A sustainable house for 3 generations

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**Short description of the project**

This is a two family house for three generations, including a family with two children and their grandparents. The ground, where this building is going to stand, is right next to Vangede station. Vangede is a suburb of Copenhagen in Denmark.

My concept was to separate the grandparents from the rest of the family, but without losing contact fully. That means, that both families has their private areas but some areas are common. The three storey house is where the family with the children is living. The one storey house is for the grandparents. These private houses are joined with a big glass-wood construction, the corridor, which can be used as a winter garden during winter and in summer you can open it up to the garden, so it will be a open terrace. The common areas are the corridor, the garden and the dining area of the family with the children.

**My sustainable plan for this house**

This house is already orientated to the south. There are big windows to the south and very small windows in the north. Through the big windows, there is coming alot of daylight into the house. So in that way, it is already a bit sustainable. But there is still alot of space for improvement.

I will work with 8 points to make the house sustainable:

1. - vacuum glazing
2. - bifolding doors in front of the glazins to protect from sun, but also to collect sunenergie
3. - use of natural ventilation
4. - highly insulated building skin
5. - use of environmental friendly material
6. - rooftop planting
7. - use of geothermal heat
8. - rainwater collection

The first five points are some solutions for already existing nonsustainable constructions. The last three points are completly new elements. So I will separate the essay in two. First I will go in detail with the first five points and give some solutions for the problems. Then I´ll give a closer look at the last three points.
The original design M1:100

Problems

- Double glazing for big windows
  - That building has so much glass on the south side, so there will be a lot of heat loss in winter.

- A lot of glass in summer it will be really hot
  - There are already wood panels in front of the big glass corridor which should give some shadow in summer and work as a special architectural element. But the big glass areas, which you can open up to come into the garden, don’t have these wood panels. So there is still coming a lot of direct sunlight inside, which will heaten up the corridor.

- Bad natural ventilation
  - There is fresh air in the area downstairs, but bad air on the second floor. There are only small windows in the rooms, but the hallway doesn’t have any windows. So all the bad air will stay inside, on the second floor.

- Concrete walls
  - You need a lot of concrete for this building. To produce concrete you need cement. Worldwide, cement manufacturing accounts for approximately five percent of total carbon dioxide emissions.

- Normal insulation
  - a lot of heat loss

Part 1: The existing construction

The modified design M1:100

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Ultra-Slim Vacuum Glazing

Vacuum insulation glazing depends on evacuating the gas from the cavity between the glass panes and reducing the pressure to levels 10^-3 mbar. External atmospheric pressure subjects the panes to loads of 10 tonnes per square meter, and to prevent them being pressed together, small supports or spacers must be incorporated at regular intervals in the barely 1mm cavity. An alternative variant for the edge fixing is also being developed, using layers of mesh. With this construction, Ug values of 0,5 W/m²K can be achieved. By 2011, suitable production techniques should be available, and the price of vacuum insulation glazing should be no higher than that for conventional triple glazing.

Multipor Insulation

Multipor is a massive, mineral insulation material made of sand, lime, cement and water. It has no harmful microorganisms and is non-combustible. The waste products of its production can be recycled or disposed of. However, Multipor's lack of flexibility makes precise jointing and careful working necessary. It is dimensionally stable, compression proof, vapour resistant and non-flammable and can be used for the internal insulation of external walls, ceilings of cellars and underground car parks, and sloping or flat roofs. Multipor has a decisive advantage over mineral-wool or polystyrene insulation materials in a thermal insulation composite system: the walls are seamlessly stable with enormous resonance.

Super Insulation

Super Insulation with 45 cm wall

U-value calculation of the wall

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Outside</th>
<th>Inside</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambient</td>
<td>-10.00 °C</td>
<td>20.00 °C</td>
</tr>
<tr>
<td>Surface</td>
<td>-9.77 °C</td>
<td>19.24 °C</td>
</tr>
</tbody>
</table>

After

U-value0,082W/m²K
Thickness1,235m
Temperature    Outside         Inside
Ambient         -10,00 °C     20,00 °C
Surface          -9,90 °C       19,68 °C

Before

U-value0,194W/m²K
Thickness1,66m
Temperature    Outside | Inside
Ambient | -10,00 °C | 20,20 °C
Surface | -9,90 °C | 19,44 °C

Solar protection - Ultra-slim glass in front of the glazing can deflect the sun’s rays or trap solar heat between the two facade layers. Therefore I took the wood panels away and replaced them with inew sliding doors as a glazing to the south and to the west.

Skylight for the hallway - I’ll use the wind pressure effect for natural ventilation in the house. The wind pressure effect makes use of pressure differences as air is drawn through ceiling vents, or through small apertures placed in suitable places throughout the house. In my house it will be through ceiling vents.

Concrete with Furnace Slag (GBFS)

Granulated blast-furnace slag (GBFS) is a waste product from steel smelting. Using GBFS or fly ash reduces CO₂ emissions by almost one tonne for every tonne of cement saved, at the same time creating denser, more durable concrete. The concrete also gets 25% stronger, if you replace the cement to 45% with GBFS. The disadvantage is, that the concrete needs twice as much time, as normal concrete, to dry.
I got inspired by the Loblolly house by Kieran Timberlake Architects in The United States. The west facade is an adjustable, double-layer system with interior folding glass doors and exterior polycarbonate hangar doors that provide shading from the sun and storm protection. The facade can be completely opened for cooling, and closed to harness solar radiation for warmth. On my design, I used the same system for all of the glazing to the south and the west. In the section above, you can see the afternoon sun in relation to the bifolding doors.

**Green Roof**

I’m going to apply a green roof on the side of the grandparents house. It doesn’t only make the roof more sustainable, but will also give a good view for the family with the children, when they look out into the garden from the second and third floor. The grandparents’ house is just on one floor. So now they also have the opportunity to enjoy their own private garden on top of their roof.

Among other benefits, the planted areas are cooler in summer, saving energy by reducing the need for air conditioning. According to the EPA “On a hot, sunny summer day, roof surfaces and pavement can be 50 to 90 degrees C. hotter than the air, while shaded or moist surfaces remain closer to air temperature.” Fast city or country, green roofs, in addition to creating significant energy savings, provide other important environmental side benefits. The plants remove carbon dioxide from the air while the soil absorbs and filters rain water, so what goes back into the environment is cleaner.

A standard roofing membrane and insulation layer is laid onto the underlying roof structure, then a stabilized, perforated drainage membrane such as Oldroyd Xv20 GreenXtra is used in addition to provide a drainage layer with reservoir capability. A filtrating drainage layer (Oldroyd Tp filter fleece) is laid down before adding the required soil loading and plantings, as shown in the diagram above. I’m going to apply a green roof on the side of the grandparents house. It doesn’t only make the roof more sustainable, but will also give a good view for the family with the children, when they look out into the garden from the second floor. The grandparents’ house is just on one floor. So now they also have the opportunity to enjoy their own private garden on top of their roof.
Geothermal heat

No matter what climate you live in, the temperature throughout the year varies. For some climates that means blazing summers that cool to frigid winters. What many people don’t realize is that the temperature below ground (regardless of climate or season) stays fairly consistent all year.

The ground is able to maintain a higher rate of temperature consistency because it absorbs 47% of the sun’s energy (heat) as it hits the Earth’s surface. Geothermal systems are able to tap into this free energy with an earth loop. This technology is then used to provide your home or office with central heating and cooling.

As shown on the picture beneath, there will be a geothermal heat system underneath my model.

Heating

During the heating cycle, a WaterFurnace geothermal system uses the earth loop to extract heat from the earth. As the system pulls heat from the loop it distributes it through a conventional duct system in your home. The same heat energy can also be used for a radiant floor system or domestic hot water heating.

Cooling

In the cooling mode, a WaterFurnace geothermal system uses your home as the condenser. The cooling process works in much the same fashion as the heating process. Instead of extracting heat from the ground, it is extracted from your home and either moved back into the earth loop, or used to preheat the water in your hot water tank. Once the heat is removed from the air, it is distributed through the duct system in your home.

Rainwater collection system

Community, rainwater harvesting systems are constructed of three primary segments: (1) a collection method; (2) a conveyance component and (3) a storage facility.

Rainwater harvesting collection, conveyance and storage systems can be incorporated into almost any existing building, although it is easier to incorporate a rainwater harvesting system into new construction. Any materials used for new construction can be used for rainwater harvesting systems. Roof or building materials used for rainwater harvesting collection systems can include any materials used for roofing or building systems.

(1) Collection method

Roof catchment is one of the simplest collection methods at work or pattern that direct the rainwater through a conveyance system and into a storage container. Roofs are ideal at catchment areas as they easily collect large volumes of rainwater. The amount and quality of rainwater collected from a catchment area depends upon the rain intensity, roof surface area and type of roofing material.

(2) Conveyance components

Components are required to transfer the rainwater from the roof catchment to storage. Conveyance is usually accomplished by connecting roof drains and piping from the catchment area (or roof top) to a site or more downspouts that transport the rainwater through a filter system to storage in tank or retention pond for reuse or recharge.

A siphonic roof drainage system is one of the most effective technologies offered for capturing rainwater from a building roof top to aid in implementing rainwater harvesting systems. In a siphonic system several roof drain outlets can be connected to a single vertical discharge pipe. Fewer discharge points and no requirement for pitch in the piping means the system can be easily set horizontally above grade, partly underground, or below grade. Various types of rainwater storage containers can be constructed above grade, partly underground, or below grade. Storage tanks should be located as close to supply and demand points as possible to reduce the distance the water is conveyed.

(3) Storage tanks (or cisterns)

The harvested rainwater main storage reservoirs are required when needed. Depending on the available space available storage containers can be constructed above grade, partly underground, or below grade. Various types of rainwater storage containers can be constructed above grade, partly underground, or below grade. Storage tanks should be located as close to supply and demand points as possible to reduce the distance the water is conveyed.

Before water is stored in a storage tank (or cistern), and prior to use, it should be filtered to remove particles and debris. Filtration is a key element in the storage and use of harvested rainwater. Upon leaving the tank, the stored water is extracted from the cleanest part of the tank, just below the surface of the water, using a floating filter.

My model has big, flat roofs. So it will be very useful for the collection of rainwater.

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