THE CRYSTALHOOD

NAIL A CLEANER WAY OF LIVING

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Interreg
North-West Europe
Climate Active
Neighbourhoods
European Regional Development Fund

Date of publication:
23rd of dec, 2016

Student numbers:
870509640130

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INTRODUCTION

SITE AND PROGRAM OF THE PROJECT

This project is carried out in the neighbourhood Spijkerkwartier in the city of Arnhem in the Netherlands. The neighbourhood consists of mainly old residential housing in narrow paved streets. Because a lot of the ground is paved, and the area receives a lot of water from the surroundings in heavy rains there has been problems with flooding. These conditions also create heatstress in large parts of the neighbourhood during hot summer days. The main aim of this project is to lower the heat island effect to make the neighbourhood more thermally comfortable, and to try to make the area energy neutral.

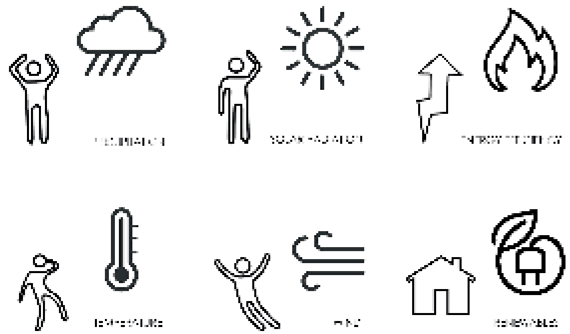
STRENGTHS, WEAKNESSES, OPPORTUNITIES, THREATS

After calculations and investigations of the area it is clear that the goal of energy neutrality is difficult to reach without compromising liveability and design-goals. It is especially difficult to replace the gas used for heating, so the system with which buildings are heated up will have to change in coming years to be able to do this. Replacing the fossil sources for electricity is successful though.

The design interventions proposed are working together with the style of the neighbourhood and aims to work also together with the architecture of the buildings. The Crystalhood proposes both large-scale interventions where it is possible and small interventions where a lot of existing values want to be kept.

THE REALITY IN 2050

Of course it is not known completely what kind of surprises the future will bring us, but there are believable scenarios published based on history and contemporary tendencies. Due to the report published by KNMI (Hurk et al., 2014) we will get a global increase in temperature, more extreme weather with more storms, rain and also drought in some parts of the world. Lower need of heating due to better insulation and better re-use of extensive heat will probably also be the reality.



CONCEPT

AIMS & OBJECTIVES

The main aim for this project is to turn the spatial weaknesses in terms of UHI effects into opportunities for sustainable energy production, storage and use. The spaces and streets which cause heatstress will be changed to harness the energy provided by solar radiation and the spaces that catch the most wind will be fitted with wind turbines to harness this energy as well.
Our spatial concept consists of two major themes: street interventions and hubs.

STREET INTERVENTIONS

Street interventions consist of local, small scale interventions at locations where there is little working space. These interventions are focused on smart integration with the current situation to reduce UHI effects and generate electricity. That is why we divide this theme into 'energy facades' and 'cool streets'. Streets interventions can be found in the long stretches of street running from east to west where there are little to no trees, and will form a network like structure within our masterplan.

HUBS

The hubs are large scale interventions at the open spaces in the Spijkerkwartier. These spaces offer the possibility to implement large structurres with a central function for the neighbourhood. These structures can offer large scale efficient energy production, as well as efficient centralised energy storage. That is why these hubs consist of 'solar energy hubs', 'wind energy fronts' and 'energy storage'.

COMMUNITY FUNCTIONS

In this project we tend to combine interventions focused on the urban climate and energy production and use with the liveability of a residential neighbourhood. In the style and function of the interventions, the character of Spijkerkwartier, community functions and improvements on liveability are are integrated. This way, this project goes further than just futureproofing Spijkerkwartier in a technical manner, but also in a social way.

STREET INTERVENTIONS

CONCEPT

The streetscape interventions in the Spijkerwartier can be divided into large-scale and small-scale interventions. This chapter will focus only the small-scale street design.

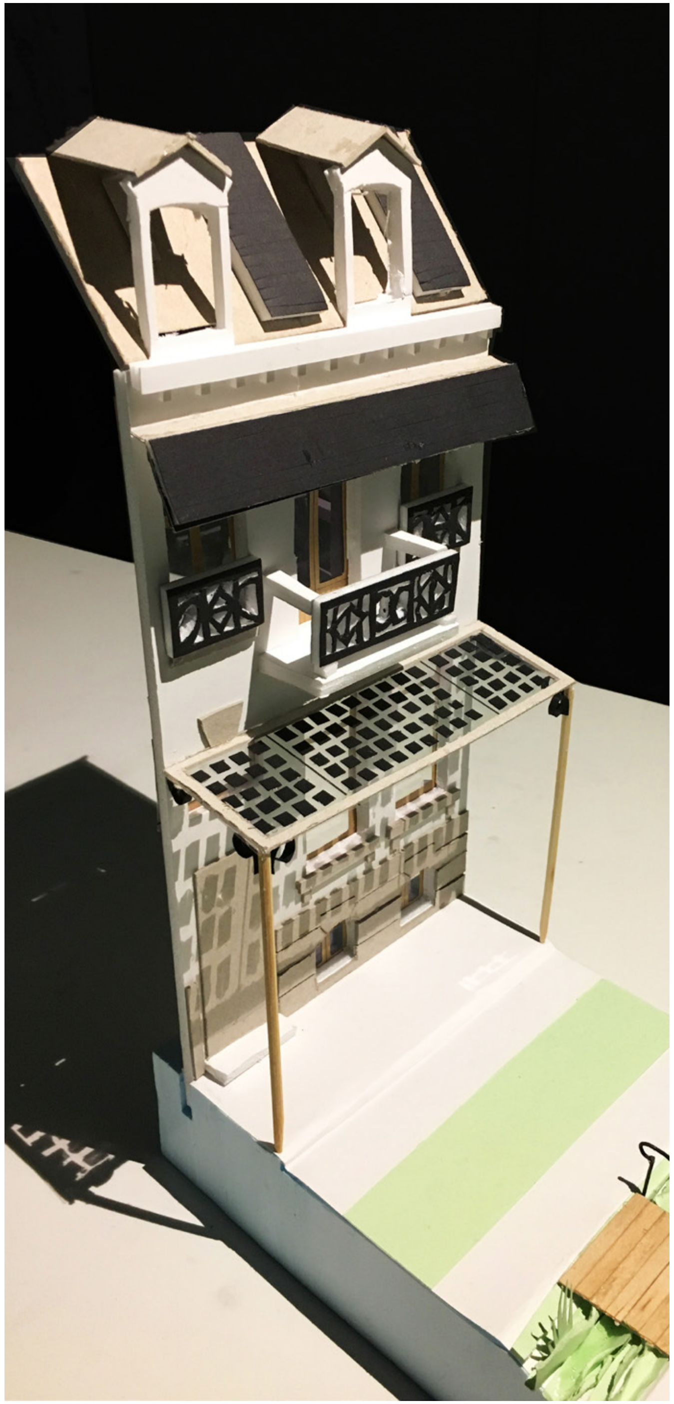
The Spijkerwartier is an old neighborhood and therefore most of the houses were built before 1900 and between 1900 to 1950 (Kadaster, n.d.). Respect for the old facades and the improvement of energy labeling in the area are the main goals to be achieved. (Leaflet, n.d.)

When comparing the Energy Label Atlas with the Kadaster maps indicating the periods of construction in the area, it is possible to relate the energy labeling of houses with their year of construction (Leaflet, n.d.) (Kadaster, n.d.). The aim of this small-scale designs is to improve energy efficiency and thermocomfort on houses and streets. The use of green facades and the addition of swales for water retention, will improve thermal comfort by cooling the air reducing the urban heat island effect. While the use of solar boilers and solar panels in the South facing buildings will provide heating and electricity for the houses. This energy will be stored in underground aquifers making this energy available when needed.

ENERGY FACADES

The north side of the streets running from east to west will catch the most solar radiation, providing these streets are not too narrow. Apart from the ground on the northern side, the solar energy also hits the northern facades, also because there are little to no trees in these streets that provide shade.

During summer, the sun radiates on these facades for the largest part of the day. Currently, this causes heat stress in the streets during the day: the primarily white facades reflect the solar radiation into the streets, causing the PET in these streets to go up. Meanwhile, the houses heat up as well during these days, as the solar radiation enters the buildings throughout the days. At night, part of the heat absorbed by the buildings is radiated back into the streets, causing UHI effects during night-time. During winter there are no problems with the heat by the sun, but with the sunlight. Although the sun can reach a large part of the street during summer, these streets are not very wide. This causes the streets to be quite dark in winter, causing also little light to reach the houses on the south side. As of now that comes into the streets only causes negative effects for the thermal comfort in the streets. But this solar energy can also be harvested for the generation of useable energy, especially during summer. The interventions on these northern 'energy facades' constitute of the following.

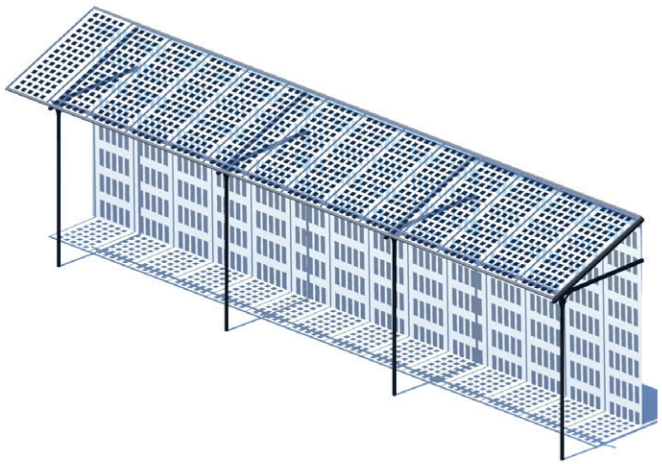


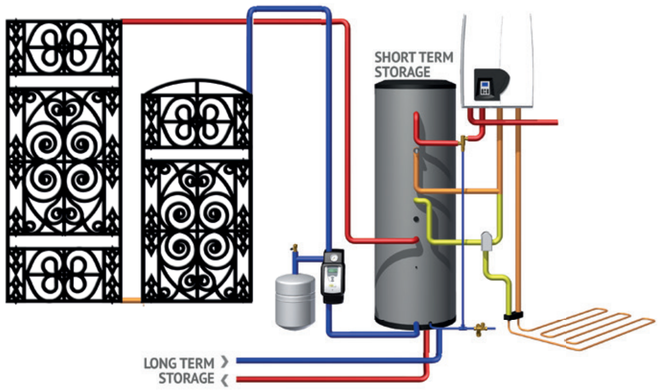
GLASS SOLAR AWNINGS

Just above the ground level of the buildings, an ornamental glass awning is placed. This awning, stretching over the northern sidewalk is covered with glass embedded with a grid of PV solar cells. The division of solar cells on the glass partly blocks the sunlight, causing more shade on the sidewalks and the ground floor, which improves the thermal comfort during hot summer days. The solar cells also produce electrical energy. They are also 'bifacial', meaning they are also collect energy from the underside of the cell along with the top. This produces around a 17% boost in energy production. The entire awning surface produces 110.214 kWh a year. This can also be seen in the model.

SOLAR COLLECTOR SYSTEM

On the first and second floors of the buildings, there are solar collectors placed in front of the windows. These boilers do not cover the entire window opening and still allows a sufficient amount of light to enter the windows, but reduces the heat entering the buildings on hot summer days. Solar collectors are also placed on other surfaces like the fronts of balconies. The primary function of these collectors is to not collect solar light, but solar heat. They consist of an intricate frame of tube works. Through these black tubes runs water, which is heated by the sun, run through a heat exchanger and heat pump and by a boiler then available for use in the form of hot tap water or heating. The short term and direct use of these solar boilers provide 2.406.011 kWh of heating energy in total, enough to cover around 7% of the heat demand of the entire Spijkerkwartier in 2050. Because the production and demand of heat does not fall within the same period, the surplus of heat during summer collected by these collectors is transported by a heat network to a centralised storage point, which will be explained later.





SEASONAL ADAPTATION

Other, more simple and dense solar collectors. with a higher yield are placed on the front of the roof and the top of the façade. The one on the top of the façade also functions as an awning, but has another feature to it. The awning can be flipped and has a different surface on each side. During the summer, this feature functions as an awning where the topside consists of a solar collector. During cold, dark winter days however, solar collectors are not very efficient. Hence, the awning flips up to a vertical position where a mirrored surface is facing outwards. The sunlight from the low winter sun reflects onto the surface of the opposite façade, making the streets less dark, and perhaps even improves the thermal comfort a little during winter.

THE COOL DOWN EFFECT - GREEN FACADES & SWALES

Before proceeding to analyze The Cristalhood project, it is important to mention the factors that affect people's experience of the microclimate and which of these can be influenced through small scale interventions. The main factors that can be influenced by small scale interventions are longwave heat radiation and shortwave radiation.

To reduce the factors that contribute to heat stress additional modifications will take place on a street level. With the creation of larger scale HUBS many parking places will be removed, leaving space for street de-paving and bio-swale creation. These measures will provide better evaporation of surface moisture. Also the evapotranspiration of plants will add a physical and psychological cooling effect. There will be air quality improvements, since the vegetation will filter dust particles; while the swales clean and retain rain water to protect the area from floods.

Another measure and the most significant one is the addition of green facades. These will provide shadow and they are expected to reduce wall temperature to a maximum of 30°C, reducing approximately 3°C in room temperature. This could lead to a reduction of 40% of the energy use for cooling (Lenzholzer, 2015)

The streetscape of the neighborhood was designed taking this into account. Figure 1 illustrates the street distribution of: solar boilers, hedges, parks and green facades species.


1 Parthenocissus quinquefolia


2 Hedera algeriensis 'Ravensholst'


3 Hedera colchica


4 Hedera helix 'Sagittifolia'

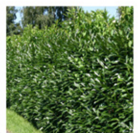

5 Vitis coignetiae


6 Fallopia baldschuanica


7 Hydrangea anomala subsp. petiolaris


8 Wisteria floribunda 'Kuchi-beni'


9 Lonicera periclymenum 'Serotina'


10 Prunus laurocerasus

Since the benefits of green facades can differ from one plant species to the other, these where carefully selected. The research 'Whats cool in the world of green facades' indicated that Hedera is one of the best performing species for thermoregulation. Having demonstrated > 7.0°C surface cooling. The same study has revealed that Prunus hedges can provide around 6.3°C surface cooling, while providing a significant wall cooling effect. Lonicera also proved to have a good cooling capacity mostly by providing shade. 'Plant physiology and leaf/area morphology should be considered when selecting species to maximize cooling in green wall applications' (Cameron, Taylor, & Martin, 2013). Plant selection (Fig.1) aimed to combine thermoregulation with aesthetic purposes and seasonal interest. Therefore, a combination of deciduous flowering plants with evergreen was made.

Most of the green facades in the Spijkerwartier will be placed in the north facing buildings. However, in some streets they will be placed in the East, West and South facing facades. This is mostly the case of narrow interior streets. In these streets the addition of flowering plants with perfume where added to create a sensorial experience for the pleasure of the inhabitants.

IMPROVED THERMAL COMFORT

Assumptions has been made that the impacts of the green additions in the streets can be 2°C cooler on a hot summer day on energy streets. In a street with green on both sides (cool street) and bioswales additionally the change could be 3°C cooler. (Alexandria & Jones, 2008)
The solar boilers can make it 0,2°C cooler during the day and 0,3°C cooler at night (Masson et al., 2014).

Rayman-calculations have been made to understand the perceived external temperature (PET) with the interventions introduced in the streets. The calculations have been made with sky view factor from two typical streets in the network of energy- and cool streets in the proposal.

ENERGY STREET

Temp: 30°C
PET: 40.6°C
svf: 37.2%

Temp: 28°C
PET: 37,7°C
svf: 32.1%

COOL STREET

Temp: 30°C
PET: 40.6°C
svf: 34.4%

Temp: 27°C
PET: 36.5°C
svf: 28.9%

It is important to note that the interventions on these facades were specifically designed with care and thought for the character of the neighbourhood. Spijkerkwartier was built as a residence for the upper class of Arnhem and features the class and elegance of late 19th century building, that is part of the city heritage. Instead of drastically changing the facades themselves, the interventions are modular and integrate with the historical building structure. The features also contain a certain ornamentation fitting with the time period and the creative character that Spijkerkwartier has nowadays.

HUBS

INTRODUCTION

Energy hubs are proposed on a large scale in the whole neighborhood. The main goal of the hub is to reconsider the underutilized urban space while solving heat issues and exploring local solar and wind energy potentials. Some current courtyards with big parking lots suffer from heat stress in the summer, and places along the railway dike, can be suitable for harvesting energy of seasonally strong southwest wind. All these urban space shows great potentials of combining energy production with improvement of social well being, particularly from the long-term perspective.

DESIGN PROCESS

There are mainly 5 locations identified for hubs development in Spijkerkwartier, based on the analysis of problems and possibilities. One of them (at the southwest corner near the Boulevard Heuvelink), is designed in detail to approach our research hypothesis. The design concept is described as follows:

1 identify space for energy hub construction from existing conditions and insert function block

The current courtyard is divided into different isolated space belonging to various ownership, including two-storey parking garage in the south, open parking ground for one printing industry, small private gardens and storage warehouses.
Except that private backyard gardens will be reserved for individual houses, ground parking and storage function are reorganized and redesigned into new inserted function blocks of the hub, therefore more space can be gained for social gathering, recreation and commercial use.

2 integrate responsive energy harvesting roof/ components

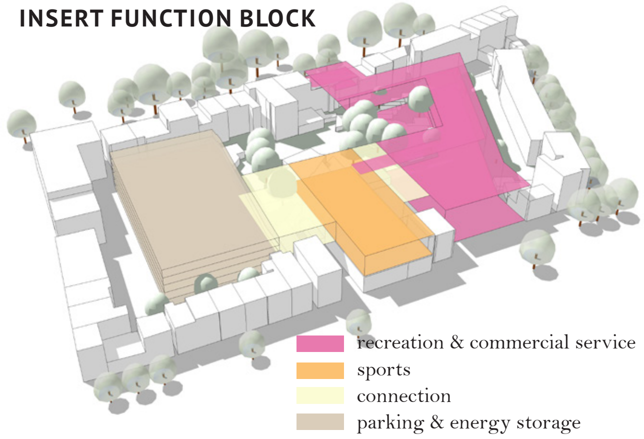
2.1 Two integrative energy production components are solar energy roof and wind energy fronts. Responsive to different functions underneath it, the roof develops in three forms of covering structures, including photovoltaic panels, glass with PV cells and steel truss structure.

2.2 WIND ENERGY FRONTS

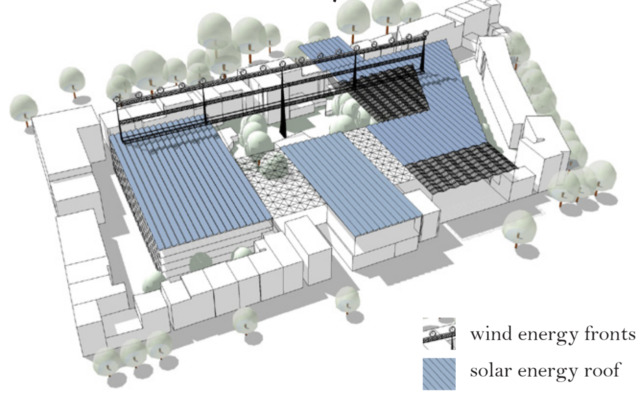
In order to capture the wind energy influx, a steel frame with small wind turbines higher than the height of surrounding buildings, is integrated into the west façade of the energy hub. Therefore, energy of prevailing winds can be best harvested without being decreased by obstacles and roughness of the canopy. Moreover, wind energy fronts with iron art detailing, serve as the landmark of ongoing energy transition in Spijkerkwartier.

EXISTING CONDITION

INSERT FUNCTION BLOCK



ENERGY HARVESTING ROOF/COMPONENTS

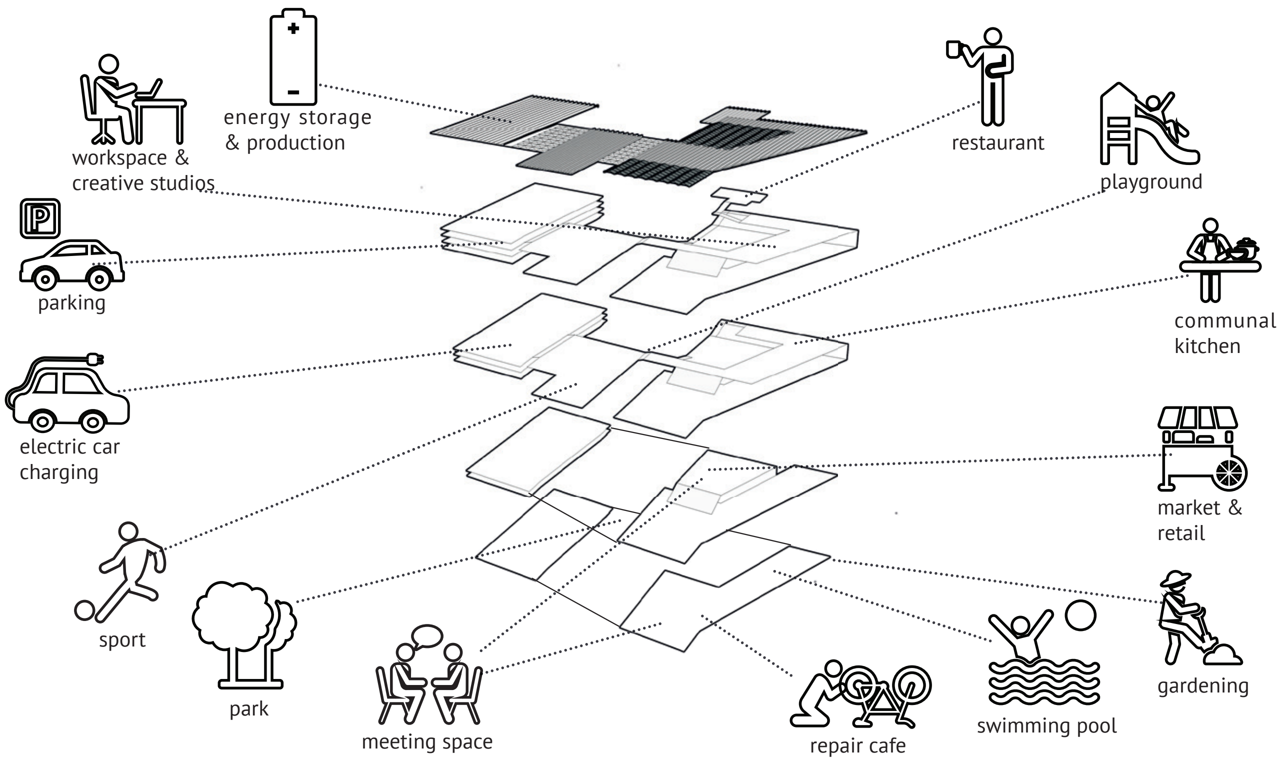


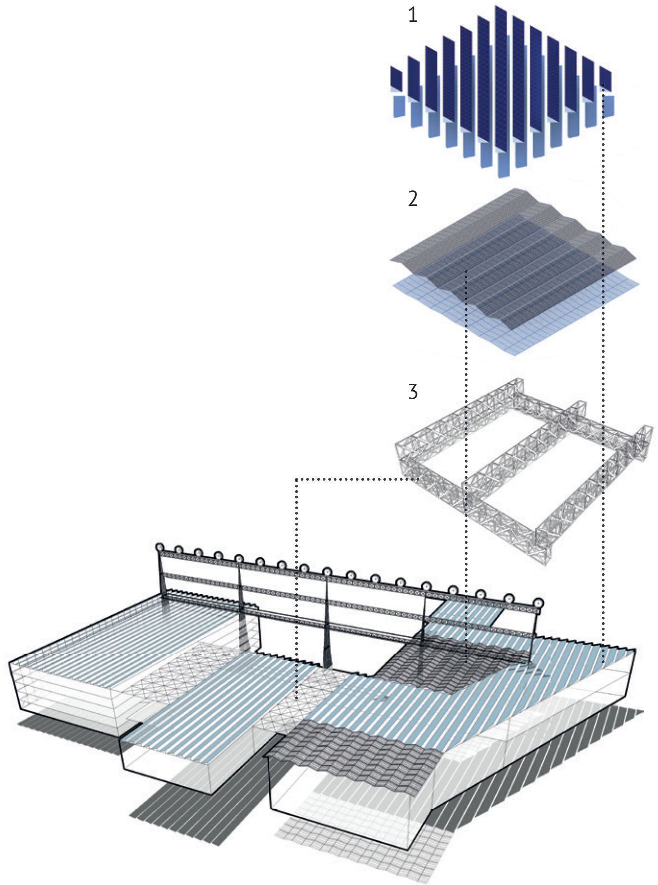
PROGRAM

The new vertical parking garage is inserted in the southern part of the courtyard, due to the fact that most of the existing parking concentrates in the south part and one car entrance is located outside Spijkerkwartier (on the Boulevard Heuvelink). The new block keeps distance from surrounding buildings based on typical local street ratio. Different kinds of function units, like the energy storage battery, sharing electrical car charging space, are also integrated into the parking garage.
The northern part (existing ground parking area for the printing industry) has a relatively wide opening next to the Rietgrachtstraat, which provides convenient access for local residents and public space for social activities. Both blocks are connected by an indoor sports center above the two-storey building of the printing industry.

SOLAR ENERGY ROOF

The first is the saw-tooth roof with south-facing photovoltaic panels and north-facing glass openings allowing indirect diffused natural light and ventilation. The second one is the full glass roof integrated with PV cells, which provides better direct illumination during daytime, and functions as greenhouse and improves thermal comfort in winter. The third one is steel truss structure. When spanning over some current buildings (due to the need of connecting different function blocks from above), the structure can help decrease the shadow effect and offer support for climbing plants. All combine to produce 5% of the total energy consumption in Spijkerkwartier.





WIND ENERGY FRONTS

In Spijkerkwartier it is installed two wind energy fronts. One on top of the biggest hub in the vest and one by the railway dijk in north-east. Together they produce 30% (see appendix for calculations) of the energy consumption in Spijkerkwartier and constitutes a big part of the renewable energy in the area.

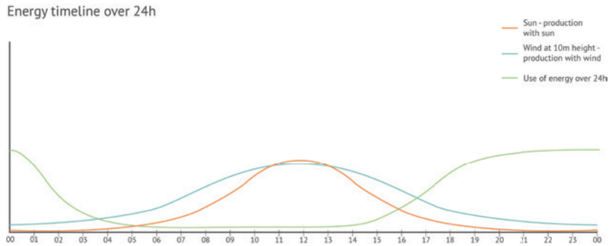
The wind turbines on the hub is placed both on the private houses and on two higher constructions 30 meters above the hub. All together they produce 10% of the total energy consumption (see appendix for calculations).

On the railway dijk the wind turbines are, according to regulations, placed 11 meters away from the dijk. Approximately 249 wind turbines placed with a radius 5x the rotor diameter are evenly placed next to the dijk. 20% of the energy consumption in Spijkerkwartier is covered by these turbinesconsumption (see appendix for calculations).

The VETAR10 turbines from Poduhvat is almost completely silent and can produce 43 000 kWh per year. The turbine consists of a double contra-rotating rotors and makes them more efficient than most turbines in the same size (Poduhvat Hydrokinetics LTD, 2016) (Grozdanic, 2013).

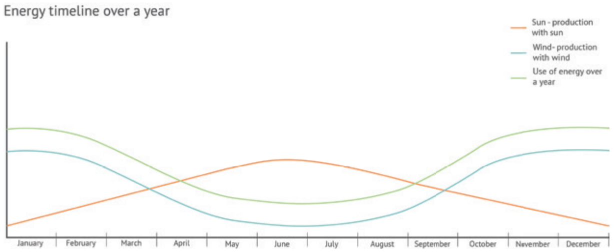
ENERGY STORAGE

Inside the hubs, not only energy production is taking place, but also storage. Looking at the daily and seasonal timelines of energy production and consumption, we can see some mismatches in time. Daily, energy is produced by solar and wind energy primarily during daytime: only then does the sun shine and there are higher wind speeds during the day. During the day however, most people are at work or school, leaving the houses empty. At the end of the day, people return home and energy is used for lighting, heating, cooking, etc. Therefore, energy storage can be needed both in electrical and heating energy. Electrical energy storage can happen centrally as it takes little effort to quickly transport this energy. Energy for low temperature heating can best be stored inside at a local, small scale (inside the houses) for this energy rhythm. Another possibility is to redirect this energy to workplaces, retail and school buildings within the neighbourhood, which do use this energy during the day.



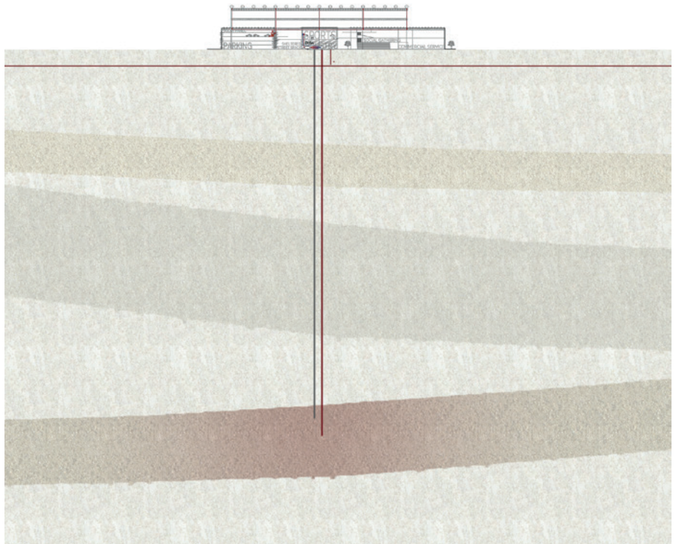
(Klimaat atlas, 2016)

There is also a yearly rhythm in the production and consumption of energy. Longer and more intense sunlight is present during summer, when there are higher temperatures as well. PV panels and solar collectors are most effective during that time. During summer however, there is very little heat demand and a smaller demand for electrical energy than in winter. Lights are used more during winter because of shorter days, and there is a higher heat demand because of colder outside temperatures. Seasonal energy storage is needed because of this. Both types of storage in this case can best be done centrally. In the design for the hubs centralised storage for both electrical energy and thermal energy are taken into account.



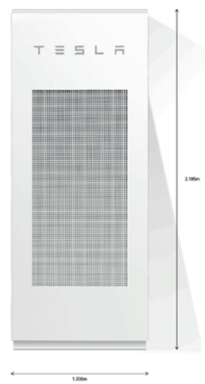
(Klimaat atlas, 2016)

The energy produced by the solar collectors in the streets is stored for a short term in the houses itself in boilers. When these reach full capacity, the thermal energy from the solar collectors is transported through a hot water heat network to a hub. In this hub there is a centralised heating facility which stores the hot water underground. Deep below the surface there is a suitable aquifer with high permeability and suitable groundwater flow speeds (Arnhem municipality, 2010). The hot water is stored in this layer during summer and pumped back again into the houses through a centralised heating system during winter. This method of hot water storage saves the neighbourhood 1.409.655 kWh of heating energy, around 4% of the 2050 heating demand. There is a possibility for this centralised aquifer storage to become part of a larger heat-cold storage masterplan for Arnhem, connecting multiple heat systems to this storage facility. (Arnhem municipality, 2010).



BATTERIES

The renewable energy provided by the PV panels and wind turbines will be stored in batteries in different sizes. The Powerpack 2 battery from Tesla will be placed within the hubs. They have an energy capacity of 210 kWh per Powerpack and a power output on 50 kWh. It can withstand all outdoor environments without an additional structure or cover. They will work as the main energy storage for Spijkerkwartier (Tesla, 2016).

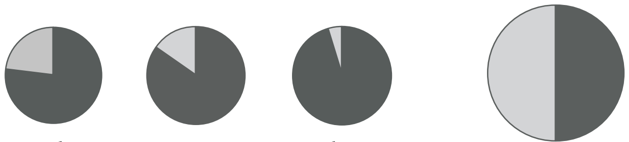


The houses with PV panels on their roofs will be provided with smaller batteries from Tesla. The Powerwall 2 is a battery with an energy capacity of 14 kWh each and can be stacked on top of each other to make bigger batteries depending on the size of the house (Tesla, 2016).

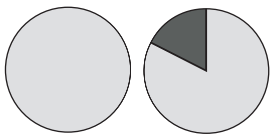
HEADING TOWARDS ENERGY NEUTRALITY

The goal for Spijkerkwartier is to be as energy neutral as possible. Implementing PV panels on private houses, hubs and glass awnings, installing wind turbines on both roofs and ground level and decorating the facades of some houses with solar boilers is a good start. These implementations produce 50% of the total energy consumption of Spijkerkwartier. In the future the efficiency of PV panels, wind turbines and solar boilers will be even higher and the goal of becoming an energy neutral neighbourhood simpler. The implementations will be less, the design and looks will be better and the amount of renewable energy higher.

With the implementations in this project the renewable energy produced is the following:



Wind 30% PV 15% Boilers 5% Total 50%



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DISCUSSION/ CONCLUSION

- What implications your plan may have on closing material cycles (‘cradle to cradle’), biodiversity, health of inhabitants, fostering local economy and supporting social inclusion
- Which solutions you consider true ‘no-regret’ solutions (i.e. robust solutions)
- What are the time horizons for implementation of your proposals? What can be implemented in short, medium and long term?

PICTURES

Appendix 1: Checklist for submission products (proposal, report and posters)

☐ Name, date and student number clearly indicated in colophon (name also on cover page)

☐ Table of content accurate and properly formatted

☐ Layout clear and attractive

☐ Text to the point and concise

☐ Text does not exceed maximum length for proposal and report respectively

☐ Scientific literature used (minimum of five scientific papers plus books)

☐ Spellcheck done and grammar checked

☐ In-text references okay (show like this: author, year)

☐ Each figure mentioned in the text (internal reference)

☐ Each figure has a number and figure caption explaining what is shown

☐ Each figure with reference stating the name of the author/designer/photographer

☐ Each map with North arrow

☐ Each map with scale-bar or approximate scale mentioned in the figure caption

☐ Each map with legend or description with words in the map

☐ List of references formatted accurately and included in the appendix (CiteItRight.pdf)