P2 Graduation plan

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Studio
Sustainable Design Graduation Studio
1st mentor: Dr. ir. Peter van den Engel
2nd mentor: Dr. Ing. Tillmann Klein

Motivation for studio:
Starting during the Bachelor programme, I developed more and more of an interest into structural, climatic and façade design. Things like sustainable innovations, new materials etc caught my attention. For that reason I choose the master Building technology.
Graduation project

Combining Natural Ventilation and Heat Recovery into a new ventilation concept
A system that combines the fresh air, user-friendliness and simplicity of natural ventilation with the controlled airflow and heat recovery of mechanical ventilation.

Location
The project is focused on the climatic conditions of the Netherlands, but may be applicable to similar climates as well. Depending on the results it might be useful for other climates too.

The aim is to create a ventilation concept that is plausible for the Dutch climate.

Problem statement
Current approaches to ventilation all have different pros and cons. There is always a downside to adding or removing features. Summarized into three categories, the problems are:

Natural ventilation:
- Heat loss
- Draft problems
- External factors (noise, burglary, rain)

Mechanical ventilation
- Air quality problems
- Not user-friendly
- Not personally adjustable
- Energy usage for fans
- Expensive in purchase and maintenance

Decentralized mechanical ventilation
- Air quality problems
- Energy usage for fans
- Very expensive in purchase and maintenance

Natural ventilation with mechanical extraction only serves to ensure sufficient airflow at all times, but does not address these problems. Apart from this, building with mechanical ventilation often lack the option to purge a room, because there aren’t openable windows.

In order to design a natural ventilation concept that won’t be affected by these problems, the following will be needed:
- Heat recovery system, to prevent heat loss and therefore reduce energy consumption
- Prevent draft problems
- Prevent external problems
- Prevent high purchase and maintenance costs, compared to ‘regular’ concepts.

Apart from that, some form of hybrid ventilation with mechanical exhaust or a combination with a solar chimney will be necessary to achieve a sufficient airflow at all times.
Research Questions

The aforementioned problems result in the following research questions:

Main research question: Can a natural ventilation concept be achieved that functions as straightforward as opening a window, that provides fresh air without discomfort at all times in the climate of the Netherlands?

Sub questions:
1. How can heat recovery be added to natural ventilation to prevent heat loss?
2. How can draft problems be prevented?
3. How can external problems like noise, smell and rain be prevented?
4. Can sufficient amounts of airflow be achieved at all times? Is nighttime purging a possibility?
5. Can this be achieved without exceeding the costs of a ‘regular’ climate concept?

All of these have to be solved in order to achieve a suitable ventilation concept.

Design assignment

The resulting ventilation concept would have to meet the following demands in order to be an ideal system. Like mentioned before, every system lacks in some way, but the more criteria a met, the better.

Air quality & comfort
- No contamination of supply air.
  - Prevent the possibility of mold growth, dirt and dust in ducts, heat exchangers and other elements
- Pre-heated air.
  - Prevent any draft problems as a result of cold entering air.
- Controlled airflow.
  - Prevent large differences in airspeed as a result of changes in wind speed.
- Ensure ventilation at all times

User interaction
- User adjustment.
  - The user should be able to influence the climate, change the temperature, airspeed, be able to open a window etc.
- The ability to purge a room.
  - To remove odors or vent excess heat, it should be possible to purge a room.
- Understandable.
  - For both user and building management. It should be clear how a system works, and what an action does. Pressing a button which should result in a change is (psychologically) not as effective as opening a window and feeling the breeze. Also maintenance should be simple and foolproof.
- Considerations/trade-offs
  - Allowing a user to choose between several options and their consequences makes them aware of certain action and content with the resulting situation. Opening a window might increase background noise, but does allow a fresh breeze. The noise might therefore be perceived as acceptable.
Thermal properties

- Nighttime cooling
  - Allows a temperature reduction during hot summer days.
- Ability to dispose of heat
  - During warm periods (when heat recovery is not wanted) heat should be disposed of by bypassing heat recovery and/or purge ventilation
- A nice breeze
  - A pleasant airflow will reduce the perceived temperature and increase the satisfaction.
- No unnecessary venting
  - When there are no/few people in a room there should be no excess venting to reduce heat loss and/or fan energy consumption.

Costs

- Low energy consumption
  - As little fans and other electric appliances as possible
- Low heat loss
  - Recover as much heat as possible to reduce heating energy in cold periods
- Low capital costs
  - The purchase of the system should not be (much) higher than other concepts
- Low maintenance (costs)
- Flexible system
  - To allow for future changes in building usage
- No waste of space
  - Through ducts, installation rooms, vents etc.

External & safety

- Burglar proof
  - To allow for ventilation when no users are nearby or are asleep
- Rain & condensation proof
  - To prevent moisture and mold growth
- Sound proof
Process- Method description

Answering these research questions and meeting these points will require several steps.

Preliminary research (before P2)
1. Literature study into ventilation, existing problems, ongoing developments
2. Research into existing climate & ventilation concepts
3. Designing a first concept for a new ventilation concept

How can heat recovery be added to natural ventilation?
1. Research into different heat recovery methods
2. Contacting manufacturers for design-specific aspects, more technical information
3. Implementing findings into the design.
4. Literature study into heat-flow modelling/calculations.
5. Fine-tuning the design.

How can draft problems be prevented?
1. Research into existing solutions
2. Implementing findings and new ideas into concept

How can external problems like noise, smell and rain be prevented?
1. Research into existing solutions
2. Implementing findings and new ideas into concept

Can sufficient amounts of airflow be achieved at all times? Is nighttime purging a possibility?
1. Research into existing solutions
2. Literature study into airflow modelling/calculations
3. Implementing findings and new ideas into concept

Can this be achieved without exceeding the costs of a ‘regular’ climate concept?
1. Literature study into installations costs, maintenance costs, energy consumption
2. Contacting manufacturers for additional information
3. Fine-tuning and estimating costs for new design concept
4. Comparison with existing solutions.

Literature and general practical reference

- TVVL-magazine, providing many articles by renowned scientists and professionals about ventilation and HVAC systems (amongst other information)
- AL-KO Luchttechniek BV, a HVAC-systems manufacturer, that supplied me with useful data and information and are willing to answer any questions I might have.

Books:

Sources for modelling and calculation will have to be found later on.
Reflection

Provided the new design meets the aforementioned demands, this would provide a new ventilation concept as an alternative to mechanical HVAC solutions. This would be a (more) sustainable approach from different perspectives:

Energy consumption (carbon emission)
The system would require less electrical energy for fans and such, because of the natural-based concept. Energy for heating and cooling will largely depend on effectiveness of the heat exchanger as well as building design.

Material usage (carbon footprint)
Preventing the need for ducting, directly reduces material usage. This also reduces floor height and therefore arguably the total material usage (and costs) for the building.

Human health
Preventing any contamination of fresh air will prevent health problems and the sick-building syndrome. Allowing users to have more influences on their environment will also increase their satisfaction and (arguably) increase productivity.

Time planning

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<td>General research/orientation into ventilation concepts</td>
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<td>Specifying research subject</td>
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