201 to 6,897 ppm.

Red Edged Dracaena	*Snake Plant*	*Aloe Vera*
Without fan Chamber VOCs level increased from 0,430 to 0,829 ppm.	Without fan Not tested.	Without fan Chamber VOCs level increased from 0,48 to 0,576 ppm.
With fan Chamber VOCs level increased from 0,228 to 2,787 ppm.	With fan Chamber VOCs level increased from 0,377 to 0,725 ppm.	With fan Chamber VOCs level increased from 0,387 to 0,229 ppm.

The test results showed that the materials of the chamber are actually releasing VOCs inside. When adding a fan, the concentration increases significantly, meaning that the materials are triggered in releasing more VOCs. It is still considered that the plants are removing part of the VOCs, while Aloe Vera specimen actually reduces the level inside the chamber, when using a fan.

SCIENTIFIC VOCs TESTING

Following section present test results for VOCs removal from specialty literature for some of the tested organic compounds. The material serves as reference values only. [Wolverton, B.C., Wolverton, J.D., (1993)]

English Ivy

Formaldehyde
1120 µm/h/0.31m^3

Xylene
133 µg/h/0.31m^3

Florist's Chrysanthemum

Ammonia
3.641 µg/h/0.31m^3

Xylene
201 µg/h/0.31 m^3

Peace Lilly

Ammonia
1.269 µg/h/0.31m^3

Xylene
268 µg/h/0.31m^3

Red Edged Dracaena

Formaldehyde
772 µg/h/0.31m^3

Xylene
338 µg/h/0.31m^3

Snake Plant

No data found

Aloe Vera

Formaldehyde
188 µg/h/0.31m^3

In lack of exact values for TVOCs at home, the further development of the product will be based on the information provided by dr. Bill Wolverton [1993-1995] in his studies regarding the benefits of interior landscape plants. However, it is trustful that the living indoor plants have capacity in removing organic toxins from the air.
As a possible further work option, the VOCs removal rate tests shall be conducted in a sealed glass chamber, while is commonly known that glass is not releasing toxins.

PM REMOVAL TEST

In order to determine the installation height of the developed product design, the team made a dust filter test to detect where most airborne dust particles will be collected. The test had a duration of three days for each height variation. [WS. 51]

The test setup consisted in an airtight chamber, with plastic foil sealing, a fan installed on one side of it and a filter through which the air flow passes.

The chamber was placed in three different heights; at the floor, in the middle of the room and at the ceiling.

None of the filters from the various heights showed an collected amount there was visible to the eye.

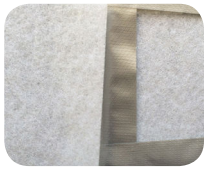
It can be concluded that the fibrous material of the filter had a too high mesh. For obtaining valid results even regarding the coarse particles, a finer filter is needed for testing.

Assume that most airborne particles will be falling on the ground floor due to gravitation, it matches the hypothesis of collecting them at the floor level.

Illu. 7.24 Test chamber

Floor

Illu. 7.25 a



Illu. 7.25 b

Mid height

Illu. 7.25 c

Illu. 7.25 d

Ceiling

Illu. 7.25 e

Illu. 7.25 f

There is a high potential in further working on a product which would help reducing the excess CO_2 level, most commonly releases toxins and in addition help collecting some of the finest particles found indoors by using living plants. A product which would incorporate all these three functions would have a significant improvement in long term for the inhabitants general health and well-being.
For being an accepted and needed part of a home, the product shall have a modern, playful design and trigger the curiosity of knowing the indoor air quality.

Illu. 8.01

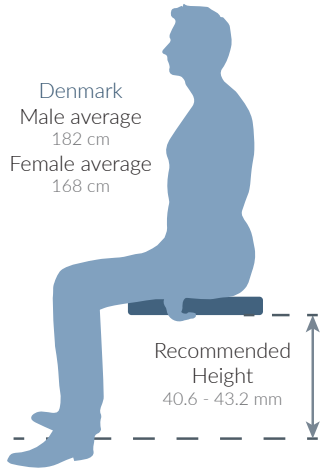
DETAILING & MANUFACTURING

The following chapter presents the multiple stages in determining the final product shape, dimensioning of internal components their exact location and function, as well as chosen material and surface finish and the color customizable parts.

SHAPE CLOSING

A final step in shape defining is to determine the diameter and height of the sitting furniture piece. Several shapes were developed with respect to average human dimensions. [WS. 52] These were subjected to group members' evaluation based on personal aesthetic considerations. It were considered which shape expresses comfort in its highest level.

Human Dimensions



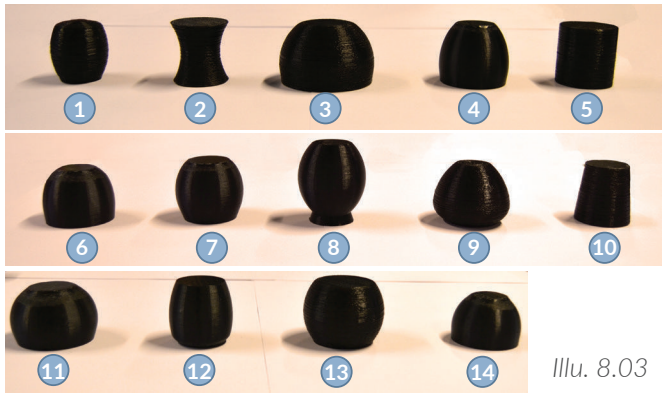
Illu. 8.02

First step in shape closing was to determine the ranges for product height and diameter. These have been established based on the Human Dimensions *[Pnaero J., Zelnik M. (1979)]* recommendations.

Total furniture height = 350 - 460 mm
Sitting area diameter = 190 - 440 mm
Largest section diameter = 290 - 700 mm

The above dimensions were used in 1:10 scaled 3D printing session of the developed shape variations. *[WS. 52]*

Scaled 3D Print



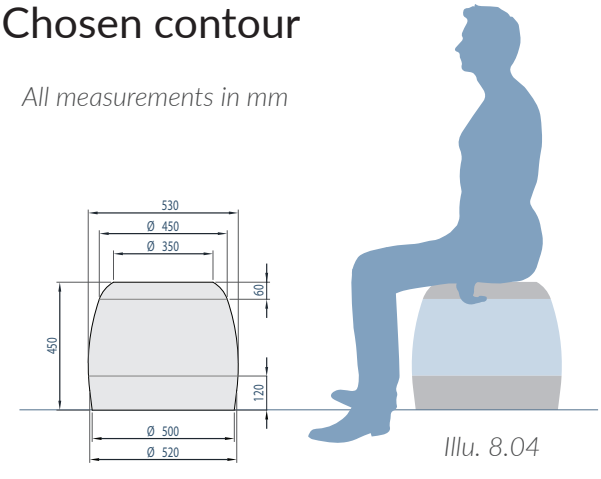
Illu. 8.03

The 3D printing session is a very fast and cost-effective prototyping method. At this stage, it had as aim the tactile evaluation of curves and space visualization of the model. *[WS. 52]*

It was also considered if the shape would provide enough stability when being seated on or pushed aside.
As well, it is assumed to be a small size furniture piece and dimensions shall be accordingly.

Chosen contour

All measurements in mm

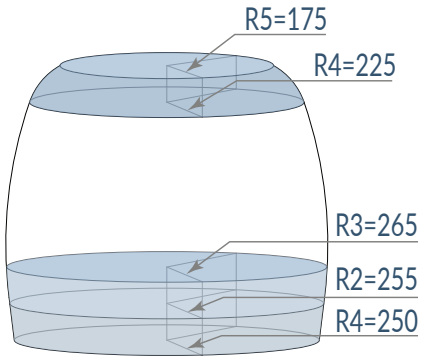


Illu. 8.04

It was decided to work further with convex curving and a smaller ratio between upper, mid and lower diameters. The bottom part will contain most of the technical components, therefore it was agreed to be 120mm high. *[WS. 52] [WS. 53]*
Next step is confirming that chosen dimensions also feel comfortable in reality. In order to test this, a mock-up model shall be built and several subjects asked to be seated on it and express their opinion on instant comfort level and possible extended sitting.

Mock-Up Building & Testing

The mock-up was built out of polystyrene foam plates of thickness 60mm. Two plates were used for the bottom part and one for the seating *[Illu. 8.04 & 8.05]*. Each plate was cut out after the larger radius and curvature was finished with sand paper. *[WS. 53]*



Illu. 8.05 a Plates division & measures

Illu. 8.05 b Final built model

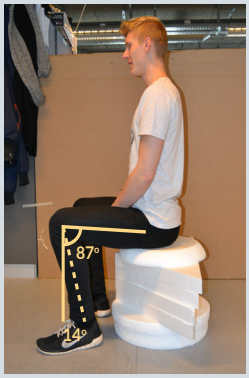
Illu. 8.06 a

Height: 165 cm

Illu. 8.06 b

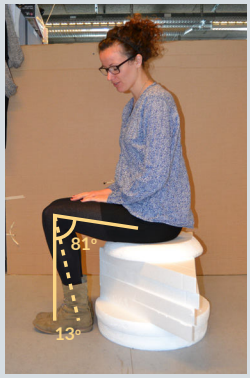
Height: 182 cm

Illu. 8.06 c



Height: 197 cm

Illu. 8.06 d

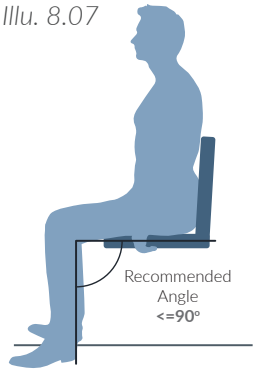


Height: 184 cm

Testing 450mm high model [WS. 53]

Sitting section in Human Dimensions *[Pnaero J., Zelnik M. (1979)]* is recommending a 90° angle or slightly less between the legs and tights when the person is seated. This will ensure a comfortable position and more important: no pressure will be applied under the tights or behind the knees. Legs shall not be suspended either, but they can rest underneath or be stretched. The 450mm high model fulfilled both comfort conditions for test subjects between 165 and 197 cm. Product development will continue with chosen dimensions.

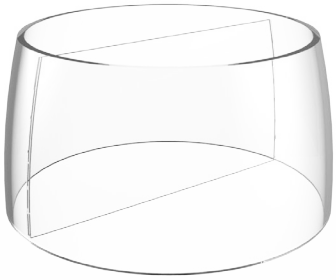
Illu. 8.07



GLASS GLOBE

This section presents the material choice arguments for the middle section of the product, as well as reasons for fully enclosing this product part. Three materials have been evaluated for the best match on accommodating both plants needs and current furniture design characteristics. [WS. 54] [WS. 55]

Full encapsulation



Illu. 8.08

- When the photosynthesis reaches its peak, the relative humidity increases significantly. In other words, plants have their own transpiration process, releasing moist in the room, when having high activity. *[Concept Development. pp. 53-54]*

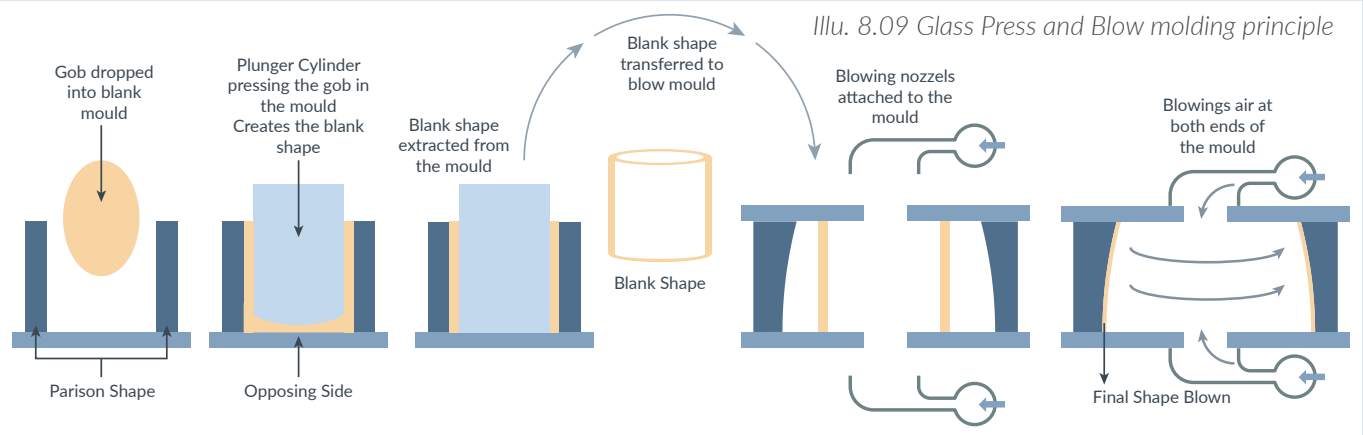
- Plants have a faster metabolism at a RH% around 1100-1500.
- This excess humidity can be collected from the plant and transform it to water for itself by the dehumidifying system.
- Inlet and Outlet supplementary filters made out of activated bamboo coal help in removing odor, additional moist, airborne particles and retain pollen.
- Pets are restricted access to eating indoor plants which are toxic for them.
- 24 hours running process due to the two separate chambers for day and night plants.
- Offer additional strength for sitting purposes

Material Requirements

	Acrylics	*Acrylonitrile butadiene styrene - ABS -*	*Glass*
PRO	Permits sun light pass through Non-yellowing from UV:10years Impact strength Easily formed to any shape	Low cost Easy to machine and fabricate Available as transparent Dimensionally stable under stress	Strong and scratch resistant Easy to clean: wipe off Permits sun light pass through Natural material
CON	Easy to scratch Must be relatively thick to withstand the body weight Low weight - may cause instability is product is pushed.	Turning yellow and loosing mechanical strength when exposed to UVs. Manufacturing and disposing the material are not sustainable processes.	Increased price for double curved shape. Brittle material - it breaks without significant deformation

Glass has been chosen based on accommodating indoor plants and targeted furniture requirements best possible. It permits sun light through but does not change color under UV exposure. Increased weight is in this case welcomed for achieving sitting stability and glass is also resistant to scratches and permits easy cleaning by whipping off the surface. Drawings of the shape have been submitted to Merit Glass A/S - glass manufacturer and detailed pricing is presented in Business Case Chapter.

Glass Forming



Illu. 8.09 Glass Press and Blow molding principle

Principle

For manufacturing the desired glass globe, one of the most probable methods could be press and blow molding. The process starts with the raw materials being mixed and fed into a furnace where they are heated until app. 1500°C. Molten glass is divided into gobs.
A molten glass gob is placed in the parison/blank mould and a plunger cylinder is used for pressing the material in the shape.

After retracting the plunger, the blank shape is removed from the parison and transfered to the blow mould. During the transfer it is 'reheated' to soften and allow final shaping. In the blow mould, air is injected from both openings and the glass takes the shape of the walls. After being removed, it is reheated in the annealing oven to remove stresses and then cooled in controlled conditions. *[WS. 55]*

Safe Dimensioning

Having a glass globe structure as part of a sitting furniture requires careful dimensioning for withstanding not only maximum assumed human weight, but also various impact which can occur in the house: tripping or stumbling into the product. In this sense, a furniture design company and a glass manufacturer have given their expertise based on the proposed glass globe. *[WS. 55]*

"When we design chairs, we consider that these should hold to 150kg, but we think about raising it to 250kg due to tendency of people to gain weight. You can use a safety factor of 2 for your product, then it should hold for 500kg."

Jens Nørgaard - Design & engineering
Hans Thyge & Co ApS - Furniture Design

"It is not possible to use hardened glass to your product, but if you give it a constant thickness of 10mm, it will hold for 500kg. You can only do physical tests on the first moulded sample to see its behavior.
Having it in one piece is the right way to design it for producing it, while having two pieces would be hard to join them and confer resistance for sitting on it."

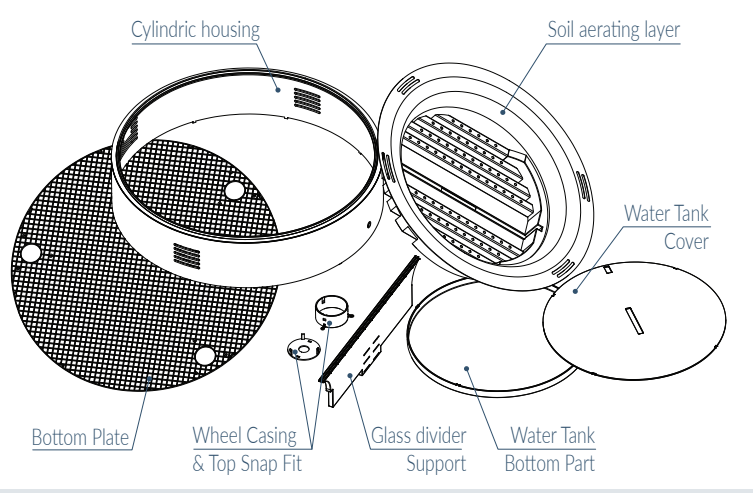
Preben Johannsen - Sales & Service
Mirit Glas A/S - Glass Manufacturer

Total Glass Globe weight is 10kg, including mid-wall

PLASTIC INJECTED PARTS

The following presented parts will be manufactured through plastic injection molding. The method was chosen for being cost effective and with high accuracy in obtaining the proposed shapes and the high degree of details. Below are the most important considerations regarding details as ribs, snap fit and assembly, as well as color palette. [WS. 56] Parts Dimensions can be found in Technical Documentation.

Plastic Injected Parts

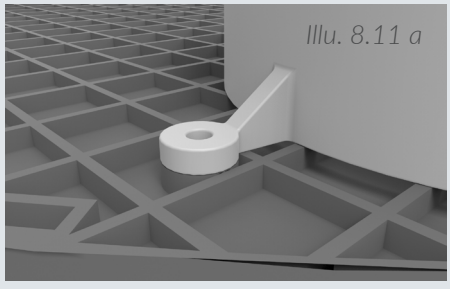


All the components presented in the side illustration are manufactured out of high-density polyethylene (HDPE)

It is a commonly recycled plastic and presents high resistance characteristics being also a good shock absorber.
Price wise, it is considered to be an inexpensive material.
All components will have a T2 finish - medium bead blast, in according to Proto Lab UK material library specifications.

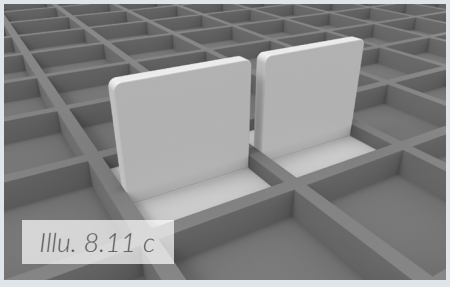
Illu. 8.10

Design considerations



Illu. 8.11 a

Designing plastic injected parts involves considering strength through adding bidirectional ribs and bosses for mounting with self fastening screws.

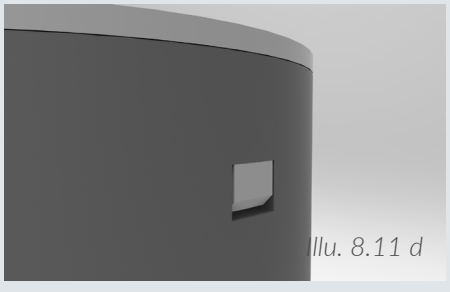


Illu. 8.11 c

The press fit supports are holding the two filters and facilitate exchanging or cleaning the filters when needed.

Illu. 8.11 b

For the wheels choice, the casing assembly consisting of top plate and a cylinder are assembled through snap fit.



Illu. 8.11 d

The separable snap fit can be pushed in with a small dimension tool, releasing the top plate and permitting exchanging or cleaning the wheels.

DEHUMIDIFICATION TECHNIQUE

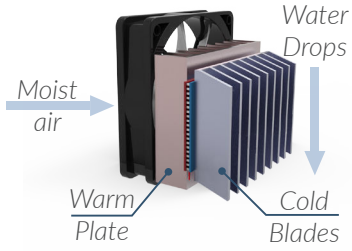
For adding product value and minimum maintenance, a self watering system is desired for ensuring the optimal moist level of the plant. The system is aiming to extract condense from ambiental air humidity. Three most common condensation methods have been evaluated in this sense based on the a set of relevant criteria for the project specific. [WS. 57]

Compressor - HITACHI BSA272CV-R1AN	*Thermo electric cooling system TEM / (Peltier)*	*Desiccant Wheel*
A compressor expands and compresses refrigerant which cools down a number of coils. When ambiental air comes in contact with the cold coils, condensation occurs and water drops can be collected.	The system has two semi-conductive plates with several thermo interconnected couples in between, connected to current wires. When voltage is applied through the wires, one plates is warmed up and one cooled down.	Air is passed through a honeycomb rotor with high surface. The rotor is made of moist absorbing material and retain water molecules. Air is dry after passing the rotor. The continuous rotation releases the condense drops.

Illu. 8.12 a

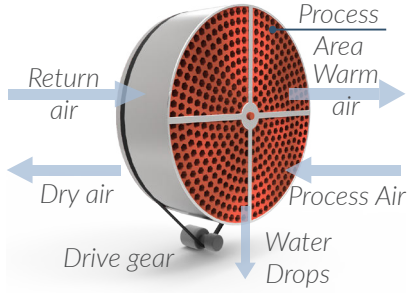
Size	*Height: 143mm Diameter: 92mm*
Power	*220-240V/50Hz*
Price	*330 DKK*
Weight	*3.5 kg*
Wear Parts	*Valves, Motor, Oil Bindings*
Environment	*Greenhouse gases Refrigerant liquid*
Noise	*49 dBA*

Illu. 8.12 b



Size (from)	*40x40x3.6 mm plates upward*
Power	*12-15.4V*
Price (from)	*100 DKK*
Weight	*app. 40g*
Wear Parts	*No mobile parts High resistance*
Environment	*Ceramic material: Alumina (Al_2O_3)*
Noise	*0-5 dBA*

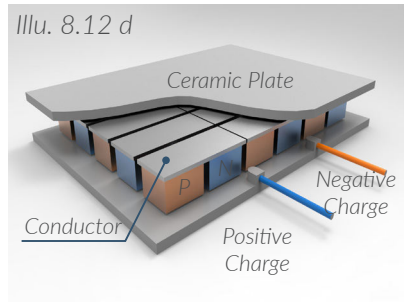
Illu. 8.12 c



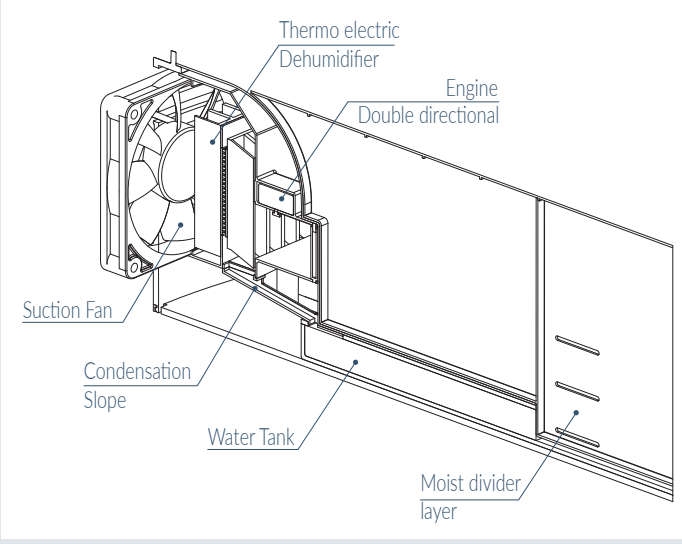
Size (from)	*Height: 100mm Diameter: 350mm*
Power	*220-240V/50Hz*
Price	*600 DKK*
Weight	*app.1.5 kg*
Wear Parts	*Multiple mobile parts*
Environment	*Depending on desiccant material*
Noise (app.)	*42 dBA*

The thermoelectric cooling system is chosen for further development due to: less required maintenance, no mobile parts, reduced size, longer product life and reduced failure, controllable cooling temperature via input voltage. Even if having a limited efficiency in moist removal from room air, it is actually a desired function in the given case. The maximum needed water quantity per week is estimated to 1 liter. This can be achieved with the TEC dehumidifier.

Illu. 8.12 d



Placing the self-watering system



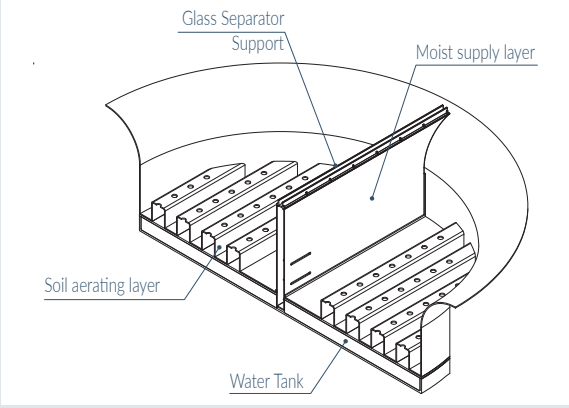
Illu. 8.13 Dehumidification system

In natural environment, plants supply their water need through the roots. Through the suction pressure, the water is afterwards spread to the leaves.
For ensuring a watering method similar to the natural one, the dehumidification system is installed in the bottom of the product. *[WS. 58]*

It consists of:

- A suction fan - standard components
- Thermo electric cooling - standard system
- A double directional engine-changes the position according to which plant cycle is in use
- Condensation slope: plastic injected, for the water drops to slide down
- Water tank - collector for the condensation
- Moist divider layer - filled with Lechuza - Pon stones *[WS. 59]*

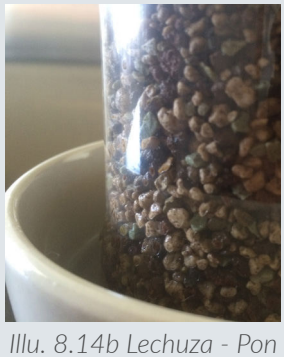
Moist supply layer



Illu. 8.14 a Moist supply

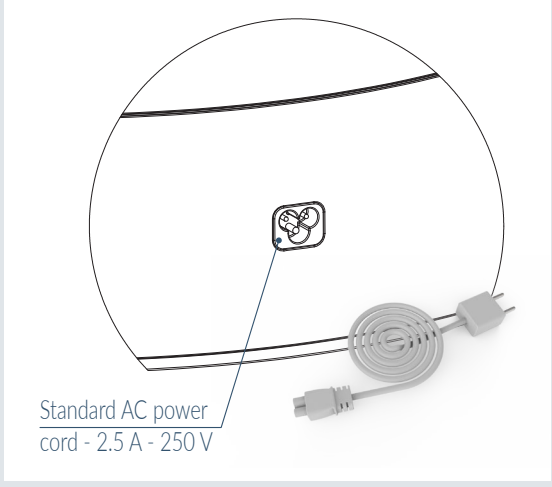
Material: HDPE injection moulded / Surface Finish: T2

The middle section is filled with Lechuza - Pon rocks, which retain water and therefore spread the moist to the potting mix.
The stones are fully moist after about 1 week.



Illu. 8.14b Lechuza - Pon

Power Supply



Illu. 8.15 Electrical Plug

As a standard, the product is equipped with an AC power cord connection to which a plug type C - 2 pins, ungrounded will be attached when in need for recharging.
Depending on where in the world the product will be sold, different plugs or adapters shall be provided.

MOBILITY AT HOME

Knowing that the glass parts will weigh about 10 kg and other internal components will have a count on the final weight, it is important to evaluate a mobility system for moving the product around in the house.
The current section presents the two possibilities for mobility, in form of sliders or wheels and their mechanism in relation to applied human weight. [WS. 60] [http://www.porsa.dk/products]

Ball Transfer with a Nylon ball and Flange connector

Illu. 8.16 a

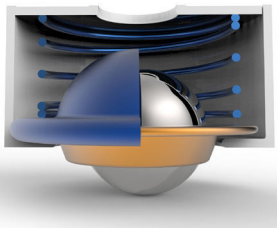
Size: 1”
Material: Nylon
Connector Details: Flange Round (2-1/4” diameter: two holes: 1-3/4” inch apart)
Load Height: 5/8”
Load Rating (Per Item): 34 kg
Finish: Carbon Steel
Shipping Weight: 0.08 kg

Spring
Carbon steel patented wire

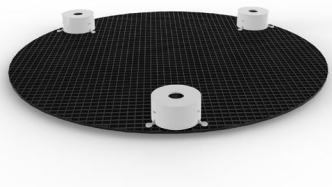
Illu. 8.16 b

Outer Diameter: 45 mm
Wire diameter: 2.8 mm
Height: 34mm
Weight: 2 grams
Load: 72 N
Compression: 14mm under load

Casing
Plastic Injection Moulding



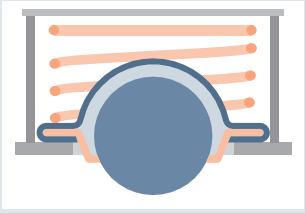
Illu. 8.16 c - Roller and spring inside cylinder case



Illu. 8.16 d - Bottom Plate with 3 wheels assemblies

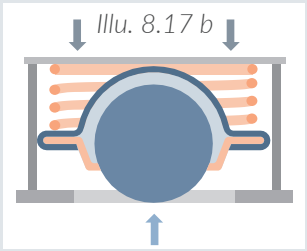
In Rest - without human load
Ready to be pushed around

Illu. 8.17 a



Under human body weight
Stable on the ground floor

Illu. 8.17 b



Mechanism principle

Slider
-for soft surfaces-

Material: LDPE
Height: 16.5 mm
Visible part: 5 mm
Outer Diameter: 40 mm

Illu. 8.17 c

Types of floors at home

Nylon rollers are suitable for hard floor surface

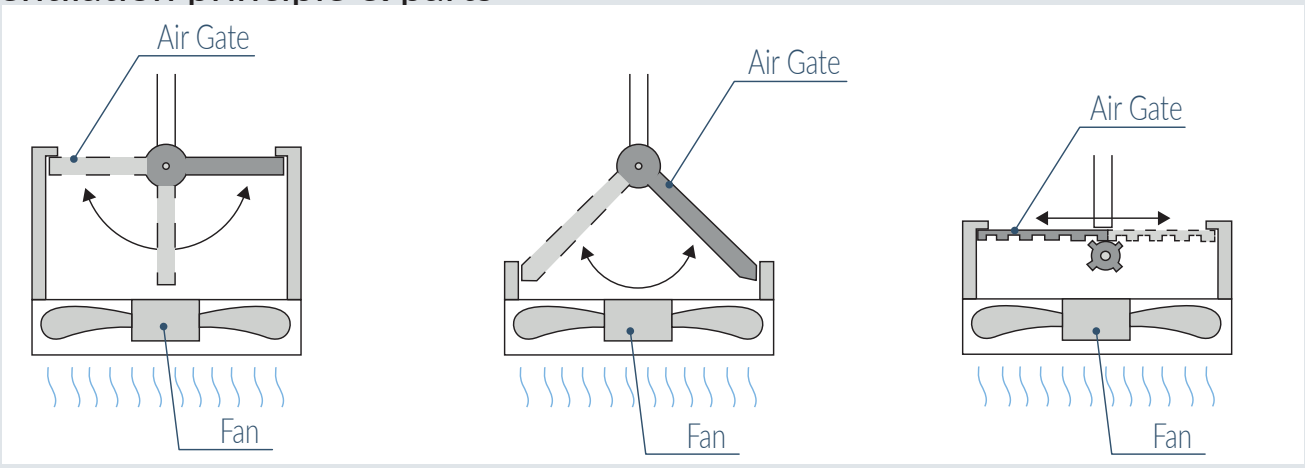
Illu. 8.18 a-f

Hard wood | *Rough carpet* | *Ceramic Tiles* | *Linoleum* | *Laminated* | *Soft carpet*

AIR FLOW

The current product has the possibility of accommodating two plants of different cycles: day and night or two of the same type. Ensuring the correct air flow is a crucial design step, since it will ensure ventilation through the right chamber in the right time cycle. Followings section presents chosen ventilation principle and different air flow scenarios, as well as the parts with holes pattern for permitting air passing through.

Ventilation principle & parts



Illu. 8.19 a

The mechanism provides most stability for the air in all the three ventilation scenarios, while it is resting on the side brackets when in use for one chamber only.

Illu. 8.19 b

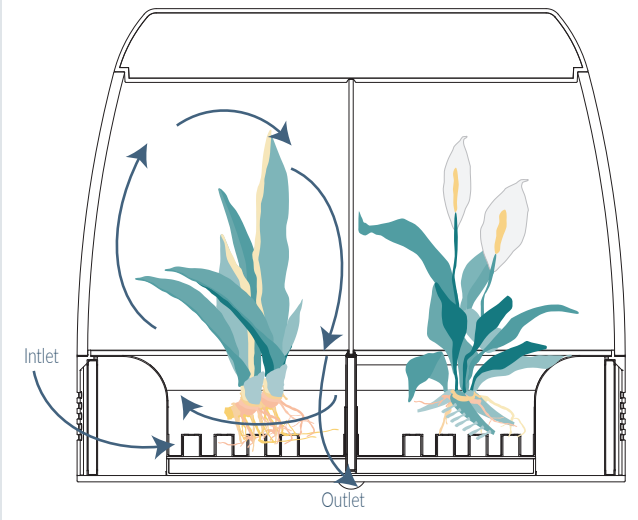
In this mechanism, the air gate can be unstable by not withstanding the air flow. Having no end brackets to rest will allow air flow to pass in the wrong chamber.

Illu. 8.19 c

The mechanism is not suitable for air flow in both chambers, since placed in the middle position it will allow only half of the possible air flow to pass through.

Two plants of different cycles

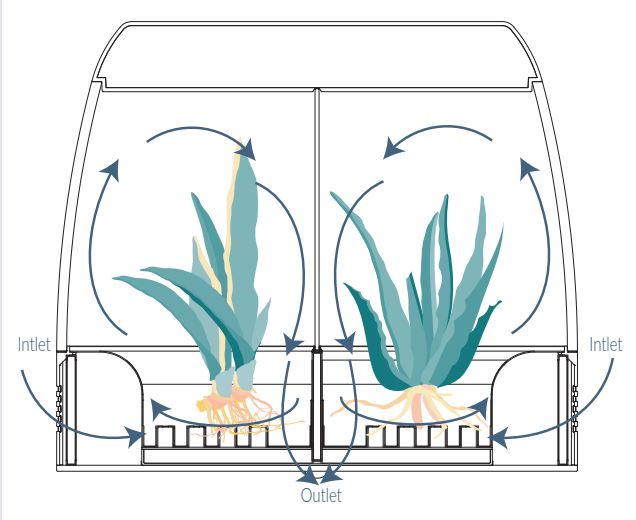
Chambers are ventilated alternatively, on their own cycle.



Illu. 8.20 a

Two plants of the same cycle

Both chambers are ventilated at the same time.



Illu. 8.20 b

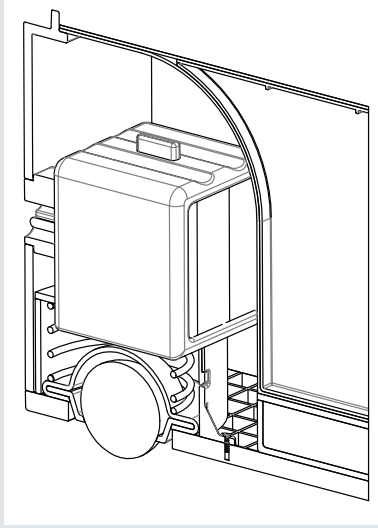
OTHER PARTS

Rechargeable battery

The product shall run on rechargeable batteries for 5 days meaning 120 hours.

The consumers are:
- The fan of 0.16 Ah - want it to run half speed - 0.08 Amh
- The engine of 0.08 Ah.

One battery provides 4.2 Ah, at 1.5 V. *[AliExpress.com, (2016)]*
The safety factor for battery supply is 1.7 *[Capacity Calculator, (2016)]*
Therefore, the needed power is the following:
(0.08 + 0.08)*120*1.7 = 32.6 Ah
The product would require 9 batteries for running for 5 days.



Illu. 8.21 Rechargeable batteries

Soil Aerating Layer

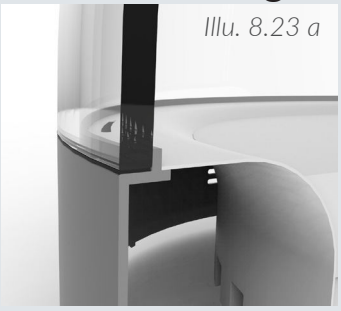
Illu. 8.22 Soil Aerating Layer

The soil aerating layer is used for enhancing the phytoremediation through roots. Plants absorb a considerable quantity of toxins (VOCs) through their root cells and also by some potting mixes.

By increasing the air circulation through the soil, a higher surface of the roots are in contact with the air flow which bring the toxins inside the product.
The air flow is allowed passing through the holes pattern.

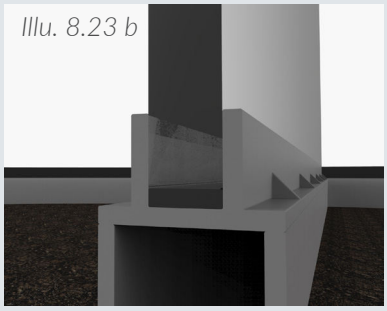
Material: HDPE Injection molded
Surface Finish: T2 (medium bead blast)

Silicone sealing



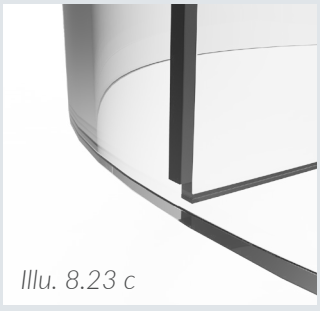
Illu. 8.23 a

Adhesive sealing under and on the glass globe



Illu. 8.23 b

Silicone tape sealing under the glass divider



Illu. 8.23 c

Clear silicone profile Sides of glass divider

- Avoid friction between the two glass components
- Improve stability
- Airtightness between chambers

Material: Silicone
Surface: 1 side adhesive - in contact with plastic parts

Inlet & Outlet Filters

Illu. 8.24

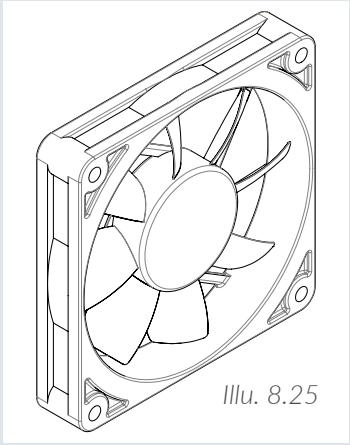
HEPA true filter

HEPA filters describe a High-efficiency particulate arrestance system, commonly used for air purification purposes.
These are widely used in medical, automotive or aircraft industries and according to their standard, are expected to remove 99.97% of airborne particles which have a diameter of 0.3 microns. This filter is placed at the outlet.

Active Bamboo Carcoal

Activated bamboo charcoal has the property of reducing odors and part of the volatile organic compounds. It is 100% natural and recyclable. Active coal in general is used in cooker hoods filters and for calibrating VOCs measuring equipments.
It also has dehumidifying properties, absorbing moist in its very large porous surface. *[WS. 61]*

Air circulating fan



Illu. 8.25

The suction fan is the one in charge of activating the air circulation through the product.
5V 2Pin 8cm 80mm x 80mm x 10mm DC Brushless Computer Case Cooling Fan 8010S [http://www.ebay.com]

Below are listed the most important parameters which have influence on power consumption and overall dimensioning:

Size: 80 x 80 x 10 mm
Rated Voltage: 5 VDC
Start Voltage: 3 VDC
Current: 30.16 A

Speed: 2500 rpm
Air Flow: 30 m^3/h
Noise level: 22 dB
Weight: 54 grams

Electric Engine

Illu. 8.26

For moving the air gate position and obtain the correct air flow, a miniature electric motor is needed.
Miniature Small Electric Motor Brushed 1.5V - 12V DC for Models Crafts Robots [http://www.ebay.co.uk]

Type: MR03
Rated Voltage: 6V DC
Opening range: 12 V DC
Rated load current: 0.02 A
Rated load speed: 2700 rpm

Length excluding shaft: 23 mm
Diameter: 32 mm
Shaft length: 10.7 mm
Shaft diameter: 2 mm
Weight: 45 g

COLOR CUSTOMIZATION

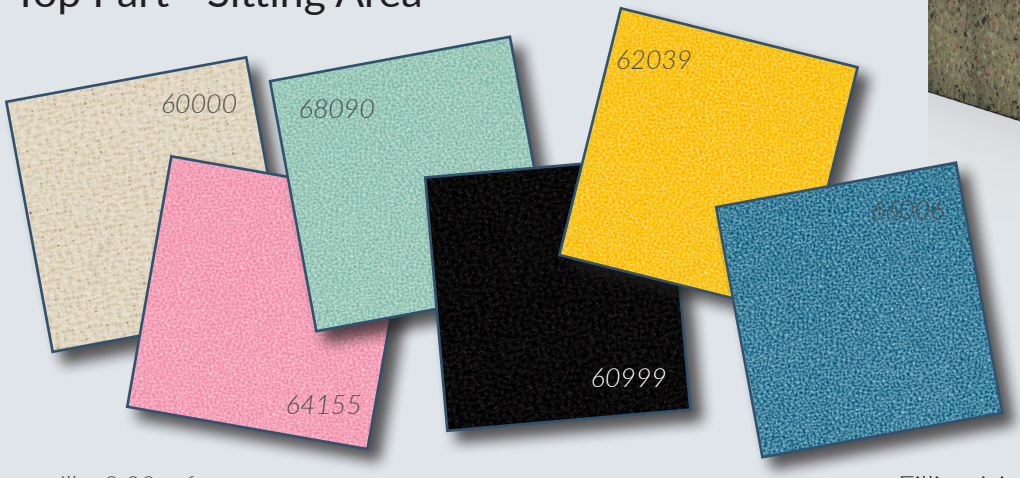
Humans have a strong pshychological response to different external stimuli, out of which color is one of the most important ones. For offering the complete user experince and liberty of choice, two of the product components are offered on color palettes.

Colors & Surface finish

Illu. 8.27

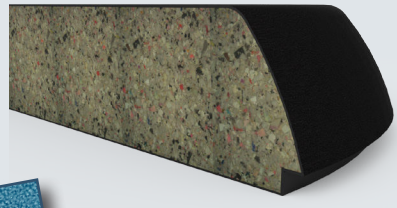
The bottom part consisting of all the injection moulded components can be available on three colors palette.
All shall have the same surface finish, while sparing additional cost from customizing the forming tools.
Surface finish: T2 - medium bead blast

Top Part - Sitting Area



Illu. 8.29 a-f

Fabric palette: Gabriel Fabrics Gaja-C2C/30862
[http://www.gabriel.dk/en/fabrics/ (2016)]



Illu. 8.28 f Cushion
350mm Diameter

Filling Material: Hard Foam
Cover: 100% Wools of New Zealand
Maintenance: Dry Cleaning
Model: Cradle to Cradle Silver
100% free of heavy metals

Reaching the end of detailing phase and having the complete overview on both the internal and external components, it can be concluded that the product complies with safety regulations stated in official Restrictions of the Use of Certain Hazardous Substances in Electrical Equipment. Considering the use and specifications of the developed product, it qualifies for the Consumer Equipment category. *[RoHS Compliant for 2016]*

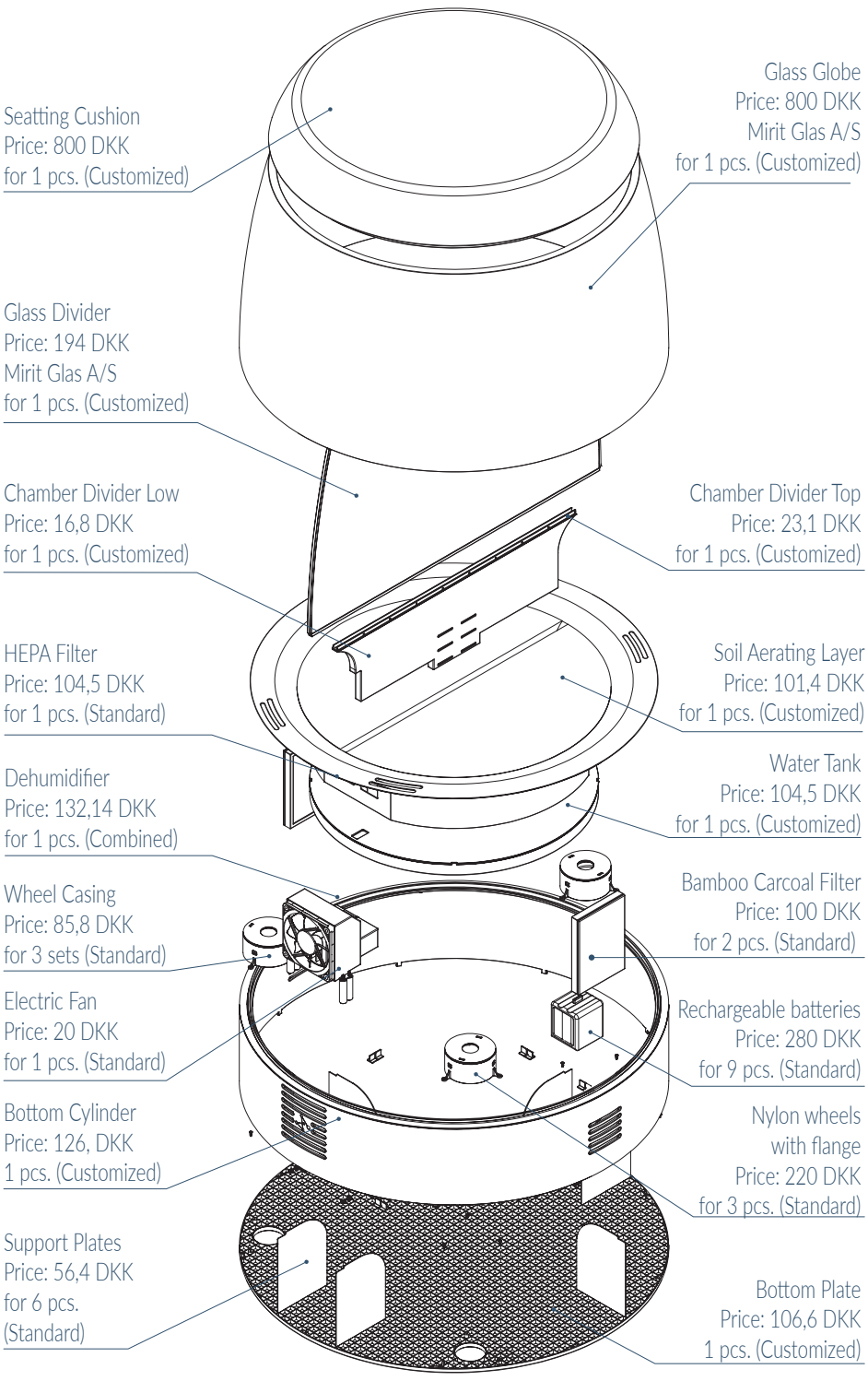
Illu. 9.01

BUSINESS CASE

Present chapter informs about the material, components and production price estimations, followed by a business plan for Europe and a worldwide expansion scenario.
Seeing and selling the product in other contexts than private accommodation is also part of the Business Case.

PRICING

The current section presents prices in DKK for the most relevant parts for the total product price. Standard components price is the current sale available one, while for the customized parts price quotations were submitter to profile companies in Denmark and Europe. [WS. 63]



Illu. 9.02

Toolbox

Self fastening
screws: 1 DKK/ 9 pcs.
Lock Nuts: 2,88DKK/ 9 pcs.
Springs : 8,04 DKK/ 1 pcs.
Sliders: 13,5 DKK/ 1 pcs.
Shock Absorbing
Rubber: 40 DKK/ 4 pcs.
Silicone Tape: 16,7 DKK
Charging cable:
20 DKK/1pcs.

Total: 65,42 DKK

Components Price

Injection moulded parts
548 DKK (1 set)

Glass Parts
994 (1 set)

Other components
1142,9 DKK (1 set)

Total: 2.684,9DKK

Mould Prices

Glass Globe mould:
25.000 DKK

Plastic injected parts
moulds:
598.674,2 DKK

Total: 623.674,2 DKK

Product Estimated selling price: 4000 DKK

DISTRIBUTION IN DENMARK

Due to the relatively high complexity of manufacturing, multiple types of materials and provenience, it is important to find a viable business strategy to launch the product to the market. The most obvious option for the beginning is to work affiliated with a company which already presents financial power, stability and recognizable branding. In this sense, IDdesign was chosen as main stakeholder.

IDdesign A/S is Denmark's largest interior design company, under the ownership of Lars Larsen Group and is represented by three brands: IDEmøbler, ILVA and the franchise chain IDdesign.

Since it is highly improbable that IDdesign would have all the in house necessary key resources in form of manufacturing equipment, it is therefore important to draw a schematic plan for the key partners.

Following Business Canvas *[Osterwalder A. (2010)]* sections are analyzed from the perspective of IDdesign having bought the design idea from AERITY and purchase and assemble the proposed product on its own.

Illu. 9.03

The proposed product is designed for the power of buying on medium income related to the European average remuneration

Value Proposition

Offer the end user a product which helps with the indoor air quality most problematic conditions and yet harmonizes with the home interior

Customer Segments

The product addresses to the mass market, all facing the same inevitable deterioration of indoor air quality. However, the customer is seen as a dynamic, curios person for trying a unique product.

Key Activities

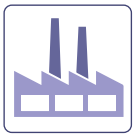
Assembly
- Place the order for the components
- Receive the components and place them at the warehouse

Advertising strategy: web pages, newspapers, social media, broadcasting
Private selling:
- Physical stores
- Online stores

Professionally selling:
- Contact relevant management areas from public sector for promoting the product

Strategic Partners

Sub-suppliers of different components
Advertisement Agencies - collaborations
Logistics: agreements on transportation to warehouses, stores and other rented facilities



Key Resources

Human: over 1000 employees *[IDdesign forside, (2016)]*
Showrooms and stores: 71
Intellectual: the brands ILVA and IDEmøbler, still continuing as stand-alone names.

Distribution Channels

Own online and physical shops, part of Lars Larsen Group
Sub-brands online and physical stores: ILVA, IDEmøbler
IDdesign: 18 shops across the world.

Cost Structure

IDesign would pay a total of 2689,4 DKK for all the components of 1 product.
To this it would be added the man hours for assembly, honoraries and contract payments for the strategic partners, salaries for employees and expenses for rented and owned facilities.

Customer Relationship

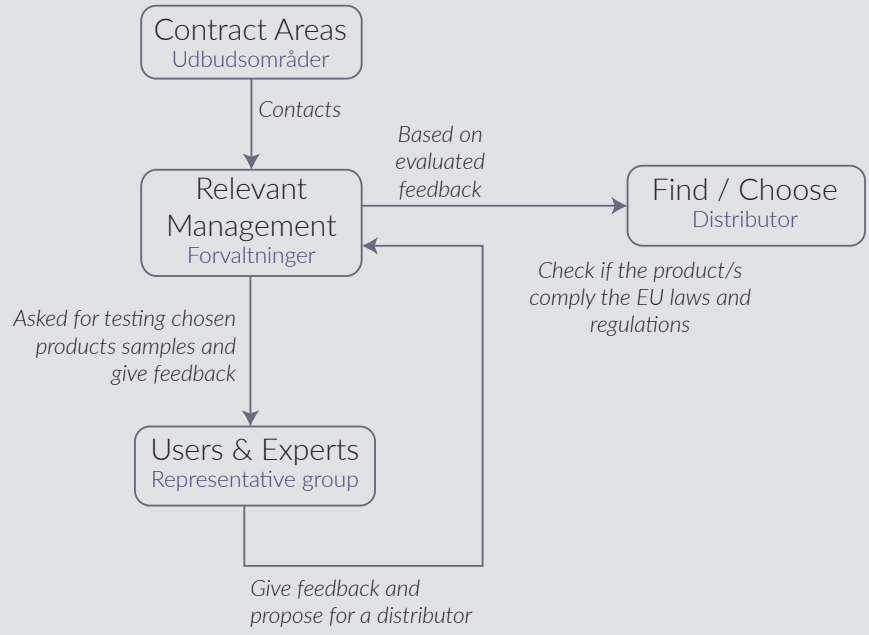
Their stores are known for careful assistance and advising when choosing a product.
Collecting the product at its life cycle end could be a valuable relation also.

Revenues

The revenue comes in form of assets sale of the physical product. The year 2013-2014 has brought the brand a total revenue of 1.7 billion DKK.
Lending the product could be a viable business plan for the future.

BUSINESS EXPANSION OPPORTUNITIES

When trying to approach professional selling, there is an entire procedure for making a product known and having it tested by users for ensuring its efficiency in different types of public institutions. Below is presented the example which the team have been offered by telephone conversation with the municipality of Aalborg.



Proposed areas of expansion for AERITY are professional selling to institutions from public sector as: hospitals, nursery homes and educational institutions as schools, daycares and kindergartens.

Offices and other relevant work areas are as well a profitable and viable expansion area. Distributing the product here would happen through private companies such as Red Office in Denmark or Herman Muller in United States.


Illu. 9.04 a


Illu. 9.04 b

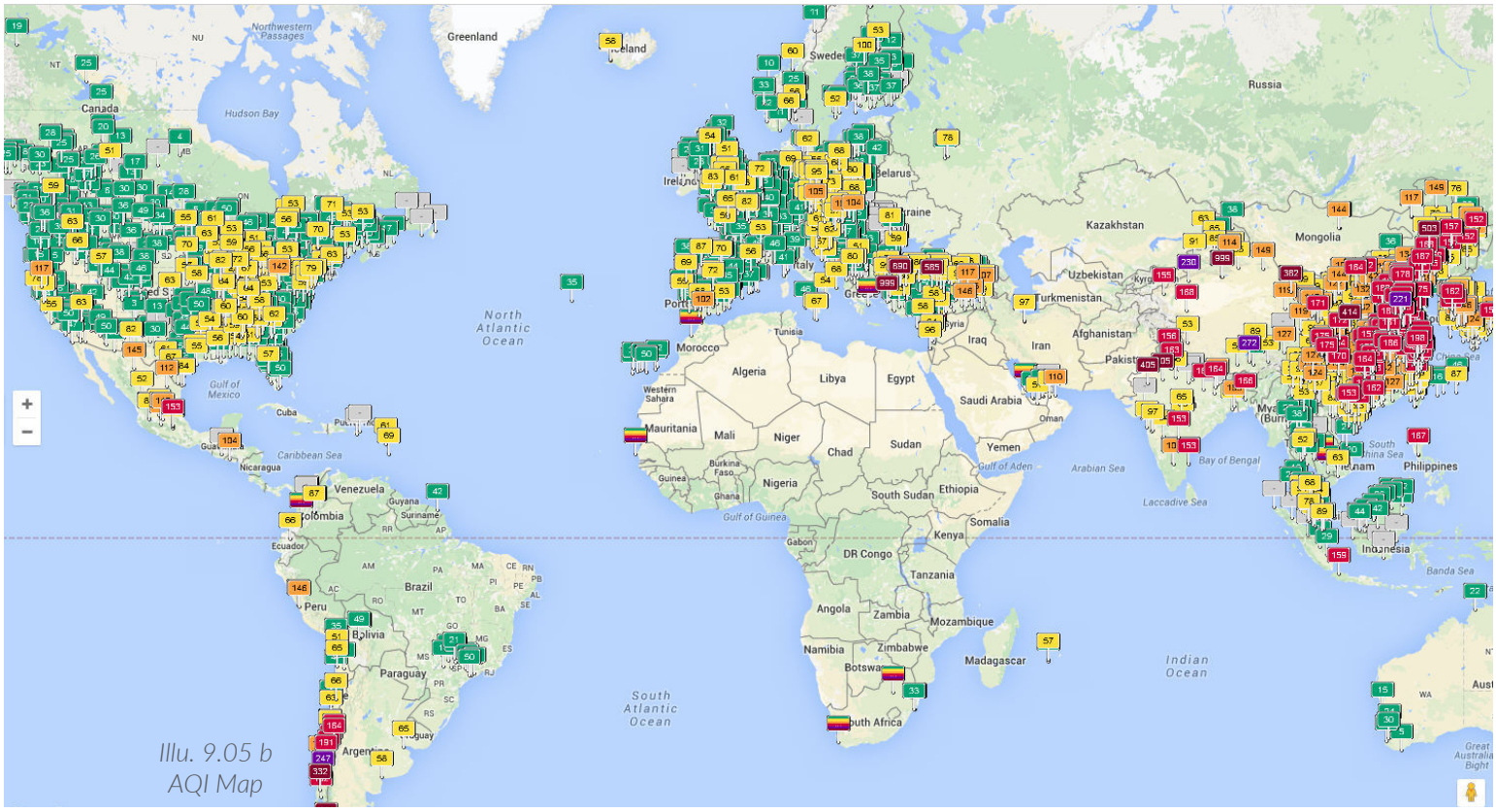
INDOOR AIR QUALITY ACROSS THE GLOBE

The National Aeronautics and Space Administration agency is continuously monitoring world Air Quality Index, especially concerning the level of PM2.5 and CO2. [W. 64]
For example, China is suffering the world's heaviest PM2.5 pollution and along with it a severely health damaging air pollution with excess concentrations of CO_2 and VOCs.

Illustration below presents the outdoor Air Quality Index (AQI) at 23.05.2016 21:10, acc. to http://www.nasa.gov/topics/earth/features/health-sapping.html.

Good (0 -50)
Moderate (51-100)
Sensibility (101-150)
Unhealthy (151-200)
Very unhealthy (201-300)
Hazardous (>300)

Illu. 9.05 a
AQI Measurement



Illu. 9.05 b
AQI Map

Taking in consideration the excessive AQI values nowadays, a global business expansion for the proposed product seems a very viable solution, meeting the need of improving the indoor air quality across the globe.

ADDED VALUE

There is a need of explaining the indoor climate to people they would take action about it. An interactive solution is always preferred. In this way, the inhabitant has right to choices which results can be interpreted and understood. Developing a smart monitor for indoor air quality and a dedicated app for both monitor and solution product is a way to connect the user to its environment though nowadays constant mobile communication.

AERITY compatible smart monitor

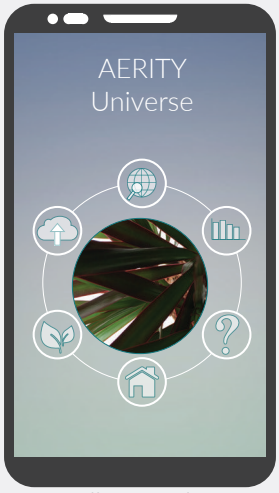
Nowadays electronics are becoming cheaper and of reduced sizes. There is a possibility of purchasing a combo indoor climate monitor with 12 different sensors for the price of only 50 DKK. *[WS. 65]*

By combining four sensors for CO_2, VOCs, relative humidity and particulate matter 2.5 would result in the necessary combination for a smart indoor monitor for matching with the action product.

The monitor shape would be a scaled down one of the action product.

A dedicated App would allow the user to register the monitor online, see the current values for the four parameters and history of these from previous days, choose the plants in use at current time and find out information and advices for taking care of the indoor plants.

Illu. 9.06 a



Illu. 9.06 b

The AERITY dedicated app has four main functions:

- Indoor air quality monitored the compatible monitor
- Worldwide air quality at a glance, all the time
- Recommendations and help on best air purifying plants
- Personal history on used indoor plants

Illu. 9.07 a

Illu. 9.07 b

Illu. 9.07 c

By developing the matching smart monitor for indoor air quality, the aim is to obtain a complete set of indicator and solution product for the selected problems with indoor climate. This meets the need expressed in Missing Link No. 3 (Market Insight)

Illu. 10.01

EPILOGUE

The following section presents group members common conclusion on the proposed product design and user interaction, reflection on completed project work and experience and possible areas of improvement and further work for AERITY.

CONCLUSION

Proposed product design might be seen as controversial due to encapsulation of two indoor plants, but it is in fact a combined air purifier and learning method on plants' photosynthetic cycle and how their biorythm can help improving the indoor air quality.
It has been challenging to test, monitor and understand the plants' activity and interaction with home stimuli. On an equal degree, the VOCs testing has brought us high awareness on the true danger around us in form of all materials involved in daily life.

A construction challenge lays in reducing the manufacturing cost without affecting the aesthetic value of the product. In this sense, the glass globe would decrease the total price significantly if being replaced with a translucent plastic one.
The environmental responsibility would on the other hand increase, by releasing a higher quantity of plastic on the market.
The product shall be perceived as an additional indoor climate solution, along with the simple manual ventilation whish is impossible to be replaced as output.

REFLECTION

The entire process period has been proven to be a road with unexpected results and turns.

Being able to obtain the right testing equipment (VOCs and CO_2 measuring units) played a crucial part in validating the approached indoor air quality problem.

It is probably the proper synchronism between the proposed product development and the increasing interest in the biphilic design and natural purification of indoor air. This served as a continuous motivation during the project work, especially each time when getting in contact with external collaborators and observing their enthusiasm on the subject.

Group-wise, it has been a true pleasure for the trio working group, when the personal skills, all different, matched in great harmony for completing all the project stages.

FURTHER WORK

Reaching the final stage of the design process, it can be concluded there are opportunities for further work, testing and implementation.

Developing a modular, smaller scale product with same working principle would be a very welcomed solution for the cars, vacation houses or camping wagons.
Perform the plants chamber tests with additional light source to reveal whether this enhances the CO2 absorption or in fact acts as a stress factor for them.

The air flow principle inside the product is a theoretical developed principle. Having the opportunity to test it in a real sized and functional model would provide highly valuable information on the true efficiency of air purification through filters, plant roots and leaves.

Further development lays in finding a viable solution for the dried leaves also, when these would eventually fall on the soil and be circulated along with the air flow.

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Appendix

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Illu. 1.02	*Own Illustration*

Pre-Phase

Illu. 2.01	*Own Picture*

Research

Illu. 3.01	*Own Picture*
Illu. 3.02	*Own Illustration*
Illu. 3.03	*Own Illustration*
Illu. 3.04	*Own Illustration*
Illu. 3.05 a-d	*Own Pictures*
Illu. 3.06 a-c	*Own Pictures*
Illu. 3.07 a	*Freepik. 2016. Free exclusive vectors by Freepik. [Online] Available at: http://www.freepik.com/index.php?goto=74&idfoto=857877. [Accessed 04 May 2016].*
Illu. 3.07 b	*Pexels. 2016. Free stock photo of love, cute, young. [Online] Available at: https://www.pexels.com/photo/love-baby-boys-family-50692/. [Accessed 04 May 2016].*
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Illu. 3.08 a-h	*Own Pictures*
Illu. 3.09 a-d	*Own Illustrations*
Illu. 3.10	*Own Illustration*
Illu. 3.11	*Own Picture*
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Illu. 3.13 a-b	*Own Pictures*
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Illu. 3.15 a-b	*Own Pictures*
Illu. 3.16	*Own Illustration*
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Illu. 3.20	*Own Picture*

User Insight

Illu. 4.01	*Own Picture*
Illu. 4.02	*Own Illustration*
Illu. 4.03	*Own Picture*
Illu. 4.04	*Own Illustration*
Illu. 4.05	*Own Illustration*
Illu. 4.06	*Own Illustration*
Illu. 4.07	*Own Illustration*
Illu. 4.08	*Own Illustration*
Illu. 4.09	*Own Illustration*

Market Insight

Illu. 5.01	*Own Picture*
Illu. 5.02 a	*Honeywell HAP-16200E luftrenser - wupti.com. 2016. Honeywell HAP-16200E luftrenser - wupti.com. [Online] Available at: http://www.wupti.com/produkter/bolig-og-fritid/klima/luftrensere/honeywell-hap-16200e. [Accessed 23 May 2016].*
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Illu. 5.07-a	Amazon. 2016. Amazon.com: SPT AC-7013 Magic Clean Air Cleaner with Photo-Catalytic Oxidation Device and Ionizer: Home & Kitchen. [Online] Available at: http://www.amazon.com/AC-7013-Cleaner-Photo-Catalytic-Oxidation-Ionizer/dp/B000JD7IM6. [Accessed 04 April 2016].

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Vision & Mission

Illu. 2.01	*Own Picture*

Concept Development

Illu. 7.01	*Own Picture*
Illu. 7.02 a-i	*Own Illustrations*
Illu. 7.03 a-b	*Own Illustrations*
Illu. 7.04 a-b	*Own Illustrations*
Illu. 7.05 a-d	*Own Illustrations*
Illu. 7.06	*Own Illustration*
Illu. 7.07	*Own Illustration*
Illu. 7.08	*Own Illustration*
Illu. 7.09	*Own Illustration*
Illu. 7.10	*Own Illustration*
Illu. 7.11	*Own Illustration*
Illu. 7.12	*Own Illustration*
Illu. 7.13 a	*Sphagnum https://en.wikipedia.org/wiki/Sphagnum [Accessed 30 March 2016]*
Illu. 7.13 b	*https://cactusglobe.com/ [Accessed 30 March 2016]*
Illu. 7.14 a-i	*Own Illustrations*
Illu. 7.15	*Own Illustration*
Illu. 7.16 a-c	*https://dk.pinterest.com/search/pins/?q=stol&rs=typed&0=stol%7Ctyped. [Accessed 18 March 2016]*
Illu. 7.17 a-b	*Own Pictures*
Illu. 7.18 a-b	*Own Pictures*
Illu. 7.19 a-f	*Own Pictures*
Illu. 7.20	*Own Illustration*
Illu. 7.21	*Own Illustration*
Illu. 7.22	*Own Illustration*
Illu. 7.23 a-b	*Own Pictures*
Illu. 7.24	*Own Picture*
Illu. 7.25 a-f	*Own Pictures*

Detailing & Manufacturing

Illu. 8.01	*Own Picture*
Illu. 8.02	*Own Illustration*
Illu. 8.03	*Own Picture*
Illu. 8.04	*Own Illustration*
Illu. 8.05 a	*Own Picture*
Illu. 8.05 b	*Own Illustration*
Illu. 8.06 a-b	*Own Pictures*
Illu. 8.07	*Own Illustration*
Illu. 8.08	*Own Illustration*
Illu. 8.09	*Own Illustration*

LIST OF ILLUSTRATIONS

Illu. 8.10	*Own Illustration*
Illu. 8.11 a-d	*Own Illustrations*
Illu. 8.12 a-d	*Own Illustrations*
Illu. 8.13	*Own Illustration*
Illu. 8.14 a-b	*Own Illustrations*
Illu. 8.15	*Own Illustration*
Illu. 8.16 a-c	*Own Illustrations*
Illu. 8.17 a-c	*Own Illustrations*
Illu. 8.18 a-f	*Own Pictures*
Illu. 8.19 a-c	*Own Illustrations*
Illu. 8.20 a-b	*Own Illustrations*
Illu. 8.21	*Own Illustration*
Illu. 8.22	*Own Illustration*
Illu. 8.23 a-c	*Own Illustrations*
Illu. 8.24	*Own Illustration*
Illu. 8.25	*Own Illustration*
Illu. 8.26	*Miniature Small Electric Motor Brushed 1.5V - 12V DC http://www.ebay.co.uk/itm/Miniature-Small-Electric-Motor-Brushed-1-5V-12V-DC-for-Models-Crafts-Robots-/130773600534?var&hash=item1e72b6c916%3Am%3Am9RPJpyNzWq1BpkMYNvQIEg [Accessed 24 May 2016]*
Illu. 8.27	*Own Illustration*
Illu. 8.28	*Own Illustration*
Illu. 8.29 a-f	*GAJA C2C SPECIFICATIONS http://www.gabriel.dk/en/fabrics/textile/Gaja-C2C/30862 [Accessed 23 May 2016]*

Business Case

Illu. 9.01	*Own Picture*
Illu. 9.02	*Own Illustration*
Illu. 9.03	*IDdesign - http://www.iddesign.as/ [Accessed 24 May 2016]*
Illu. 9.04 a	*Den danske folkeskole er for de middelmådige elever http://politiken.dk/debat/laeserbreve/ECE1543861/den-danske-folkeskole-er-for-de-middelmadige-elever/ [Accessed 23 May 2016]*
Illu. 9.04 b	*Stort potentiale i nye enestuer til patienterne http://www.kora.dk/nyt-og-presse/nyheder/2015/stort-potentiale-i-nye-enestuer-til-patienterne/ [Accessed 23 May 2016]*
Illu. 9.05 a	*Own Illustration*
Illu. 9.05 b	*The World Air Quality Index project. 2016. Air Pollution in World: Real-time Air Quality Index Visual Map. [Online] Available at: https://aqicn.org/map/world/[Accessed 25 May 2016]*
Illu. 9.06 a-b	*Own Illustrations*
Illu. 9.07 a-c	*Own Illustrations*

Epilogue

Illu. 10.01	*Own Picture*

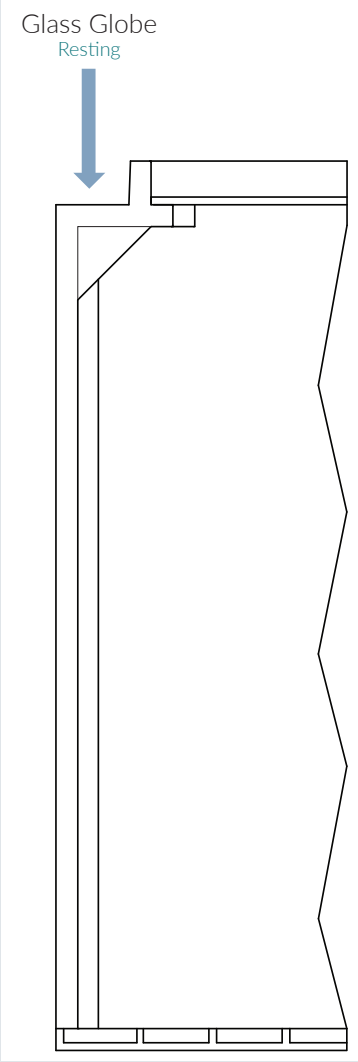
Appendix

Illu. 12.01 a-b	*Own Illustrations*
Illu. 12.02 a-c	*Own Illustrations*
Illu. 12.03 a-b	*Own Illustrations*
Illu. 12.04 a-e	*Own Illustrations*
Illu. 12.05 a-b	*Own Illustrations*

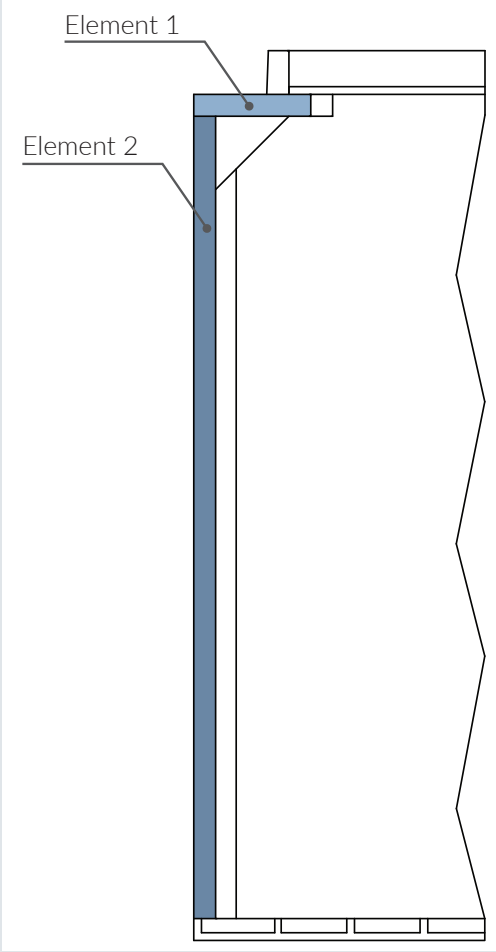
STRENGTH CALCULATIONS

Glass is a natural and living material and therefore no strength calculations can be made on it.
The glass globe rests on the bottom part which is aimed to be a plastic injected components.
The strength calculations are therefore made on the bottom component, in order to find out which is plastic material will withstand to the applied load. [Rump T. (2011)]

Shape Segmentation



Illu. 12.01 a



Illu. 12.01 b

Illu. 12.01 a presents the plastic component of the product which is subjected to the load.

For obtaining the load value, the toal mass is calculated as:
$Q_T = Q_H + Q_P + Q_G$

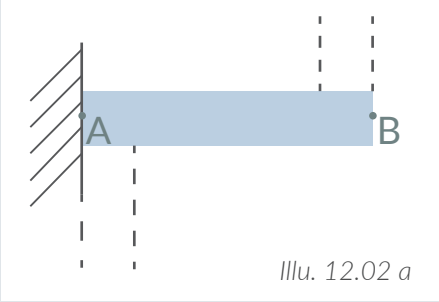
where:
Q_H = Max. human weight = 250kg
Q_P = Weight rest of top components = 3 kg
Q_G = Weight Glass Globe = 10kg

Q_T = total mass [kg] = 263 kg

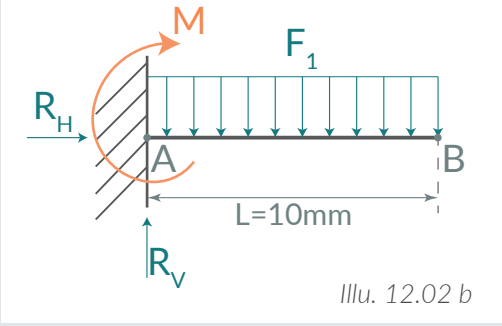
Total applied load:
F= 263kg * 9.82 = 2582.66 N
9.82 - Gravitational constant

The affected part by load can be segmented in two simplified elements:
1 - Cantilever beam
2 - Column

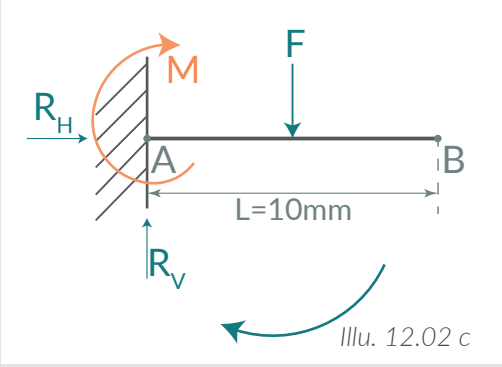
Element 1



Illu. 12.02 a



Illu. 12.02 b



Illu. 12.02 c

Element 1 will be assumed as a simplified beam, supported at one end=A *(Illu. 12.02 a)*
In this case, it is necessary to calculate the movements the beam can have under the total load. *(Illu. 12.02 b)*
M=Bending moment at point A
R_H=Sum of forces on horizontal direction
R_V= Sum of forces on vertical direction

Illu. 12.02 b presents the distributed equal load which can be assumed in a simplified way to be the concentrated force applied at the middle of the beam. *(Illu. 12.02 c)*

Below are the 3 equations of equilibrium:

$\Sigma F_x=0$
$\Sigma F_y=0$
$\circlearrowleft + \; M_A=0$

$\Sigma F_x=0=R_H \Rightarrow R_H=0$ (There is no possible move on X)
$\Sigma F_y=0=R_V-F \Rightarrow R_H=F_1*L$ (Movement on Y)

$\circlearrowleft + \; M_A=0 = M_A-F*L$
$M_A=F*L/2$
$M_A=2582.66\ N*\ 0.005m=12.9133Nm$
The rotation moment to be withstand.

Element 2

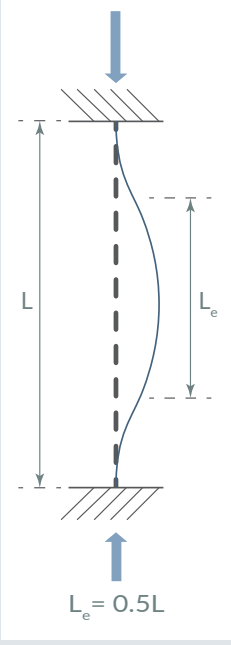
Illu. 12.03-a
Before deformation

Illu. 12.03-b
After deformation

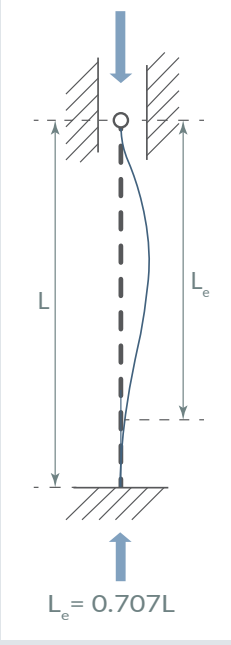
Element 2 is assumed to be a beam.
In order to determine which deformation will have under the applied load, a physical test was made with a similar scaled plastic object, to which pressure was applied from top. *(Illu. 12.03 a-b)*

The compressive load applied was of 6.636 kg, without pressing with hands.

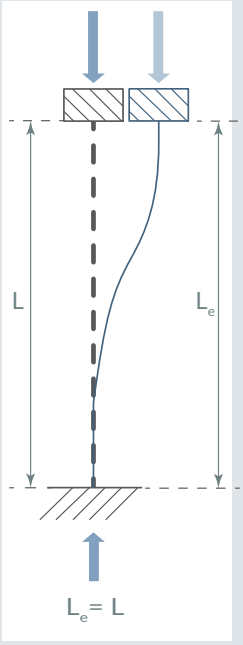
Local Buckling



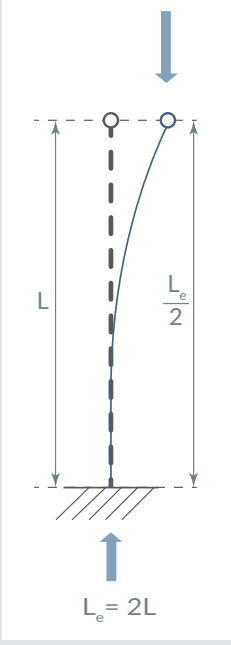
Illu. 12.04-a
Clamped-Clamped



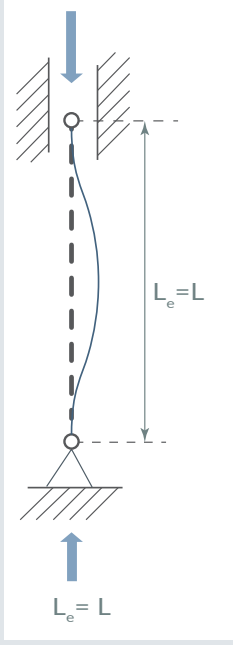
Illu. 12.04-b
Clamped-Hinged



Illu. 12.04-c
Clamped-Guided

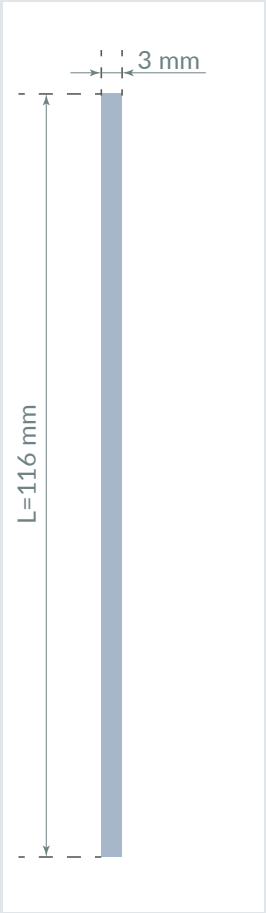


Illu. 12.04-d
Clamped-Free End

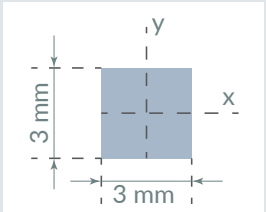


Illu. 12.04-e
Hinged-Hinged

Short before the part collapsed, it showed signs of buckling as in Illu. 12.04-a.
This illustrates a column fixed at both ends.
Following computations on the buckling analysis will be based on this assumption.



Illu. 12.05-a
Clamped-Clamped



Illu. 12.05-b
Column Section

It is assumed that the column cannot move at any end.

Calculating the maximum load which a column can support before becoming unstable.

Both ends fixed:

$L_e = L/2 = 58mm$

$$P_E = \frac{\pi^2 * E * I}{L_e^2} \quad \frac{N}{mm^2}$$

Where:
P_E=Euler's Buckling Load
L=Column Length=116mm
π=Constant= 3.14159
E=Modulus of Elasticity (Pa) or (N/m^2)
I=Moment of inertia (mm^4)

Moment of inertia for square beam:

$I=(base*height)^3/12$
$I_{xx/\ yy}=3*3^3/12= 6.75\ mm^4$

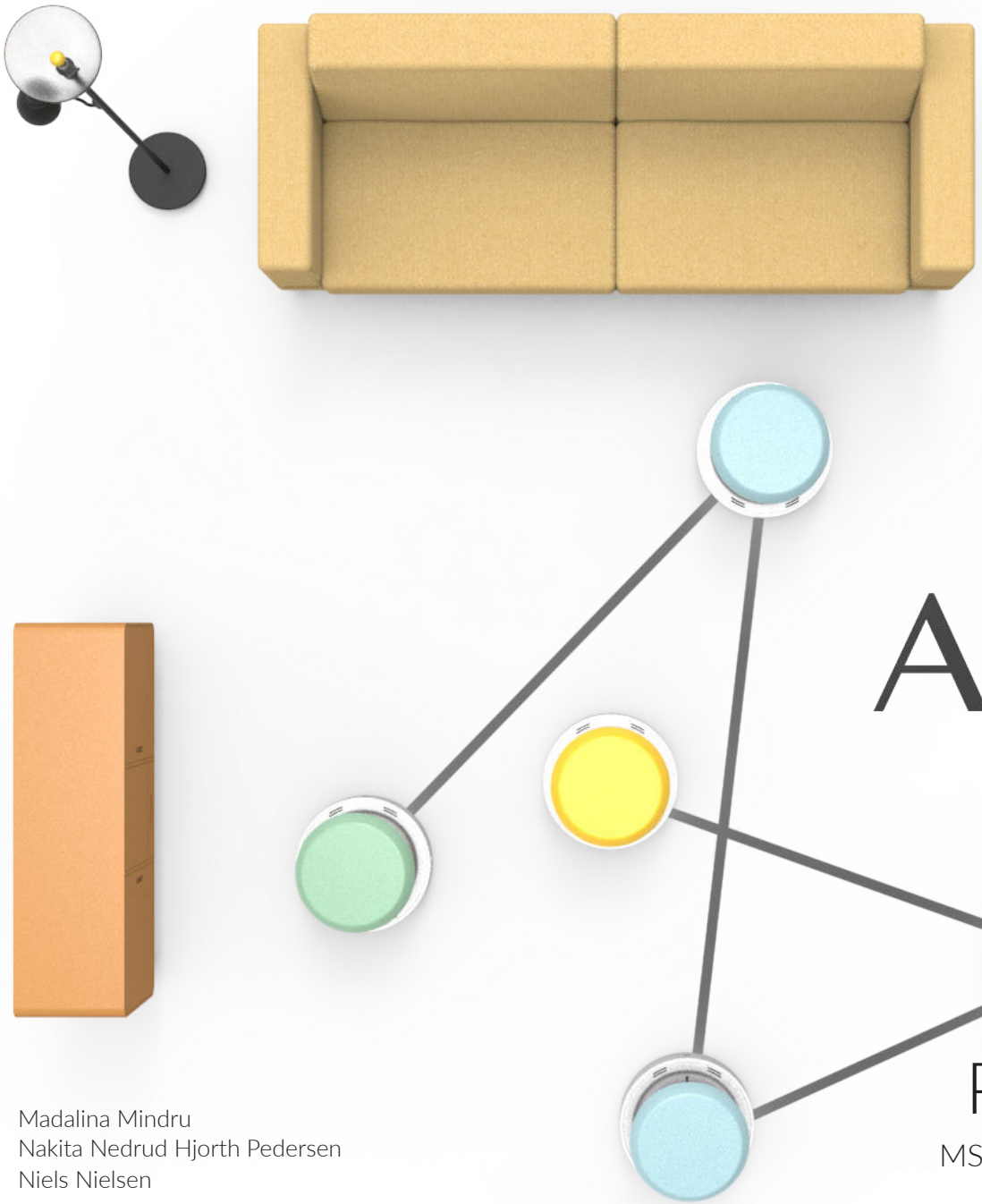
$$P_E = \frac{\pi^2 * E * 6.75mm^4}{58^2 mm^2}$$

$$2582.66\ N = \frac{\pi^2 * E * 6.75mm^4}{58^2 mm^2}$$

$E= 130412\ N/mm^2$

Choice of material

Modulus of elasticity for chosen material shall not exceed the obtained value of:
$E= 130412\ N/mm^2$



AERITY

AERITY

Indoor Air Purification

PRODUCT REPORT

MSc04 ID | Team 07 | Master Thesis | Spring 2016

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MSc04 Industrial Design
Team 7

Project title	AERITY
Area of interest	Indoor Air Quality
Project period	01.02.2016 - 25.05.2016
Supervisor	Finn Kehlet Schou
Technical supervisor	Mikael Larsen
Total no. of pages	24
Editions	7

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Nakita Nedrud Hjorth Pedersen

Niels Nielsen

ABSTRACT

Dette projekt er udarbejdet af et team afgangsstuderende på linjen Industriel Design på Aalborg Universitet i løbet af foråret 2016.

Fokus under dette projekt har været på indeklima samt luftkvalitet. Projektet udsprang i fugt komplikationer men ændrede retning, da teamet blev bevidste om usynlige og alvorligere parametre som flygtige organiske stoffer, kuldioxid samt fine partikler. Disse parametre er alle usynlige og det er utroligt svært at afgøre hvorvidt niveauet af de pågældende er indenfor den humane komfort zone eller forhøjet, hvilket kan lede til alvorlig forringelse af den individuelles helbred.
Projektet er baseret på ekspert viden, tests foretaget af teamets medlemmer, mock-ups, interviews, undersøgelser samt begrundet data fra anerkendte forskere.
Resultatet er et multifunktionelt møbel, der renser luften ved at anvende naturlige elementer som planter og aktivt bambus kul. Produktet henvender sig til enhver der er interesseret i at forbedre indeklimaet i hjemmet – til brug i det private samt det offentlige.
Denne rapport giver læseren det komprimerede men dog detaljerede indhold der understøtter det færdigt udviklede produkt.

AERITY

INTRODUCTION

Magna is the home air purifier, which enhances the natural power of indoor plants in removing toxines and excess carbon dioxide from the ambiental air.

It has an unique air flow designed to circulate through an initial HEPA filter, the plants' roots, leaves and then leave the product through a second HEPA filter. It therefore combines three very important solutions for a healthier indoor climate: phytoremediation, photosynthesis and arrestance of dangerous air particles.

Team AERITY recommends six plants: two suitable for night cycle and four for the day.

The double chambered Magna allows individual or common air flow for plants combinations of different or same cycles.

In addition to air filtering, Magna offers selfwatering incorporated system for the used plants. A thermoelectric cooler collects moist from both the plants transpiration and ambient and transforms it into condense drops.

Magna can be placed in any house division and be freely used as a small sitting furniture or table.

https://static.pexels.com/photos/29907/pexels-photo-29907.jpg

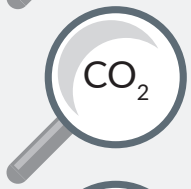
THE PROBLEM

INDOOR CLIMATE

We are spending most of our daily time indoor. Many of these hours are at home, in the most comfortable environment, enjoyinf family and friends, preparing meals together and sharing the simple moments together.
What we do not realize is what harms us in our nest. It it precisely the air we breath, infused with pollutants from the objects we care most in our homes and from ourselves.
It is exponentially threatening our health since our homes are becoming more insulated and the natural fresh air exchange is harder to achieve nowadays.
We are facing a relatively modern problem us humans has created through the technological development.
Being in a dangerous environment in the own home is a world aknowledged problem, intitulated 'The Sick Building Syndrome'.
It is targetting the occupant of the building, being prolongued exposed to improper ventilation, heating, outgassing and air particles.

THREATENING PARAMETERS

Volatile Organic Compounds represent a large group of carbon-based chemicals which evaporate at room temperature. They are released by materials as: wood, paints, polish, fabrics, leather, plastics, rubber, detergents and personal care products.



By breathing out, us and our pets exhale dioxide carbon. Excess concentrations act as a narcotic, conducting to diziness, lack of concentration or sleep disturbance. CO_2 quantities are released from combustion processes also.

Particulate Matter 2.5 reffers to the fine air particles, with dimensions under 2.5 microns diameter. These are seen as the ones with higher risk for pulomary diseases. Their provenience is all from pollen, pet dander, exhaust, germs.

WE ALL BREATHE IT

Who is at risk in a home with improper air quality?

Children

The small body and still in developing immunitary system cannot protect children from the high risk of contracting allergies and sensibilities in early stages of life.

Elderly

Degeneration of body cells in time has the natural effect of slowing the body functions. Breathing, concentration ability and blood circulation are at this age hampered. The result on general health condition stays in the respiratory difficulties and increased risk for asthma.

Each of us

Even if having a full grown body, prepared and immune to threats from surroundings, the respiratory system is at high risk when in continuous contact with airborne particles, excess level of carbon dioxide and a high range of dangerous gasses.

Context

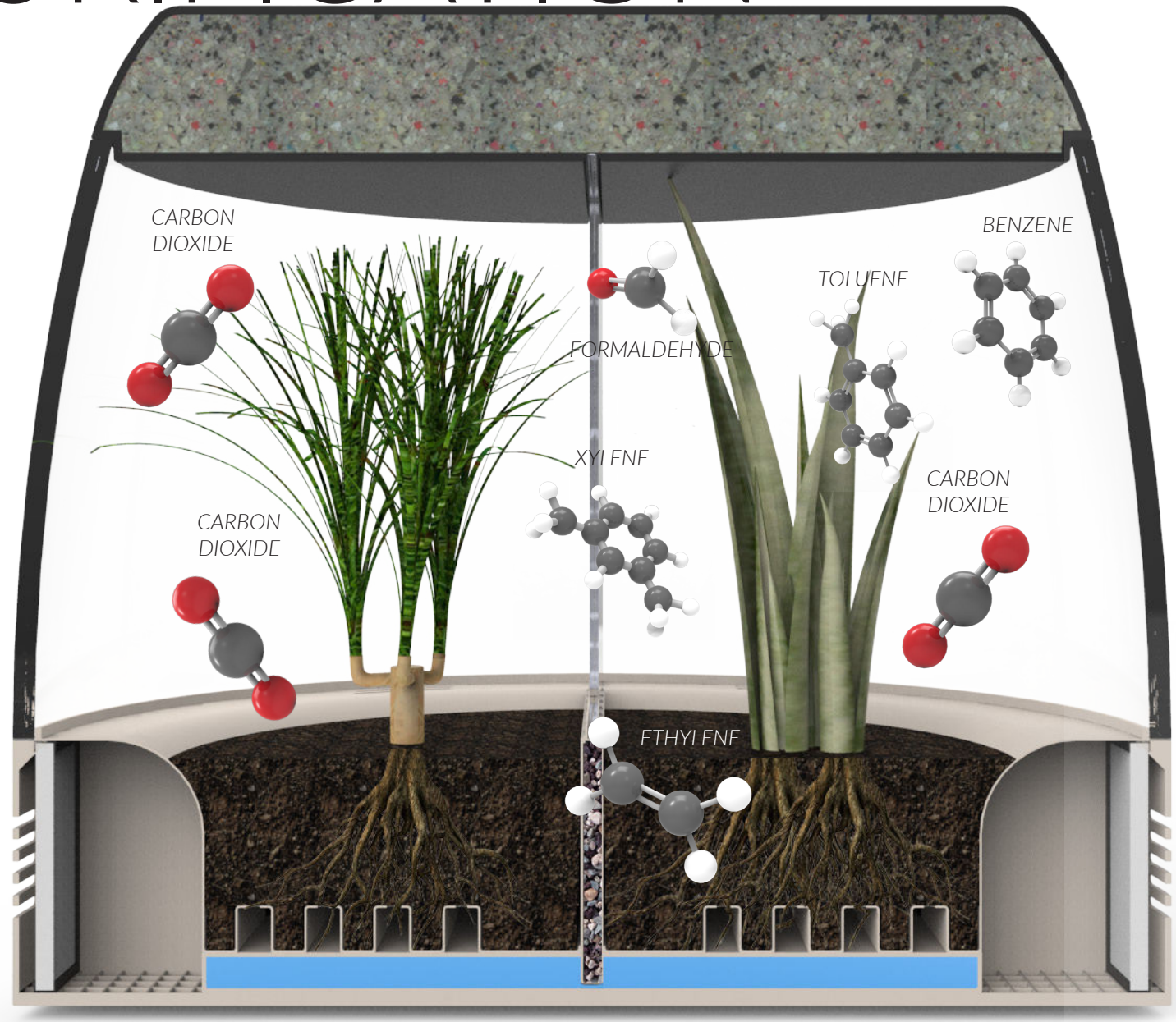
The risk of living in poor indoor climate can happen in any home environment. Wether is the sleeping room, kitchen, or other areas where people tend to spend more time, it evenetually decreases the air quality.

AIR PURIFICATION

The most natural and cost effective method of air purification is through nature. Living indoor plants have the invincible continuous process of phytoremediation though roots and leaves, assimilating the ambiental toxine. Carbon dioxide is used as a natural fuel for their photosynthetic process, which has as output oxygen formation, the most important gas for human survival.

Most common toxines are: (Volatile Organic Compounds)

- Formaldehyde
- Benzene
- Toluene
- Xylene
- Ethylene

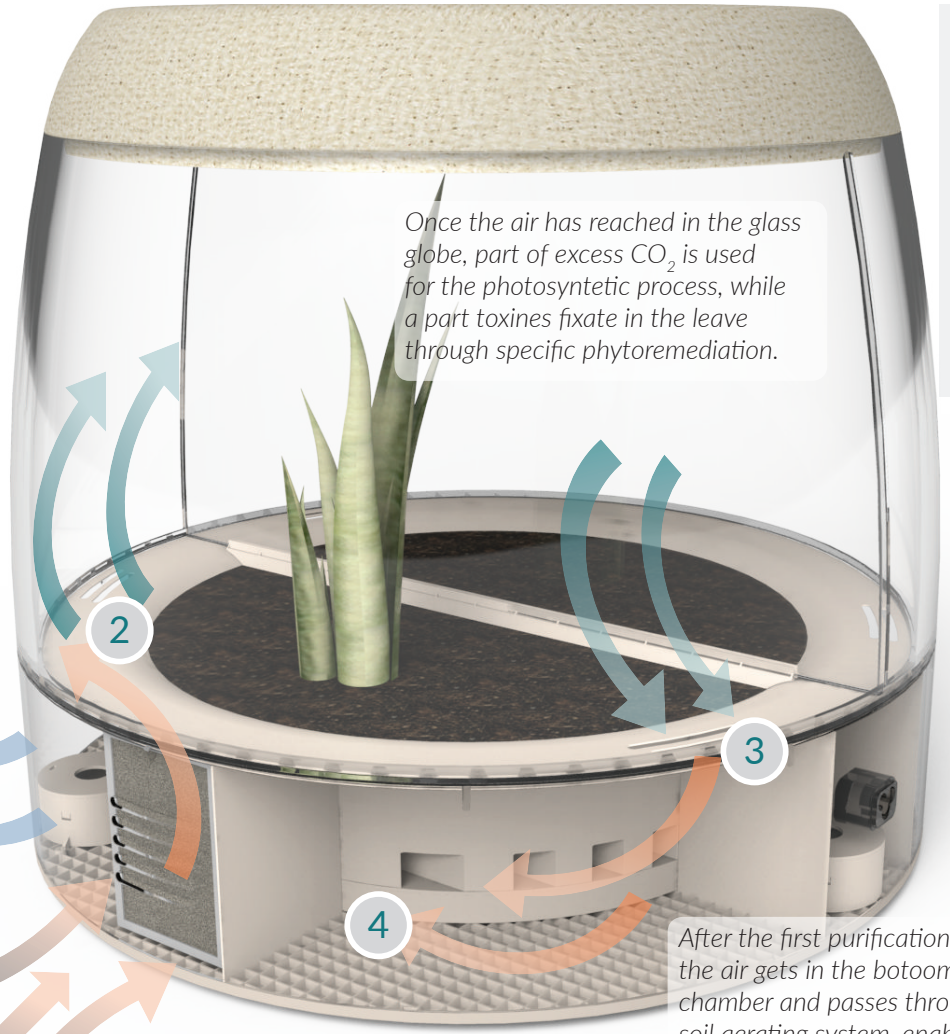


MAGNA FLOW

Magna is desined for both individual air flow cycles and double ones, depending on the plant combinations.
Below is the air flow principle scheme for a single chamber cycle.
The exact same flow takes place in the case of a double chamber run.

The suction fan is the component dictating when the air flow is allowed to pass by.
The outlet grate is located on this side, where the dehumidification system is found as well.
The placement ensures that the possible moist air from inside the glass globe is dehumidified before being released back in the room.

The air volume is finally sucked out by the fan, passing the slots in the plastic injected soil aerating component.
A HEPA filter is mounted on the outlet and retains the finest particles (pollen, germs, smoke)



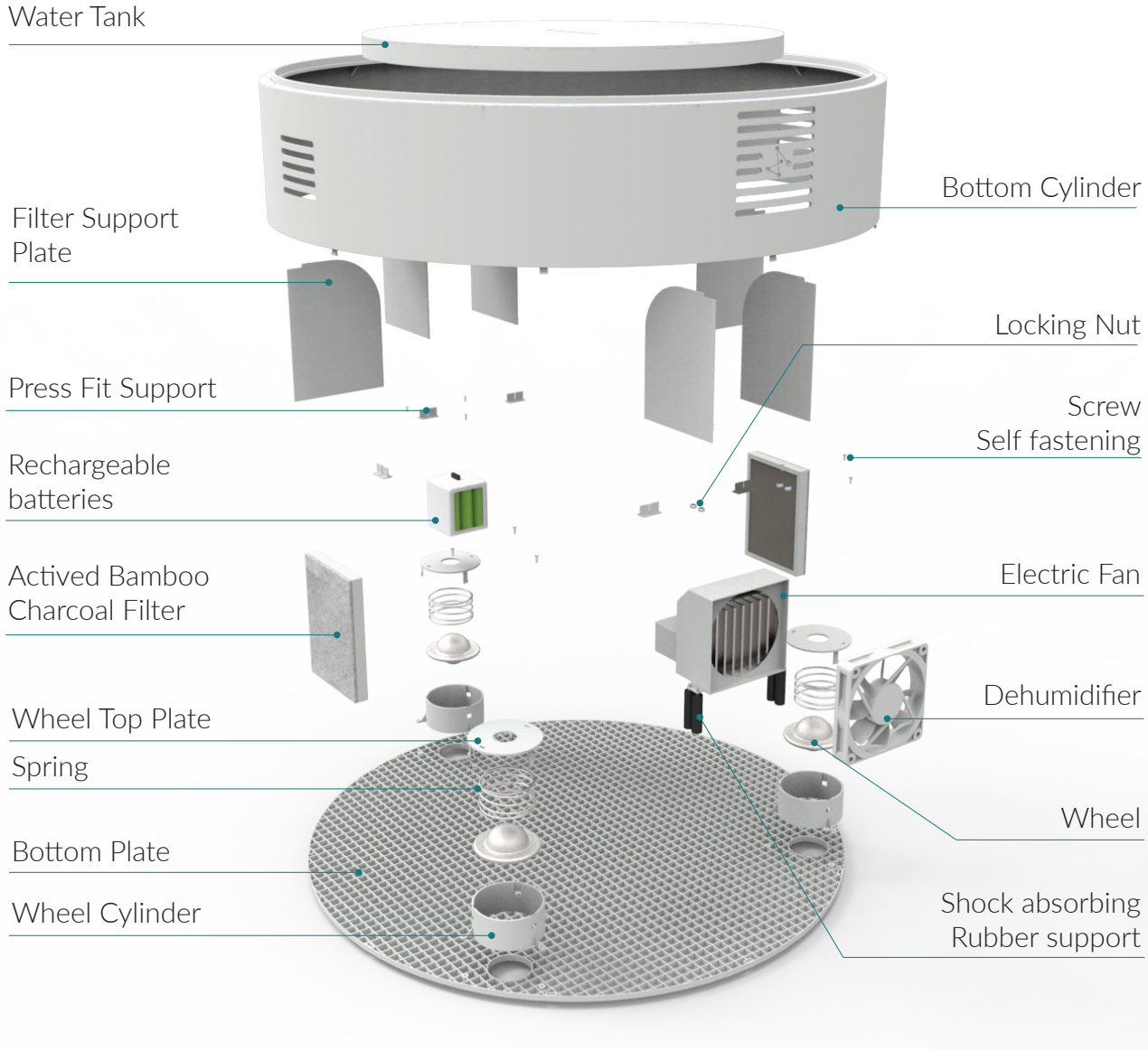
Once the air has reached in the glass globe, part of excess CO_2 is used for the photosyntetic process, while a part toxines fixate in the leave through specific phytoremediation.

After the first purification system, the air gets in the botoom part chamber and passes through the soil aerating system, enahncing the roots phytoremediation process.

The unfiltered air from the room is absorbed through the side grates inside Magna.

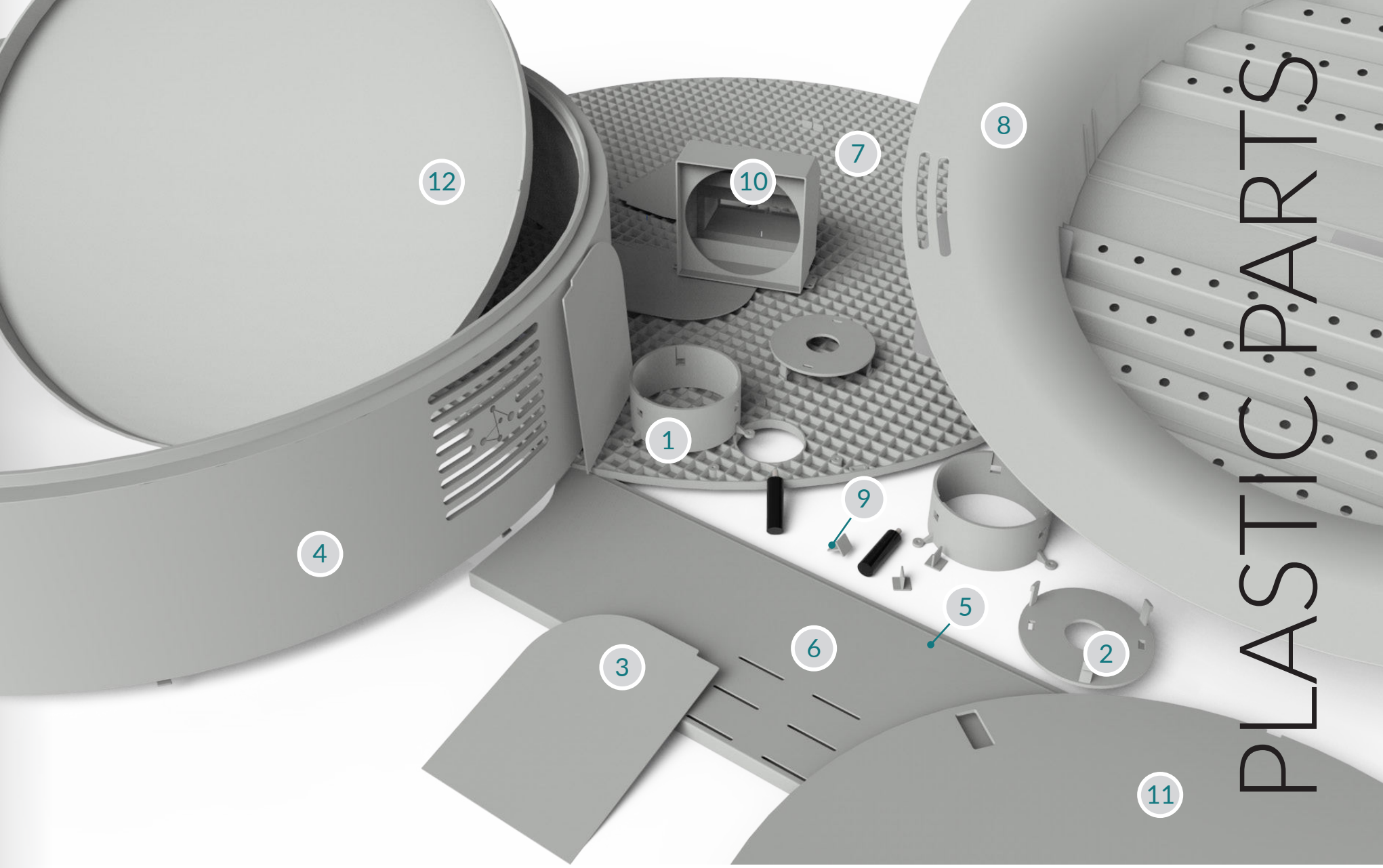
It passes through the activated bamboo charcoal layer and reduces odors.

INSIDE



Component	Specification
Rechargeable batteries	Alkalines, 42 Ah, 1.5V - AA Battery
Active Bamboo Carcoal Filter	Odor reducer
Spring	Load: 72 N Outer Ø = 45mm Height = 34 mm
Locking Nut	M3 AISI 316L
Self Fastening Screws	Body Ø = 4mm Effective Length = 5 mm
Dehumidifier	Heat Zink plates Thermo electric cooling plates HDPE Housing Electric Motor Spped: 2700rpm
Electric Fan	Speed: 2500rpm Noise level: 22 dB
Shock absorbing Rubber support	Ø=9mm H=4mm

PLASTIC PARTS



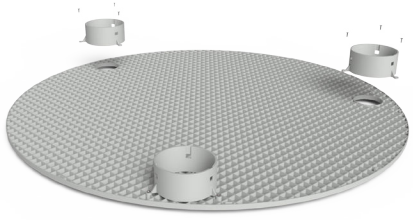
Item No.	Description	DKK/ 1pcs.	QTY	Mould (DKK)
1	*Wheel Cylinder*	*20,2*	*3*	*41.218,7*
2	*Wheel Top Plate*	*8,4*	*3*	*35.888,2*
3	*Filter Support*	*9,4*	*6*	*0*
4	*Bottom Cylinder*	*126,2*	*1*	*132.618,3*

Item No.	Description	DKK/ 1pcs.	QTY	Mould (DKK)
5	*Chamber Divider - Top*	*23,1*	*1*	*39.539,6*
6	*Chamber Divider - Bottom*	*16,8*	*1*	*40.941,4*
7	*Bottom Plate*	*106,6*	*1*	*100.631,4*
8	*Soil Aerating Plate*	*101,4*	*1*	*120.667,0*

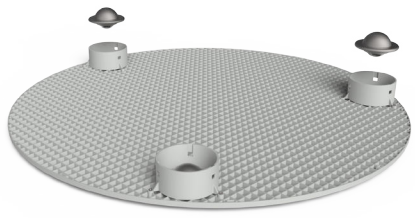
Item No.	Description	DKK/ 1pcs.	QTY	Mould (DKK)
9	*Press Fit - Filter Support*	*2,4*	*12*	*8.881,9*
10	*Dehumidifier housing*	*5,9*	*2*	*11.655,2*
11	*Water Tank top plate*	*53,8*	*1*	*33.316,2*
12	*Water Tank bottom plate*	*50,7*	*1*	*33.316,2*

BOTTOM ASSEMBLY

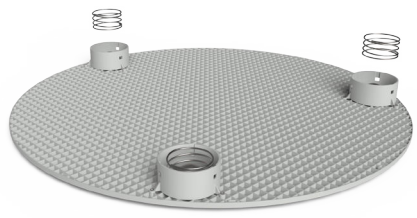
For an easier transportation to the distribution centers and eventually to the end user, the bottom part can be a sub-assembly on its own and be packed allready separately.



The three wheel cover cylinders are mounted on the bottom plate by using self fastening screws

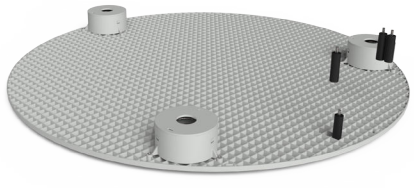


The three nylon wheels are placed each in a cylinder. The wheels support the weight on their flanges.

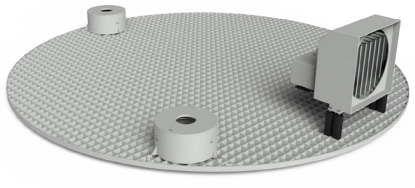


Three springs are then placed, each inside of a cylinder.

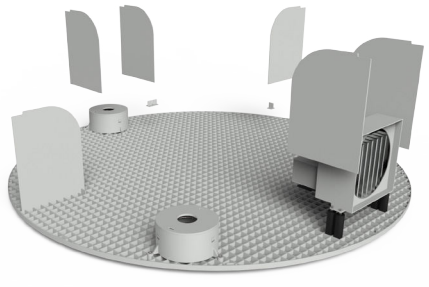
The top plates for the wheel housings are mounted by snap fits on top of the cylinders.



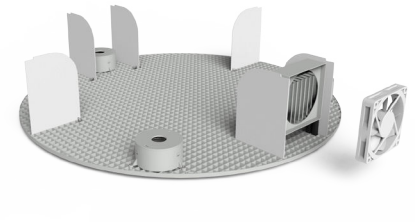
Four rubber supports for the dehumidifier are fixed by pressure in the ribs of the bottom plate.



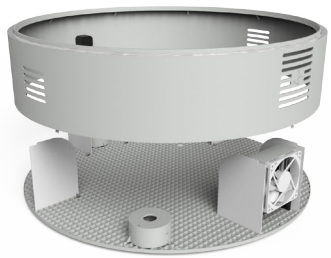
The dehumidifier system consisting of: heat zink plates, thermo electric coupling, engine and housing is placed on the supports.



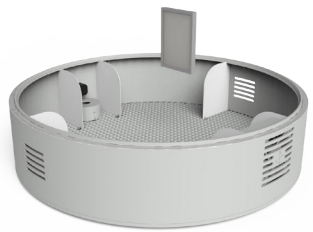
Eight support plates are placed on the bottom plate with help of press fit brackets.



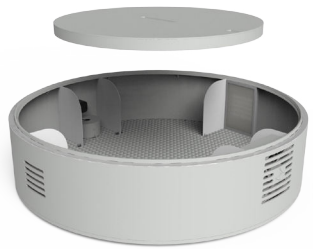
The suction fan is mounted on the outer side of the dehumidifying system.



The large cylinder is pressed on the bottom plate and fixed in place by separable snap fits.



The two bamboo filters are placed on the inlet sides. Charging socket is installed also.

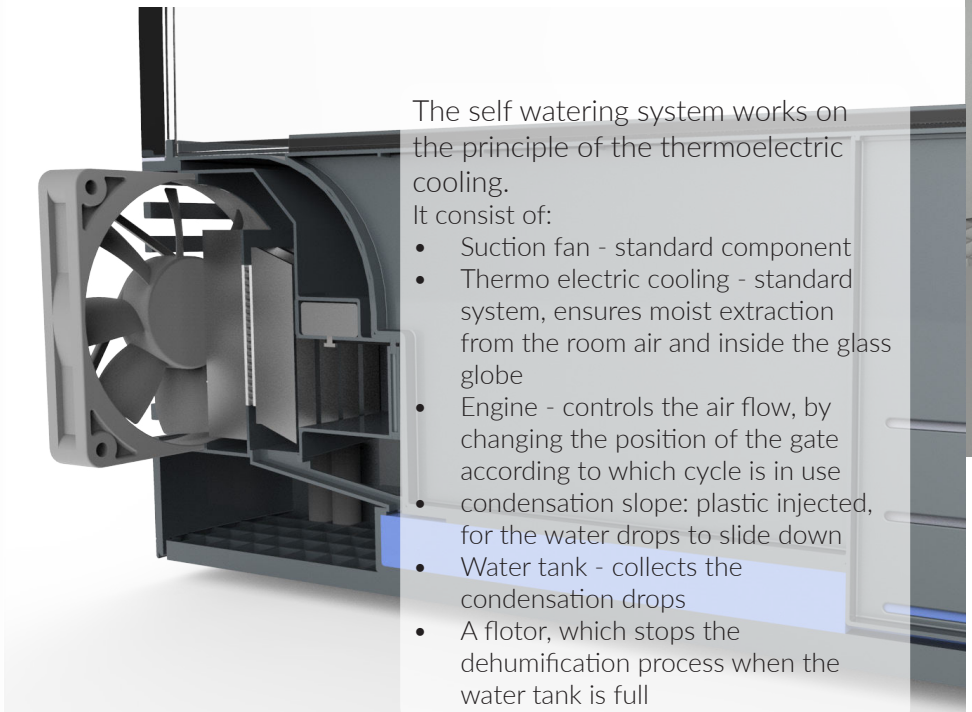


The water tank is slided vertically inside, resting on the bottom plate.

The HEPA filter on the side of the soil aerating layer, which is placed on top of the water tank.

The chamber divider assembly is slided in on the aerating layer, following mount hole.

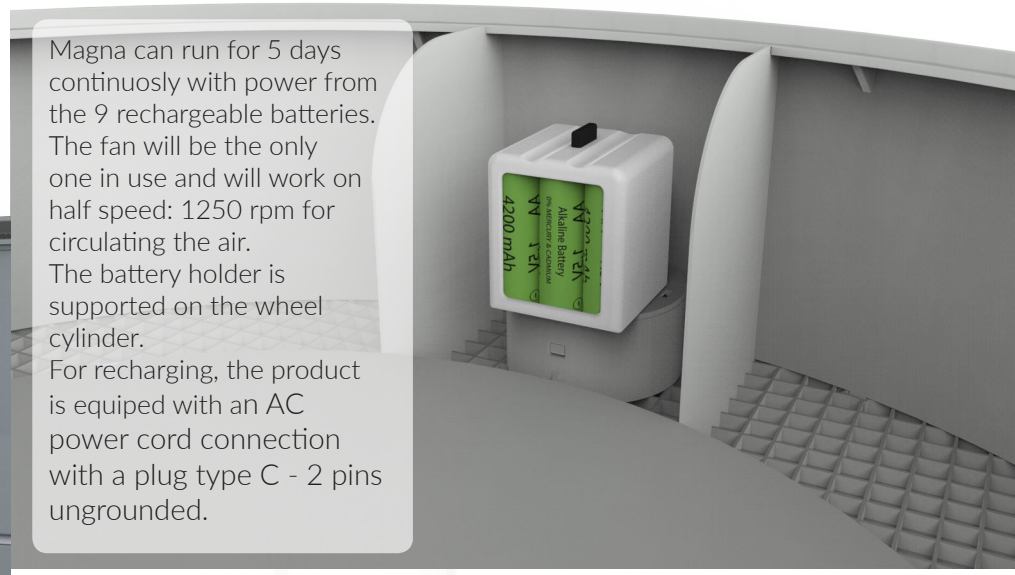
SELF SUPPLY



The self watering system works on the principle of the thermoelectric cooling.
It consist of:

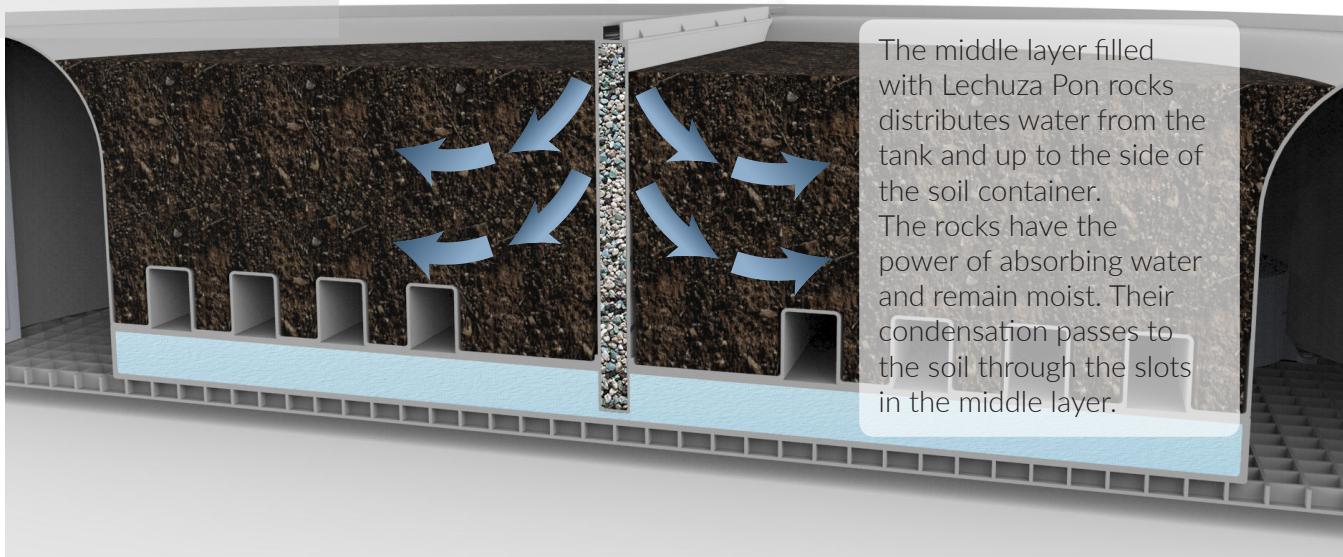
- Suction fan - standard component
- Thermo electric cooling - standard system, ensures moist extraction from the room air and inside the glass globe
- Engine - controls the air flow, by changing the position of the gate according to which cycle is in use
- condensation slope: plastic injected, for the water drops to slide down
- Water tank - collects the condensation drops
- A flotor, which stops the dehumification process when the water tank is full

DEHUMIDIFICATION



Magna can run for 5 days continuosly with power from the 9 rechargeable batteries.
The fan will be the only one in use and will work on half speed: 1250 rpm for circulating the air.
The battery holder is supported on the wheel cylinder.
For recharging, the product is equiped with an AC power cord connection with a plug type C - 2 pins ungrounded.

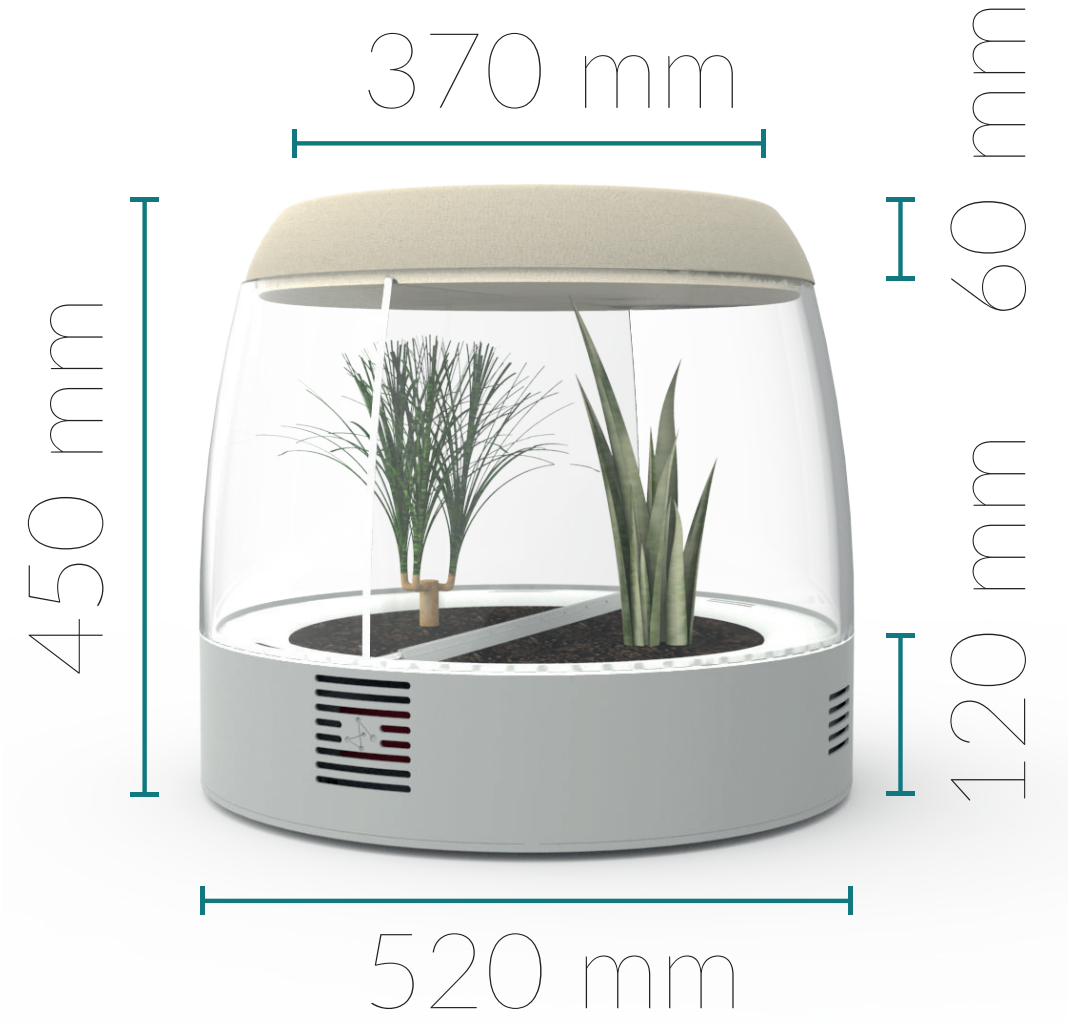
RECHARGING



The middle layer filled with Lechuza Pon rocks distributes water from the tank and up to the side of the soil container.
The rocks have the power of absorbing water and remain moist. Their condensation passes to the soil through the slots in the middle layer.

WATERING

DIMENSIONS



Glass Dome
10,215 kg
Thickness= 10mm

Hardened Glass
1,223 kg
Thickness= 4mm

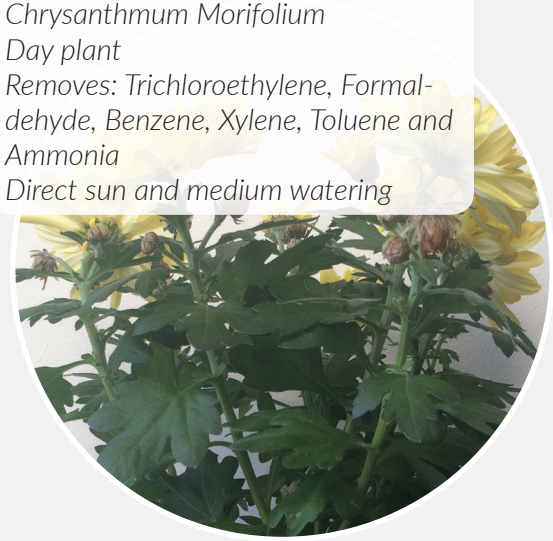
Magna has the recommended dimensions for a sitting furniture, to meet both the comfort need and the ergonomy in human position.

PLANTS

English Ivy - *Hedera Helix*

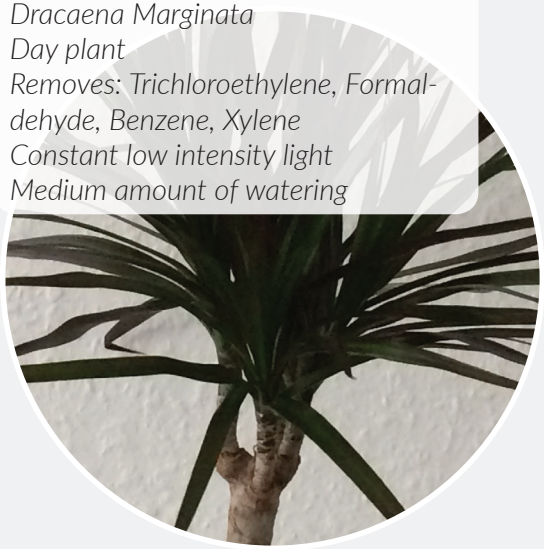
Day plant
Removes: Thricholoethylene, Formaldehide, Benzene, Toluene and Xylene
Light: Bright light, but no direct sun
Water: Evenly moist soil

Florist's Chrysanthemum
Chrysanthmum Morifolium
Day plant
Removes: Trichloroethylene, Formaldehyde, Benzene, Xylene, Toluene and Ammonia
Direct sun and medium watering



Peace Lily
Spathiphyllum Mauna Loa
Day plant
Removes: TTrichloroethylene, Formaldehyde, Benzene, Xylene and Ammonia
Bright light and evenly moist soil

Red Edged Dracaena
Dracaena Marginata
Day plant
Removes: Trichloroethylene, Formaldehyde, Benzene, Xylene
Constant low intensity light
Medium amount of watering



Varigated Snake Plant
Sansevieria Trifasciata
Night plant
Removes: Alcohol, Acetone, Trichloroethylene, Formaldehyde, Benzene, Xylene
Medium light and very little watering

Aloe Vera
Aloe Barbadensis Miller
Night plant
Removes: Formaldehyde, Benzene
Direct sun as much as possible
Soil must be dry before watering.
Leaves have water storing property

Team AERITY recommendations of six most effective indoor plants

USER SCENARIO

FIRST TIME

Freja receives and opens the boxes and takes out the parts and sub-assemblies.

She is placing the bottom cylinder on the floor and the aerating layer on top.

She finds the starting soil mix kit and starts planting her two plants, each on a side.

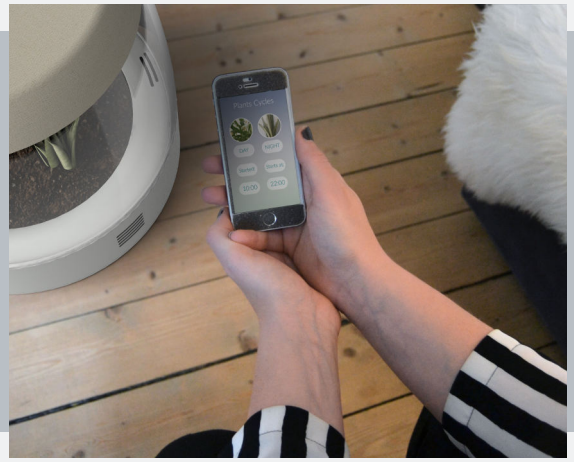
She places the glass divider on the middle and then the glass globe gently on top.

She is afterwards placing the seating part on top of the glass globe.

Finally, she plugs the recharging cable in so and Magna is now ready for running.

IN TIME

From time to time she cleans the glass globe inside and out with a cleaning cloth.

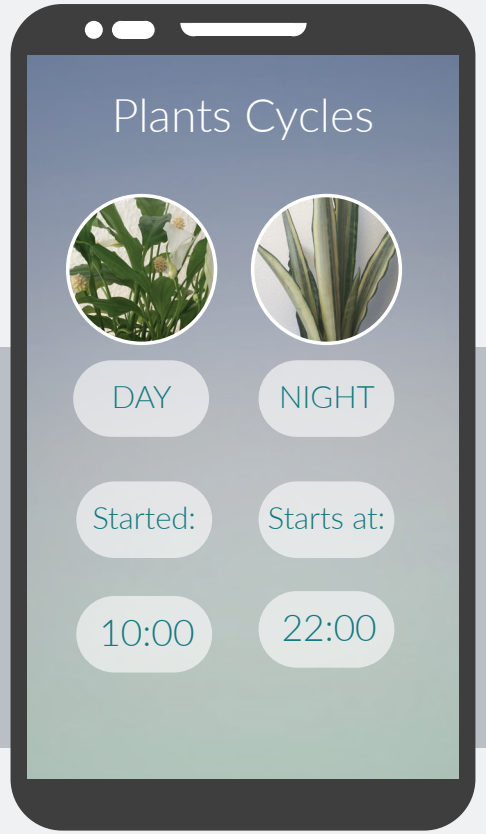


All the procedures are found in the booklet or on the AERITY Universe App.

Team AERITY has a recommendation of six most effective plants for both carbon dioxide and volatile organic coumpounds.

Four plants have the higest removal CO_2 removal rate during the days, while the other two are suitable for the night.
Day plants can be used in rooms where there is activity during day time, while the night plants are perfect for bedrooms.

The dedicated App allows controlling the type and start time of each cycle. The function is necessary since the day legnth is different acorss the globe.



COLORS & MOVE

Home interior are simply like us people,
all unique and with own personality.
It is AERITY's pleasure to give the customer the
choice opportunity in customizing its Magna.

SEATING CUSHION

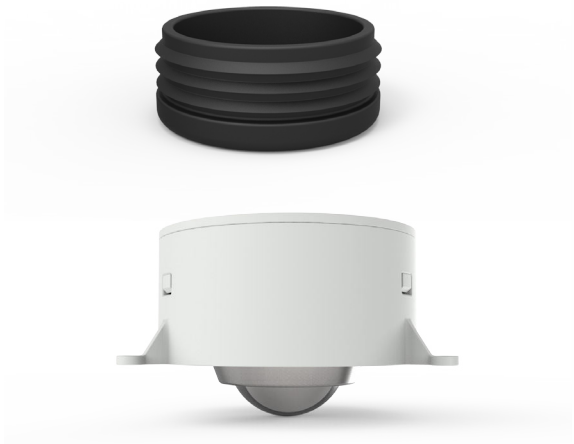
Gabriel Gaja C2C color palette fabrics

The sitting cushion comes in a six colors palette fabric. Clients are invited to choose their preffered one directly when purchasing. The fabric cover is removal and can be effectively cleaned by machine washing, with regular clothes detergent.

BOTTOM PART

The bottom part accomodating the living plant is available on a three colors palette. Clients are again invited to chose their best match with home interior when purchasing the product.

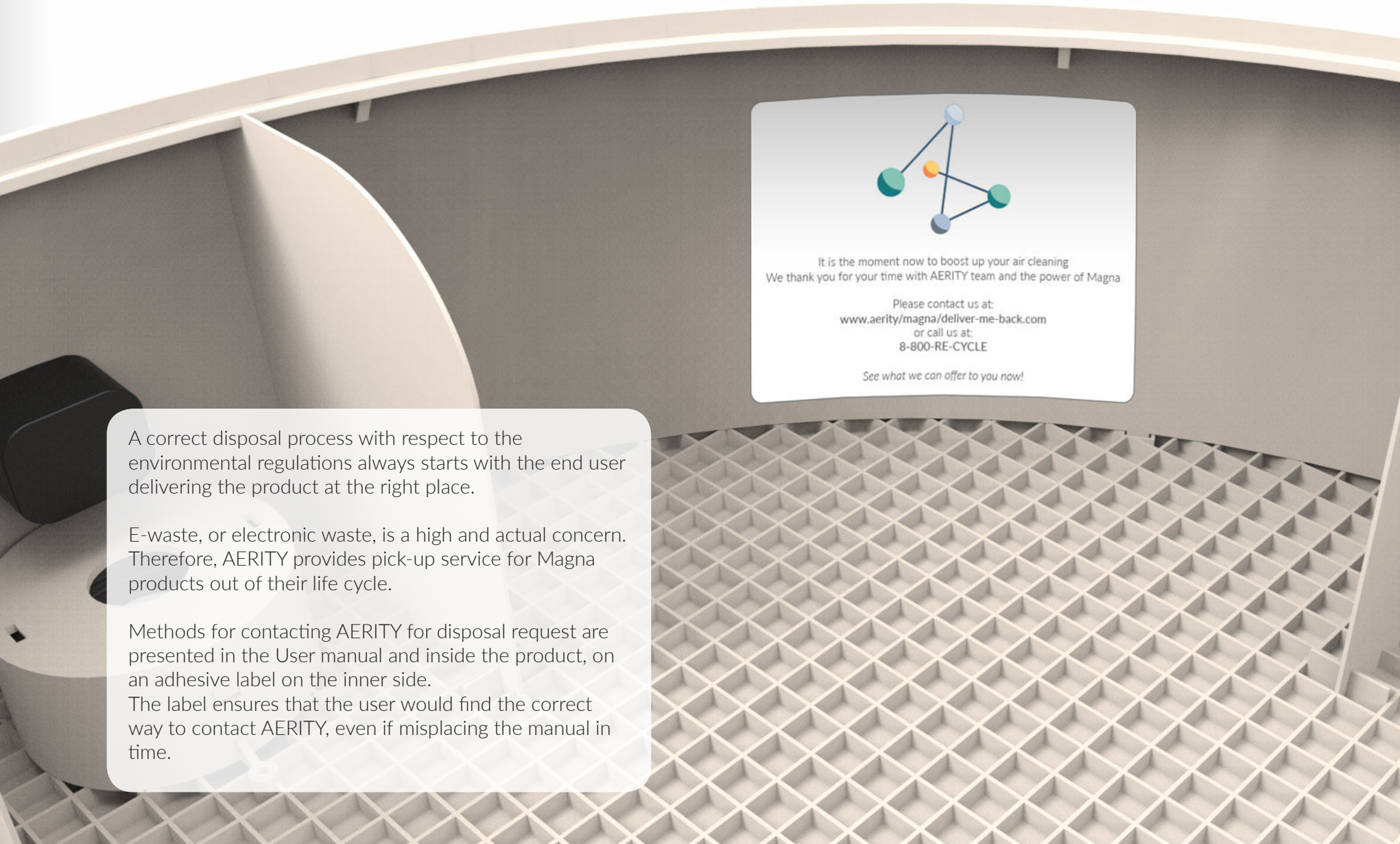
MOBILITY CHOICE



A dosis of our daily comfort comes from the surface texture and cover of the home floors. Whether it is a soft carpet, hard wodden floor or ceramic tiles, Magna is prepared to meet the mobility needs. Nylon rollers are recommended for hard surfaces, while the sliders provide easy mobility on soft textures.

http://www.gabriel.dk/en/fabrics/colourscale/Gaja-C2C

END RETURN



A correct disposal process with respect to the environmental regulations always starts with the end user delivering the product at the right place.

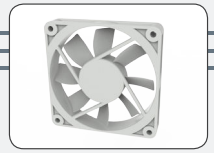
E-waste, or electronic waste, is a high and actual concern. Therefore, AERITY provides pick-up service for Magna products out of their life cycle.

Methods for contacting AERITY for disposal request are presented in the User manual and inside the product, on an adhesive label on the inner side.
The label ensures that the user would find the correct way to contact AERITY, even if misplacing the manual in time.

PRODUCT PRICING

Standard purchased Components

Electrical Fan

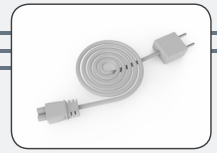


20 DKK/ 1 pcs

Wheel

219 DKK / 3 pcs.

Cable Connection

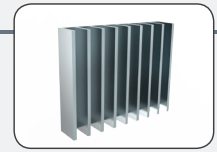


20DKK /1 pcs

Batteries

280DKK/ 9 pcs.

Heat zink

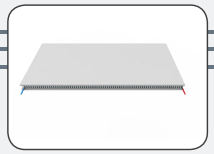


40 DKK /2 pcs.

Spring

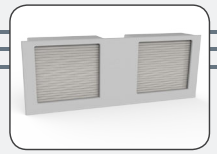
9 DKK/3 pcs.

Thermo electric plates



33.2 DKK / 2 pcs.

HEPA Filter



Price: / 1 pcs.

Toolbox

Price:

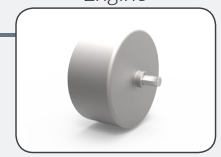
Active Bamboo Carcoal Filters

Price: / 2 pcs.

Slider

13.5 DKK /3 pcs.

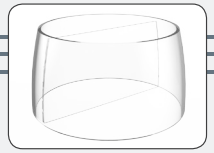
Engine



53 DKK / 1 pcs.

Customized Manufactured Parts

Glass Globe



800 DKK / 1 pcs.

Glass Divider

194 DKK / 1 pcs.

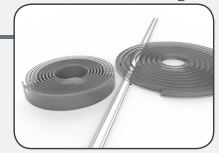
HDPE Injection moulded parts

615 DKK/ 1 set

Sitting Cushion

330 DKK /1 pcs.

Silicone Sealing



16.7 DKK / 1 set

Shock absorbing Rubber Support

15.06 DKK / 1pcs

Assembled & packed on segments by: IDdesign Main Stakeholder

Seating + Bottom Parts

4.651 kg

Glass Parts

11.438 kg

Soil & Fertilizer Start kit

2 bags - 1 kg each

Lechuza Pon Rocks Start kit

1 bag 0.2 kg

BUYING PRICE

2.684,9 DKK

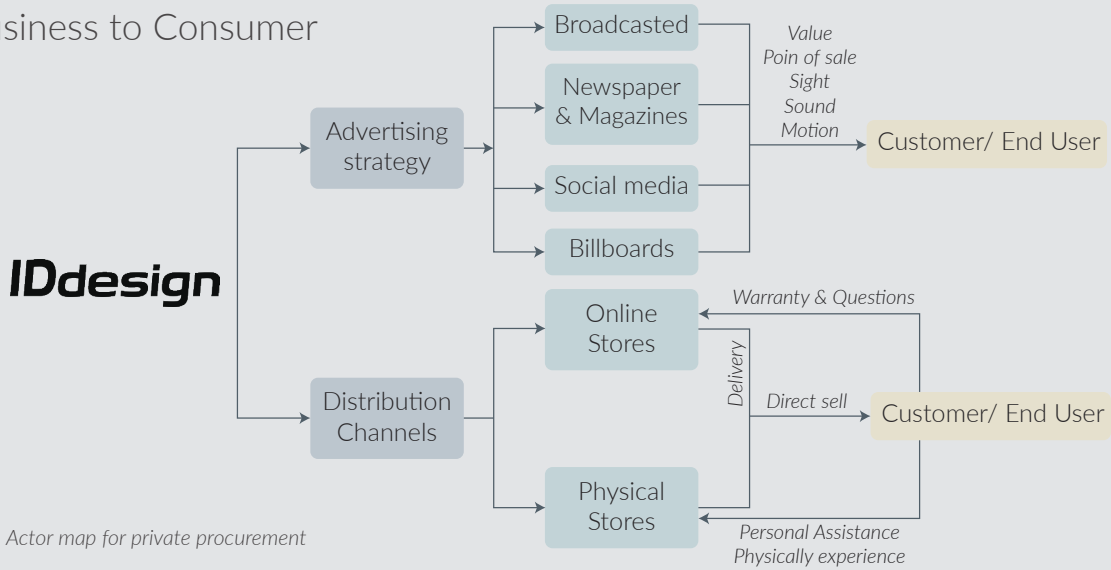
SELLING PRICE

EUROPE

4000 DKK

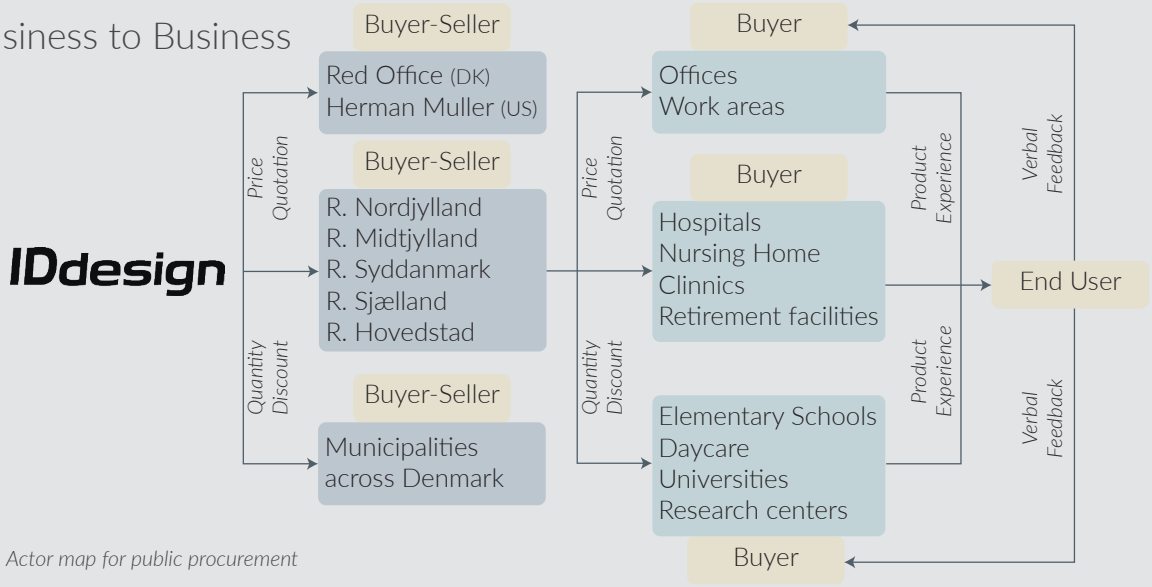
BUSINESS JOURNEY

Business to Consumer



Actor map for private procurement

Business to Business



Actor map for public procurement

IDdesign A/S is Denmark's largest interior design company, representing the three brands: IDEmøbler, ILVA and the franchise chain IDdesign.
Their 18 selling points covers a large international area, from Europe to Orient. Their products follow the modern trends, playful, simple, with color and harmony.
Below are presented the two scenarios for trading Magna through IDdesign A/S. [http://salgskarriere.dk/om-iddesign/]

MAGNA

Part of your home and air

3499.-

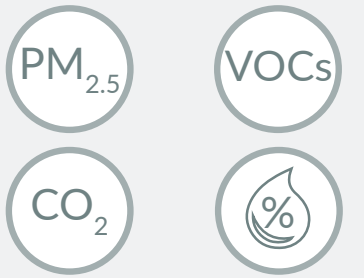
SPAR 500.-

MAGNA Air Purifier

"A unique design, bringing the nature in play as main actor.
It is a selfwatering system providing care to indoor plants and inhabitants.
A silent and excellent helper for the air quality in the bedroom, children's rooms and other areas at home.
Please be seated on this furniture piece or simply use it as a small table around in the house."

http://decor8blog.com/

PARUM - YOUR AIR - YOU MONITOR IT



The invisible indoor air pollutatnts are now to be seen with help of Parum.
Being under extended exposure to air pollutants conducts to serious cronical respiratory and allergic affections.

It matters what you breath at home and AERITY is in charge of it. Parum is the design and functional compatible smart monitor for the house.
It detects harmful organic compunds (VOCs), the ambiental carbon dioxide level (CO_2), the fine particulatte matter (PM 2.5) and relative humidity (RH%).
Its red LED light informs when the average of pollutants defines a harmful AQI - Air Quality Index.
With a simple check on the dedicated app, the right action is closer to meet the health needs.

Get to know your indoor climate

Come in the AERITY Universe!
Download the app and register with your unique Monitor No.

Understand Parum

Red LED light allert signalizes an AQI corresponding to Unhealthy, Very Unhealthy and Hazardous climate.
While having Good or Moderate climate, there is no ligh present.

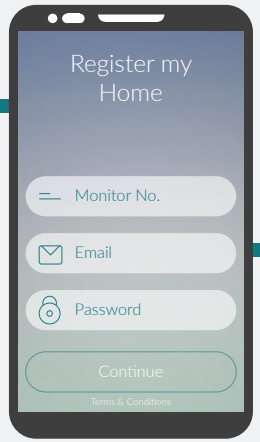
- Good (0 -50)
- Moderate (51-100)
- Sensibility (101-150)
- Unhealthy (151-200)
- Very unhealthy (201-300)
- Hazardous (>300)

Recharge easy at any time, with the mini USB original cable.
Blinking LED light will alert on low battery.
Optionally, the battery state can be checked on the App also.

Discrete colors matching any indoor

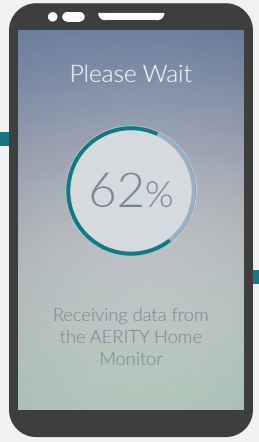
KNOW YOUR ENVIRONMENT

AERITY knows that people like to know what is happening around and how does this influence their daily life. It has therefore developed a dedicated app to explain all one wants to know about the indoor air quality, give advices, help with the best plants match for Magna and give the opportunity to check what is the Air Quality Index across the globe. Account registration can be made with e-mail adress or Monitor No.



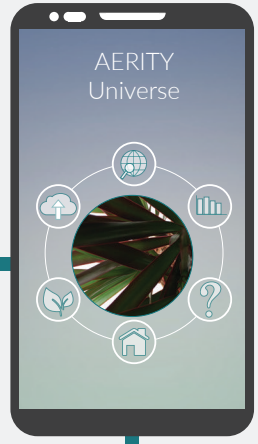
Create the online account using e-mail or Monitor No. This is found on the bottom side of your Parum

Make sure the monitor is ON.



It is now retrieving data

You are now in your AERITY Universe



My home
AIQ real time

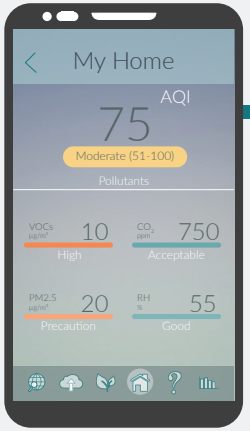
Plants
Best match for you

Worldwide
AIQ real time

Help
In doubt? Contact us!

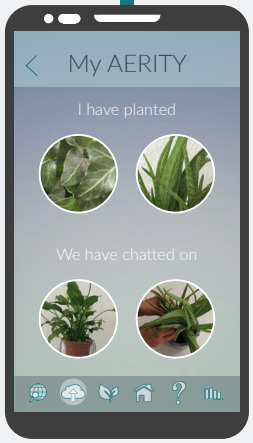
History
Your AERITY activity in time

Data Log
All your records at any time



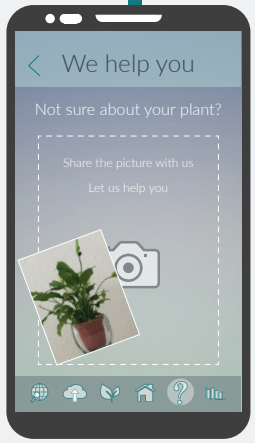
Computes the AQI based on the registered pollutants and expresses it according to standards

Real time information on AQI across the globe, at one touch distance. See how others are doing!

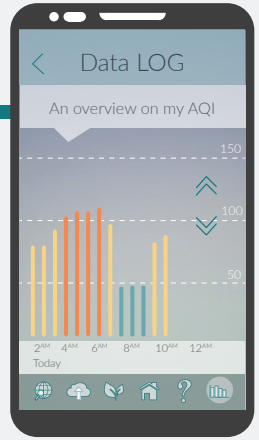


Records of the plants you grew in Magna and topics you have discussed with team AERITY

All you need to know about the best purifying plants: potting, division, fertilizer and sunlight



In doubt of how your plants are doing?
Send us a picture and you will get all our support



Trace your AQI over time and see where and when you should improve the conditions.

CONCLUSION

Magna is in its essence a modern, playful and dynamic air purifier, which bring the living indoor plants as the main object of work.
The plants were carefully selected for meeting the highest efficiency in reducing CO_2 and VOCs. The aesthetical value plays a high role also in the product, combining the relaxing green of the plants with the glass globe which allows the curious mind to be part of the purification process.
It is dynamic playground for understanding the power of plants and their natural cycle.
Magna use the indoor plants wisely according to their photosynthesis time and choose the right plant-room combination: night plants for bedrooms and day ones for rooms with intense activity during day hours.

There is always place for improvement, espcially if having the opportunity of receiving feedback from users.
In meanwhile, Team AERITY takes in consideration possibilities of transforming the seating part into a hard surface, so Magna could be better used as a small table.

A reduced version of Magna, working on the same principle of air purification would be a very welcomed idea for car travelling or vacation houses.

Finally, the most concludent reflection would come after producing one sample and perform tests of it professionally.

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ARKITEKTUR & DESIGN

MAGNA

[latin] large

PARUM

[latin] little

AERITY