Introduction

Prêt-à-Loger proudly presents a solution for 1,4 million energy consuming Dutch row houses from around 1960. By putting over a Skin the house becomes energy neutral and more space is added, while the quality of a home remains untouched: improving the house, preserving the home. As a case study a typical 60's row house in Honselersdijk is selected, being the parental home of a fellow student. The pavilion is a copy of this house, slightly adapted to competition conditions, even showing parts of both neighbouring houses without a Skin.

Structural design

Concerning the structural design, the most challenging and innovative component resides on the south side of the Skin system, where a light glasshouse structure is adapted to the existing row house. This glasshouse is in fact an integrated system, combining energy production through PV panels on its roof and façade, reduction of the energy for heating through forming a thermal buffer and creation of an extra, high quality space by forming a direct connection between exterior and interior. Most importantly, all these are achieved by keeping the existing home alive. The conceptual directions are translated in the structural design by the following criteria:

1) Spatial connection: No structure can block the transition between inside and outside, to achieve the maximum effect of extending the space to the garden.
2) Climate performance: Adaptability to the seasons, open completely during summer.
3) Applicability: Simple and easy construction , minimizing weight and interventions while designing for wide adaptability to the different typologies of row-houses.

In coordination with the various designers, engineers and sponsors of the team, a system was designed to achieve the above. Is comprises of a light steel skeleton supporting an aluminium frame system that the PV panels are fixed on.

The aluminium structure follows the grid of the photovoltaic panels, seamlessly integrating them into a single glasshouse structure, while keeping all the construction requirements like water and air-tightness. The steel skeleton is designed for structural and construction efficiency to achieve minimum profile size and number of components. It is composed in the roof by a system of main and secondary beams and in the facade by a portal frame. For the roof, the grid of the secondary beams follow the one of the PV panels, minimizing the span of aluminium skeleton, while the main beams (rafters) are on a grid of 1.20m, following the functional grid of the row-house. The main beams distribute then the load to a ridge steel beam on the top and a steel portal frame on the bottom. The ridge beam is simply supported by the existing house through connections in the chimneys.

The portal frame is used for many other functions than transferring the roof load. Structurally, it works as a beam element with adequate height to hold the heavy glasshouse door and as a bracing for the side wind through welded diagonals. Additionally, vertical PV panels are installed upon it to produce more energy. The Skin is simply connected to the house on its upper side and on surface foundations on its lower part, thus dividing the total load. Since the self-weight of the total added construction is minimal, the bearing capacity of both ground and the existing house is not exhausted.

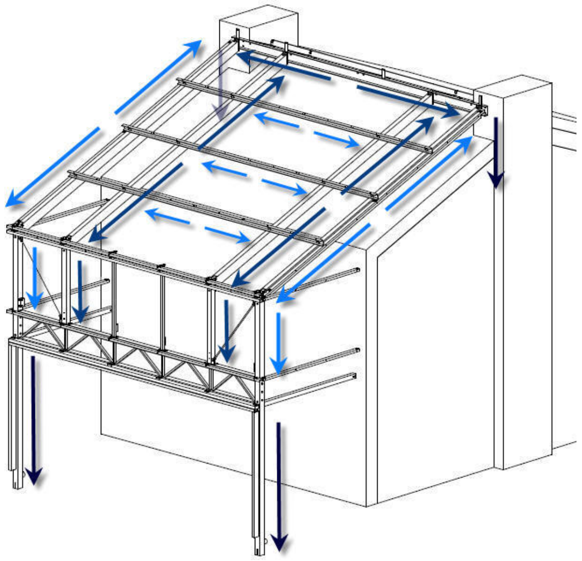

Figure 7.37 — Vertical load transfer on the glasshouse

Component	Weight (kN)
PV-panels	9.35
Supporting structure	27.85
Total	37.2
On the foundations	25.02
On the house	12.18

Figure 7.39 — *Weight distribution*

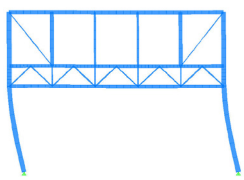

Figure 7.38 — *Lateral deformation*

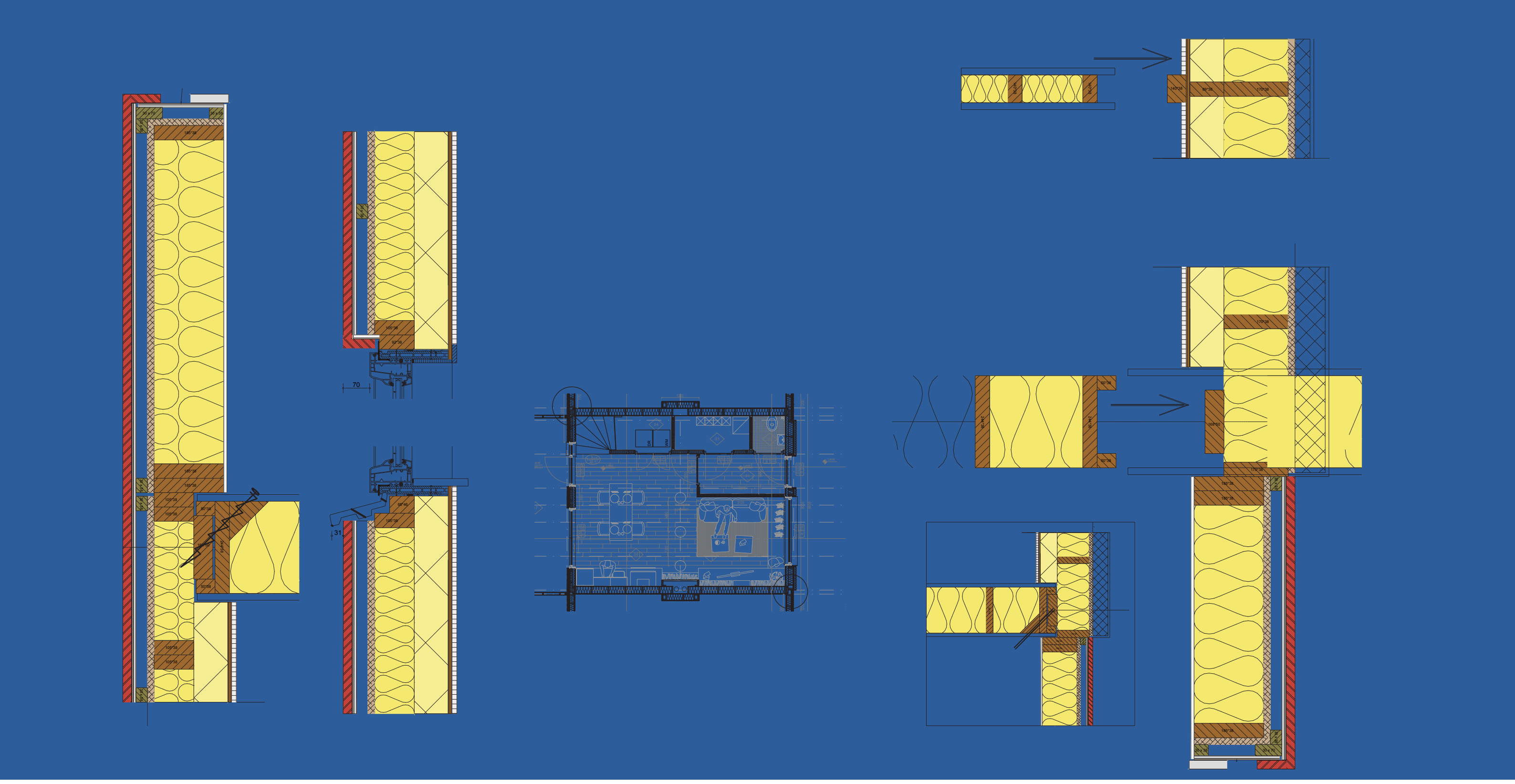

Figure 7.41 — *North and south façade construction details of the Prototype house*

Constructive design

The constructive design is based on integration between the concept of an existing house intervention and the requirements of the competition. For the first, the ideal solution would be to literally bring a real house from the Netherlands and apply the Skin on it in Versailles. Because of the limited feasibility and the strict requirements of the competition, a compromise is made for a representation of the existing house. Nevertheless, the Skin system and its application is exactly the same as in the concept.

For representing the existing house, a timber frame panel structure is chosen. By offering the most light-weight market solution, the transportation and assembly of the house become simple and fast, allowing also for lighter foundation design. The sustainability of the timber structure as well as its demountability were further reasons for the construction of the Prototype pavillion. In a way, the house is both a representation and an original, even if the existing Honselersdijk house is having load bearing masonry walls. Nevertheless, by using brick strips on the façades, the aesthetic results on the external walls is similar to the existing masonry house.

The composition of some of the components is shown in the above figure. It should be noted that, even if all the layers are not an exact representation in dimensions and materials, they nevertheless simulate the main parts of the refurbishment. Examples of these parts are the insulated panel that is placed on top of the northern façade as well as the green roof. Both of these components are exactly the same in the refurbishment solution, comprising the northern part of the Skin system.

The innovation in the constructive part is practically the Skin system itself, as a result of bringing together various products, companies and multidisciplinary designers of the building sector. This process involved extensive communication and collaboration, especially in the intense "pressure cooker" design meetings with all the stakeholders present. Even if in the end the Skin comprises of many usual market products, the combination and the holistic design approach led to one unified product, augmenting the result for the user. This is taken even further by the customization offered by the refurbishment toolbox, developed by the team in relation with the main concept. There, different options for refurbishment components are presented to the user, along with their cost and performance in energy efficiency and sustainability, in order to support his decision-making.

PV panel design

From the very conceptual beginning, Prêt-à-Loger team explored the idea of using a Building Integrated PhotoVoltaic (BIPV) system to power the house. The main criteria for the selection of this system is to combine seamlesslly efficiency, aesthetics and integration into an affordable package. This resulted in using a innovative BIPV system in relation with the Skin, to achieve transparency (around 35%), with the use of glass-glass modules and optimum Watt-peaks (Wp) to ensure that the structure is at least energy neutral for domestic use. The BIPVs' selected technology is monocrystalline Silicon (mono c-Si) with about 19.5% cell efficiency.

The BIPV modules are of two types on the installation. The 20 roof BIPV modules (200Wp) and the 5 window PV mod-

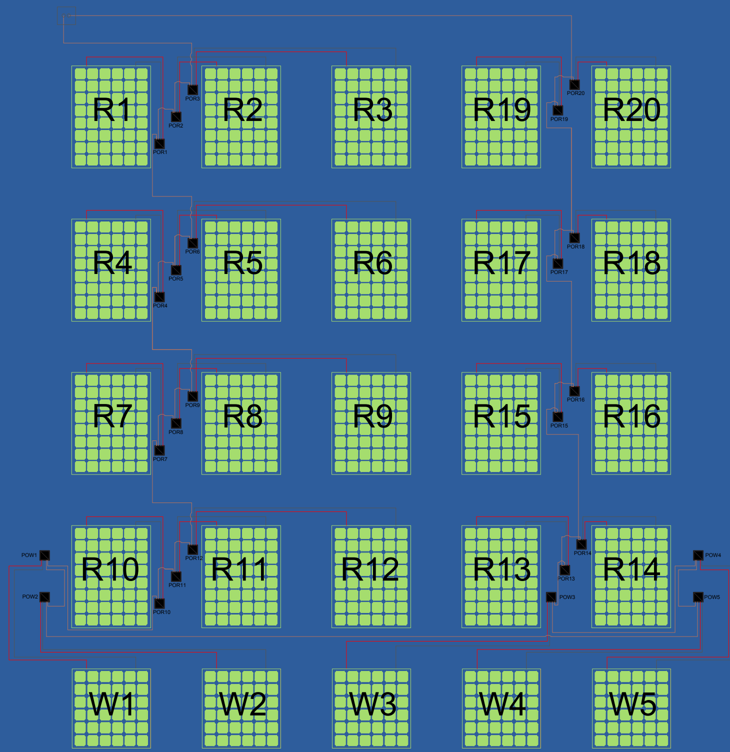

Figure 7.42 — *PV panel integration on Skin system*

Figure 7.43 — *PV panel connection diagram*

ules (175Wp) offer an installed power of 4.875 kWp with an efficiency of 16.5%. The connection of the BIPVs with the inverter is done via Power Optimizers which track the maximum power point of the I-V curve. As the concept represents the existing situation on Honselersdijk in the Netherlands, the orientation of the Prototype house is, by design, the same as of the original. That is 138 degrees azimuth (42 from the south) and 21 degrees inclination (window BIPVs - 23 degrees). As a consequence, the annual electricity generation is estimated to be around 3,800 kWh (PVsyst simulation).

Electrical design

Considering the electrical installation of the house, the Prêt-à-Loger team seized the opportunity to implement many innovative solutions while trying to represent the design of the house in Honselersdijk. Nevertheless, since safety and functionality are considered here the crucial factors, the design provides maximum security without compromising the house's functionality.

For the above reason, four RCD's were used for the house installation compared to one RCD that is normally used. Every one of those RCD's is connected to either three or four electrical groups. This means that in the case of current leakage, the correspondent RCD will trip but partial functionality in the house will be maintained. The reason is that only a section of the electrical groups will be disconnected instead of the entire electrical installation.

A second innovation is the plug and play cable installation. It enables newly added electrical elements to be implemented directly, by plugging them into the existing system without any major change to it. It is a simple process that allows for maintenance and replacement with minimal intervention, compared to the mainstream solutions. All the cables can be replaced by just removing the skirting board, while cable junctions are used to connect the various cables, promoting flexibility and achieving a swift and clean process.

Another innovation can be found in the lighting design, where switches with RF emitters are used, along with RF adapters placed on the lights. This means that the lights can be turned on and off through RF (wireless) signaling and not by using the typical wired connection between the lights and the switches. This has two advantages. The first is the simplicity achieved in the electrical design, leading to minimum amount of required cables and a shorter time needed for design and installation of the system. The second is the level of control, since the lights can be turned on and off not only by the switches but by the domotica system as well.

Continuing with the innovations in the light installation, a special reference should be made to the lights used. All the lights installed inside the House with a Skin are energy-efficient, solid state LED lights. Additionaly, Solatubes are used, which provide a combination of natural lighting through the roof during the day and artificial lighting when the illuminance is not enough. The combination of LED lights and Solatubes minimize the energy need to illuminate the house during both day and night.

Apart from the lights used, every appliance installed is considered as state-of-the-art in its consecutive field and it is chosen with the following three criteria:

1) lowest possible energy consumption
2) very high service standards
3) attractive design

The final major feature is the automation system for the climate control. Small scale motors are installed to control the glasshouse openings and the shading system. Additionally, an air fan and a heat exchanger are installed in order to control the climate of the pavilion in combination with the PCM box. In total, the system aims to provide optimal climate conditions according to the residents' needs and desires. All those components are coupled into two groups in the electrical box and they are controlled through the domotica system.

Plumbing design

Following the main concept, the plumbing design relates to the usual solutions found in a dutch row house, except that instead of central connection, tanks are used for fresh and waste water. However, special fixtures and sanitary appliances are used, leading to reduction in water and energy losses. One of the most important is a heat recovery system in the shower, which allows for a maximum of 50% reduction in energy used for heating the water. Furthermore, special plumbing installations are created to implement the solar water heating system of Solar Compleet, including connections between the boiler and a special energy panel on the roof. Additionally, it is noted that the main piping is using the free space inside the chimney for vertical transport, representing a possible solution in refurbishing the plumbing of an existing house and minimizing construction interventions. All the above enhancements of the plumbing system can be also used in the refurbishment in the Honselersdijk house.

On the contrary, one of the major features that can be found only in the refurbishment concept but not in the prototype in Versailles is the rainwater use. Specifically the rainwater coming down from the glasshouse is gathered in a tank and is used for flushing the toilets, thus covering one of the most consuming uses of domestic water. Nevertheless, this system will be implemented in the relocation of the Prototype house in Delft. A more limited system will be used in the competition, to gather rainwater in a tank integrated in the glasshouse of the Skin system. This rainwater will be used solely for watering the plants of the garden.

Solar Thermal System Design

Combining the design philosophy of Prêt-à-Loger and the Solar Decathlon competition, the starting points of this design are high efficiency, affordability, wide applicability in existing Dutch row houses and being able to function all year long. Following the concept of the Skin refurbishment solution, the glasshouse can provide an integrated solution for the above goals. Because of the energy production of the PV panels and the transparent enclosed space, it can function as a solar thermal energy harvester that can be used for covering the hot water needs of the house.

The system used to convert this energy source is Solar Compleet, a thermodynamic solar system. Both affordable and easily applied to existing houses and the glasshouse, Solar Compleet provides hot tap water during the whole year and heating for the radiators in the winter. In principle, the system's collectors extract heat from the PV panels, cooling them down and increasing their efficiency, while simultaneously generate hot water. These thermodynamic collectors are formed by a metallic panel which is directly exposed to the sun, acting as a heat pump circuit evaporator to collect heat from the sun and the environment. This is then passed on the water via a condenser, surrounding the outside of the boiler. The boiler is housing a heat pump of 4kW capacity with an average COP of 4, which is able to reach a reduction of 90% for hot water energy needs. The water has a maximum temperature of 55°C and is stored in a 300 liter tank, integrated under the heat pump. This capacity is sufficient for a family of 4 members, for more than a day. The system is also featuring a back-up heat pump, which uses the ambient air in the control room to continue the hot water generation even in the winter.

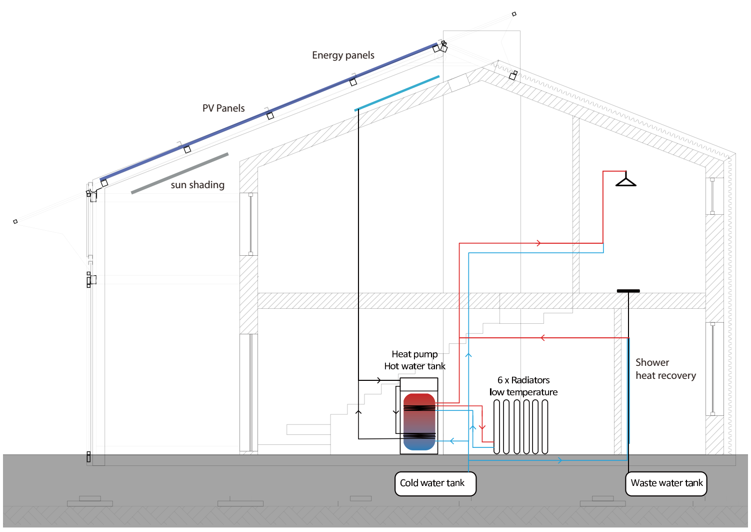

Figure 7.45 — *Solar Compleet system application*