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If one sheep leaps over the ditch the rest will follow.
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This booklet is made as a part of the spring 2017 graduation studio given by the Chair of Architecture & Dwelling on the faculty of Architecture at the TU Delft. The graduation project is the final assignment for every student before graduating at the university. The main field of research is the issue of Dutch housing design in the near future, but every student addresses this issue according to his own personal interests and beliefs. The focus of this studio lies on a dense redevelopment of the inner city of Amsterdam. The research in this booklet on the other hand will focus on sustainable interventions for dwellings with the main focus on natural ventilation.

P2 etc. vermelden

Where is the booklet for
What is the studio
Acknowledgements

Alexis Huisman, 02-05-2017
Chapter 1
Problem statement
We live in a world driven by a spirit of the time. This spirit of the time has evolved for centuries and arrived at its current state. We cannot speak about one distinctive spirit of this time since different people see the world in different ways. But we can see the main overlapping characteristics of the globalized society.

I would like to refer to Abraham Maslow in order to understand these characteristics. Maslow’s hierarchy of needs is a theory about human motivation and needs which originates from 1943. Maslow argues in his theory that human motivation generally moves through certain needs (figure 1). When the most fundamental needs are fulfilled, one will focus more on secondary or higher levels of needs.

The developed western society is currently mainly focused on psychological needs. It has been argued that the change from basic to psychological needs took place from the industrial revolution and onwards. Our focus has switched from survival towards the need to become happy and towards a feeling that we have accomplished things in our life. We want to show others that we are capable of caring for ourselves. We have a need for (self)esteem.

**Figure 1: Maslow’s pyramid**

![Maslow's Pyramid](image-url)
At the same time we have become aware that our deeds have consequences on the environment. We know that we are the cause of global warming — which has grown almost exponentially since the start of the industrial revolution — but the majority of the people does not properly act in order to drastically reduce our impact on the planet. We could sum up a huge variety of reasons explaining the motives of those people, but for this research it will be sufficient to focus on the ones who do try to actively participate in a sustainable environment and see sustainability as an essential element for the continuation of human development and future generations. In other words, sustainability should become a basic need in Maslow’s pyramid.

The main difference between these two groups can be summarized with the understanding of the difference between the words ‘awareness’ and ‘consciousness’. Awareness is the determination of a happening while consciousness thinks one step further and is active in finding the reasons behind this happening (dictionary source?). Therefore we link consciousness to the higher order of Maslow’s pyramid (Roubanis, 2008, p. 212).
Conscious people started to understand their need for (self)esteem and understand that achieving this should not be at the cost of the environment. The focus should change from egocitizen to ecocitizen. It is an ecocitizen who recognizes the ecological impact of our decisions and choices and is active in finding solutions to the problems (Marchand, Walker, 2010). At the same time we should acknowledge that every person has its own interpretation on the world — which is being reflected through his lifestyle — and that it is hard to change someone’s lifestyle (Ahmad, Batson, 2002).

The most that we can do is to make the leap to sustainability ourselves so others might be inspired to start thinking about it themselves and eventually start participating (figure 2). If one sheep leaps over the ditch the rest will follow.

Figure 2: Maslow’s pyramid reconsidered

1. Recognize and understand the problem
2. Find solutions to the problem, change lifestyle
3. The new lifestyle will slowly becomes common
Sustainability and architecture are like .. and .. are for each other. You can not have architecture without sustainability. Sadly enough it still happens too often that architecture is being made without thinking about sustainability. As an architect we are in the position of changing the built environment and thus changing that what people perceive. We have the privilege to argue about our believes and make those visible to the people in such a way that one does not bother. We can make showcases which at least unconsciously will change ones perception, literally and hopefully figuratively. Therefore I would like to design a complex in which people who already think and try to act consciously can live. This requires a good understanding of the target group but perhaps even more important, a complex which reflects their ideology. This led to my research question:

**What technical characteristics does a residential complex require in order to meet the needs of the voluntary simplicity movement?**

Since this question has a lot of variables, it is the starting point of the research and the question will become more specified while the research takes place. It is of importance to firstly find the right target group which has to meet certain demands. These demands are bound to the context of the building, Amsterdam.

**What makes the voluntary simplicity movement different from other ecological minded movements and why would this target group be suitable for a dense city like Amsterdam?**

**What are the characteristics of this target group and how can they be translated into architecture?**
Since further specification of the research question is based on the results of the preceding questions, it is advisable to read chapter 2 in order to understand the relevance of the upcoming questions.

What are the approaches for building sustainable residential complexes?

What technical features result in the simplification and reduction of the energy usage of a dwelling?

Up until what extend can natural ventilation minimize the need for mechanical additions in a Dutch climate?
Hypothesis target group:

Since there is a trend of people moving from cities towards so called ecovillages, it is expected that more of such equally minded people are living in the cities. Those people will have different motives for the wish of acting sustainable and there will be a diversity in the rate of motivation of acting in such a way. Furthermore it can be expected that these people are mainly triggered to act different than the common way of acting in the present society because they think consciously about the effects that this society has on the environment. This means that it is expected that the lifestyle of the target group will be quite different than the conventional (is dit een goed woord voor ‘algemeen gebruikelijke levensstijl’?) lifestyle.

Hypothesis sustainable dwellings and natural ventilation:

Building sustainable will not be the main problem. We have the materials and easily available knowledge to build a dwelling which can produce what is uses. It is more important to find new and sustainable techniques which reduce the need for energy and try to focus on an autonomous complex. There is a big change that energy reducing methods can already be found in nature itself since it has evolved towards a circular life for centuries (source terugvinden). It should be possible to eradicate the need for mechanical heating and ventilation by using the inexhaustible resources of the environment.
1.4 - Plan of approach

Stap 1:

Design by research:
Onderzoek -> bevinding -> specificering -> onderzoek -> etc

Stap 2 (na P2):

Research by design & design by research

Laatje maken om het in één oogopslag inzichtelijk te maken!
Chapter 2
Target group
2.1 - Sustainability

Een duurzame doelgroep zou de fricties tussen de drie P’s moeten weten te overbruggen of in ieder geval rekening mee moeten houden.

A sustainable mindset is guided and underpinned by a mindful mindset that reflects a conscious sense of caring toward self, community and nature (Balderjahn et al., 2013).

A self sufficient city => gebruik duurzaamheidsthemas! Hier uitleggen

Figure x: Frictions between the elements of sustainability
own work, based on (Campbell, 1996)
2.2 - Ecovillages

The recent movement of ecovillages originates from 1975 when Richard Register founded Urban Ecology in order to “rebuild cities in balance with nature” (Roseland, 1997). In 1991, Robert Gilman defined an ecovillage as: “A human-scale full-featured settlement in which human activities are harmlessly integrated into the natural world in a way that is supportive of healthy human development, and can be successfully continued into the indefinite future.” (Gilman, 1991). Ecocitizens are conscious about environmental problems and are active in finding solutions (Marchand, Walker, 2010). Because Dutch governments are quite unfamiliar with the concept behind ecovillages and the huge social impact it will have, they are reluctant to the concept. It is only since recently that cities like Deventer have become interested in it after seeing the success of such villages in the near surroundings (Marselis, 2017).

There is no such thing as a typical ecovillage. Each village has its own characteristics based on the location, climate, and culture. Ecovillages vary in sizes from a few houses to hundreds of people. According to Dawson (2006) they do have certain principles which distinguish them from other urban or rural areas (figure x). Their main motivation is characterized by a reaction against the from nature alienated and materialism orientated industrialised society. They have a strong wish to throw off the influence of the industrialised societies and return to precedent norms and values which were — unconsciously — sustainable orientated (Sevier, 2008).

![Figure X: Principles of an ecovillage community](image)  
*own work, based on (Dawson, 2006)*
Kosha Joubert, president of the Global Ecovillage Network, claims that ecovillages “rebuilt economies that do not serve profit, but serve live on this planet” and “focus on sharing instead of personal profit” (Joubert, 2015). When comparing this to the four possible motives that drive a person towards an action (Ahmad, Batson, 2002; Johnston, Burton, 2003), we see that ecocitizens have made a shift from which the focus lies more on a personal benefit towards a rational, ecological, benefit and therefore indirect a communal benefit (figure X). A change has been made from ego- to ecocitizen (Marchant, Walker, 2010).

If ecovillages would be the future of housing and living, then why are they located at the border of villages or even beyond them? As Marselis mentioned, governments have become less reluctant towards such initiatives since the notice of their successes. On the other side, some of the characteristics — spirituality and education — does not seem to be applicable in a showcase for the city centre. Spirituality for the fact that the majority does not have the need to share things on a spiritual level with a community (Marselis, 2017) and intended education for the restrained effect it can have on third parties who could interpret sustainable living as a complex lifestyle. A showcase should be public in order to see the simplicity of the lifestyle so people can identify the similarities and differences compared to their own lifestyle. One will start to understand the width of the ditch they have to jump and become conscious.

Figure X: Personal interpretation of the lifestyles based on the four motives (Joubert, 2015; Marselis, 2017; Ahmad, Batson, 2002)
As mentioned, ecovillages tend to be located at more remote locations. The Netherlands has wide spread community of people interested in living in ecovillages (ecodorpennetwerk.nl) or want to individually adapt their ideologies onto their own lives. Voluntary Simplifiers (VS) tend to emphasize on individual actions and are mainly present in the urban environment (Marchand, Walker, 2004). VS are people who choose “out of free will rather than by being coerced by poverty, government austerity programs, or being imprisoned, to limit expenditures on consumer goods and services, and to cultivate non-materialistic sources of satisfaction and meaning” (Etzioni, 1998).

The problem is that VS are interwoven with the ignorant, negligent, self glorifying, or financially restrained society. They do not form a strong front which can (un)consciously make a firm statement. Therefore I propose an in the society interwoven residential complex for this target group in order to become an unobtrusive showcase for the society. To bring this group together and make the society familiar with their ideology (Figure X). This corresponds to the ‘action competence’ approach (Bonnett, 2002) in which a certain rational critical attitude is encouraged by practical situations to which the society is confronted in local circumstances. It assumes the sufficiency of pure rationality to the understanding of environmental issues and is the opposite of the ‘environmentalist’ approach which implies a systematic educational approach of those who have knowledge onto the ones who do not.

![Figure X: Urban sustainability approach](image-url)
There is a gradation in the dedication of Voluntary Simplifiers. The consulted sources use different terms but the concept behind each term is the same (Elgin, Mitchell, 1977; Ray, 1997; Roubanis, 2008; Bozoklu, Korkmaz, Sertoglu, 2015). This report will use the most accurate source that is consulted during the research (Elgin, Mitchell, 1977).

Voluntary Simplifiers can be divided in three groups, leaving one group unaddressed, the people opposed to the ideology of VS. It should be noted that people who are financially incapable of acting according to the VS ideology are also placed in this group. Ascending in terms of dedication there is the VS sympathizers (VSS). VSS has the potential of participating but are neither encouraged nor motivated to do so. Partially VS (PVS) partially incorporate the VS ideology. This group might be more of a fashion statement since they do not tend to give up the luxurious lifestyle (Bozoklu, Korkmaz, Sertoglu, 2015). The most dedicated are the Full VS (FVS). They fully incorporate the VS ideology in their lives.

This gradation is interesting for the creation of a showcase. By understanding the differences between the target groups we are capable of focusing on the dedicated gradation while knowing that the less motivated gradations will be stimulated to act. This results in architecture that will not force a lifestyle onto someone but will merely be a tool to trigger ones incentives by getting them to understand the ideology behind the VS movement.

Figure X: Schematic representation of the subdivided target group

1. Undifferent or opposed
2. VSS
3. PVS
4. FVS

own work
Studies over the years show the growing interest in Voluntary Simplicity (Elgin, Mitchell, 1977; Ray, 1997). This is also visible in the public environment where bag free shops and tiny-houses try to gain foothold, car sharing becomes a mainstream concept, and companies like Uber try to make the business more human scale (newspaper, date; newspaper, date). Contemporary research on the percentage of VS is missing, but a recent sample (Bozoklu, Korkmaz, Sertoglu, 2015) taken from an educated Turkish target group shows the gradation within the group of VS. Colours resembling the same gradations are used to assure readability (figure X).

Figure X: National gradation of VS (1977 & 1997) and gradations within the VS group (2015) own work
Elgin and Mitchell (1977) identify five central key values for Voluntary Simplifiers (figure X) which are up until now still present in recent definitions of VS (Hwang et al., 2006). The values of VS are based on a criticism towards the consuming culture and its consequences on the human and natural heritage (Marchand, Walker, 2004).

*Material simplicity* implies consuming less products and services. Favoured are recourse efficient durable products which have a smaller ecological impact. The price of the products should not be taken into consideration. Possessions should be supportive rather than central to the process of human growth, it is useless to take more than necessary.

*Human scale* focusses on working and living in environments which are smaller, decentralized and less complex. Reduction of scale is about restoring equality and minimize anonymity. It is a mean of getting back to basics by reconfiguring life to a more human and uncluttered perspective.

*Self-determination* involves a reduced reliance on large cluttered companies such as supermarkets. It includes notions of self-sufficiency by producing your own food and energy. To life without being depended on impersonal bureaucracy. VS are in favour of less specialization so that the relationship between their work and their contribution to the whole is more evident. They also seek to be less influenced by the media or the expectations of others by looking for guidance through your own values (Hwang et al., 2006).
Ecological consciousness is central to the Voluntary Simplicity movement. It focusses on resource conservation, waste reduction and the protection of nature. Social responsibility is part of this topic and is expressed by the willingness of sharing with those who are disadvantaged.

Personal growth concerns the development of self-realization. This should not be associated with any particular philosophy or religion since it is based on personal and rational values.

It is on the point of personal growth where many of the ecovillages — resulting in a generalized image — break with the ideology of VS. While many ecovillages value group meditation (Marselis, 2017), VS tend to work on this point individually.

Voluntary Simplicity should not be equated with a back-to-nature movement (Elgin, Mitchell, 1977). They ascribe densification as a sustainable way of living in which distances are reduced and society can evolve (source).
Voluntary simplicity should not be compared with a back to the land movement. Even though they share some of the same ideals — such as anti consumerism, self sufficiency, life enjoyment, respect for nature, and non violent justice — (Cherrier, 2009), voluntary simplifiers tend to take part in a collective development of a sustainable society. Therefore it is necessary to make people conscious about the predominant mindset in society. A mindset which is focussed on materialism and the fact that consuming provides comfort and therefore satisfies psychological needs by contributing to ones self esteem through respect by others and therefore respect for the self (Cherrier, 2008). VS on the other hand, are argued that they have met their needs for self-esteem and are seeking to achieve a sense of authenticity and satisfaction behind materialism. Zavestoski linked these characteristics of Voluntary Simplifiers to Maslow’s higher order need of self-actualisation (Figure X) (Zavestoski, 2002).

When comparing some of the characteristics of Voluntary Simplifiers to the People, Planet, and Profit triangle of sustainability, all three topics are paid attention to (figure X). It should be noted that profit is valued as a lesser of the three P’s. Profit should be a collective profit which supports human development instead of someone’s personal wealth. This would result in a fair and equal world in which that is taken from nature which is necessary for humans to develop without compromising the ability of future generations to live with at least that what we currently need.

There is not one way for a Voluntary Simplifiers to live. There is no code or method. VS is rather about questions than answers, in the sense that practising simplicity calls for a creative and personalized interpretation of societal and personal values. For these reasons, Voluntary Simplifiers are a perfect target group to slowly change — or at least foster consciousness in — the mindset of the unsustainable materialistic driven society.
Figure X: VS on the Maslow pyramid

own work

Figure X: VS on the PPP pyramid

own work
Voluntary Simplifiers are ascribed a lot of characteristics and motives which are based on the five key values. In order to assure the readability of this research, their characteristics will merely be mentioned pointwise. It should be noted that not every Voluntary Simplifier shares the same characteristics or motives. For further information on each characteristic, I refer to the consulted sources mentioned below.

- Free choice of a frugal lifestyle
- Rejection of consumerism
- Low material dependency
- Environmental concerns
- Consciousness about their own ecological footprint
- Respect the rights of flora and fauna
- From diverse cultures
- From diverse social classes
- Families and older individuals
- Youngsters
- Urban residents
- Mainly middle or upper class background
- Well educated
- Average to high income
- Be a healthy role model for the next generation
- Escape the “rat race”
- Stressful working conditions
- Search for autonomy
- Partly activists
- Actively promoting
- Use internet as a source of information
• Individual: live better with less
• Collective: take part in the development of a sustainable society

• Sharing of resources
• Trust and fairness
• Conscious approaches to life rather than impulsive behaviour
• Focus on the essentials
• Simplify the details which frittered the essence of our lives away
• Search to achieve a sense of authenticity
• Live a more meaningful life
• Support human development
• Durable relationships with others and nature
• Enjoy life in its unadorned richness

• Sustainable economical development
• Greater financial independence by cutting back spending on extras

(Elgin, Mitchell, 1977; Marchand, Walker, 2004; Roubanis, 2008; Elgin, 2011; Bozoklu, Korkmaz, Sertoglu, 2015)
When translating the ideology of VS to the built environment, a ‘less is more’ ideology seems to be the legit approach. A less reliant life and architecture, less complicated architecture, and architecture which is more interwoven with the (ecological) surroundings.

VS value intellectual and emotional understanding and appreciation. Architecture designed as an expression of wealth or as a confirmation of the architects aesthetic competence should be avoided. The essence of architecture should initially lie in constructional, functional, and ecological logics. This suggests a to the point architecture where unnecessary details are left behind in order to focus on the real essentials of architecture as a part of life. A life which should be integrated within the ecological structure without compromising the ability of future generations and species to meet their own needs. A closed loop should be created where both the planet and humans mutually benefit of each others resources and waste.

In concrete terms, architecture should:

- Be clear, simple, and logic
- Be built with sustainable materials
- Have a circular and ecological economy
- Give the ability of own or communal food production
- Harvest and recycle water
- Be energy independent
- Accommodate small scale companies
- Have medium to small sized dwellings
- Contain collective spaces
- Contain smart basic solutions instead of complicated technical solutions
Concluding on the reasoning of the VS movement, an architectural translation can be made into four topics. Housing typology, workspace, the complex, and communal space (figure X). Each of these topics have the potential to be completely detailed worked out during a graduation studio, so the further focus in this research will be focussing on one of these topics; the building process of the complex. Hereby taking into account that other students will be specifying on some of the related topics which in the end will be used in order to come up with a final design.

- **Housing**
  - Medium to small dwellings
  - Sustainable dwellings
  - Composition of the household

- **Workspace**
  - Human scale companies
  - Balance living-working

- **Communal space**
  - Balance communal-private space
  - Sharing
  - Food production

- **Complex**
  - Self-sufficiency of the complex
  - Circular and ecological economy
  - Simplicity

- Central room
- Dining space
- Kitchen
- Offices
- Guest room
- Ateliers
- Repair space
- Storage
- Cars
- Meeting rooms
- Laundry area
- Play garden
- Child care
- Information board
<table>
<thead>
<tr>
<th>Motivations</th>
<th>Lifestyle</th>
<th>Characteristics</th>
<th>Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disintegration of the social fabric</td>
<td>Maximize control over own life</td>
<td>High educated</td>
<td>Internet as a tool of information</td>
</tr>
<tr>
<td>Criticism on the consuming culture</td>
<td>Get to the essence of life</td>
<td>Mainly wealthier than average</td>
<td>Sharing of materials</td>
</tr>
<tr>
<td>You cannot buy happiness</td>
<td>Live better with less</td>
<td>People from different social &amp; cultural classes</td>
<td></td>
</tr>
<tr>
<td>Minimize dependency</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feeling of being lived</td>
<td>Low environmental impact</td>
<td>Mainly live in an urban environment</td>
<td>Fair-trade</td>
</tr>
<tr>
<td>Lack of time and meaning</td>
<td>Anti-consumer lifestyle</td>
<td>Social but independent</td>
<td></td>
</tr>
<tr>
<td>Excessive stress</td>
<td>Low resource utilization</td>
<td>Broad mindset, globally orientated</td>
<td></td>
</tr>
<tr>
<td>Inequality</td>
<td></td>
<td>Different degrees of involvement</td>
<td></td>
</tr>
<tr>
<td>Be part in the development of a sustainable society</td>
<td></td>
<td>Support human development</td>
<td></td>
</tr>
</tbody>
</table>

Makes it more comprehensible for the awareness group which results in better understanding (Campbell 1996)

**Figure X:** Motivation, lifestyle, characteristics, and usual tools of the VS movement own work, based on (Elgin, Mitchell, 1977; Marchand, Walker, 2004; Roubanis, 2008; Elgin, 2011; Bozoklu, Korkmaz, Sertoglu, 2015)
Chapter 3
Building sustainable
3.1 - Introduction

Focus lies on the building process!! Not a sustainable society, that will be after P2!

Translating the ideology of the Voluntary Simplicity movement into a residential complex requires to re-evaluate the essence of a complex. While a normal residential complex is intended as a place of safety, privateness, social meeting, and enjoyment (source!, doelen van een woningcomplex opzoeken), a residential complex for VS should reflect their ideals. Since their main ideals are fostered by environmental problems and their will to become independent from the materialistic driven society, their living environment should reflect those ideals. Self-sufficiency, simplicity, and sustainability are therefore key elements for designing a residential VS complex.

Focus should lie on making the complex independent of external factors such as energy or water supply, reducing energy and water needs, usage of sustainable building materials, and simplification in order to focus on the essentials (figure X).

Topics which focus on sustainability but do not directly relate to the building process will not be researched before P2. These topics concern the production of food, living-working balance, shared spaces, and dwelling sizes.

Figure X: The necessities of a residential complex for Voluntary Simplifiers

Sustainable materials  Simplification  Energy harvesting  Reducing energy needs
Water harvesting  Reducing water needs
Dutch regulations regarding the energy performance of buildings is based on the European Energy Performance of Buildings Directive (Kranenburg, Stephan, 2015). According to these guidelines, all new buildings should be almost energy neutral from 2020 on. In order to measure this, Dutch building regulations introduced the ‘Energy Performance Coefficient’ (EPC) (rvo.nl). 1 EPC is equal to the average energy usage of a Dutch dwelling in 1990. Kranenburg and Stephan (2015) mention three different ambition levels regarding to energy neutral and sustainable dwellings (figure X).

The first ambition level is an energy neutral dwelling. They have an EPC of approximately 0,00. Energy sources are preferably renewable.

‘Energienota nul’ and ‘Nul op de Meter’ are the second ambition level. These two terms take the energy consumption of the user into account which leads to a negative EPC in order to make the dwelling and its usage energy neutral.

The last approach is called the passive house approach. A passive house reduces building related energy consumption to a minimum and generates as much of its own energy consumption on a sustainable way. It strives for a maximum energy consumption of 15 kWh.m². (Kranenburg, Stephan, 2015).

When taking the wishes of the Voluntary Simplicity movement into account, it is self-evident to focus on reducing the energy consumption of a dwelling. For this reason the focus during the design phase will be on a realising residential complex with the principles of a passive house while continuously taking the wishes of the target group into account.
3.3 - The five principles of a passive house

The passive house is a concept which has its roots in the seventies when the oil crisis stimulated the creative industry to come up with energy reducing concepts. The passive house is based on five principles.

Designing a passive house is a matter of careful detailing and adding insulation in order to assure the autonomy of the building. Designing a passive house for VS on the other hand requires thoughtful picking of sustainable materials with the least impact on the environment. Materials with a high CO₂-emission should to be used. Local and environmental friendly materials on the other hand are desired.

A disadvantage of the passive house is the compromise it has to make in relation to passive ventilation and therefore the wish of the target group to simplify and get rid of useless materialistic driven additions to the building which reflects the ideals of their life. While the passive houses are designed to be autonomous, airtightness results in a dwelling which either needs mechanical ventilation with a heat recovery system or a separate space for the inlet and outlet of natural ventilation where the air can be pre-heated of cooled. Such separate spaces are common in the Earthship houses, a self sufficient dwelling principle which will be elaborated further on.

Figure X: The five principles of passive houses (passiv.de)
In order to limit additional heating, several techniques are being used (figure x). These techniques pay attention to the orientation of the dwellings and use the renewable sources of its surroundings. The most recognizable feature is the addition of a glass house on the south wall. The glass house is used as a buffer zone during extreme conditions. In the summer access to the glass house is closed in order to keep the heat out of the dwelling while warm air heated during sunny winter days is used to warm up the core of the house.

Figure X: Techniques to limit additional heating

- Veranda on the south as transition zone
- Insulated north facade
- Mass as thermal regulator
- Heat pump

own work
3.4.1 - BedZED London, Bill Dunster, 2002

**Situation**

[Map of BedZED London]

**Materials**

1. Local concrete and brick (mass)
2. Hardwood window frames
3. Atrium for natural daylight
4. PV cells (south)
5. Wind cowls

Extra:
- Biomass energy
- EPC = 0
- Heat pump
- 300 mm insulation
- Water treatment
- Hot water tanks
Communal space

Figures

- 99
- 1405 m²
- Ø x m²
- ?
- ?
3.4.2 - Aardehuizen Olst

Situation

Materials

1. Timber frame
2. Hardwood window frames
3. Straw bales insulation
4. Reed protective covering
5. Solar panels (south)

Extra:
- Car tires insulation
- EPC ≈ 0
- Heat pump
- Small scale food production
- Water treatment
- Clay plaster and floors
Communal space

Figures

23 (75-175m² per dwelling)

No offices

43

34
3.4.3 - Strowijk Iewan Lent

Situation

[Map of the location of Strowijk Iewan Lent with a compass indicating north]

Materials

1. Timber frame
2. Hardwood window frames
3. Straw bales insulation
4. Solar panels (south, west)

Extra:
- Small scale food production
Communal space

Figures

- 22
- 5 office spaces (co-work)
- 5 x m²
- 44
- 6
Chapter 4
Natural ventilation
According to the target group, voluntary simplifiers, simplification should occur whenever there is a benefit for one of the sustainable dimensions without an overruling negative impact on the other dimensions. Passive houses already simplify the dwelling by almost eliminating the need for heating by adding a lot or efficient thermal insulation and by airtight detailing. Next step is to strive for a building which does not need any mechanical tools at all in order to function desirably. Heating is one of the two essential components that the dwelling offers for a healthy living environment, the other one is ventilation. The building should be able to breath by itself without any external help, just as it had to do before the invention of mechanical tools.

An average household in 2008 used approximately 20% of their energy consumption for ventilation and 50% for heating (Santín, 2010). Since the principles of the passive house are meant to eliminate the need of heating, we assume that 40% of the total energy usage is spent on ventilating the dwelling.

Even though we are nowadays in the luxury that we can talk about barely no needed for energy to sustain a house, it remains important to focus on eliminating any need of mechanical energy usage. Especially when looking at the embodied energy which those installations need. A solution should be found by creating passive systems based on sustainable materials.
In order to maximize the effectiveness of natural ventilation, it is important to understand the basic underlying principles. In this way well-considered decisions can be made in a later stadium.

Natural ventilation is the process of refreshing air in a space by natural means. Natural ventilation can be achieved by operable windows but this implies the collaboration of a third party which could be a personal or a mechanical instrument. Since the target group implies on self dependency, it only seems self evident that their dwelling should behave in the same way while taking in regard that adaptations according to personal preferences should be able.

The challenge of natural ventilation is to maintain a comfortable indoor climate while assuring that enough draw takes place in order to ensure a healthy climate (Fitzsimmons, Martin, 2000). The research on natural ventilation should therefore conclude with a sustainable ventilation system for a residential complex which is self sufficient through the whole year, regardless of the variable weather. In addition, the system should be manually operable when desired without exceeding its maximum capacity.
The movement of air is based on two principles (Das, 2015). Both of these principles are based on a difference in pressure resulting in the movement of air. The first principle is called the ‘pressure system’. The pressure system relies on pressure created due to the differentiation of air density caused by the velocity difference between to airflows. The second principle is called the buoyancy system (Bhargav, Kaushik, Lal, 2013). Buoyancy is the opposite force of gravity. Buoyancy takes place when the density of an object is lower than the density of the object in which it is located. Heated air rises due to the buoyancy principle. This results in a low air pressure below the risen air.

The two causes of these principles are relatively air movement driven by wind (induced flow) and air movement driven by heat (thermosiphon flow) (Soar, Turner, 2008).

**Figure X: The pressure and buoyancy principle**

(Own work)
4.3 - Four techniques to create natural ventilation

There are different techniques which can be used to achieve natural ventilation (Das, 2015). These are the stack effect, wind tower technique, the courtyard effect, and solar chimney technique (Figure X).

Stack effect occurs when there is a pressure difference between the inside and outside air caused by a difference in temperature. Cold air gets sucked in from below. The higher the stack, the greater the stack effect.

The wind tower relies on the pressure principle. Fresh air is pushed into the windy side of a wind tower and cools down and sinks down. Used air is withdrawn from the other side of the tower resulting in a continuous flow of air through the building as long as it is windy enough.

The courtyard effect is based on the heating of an (partially) enclosed courtyard. The courtyard is heated and fresh air is sucked in through the complex and is therefore ventilations the dwellings.

A solar chimney combines the two principles. Buoyancy takes place in the solar heated chimney causing an internal stack effect. A venturi system at the exhaust is used to enhance the suction of air through the building.

![Figure X: Four techniques of natural ventilation](own work)
When assuming that a building meets the requirements which create natural ventilation, it is of importance to understand how the flow paths in a single room works. There are three main flow paths of natural ventilated air in buildings. Cross ventilation, single sided ventilation, and passive stack ventilation (Figure X) (Fitzsimmons, Martin, 2000).

Cross ventilation can ventilate a room up to five times the floor-ceiling height. Wind induced pressure differences drive the air through the building. Fresh air should enter from as high as possible in order to have time to blend with the temperature of the room.

Single sided ventilation can ventilate a room up to approximately 2.5 times its height. Tall windows or an opening in the bottom and top are necessary to create a stack effect which set up a convection circulation. Cool air enters from the bottom while the warmer air leaves from the top.

Stack ventilation uses the technique of the solar chimney. In peak summer conditions, temperatures in occupied areas should not be higher than in the solar chimney for the stack pressure will be minimal. In these cases, wind pressure created on top of the solar chimney, will be the main driving force behind the ventilation.

Figure X: Cross ventilation, single sided ventilation, and passive stack ventilation
Adapted version of (Fitzsimmons, Martin, 2000)
4.3 - Differences between offices and residential buildings

Most of the buildings which rely on natural ventilation are offices and public buildings. Buildings where the occupancy rate is higher than in dwellings produce more heat which positively contribute to the stack effect. Dwellings produce less heat and they therefore need a more independent functioning design which relies on external unreliable weather factors. Solutions need to be found to make those factors more reliable.

Where public buildings use night cooling in order to release excess stored heat, residential buildings will have to regulate their temperature and ventilation rate during day and night. This results in more extreme conditions and a more sophisticated design. Thereby, the freedom of residents to manually ventilate their dwellings should be taken into account.

The biggest challenge will be maintaining natural ventilation while outside temperature is warmer than inside. This would result in a reversed natural ventilation since the relative colder internal air is moving downwards. It is therefore of importance to keep the ventilation shaft warmer than outside or use the pressure system to assure the ventilation direction.
The toilet and kitchen area require extra attention when using natural ventilation. They comply to strict regulations regarding ventilation rates in order to assure safety and living quality. These zones should be the end station of the natural ventilation flow and it should be assured that enough ventilation takes place. Additional difficulty is the fluctuating amount of ventilation which is needed between usage and non usage. Attention should also be paid to adding a filter in order to retain oily substances for permeating into the ventilation shaft. It is the occupants responsibility to regularly clean the filters. It is advisable to use a separate ventilation system for those areas (Bronsema, 2017).
When looking at natural ventilation, lessons can be learned from life in nature. Life has evolved itself for ages in order to achieve a healthy and autonomous environment. All that we have created has already been made in nature, only in a sustainable way without harming the planet (Husukic, Zejnilovic, 2015). Biomimicry is defined as: “mimicking the functional basis of biological forms, processes and systems to produce sustainable solutions.” (Pawlyn, 2011). It happens too often that biomimicry is linked with the mimicking of the aesthetics of the biological forms. There is a difference between mimicking aesthetics and conceptual mimicry. Mimicking a shape does not guarantee that the conceptual idea behind the mimicked is translated. Another form of biomimicry is biodesign. Biodesign combines biomimicry with living organisms in order to mutually benefit (Zari, 2007).

Central heating and air-conditioning is bested by the termite mounds which uses passive ventilation and temperature regulation to keep the internal fungus growth at a constant temperature of 29-32 °C while outside temperatures can reach from 0 to 50°C (Husukic, Zejnilovic, 2015; Alleyne, 2013). There are different theories about the way how a termites mound functions but it is only since recently that new proof has been found that we misinterpreted it (Alleyne, 2013). Nevertheless the ‘wrong’ interpretations are the ones used in architecture and are very valuable.
Termite hill architecture used to be based upon two models. The first model is the “Thermosiphon flow model” in which hot air created by the nest results in an internal flow of air (figure X). Air is refreshed through the porous surface of the mound.

The second model is the “Induces flow model” (figure X). This model is based on the pressure principle. Fresh air is drawn in from the lower levels due to an unidirectional flow. A relative high wind speed at the top draws air from the chimney (Alleyne, 2013).

![Figure X: Two wrongly interpreted models of the termite hill](Soar, Turner, 2008)

A famous biomimetic based building which uses these two models is the Eastgate Centre in Harare, Zimbabwe (figure X). The Eastgate Centre designed by Mick Pearce has an extensive tube system within the walls and floors. Heat generated in the building and the mass create a thermosiphon flow while chimneys create a stack effect. Nevertheless low capacity fans are used to assure a continuous flow (Alleyne, 2013).

![Figure X: Conceptual drawing of a room in the Eastgate Centre](Mick Pearce)
So why does the Eastgate Centre still need mechanical ventilation? Thermal capacity is used to damp temperature excursions through the day. This is effective on short term, but in long term — as termite mounds prove (figure x) — damping is less effective (Soar, Turner, 2008). In the case of the Eastgate Centre, high volume fans are deployed in order to extract the stored heat from the building’s high-thermal-capacity walls.

In order for a building to be ventilated reliably, right aspects of the wind should be taken into account. Wind by nature is very unpredictable and in order for wind to have a practical value as an energy source, it should be predictable (Soar, Turner, 2008). A wind velocity vector is highly unpredictable, but induced flow has its potentials because it is more reliable. Induced flows are created by a wind velocity gradient between two points. The reliability rises when the height difference between the two points is increasing. This system works for high-rise, but the efficiency lessens when the building is low-rise, like a termite hill.

Surprisingly there is no evidence that the nest of a termite hill is ventilated. On the contrary, measurements indicate that air in the mound is almost never driven to the nest (Soar, Turner, 2008). This means that a different mechanism than ventilation is occurring in the mound. Would this mean that ventilation could become redundant?
4.5 - Respiratory gas exchange in termite mounds

To understand the mechanism of a termite mound, we will use the lung as a reference (figure X). Just as in the lungs, a termite mound consists out of three zones. The first zone is the lung’s upper airway. Here gas exchange is dominated by forced convection by the respiratory muscles (Soar, Turner, 2008). How this works in a termite hill will be described later on.

The third zone is the terminal passage. In this zone there is barely any mass flow and gas exchange is dominated by diffusion. Here the termites themselves play a role as mobile alveoli. They exchange their inhaled air with fresh air.

In between these zones is a region where neither forced convection nor diffusion dominates (Soar, Turner, 2008). This mixed mid-zone functions as a bridge between the other two zones. When ventilation takes place, the mid-zone will contain relative more fresh air than before ventilating.

The mound is the interface between the complex and its environment. Wind energy is caught in the chaotic transients that are defining features of the turbulent winds which occur at the peak of the

![Figure X: Functioning of a lung compared to the termite hill (Soar, Turner, 2008)](image)
mound (Soar, Turner, 2008). Functioning of the mound’s lung relies on a continuous flow of wind which sporadically penetrates the mound up until the mid-zone where gas exchange takes place During this process, the complex tunnel network filters particular frequencies of the turbulent wind leaving room for longer interval transient wind energy (figure x) (esf.edu).

Mixing gas between the second and third zone happens by collaboration between the buoyancy and pressure principle (Soar, Turner, 2008). Here the width of the canals in the mound cause a difference between strong and weakly driven bursts of airflow pushing air up- or downwards. An upward buoyant force caused by the colony’s excess heat production functions as a counterpart. The oscillation difference between the strong and weak flow result in directional switching airflows refreshing the steady upward buoyant force by fresh air (figure X) (Turner, 2011).
These insights offer a new spectrum of wind energy to be discovered. Ventilation does not by default need an induced or thermosiphon flow. We are buildings walls as barriers to isolate spaces in order to be insulated, but because we make them air tight, ventilation cannot naturally take place without opening a window.

The concept of the wall could reconsidered and be designed as a breathing membrane which filters turbulent winds within a complex reticulum and therefore become wind ventilated without the need of high chimneys (figure X) (Soar, Turner, 2008).

Another option would be mixing of air by acoustics (Turner, 2011). When “tuning” the transients in turbulent wind through a serie of pipes, a wave of 8Hz could be created which promotes vigorous mixing (esf.edu; Turner 2011).

Since these techniques are based on recent and progressive literature, no reference projects can be found. Thereby mentioning that the complexity goes against the ideology of the target group, it will be wise to stick to induced and thermosiphon ventilation. Besides, questions arise about the applicability of such a complex system to relatively large rooms. The idea might work on small scale, but gas exchange dominated by diffusion seems unlikely to work in a space as big as a room or dwelling. To answer this question, a study into complex physics would be necessary.
4.6.1 - Case studies introduction

Introduction on the Earthship and Earth, Wind, Fire concept.

Address the similarities and main differences of how natural ventilation works. Perhaps better after the explanation of the two concepts.

Conceptual case studies and Manitoba Hydro Place
4.6.2 - Earthship concept

- Concept by Michael Reynolds
- Is already built in the Netherlands

- (Earth) mass as thermal buffer
- Use the sun to create a stack effect
- No heat recovery
- Specially designed vents absorb and radiate the sun’s energy

- Tries to stay as close to nature as possible.
- Usage of natural materials and recycling of waste (old car tires).

Open up in the winter to get the heat in, close in the summer to keep the heat out

6 principles of an earthship (±33:45)
1 water harvesting
2 contained sewage
3 thermal mass
4 building with recycled and natural materials
5 solar and wind electricity
6 food production
principles of an earthship (±33:45)

1. water harvesting
2. contained sewage
3. thermal mass
4. building with recycled and natural materials
5. solar and wind electricity
6. food production
4.6.3 - Earth, wind and fire concept

The earth, wind and fire concept (EWF) reduces approximately 40-60% of the energy consumption needed for ventilation. It is based on three concepts which can function separately (Figure X) (Bronsema, 2011).

The first building incorporating all the three concept is hotel BREEZE which will be opening in 2018 (Bronsema, 2017). Essential for the ventec roof is a strong wind flow in order to assure the pressure effect. Since the graduation project is located in the city where wind velocity is relatively low, the ventec roof will be inefficient. The shown scheme explains the purpose of each element of the concept.

- Heats and cools
- Humidifies and dries
- Water sprayed with a T around 13°C
- Multiple sprinklers to vary spraying capacity
- Aerodynamic and hydraulic pressure

- Water filters dust
- Can be architectural element

- Heat and cold stored underground used to pre-condition the building

- Overpressure to avoid unwanted flows
- Mechanical help to assure ventilation rate

- $T_{\text{chimney average}} > T_{\text{out}}$ to assure a buoyancy effect
- Glass surface and materials influence T
- Depth determines flow speed

- Venturi- and pressure effect
- Influence is relative low in an urban environment
- Depth determines flow speed
- Heat exchanger in order to store excess heat underground
Critical are the four shafts, two in which pressure varies resulting in an upwards of downwards flow and two shafts connected to the in- and outlets of the dwellings which have a constant temperature to assure a equal distribution. It is possible to subdivide these shafts in order to gain more freedom in configuration (figure x) (Bronsema, 2017;2). It is advisable to use one solar chimney at the same time. This assures an equal wind velocity through the whole building.

Wind direction is depended on the difference between the temperature — and thereby the airpressure — in the solar chimney and outside. When outside temperature is lower than the temperature in the solar chimney, internal air will rise. The temperature in the solar chimney is depended on several variables; material characteristics (heat retaining capacity), glass composition, glass surface, tower height, and solar radiation (Bronsema, 2011). The difference in internal and external airpressure can be calculated with the formula:
\[ \Delta P_t = \rho_o \cdot g \cdot h \cdot 273 \cdot \frac{(T_1 - T_2)}{(T_1 \cdot T_2)} \]

In which:

- \(\Delta P_t\) Stack effect [Pa]
- \(h\) Height difference [m]
- \(g\) Gravitational acceleration [m/s\(^2\)]
- \(T_1\) Absolute temperature inside [K]
- \(T_2\) Absolute temperature outside [K]
- \(\rho_o\) Mass of air at 273 K [kg/m\(^3\)]

Since the temperature in the solar chimney varies, the average chimney temperature is used for \(T_1\). In order to simplify the formula, the chimney temperature is calculated by multiplying the glass facade of the chimney by the solar intensity with a rendement of 60% (Bronsema, 2011). When using these formulas while varying in the external air temperature and solar intensity, a graph can be made showing the thermal pressure difference (figure x). When the thermal pressure gets below 0, mechanical ventilation is needed to assure suction.

![Figure x: Thermal pressure difference in Pa (Bronsema, 2017; 2)](image)
4.6.4 - Earth, wind and fire shortages

Air velocity formula.

- The central facility for air treatment (climate cascade) is not suitable for dwellings (Bronsema, 2011). When designing a residential complex it is possible to use parts of the concepts.
  - A substitute has to be found for the climate cascade. This will probably be in the form of mass to pre-cool and heat the air.

- When the sun does not heat up the solar chimney, no stack effect is created resulting in a too low ventilation rate. Solutions have to be found in order to maintain the ventilation rate on cloudy days in a natural way.
  - Research has been done in adding a cavity wall in the solar chimney which is heated by renewable energy in order to assure the stack effect. Results were positive and will be elaborated here.

![Figure x: Average solar intensity per month per hour](Bronsema, 2011)
Manitoba Hydro company, the province’s only energy provider built a new headquarter which was completed in 2009. The extreme climate of Winnipeg, Canada, was reason for the design team to use abundant solar and wind energy to operate the building (Akerstream, Auer, Klym, Kuwabara, 2011).

Winnipeg’s wind direction is mainly southern (figure X), temperatures vary from -35°C to +35°C, and the location receives relatively more sunlight than other major Canadian cities. Their goal was to reduce energy consumption with up to 60% of Canadians standard. Fifteen designs were tested from which three were detailed developed and tested for its passive efficiency.

The southern atriums are shifted from the street grid in order to face exact south and maximize sunlight heating during the winter and the capturing strong southern winds (figure X). The offices are separated by winter gardens which maximize solar heat gain. Lofts on the northern side reduce direct northern exposure and minimize heat loss. A double facade curtain wall on the east and west side act as buffer zones. These zones are closed during the winter in order to retain the solar heated air and are opened in the summer in order to cool the allow wind to ventilate the double facade. Automated shades keep solar heat outside.

The three stacked six story high winter gardens function as the lungs of the buildings. All of the building’s fresh air goes through the winter garden. In the winter, outside air is preheated by fain coils to 5°C. The curtain wall provides the remaining demanded heat. Humidification and cleaning of the air is provided by 24 meter tall water curtains which are heated to 32°C. In the summer, fan coils are disabled and vents bring fresh air naturally into the building. The water feature has a temperature of 10°C in order to dehumidify the air.

Natural stack effect distributes the fresh air throughout the building. Displacement ventilation is used to distribute the air, slightly cooler than space temperature, into the offices. Stale air is drawn to the lower pressure area in the northern side cause by the buoyancy principle
which occurs in the solar chimney.
Even though natural ventilation is used, only 35% of all the ventilation is naturally (Figure X). During extreme conditions, natural ventilation barely takes place. This might be because of the positioning of the solar chimney which does not maximize the solar potentials in order to enhance buoyancy.

Active radiant slabs provide heating and cooling when required. Tubes are embedded in the concrete and slab temperatures are modulated between 20°C and 23°C. The thermal mass minimizes fluctuations in the temperatures.

A ground heat pump, exhaust air heat recovery, and condensing boilers reduce the energy use for heating to 28 kWh/m² annually, almost 10 times less than a typical heating load in Winnipeg.
Figure x: Manitoba Hydro Place exterior and southern atrium
(Akerstream et al., 2011)

Figure x: Percentage of hours in natural ventilation (35% annually)
(Akerstream et al., 2011)
Figure x: Manitoba Hydro Place ventilation principles
(Akerstream et al., 2011)
5.1 - Sources


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