Transformation of empty office buildings to Housing by the use of sky greenhouses
Abstract

This report studies about the transformation of empty office area to housing area by integrating greenhouse into the air field of the dwelling. There are some cases integrating greenhouse into the house due to the contribution of energy saving aspect. Making low-energy consumption area is indispensable consideration in the project. One plot in Amstel III where is empty office zone is selected as a case site. Green house can play a key role to make energy-sufficient area in terms of energy generating, conserving and growing crops. Further, greenhouse can provide inhabitants gathering space. As a lively residential area, it is important to understand the hierarchy of public space in housing plot. There are two strategies to transform abandoned office zone to low energy and lively residential block. First, plants and people have different metabolism. The indoor environmental condition should be satisfied to make comfortable environment for both of them. Greenhouse as a collective space to the housing plot is also highlighted. Optimal solutions, subsequently, are adapted to the site in Amstel III (the Netherlands)

How to design self-sufficient Dwelling area with greenhouse

- Transformation of existing building facade respond to local climate condition
- Energy flow process (Harvesting – Store – Distribution)
- Green house form respond to climate
- Green house form respond to function
- Energy saving through the energy exchange between green house and building

Those goals are achieved in this final project and provide a lively dwelling area to the inhabitants. The project, further, contributes to make a lively residential area by converting office block. It can be applied not only to one office block but also into other vacant office blocks in the hereafter.
The Netherlands, Amsterdam in particular, witnessed planning and construction of monofunctional office zones through 1970s and 1980s. However, this idea of monofunctional office zone was soon outdated as public demanded dwelling and commercial buildings in near vicinity of their office space. This recent trend towards a more integrated, multifunctional zone planning has left numerous office buildings to be abandoned. While more office buildings are left unused, demand for dwelling space in cities increase every year.[1] This has led to discussions and plans to transform abandoned office space to dwelling.

An important aspect to consider when redesigning dated buildings is to improve energy management towards a more environmentally friendly concept. Space and water heating accounts for 82% of total residential energy consumption in Europe.[2] Residential heaters heavily rely on nonrenewable energy sources. By implementing a greenhouse with aquifer to a building, energy neutrality of a building can be increased.

Another benefit of integration of greenhouse to dwelling is that it offers food production. Imported fruits and vegetable by airplane account for respectively 70% and 23% of the total food consumption per year. If inhabitants each had their own garden space of 35 to 40 m² to grow vegetables and soft fruits, then the amount of imported vegetable and soft fruits can be decreased by 2%. (Blythman, 2007; Wervel, 2011) This will improve the economic burden of inhabitants along with the environment.

Integration of greenhouses into buildings to improve sustainability is a strong motivation. However, the aspect of coexistence between human and plant life have to be considered. The problem is that human and plants have different metabolisms. The main difference is that human and plants require different atmospheric conditions such as CO₂ levels, temperature and humidity.

The main intention of this technical research paper is to discuss and evaluate how to realize closed and balanced energy circulation between two climate zones for human and plants while maintaining high energy efficiency. In particular, the adaptation of underground aquifer to improve both heating and cooling of greenhouse and dwelling will be considered.
Amstel III is the mono-functional office district, to the south-east of Amsterdam, where is planned in 80s. There are many structurally vacant offices in Amstel III. The reason is that employees prefer working with the high quality working condition and closer distance from their home. The site is remote from city central. Companies also try to move to the new office building located in well developed socio-infrastructure area such as city centre.

Public spaces also should be pondered in aspects of cultural sustainability. By investigating different ways of greenhouse integration to housing block, it can be considered the interplay among public, collective, private spaces. It is predicted to be planned social dynamic activities between buildings. It will bring that residents can enjoy new cityscape. It is necessary to approach an experiential sensory design and low energy design to regenerate structurally vacant spaces.

There are three visible problems in this stream. Firstly, the area has low quality of outdoor condition. For instance, Public spaces are only used as parking lots in office zone and it is lack of greenery space to do something such as social activities. The atmosphere of existing condition is not lively at all to inhabitants live in.

Another issue is that office zone are normally planned to strengthen security due to some business reasons so that each buildings are individually designed and not connected each other. In terms of security the plan is suitable for office buildings. However, it is an obstacle to transform office zone to housing zone.

Thirdly, mono-functional office zone means that there are no urban facilities, for example, catering, restaurant, café, fitness centre and education. On that account, even if buildings are transformed to housing no one wants to live in the area.
The research is conducted with different types of methodologies and it is proved following research and design chapter.

- Field work: mapping/pictures/context/user analysis
- Analytical drawing and modeling: use of district/relation with neighbours/surrounding conditions/infrastructure/user analysis
- Literature study: Energy circulation/greenhouse/social spaces in the city/sustainable technology
- Case study: references for greenhouse, sustainable building design and solar combisystem, Dwelling typologies
- Static data collection: the numbers for solar collecting and energy consumption
- Site climate based analysis (Webpage or calculator)
- Energy flow & ventilation simulation software (Design builder)
1. Design research

To build greenhouse, normally, use ground field. It is the basic way of integration of greenhouse. However, it makes high density of land use. What is the alternative way to put greenhouse into housing block. The air field can give a solution.

Integrating greenhouse with buildings already has been done in aspect of sustainability. However, consideration of greenhouse in the different level of public space is not that much accomplished. Assigning certain urban programs to the solar green house and technically making closed energy circulation between two climate zone for people and plants will be new strategies. By providing the green house as the collective spaces in residential area, it can solve the problem the office zone has isolated and dry circumstances. It should be taken into account social and cultural human activities to promote lively urban space.

1.1 Greenhouse typology

Greenhouse typologies are based on preced existing project by many architects. The different typologies are reflected to the project site and assessed based on the criteria connectivity, installation, stability, density, environment and economy in order to accomplish the design goal.

1.2 Hierarchy of spatial structure in the city

Urban structure are considered as telling story of experience (sequence of people flow), visual communication (details, symbols) and participation (through the senses, action and memory) It is consist of four territories such as public – semi-public – semi-private – private. (Tiesdell and Carmona, 2007).

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Temperature (people): Summer 20°C - 24.5°C, Winter 22°C - 24°C

Relative Humidity (people): Summer 35-45%, Winter 30-40%, depend on types

Relative Humidity (plants): Summer 70-85%, Winter 50-60%

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Figure 5. Design concept

Figure 6. Indoor condition for greenhouse and house
The diagram shows a hierarchically organized housing area. This clear structure improves the possibility for making group (From Oscar Newman)(Gehl, 2011)

When it is adapted to only garden housing concept, it can be said that it is composed with street – court yard – communal greenhouse shared by inhabitants who live in the same building – housing units are having their own small garden. The clear hierarchical system helps natural flow of spaces and transitions among different categories of public spaces physically and psychologically. However, how they make connection to each other and what the relationship among them is the most important point in order to make boundaries, otherwise, is it really necessary to make visible boundaries between them?

Likewise if the greenhouse is just implemented to the building or to the site somewhere it will not generate vigorous social activities.

The design methods for office zone are apparently different from those of residential zone. To make lively residential area, first and foremost, the site should provide places people can stay and sit for a long time because sitting and staying are basic human actions people can do in outdoor space. When open space is satisfied the condition for doing human behaviour, further, people can do more unplanned activities at the site.

1.2.1 Sense of belonging for inhabitants

Residents mostly feel safety when they arrive near their house even though they do not enter their own house. The reason is that they already can feel sense of belonging near dwelling area. This is another social condition dwelling block should be included.

According to Jan Gehl, people are more likely to stay at the edge of spaces because they feel they are protected and contained to the space. Moreover, when people want to sit and stand, they carefully choose a place. Spatial boundaries are preferred to sitting area in the middle of a space. (Gehl and Svarre, 2013)

The two drawings below clearly show that tendency of people behaviour in the open space.

In addition, in front of setback buildings people tend to gather. It means that not only the edge such as facade but also corner also provide sense of belonging to people.

1.2.2 Collective space in housing block

The characteristic of social space in housing area is determined by collective spaces. The strategies mentioned above can be applied to empty office zone when it is transformed to dwelling.

Generally, there are some characteristics of the office zone. In terms of urban plan, it has quite symmetrical axis and all buildings are independent and no network between buildings not only for reasons of security but also high readability on the street. It should be easy to recognize companies for people to find them. The distance between buildings is also far from each other. It can be a limitation to transform into housing. Another consideration is most of open spaces has desolated landscape with no enough green space and paved for parking lot.
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Figure 7. Assessment

Figure 8. Greenhouse connection & hierarchy of collective spaces
1.3 Transformation of existing building

Figure 10 shows the transformation process of existing office building. Existing office building conditions are inappropriate to change to dwelling. While maintain main structure of the building all facade and interior is changed according to the local climate condition.

The angle of the building facade is designed to capture solar radiants. $\pm 22.5$ degree is the best angle to capture it. Some part of four buildings face to north. However, the north facade dwelling has unpleasant indoor condition. So, the facade angle is designed to avoid to face to north as much as possible.
2. Technical research

2.1 Renewable energy use

Greenhouse can indirectly support heating for dwelling by using renewable energy sources from underground.

2.1.1 Energy circulation (Summer)
Around 30°C heated air underneath of the greenhouse roof intakes and pass through heat exchanger located underground. During the time the temperature is cooled down to 18°C by water from cold well part of aquifer system. Each dwelling has its own boiler and heat pump using a source from the aquifer. It reduces heat losses can occur during hot water supply. About 23°C warm well water is supplied to each household heat pump then it is heated up to 40°C. People can get 50-55°C of hot water for shower and drinking by using boiler. Over 50°C of water can sterilize bacteria. 

2.1.2 Energy circulation (Winter)
In winter, cold air near the greenhouse roof is inhaled and circulated. The air of 5°C gains heat in a heat exchanger by 15°C. The temperature is enough to grow winter crops. Ground water from warm well part lose heat before arriving heat pump. It may go down to 18°C after passing heat pump it is kept 40°C. Boiler generates 50-55 degrees water for shower.

2.1.3 Ventilation
Glass box between dwelling and greenhouse plays a role as a corridor linking two different functions. At the same time, it is transition space for air ventilation. Air-air heat exchanger is installed Inside of the box. Fresh air from outside passes thorough the heat exchanger and supply to dwelling through the pipes. However, it is worth to take note in carbon cycle between the greenhouse and the dwelling. During daytime, plants need to maintain around 1000ppm of carbon dioxide. The amount of CO₂ is supplied from dwelling containing high rate of CO₂. Human must not
Results

Figure 11. Building sequence

Figure 12. Transformation of office to dwelling
Figure 13. Total energy consumption according to heating system CoP

Figure 14. Energy plus output (Design builder simulation results)