THE WAVE

Energy Performance Documentation

Table of Contents

2.A

Window to Wall Ratio - Parcel 1 & 2

North

Step 1: Total area of light transmitting glazing surfaces on north facade: **185.77 m^2**

Step 2: Total area of north façade: **1249.19 m^2**

Window-to-wall ratio of north façade = $\frac{\text{number from step 1}}{\text{number from step 2}}$ = **0.15**

East

Step 1: Total area of light transmitting glazing surfaces on east facade: **372.00 m^2**

Step 2: Total area of east façade: **1397.97 m^2**

Window-to-wall ratio of east façade = $\frac{\text{number from step 1}}{\text{number from step 2}}$ = **0.27**

South

Step 1: Total area of light transmitting glazing surfaces on south facade: **380.81 m^2**

Step 2: Total area of south façade: **1213,88 m^2**

Window-to-wall ratio of south façade = $\frac{\text{number from step 1}}{\text{number from step 2}}$ = **0.31**

West

Step 1: Total area of light transmitting glazing surfaces on west facade: **411.57 m^2**

Step 2: Total area of west façade: **1502.20 m^2**

Window-to-wall ratio of west façade = $\frac{\text{number from step 1}}{\text{number from step 2}}$ = **0.27**

Total Building Window-to-Wall Ratio

Step 1: Light transmitting glazing$_{total}$ = step one$_{north}$ + step one$_{east}$ + step one$_{south}$ + step one$_{west}$ = **1350.15 m^2**

Step 2: Façade area$_{total}$ = step two$_{north}$ + step two$_{east}$ + step two$_{south}$ + step two$_{west}$ = **5345.24 m^2**

Total window-to-wall ratio = $\frac{\text{number from step 1}}{\text{number from step 2}}$ = **0.25**

2.B

Window Openings & Window Shading

East facing
U-factor: 1.2; SHGC: 0.5; Visible Transmittance: 0.72

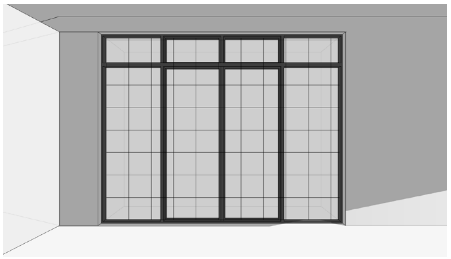
South facing
U-factor: 1.2; SHGC: 0.5; Visible Transmittance: 0.72

West facing
U-factor: 1.2; SHGC: 0.5; Visible Transmittance: 0.72

North facing
U-factor: 1.2; SHGC: 0.5; Visible Transmittance: 0.72

2.B
Window Shading Diagrams South

March/September 21st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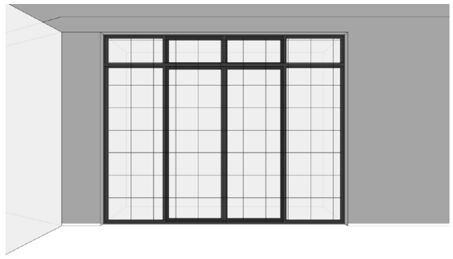
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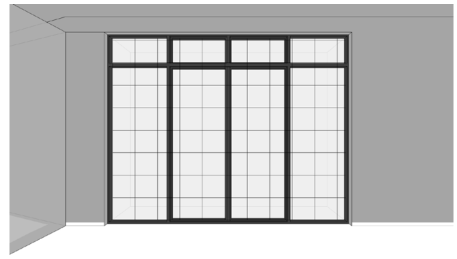
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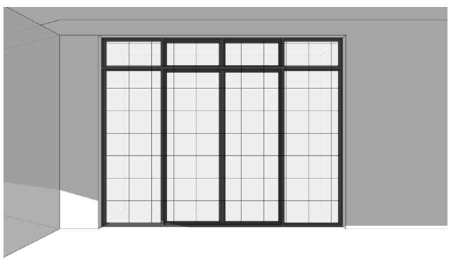
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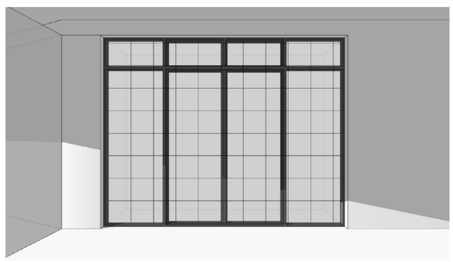
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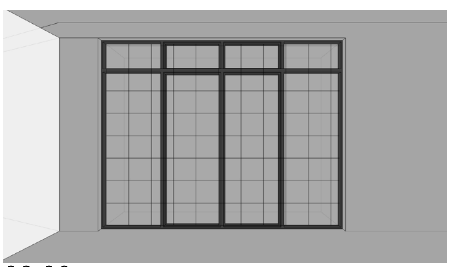
June 21st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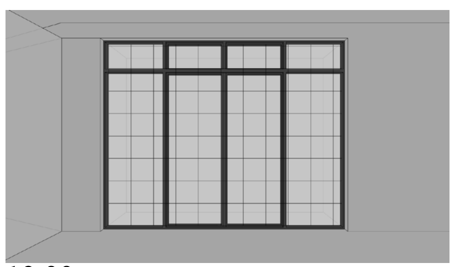
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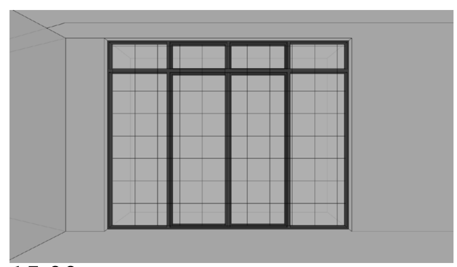
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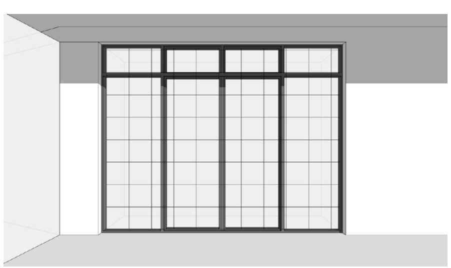
December 21st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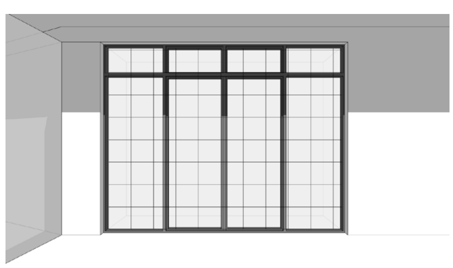
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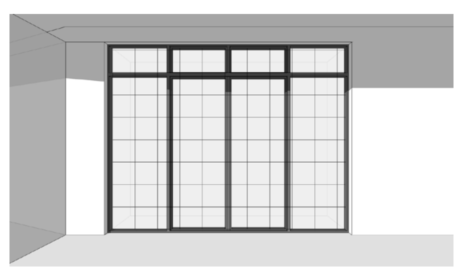
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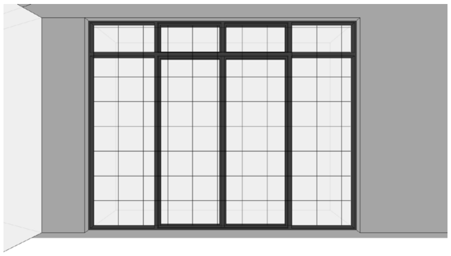
2.B
Window Shading Diagrams West

March/September 21st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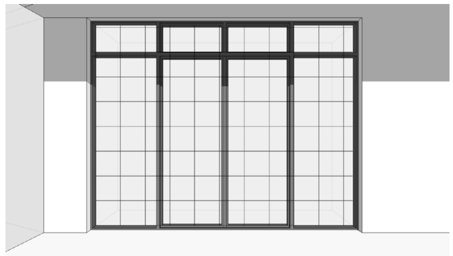
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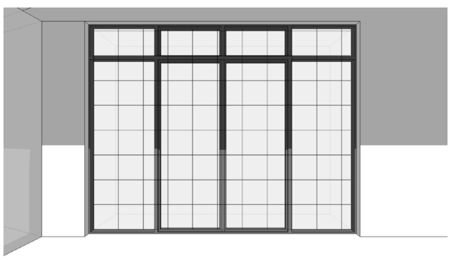
16.00 (with shutters)

June 21st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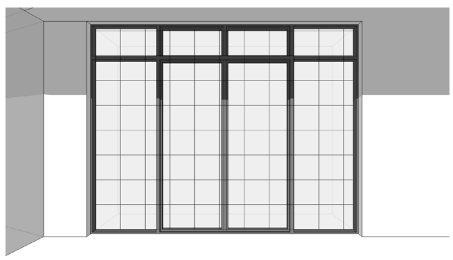
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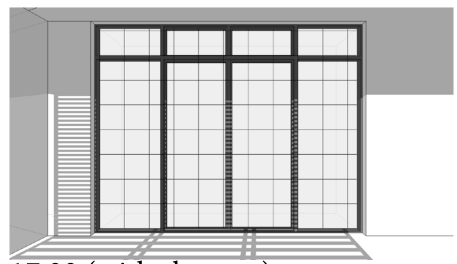
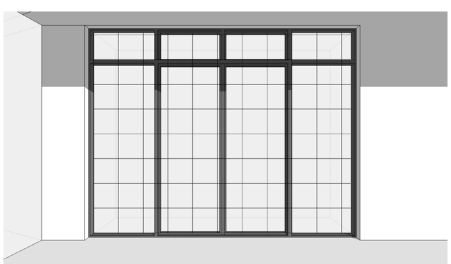

17.00 (with shutters)

December 21st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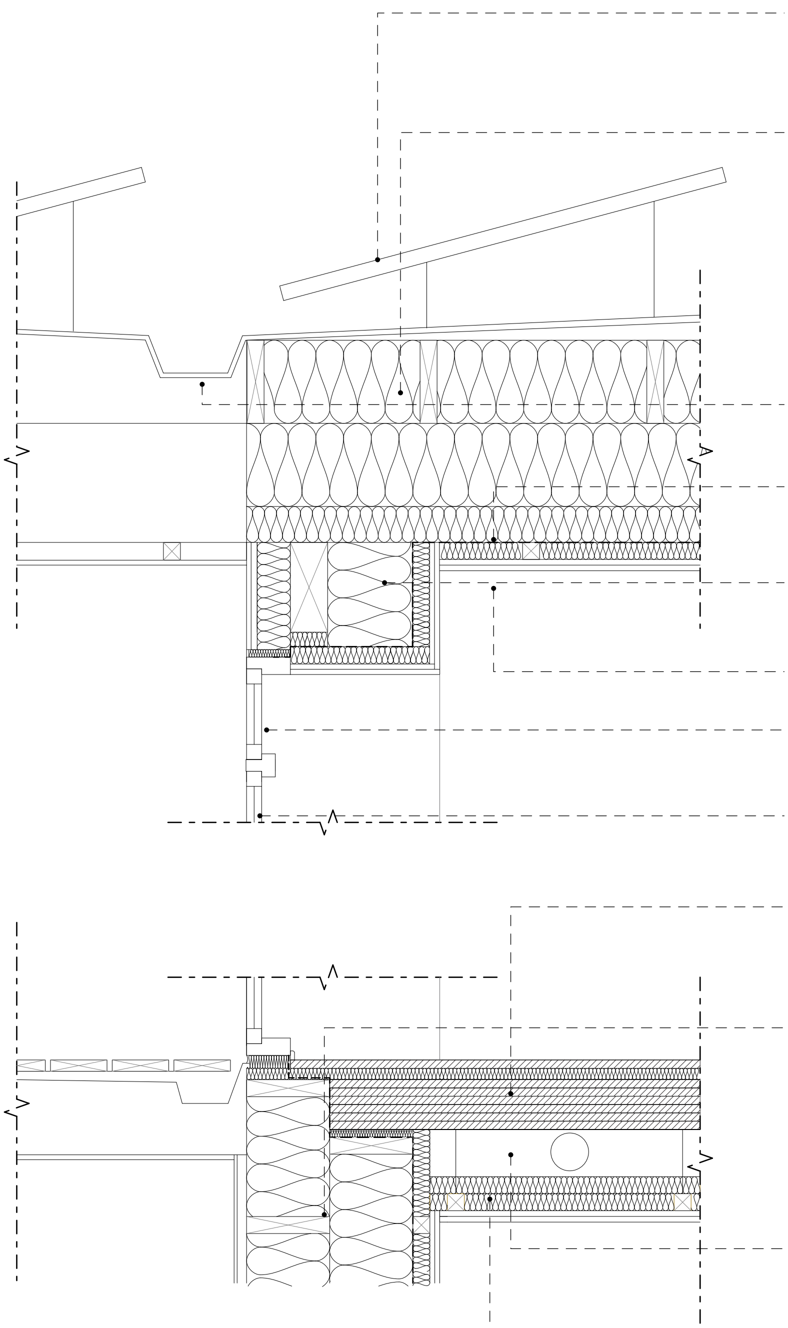
2.C
Building Enclosure Detail

Detail section parcel 2. The general solutions applied are relevant for the full development.
Timber is used as the general building material for its low carbon footprint, transversal construction in the exterior walls and cross laminated timber in the separating walls and slabs.
Windows are generally placed in the insulation to make a line-loss of 0.

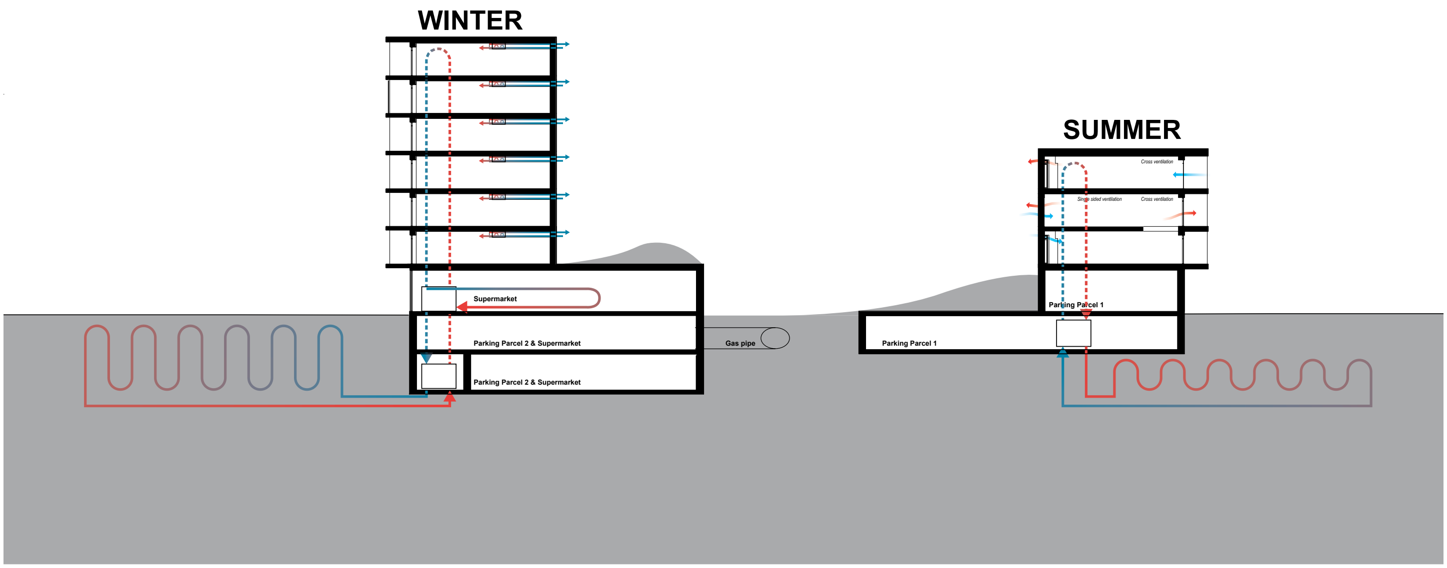


Scale - 1:20

2.D
Whole Building Heating & Cooling

Heating season
In the heating season the mechanical ventilation units situated in each apartment takes over. These units efficiently keeps the heat inside using heat recovery while providing fresh air from outside. On parcel one geothermal heat is utilized using heat pumps and on parcel 2 the excess heat from the supermarket is supplemented by another geothermal system as well.

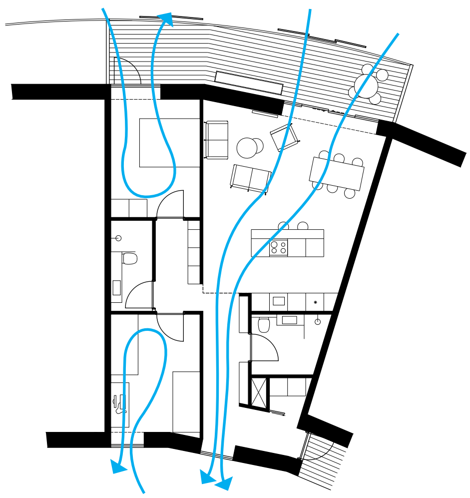
Hot season
In the summer the building is cooled down by an efficient automatic natural ventilation system capable of creating an air change which will keep an acceptable temperature. This is supported by shutters which helps shield up to 80% of the incoming heat transfered by radiation and a system of circulating fluid cooled by the geothermal system.



2E

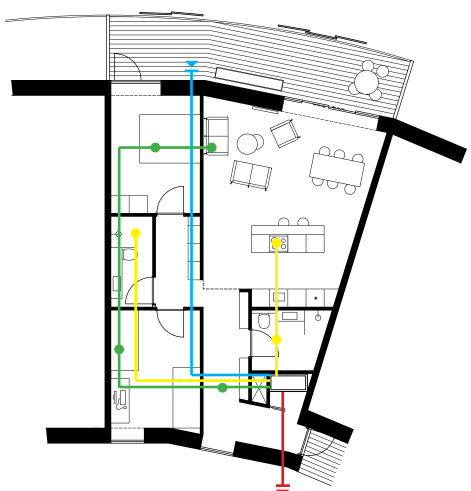
Diagram Sketches of Residential Unit System

All systems described below are relevant for both parcel 1 & 2.



Ventilation in hot-season

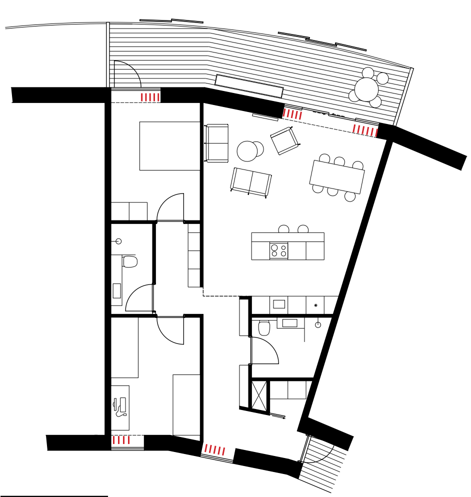
Wind and stack effect is used as natural driving forces to ventilate overheating in summer season through appropriate cross or single-sided ventilation strategies. An indoor climate system measures the temperature and CO2 levels of the rooms and automatically controls the windows installed for the purpose of regulating the indoor climate. In this way overheating can be prevented and these openings are burglary safe due their small size. This solution based on windows has a better insulation capability than trickle vents, when not in use. Furthermore implementation of trees and more green on and around the building complex aids to clean the air from particle pollution caused by the surrounding traffic, and provides a healthier climate indoors as well as outdoors



Ventilation in heating season

As the mechanical ventilation system, decentralized efficient units with a low pressure loss and a high heat recovery ratio from the exhaust air is chosen. Energy for the fans are covered by the electricity production from the PV-panels. Air is generally provided in the clean areas of the apartment such as living spaces and removed through the toilets and kitchen areas.

- Air provided
- Air extracted
- External inlet
- External output

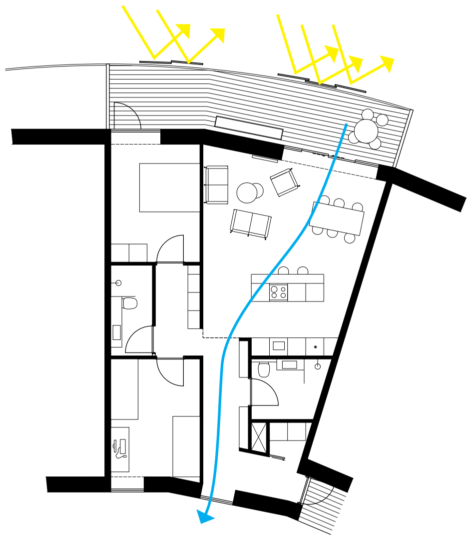


Heating

Heat pumps (COP of 4+)recovers heat stored in heavy building parts in the parking facility, geothermal systems as well as leftover heat from the supermarket. Heat from gray water is regained and used to heat up new water. In general the apartment is so well insulated and with such a low level of infiltration that the people and equipment such as the refrigerators has a high impact on the energy balance between inside and outside. Therefore it is advised to use low energy appliances to allow for a more steady conditions and save electric energy. Electricity generally have high distribution loses and therefor a high primary energy factor. IIIIII = Radiators

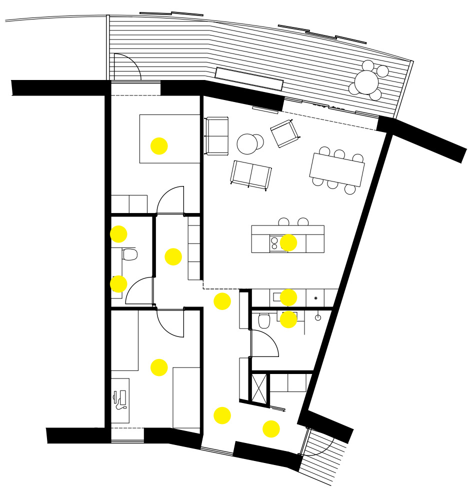
2E

Diagram Sketches of Residential Unit System



Cooling

Shutters and automatic natural ventilation systems minimizes the need for cooling. In rare situations water cooled from the geothermal system can be used to cool via the mechanical ventilation system.



Lighting

It is calculated that all parts of the apartment have a sufficient level of natural daylight to decrease the need for electric light. When the daylight is not sufficient LED lighting is the chosen type of lights since they have a high efficiency. Vacancy sensors is installed in the bathrooms and wardrobe to lower the energy use.

2.F
Renewable Energy

Reaching a Zero Net Energy development

The aim of the project has been to minimize energy consumption due to the need for mechanical cooling as well as heating. The main focus has therefore been on activating suitable passive, active and renewable strategies for this particular site and context. Iterative design studies have especially showcased passive strategies as a crucial factor on the energy consumption. In order to minimize heating a compact architectural form has been designed with a low floor to facade area ratio with most living spaces oriented towards south and west. This combination, plus windows with a balanced g and u value, including shade from balconies and flexible shutters prevent overheating and ensures natural daylight. In addition the placement of the windows and building depth enables efficient natural cooling and fresh air through natural ventilation.
The low u-values in the windows and high-insulated climate screen with low line losses prevent unwanted heat transmission, and hereby minimizes the need for heating. Heat recovery and heat pumps enables the ventilation system to cool or recover heat more energy efficiently.
The energy consumption calculation of the building volume has been ongoing and the energy strategies have been tested, optimized and balanced to reach a satisfying goal.
Since we have chosen to work with a connected building volume, the results are for both sites at once.

Energy Production

Solar potential for fixed photo-voltaic panels with a 15deg inclination towards the south in Oakland has been calculated to be 5,07 kWh/m^2/day (http://pvwatts.nrel.gov/)
Photovoltaics on the roof: 1940 m^2 + 860 m^2 operating at 80% due to occasional shadows from buildings
Type: Primary energy factor: Electricity 2.89 (Factors for Energy Use in Buildings - www.nrel.gov/docs/fy07osti/38617.pdf)

Zero energy goal

Electricity per unit for low energy light and appliances: 2000 kWh/year.
Using the passive and active strategies uitilized in this project it is possible to bring down the energy need for heating and cooling to an extent where it is the consumed electricity which is the largest entry. By producing electricity on-site the high losses normally seen from production to consumation can be eliminated and therefore, when taking this into account - a net zero energy development can be a reality.

Energy demand

Average for apartments:
11.2 kWh/m^2/year
3,55 kBTU/sf/year

Total for apartments:
128.800 kWh/year
439.483,84 kBTU/year

Light and appliances:
500.000 kWh/year
1.706.070,82 kBTU/year

Grocery store (73,3 kBTU/sf/year):
644.298,66 kWh/year
2.198.438,28 kBTU/year

Renewables

Total PV Production:
729.986,47 kWh/year
2.490.817,23 kBTU/year

Energy Balance

Balance without primary energy factors:
-543.112,19 kWh/year
-1.853.175,71 kBTU/year

Balance with primary energy factors:
+525.878,40 kWh/year
+1.794.371,58 kBTU/year

2.G
Occupant Behavior

The building is laid out to make tenants able to enjoy the outdoor spaces even in the raw context characterized by traffic, and large parking spaces. By placing gardens on the top of the base, the inhabitants is provided with a space which is distanced from the traffic of the surrounding streets. On top of this a new square is established in front of the supermarket, and the general parking facilities are placed underground. A vast amount of our carbon emission comes from transportation in cars, so the intention is to make it easier and more favorable to move on foot or on bike – these design features among others creates a base for this.

On an apartment level small information screens shows the current energy consumption in the unit as well as other data concerning energy production and consumption. This is an important aspect of making the inhabitant conscious of their energy use and helps to make it a common project to bring down energy demands and live in a more sustainable way.