Since our formation in 2008, the Zero Carbon Hub continues to work with Government and industry to create a zero carbon definition that can be delivered by the mainstream house building industry.

This series of building profiles gives examples of manufacturers, developers and clients who have embraced the challenge and are developing practical, commercially viable ways of delivering energy efficient, low carbon homes.

SUMMARY

Built by a consortium led by Caplin Homes, the Solar House was constructed in 2013 as an exemplar project to demonstrate to members of the building sector that zero-carbon buildings are not just possible but are also affordable and economically viable.

SPECIAL FEATURES

The Solar House integrates a Fabric Energy Efficiency Standard (FEES) with a number of key technologies, including an array of hybrid solar panels (PVT), solar walls to pre-heat incoming ventilation air, and an Earth Energy Bank (EEB) and heat pump to store and retrieve heat collected in the summer months for use in winter. The combination of high fabric specification and low carbon technologies has dramatically reduced both running costs and CO₂ emissions from the buildings energy use.
PROJECT STRATEGY

KEY PLANNING CHALLENGES

The largest challenge faced by the Solar House in achieving planning permission related to its nature as a single dwelling in a rural landscape. Under paragraph 55 on the National Planning Policy Framework (NPPF) the development had to show its innovative nature and high build standards. With strong support from Harborough District Council planning permission was granted in December 2012.

Another key consideration during the planning stage was the sites elevated nature. Due to the design and construction methods of the Energy Earth Bank System any significant future change in rainfall or ground water retention may have negative impacts on both the system and building’s energy performance. By constructing the home on an elevated site it is hoped this potential future issue can be avoided.

DESIGN AND CONSTRUCTION

To ensure the quality and energy performance of the home, it was decided to construct the Solar House through offsite manufacture using closed timber frame panels. By using a timber frame structure, manufactured under factory controlled conditions, it was hoped that the development would be able to more accurately ensure the consistency and build quality. This in turn helping to reduce any potential performance gap between the design and as built energy performance.

Despite the use of offsite construction methods, progress on the development; during the earlier blockwork phase, was delayed on site for one month during March 2013 due to exceptionally harsh weather conditions.

CULTURE

To further guarantee quality on site Caplin Homes employ a team of sub-contractors specialising in low energy buildings, who are trained by the developers and systems manufacturers to deliver the homes to specified standards with minimal supervision.

PRODUCTS AND SYSTEMS

A number of innovative building systems were incorporated into the Solar House. These include the integration of:

- **SolarWall** – Passive ‘outer skin’ which uses thermally conductive material and perforated steel sheets to pull preheated air into the buildings ventilation system.
- **PVT Panels** – Advanced solar energy capture, generating both electrical and thermal energy, using HYBRID PV-T panel arrays.
- **The Energy Earth Bank system (EEB)** which uses 56 boreholes – 1.5m deep beneath the building – to store solar energy captured in the summer for use in the winter period.

FORWARD THINKING

One of the project’s key considerations was to demonstrate that the technologies incorporated in the Solar House could be applied to more ‘mainstream’ housing designs and non-domestic builds. To ensure this, the Solar House was modelled thoroughly and monitored extensively throughout its development process and into occupancy.

A further 12 sites incorporating the Solar Homes Zero Carbon technologies are under consideration or are currently being monitored. By 2017 these sites will have provided additional evidence as to the extent of the systems performance and viability.
AIRTIGHTNESS AND VENTILATION

AIRTIGHTNESS
2.9 m³/m²h at 50 Pa (tested)

To help reduce any potential air leakage the Solar House employs a robust airtightness strategy in its construction.

- Insulation in each frame is sealed to the inside edge;
- All frames being sealed to their neighbours;
- Multifoil wrap taped to each seam to form an impermeable membrane;
- Plaster board and skim to form a final barrier.

While these processes aim to reduce leakage in the homes structure, further seals, such as around LED lights and structural openings, must be addressed separately and checked regularly throughout construction.

VENTILATION
90% MVHR Efficiency

The Solar House concept uses MVHR linked to the SolarWall system. This system provides pre-heated air to the whole building while extracting stale/moist air from specific rooms.
KEY LESSONS

DESIGN, CONSTRUCTION AND COMMISSIONING STAGE

Due to the Solar Houses offsite construction methods and trained labour force, a large number of potentially problematic areas for this development were avoided. This was particularly evident when considering the Solar House insulation, where the pre-filled, closed time frame panels ensured the correct level and proper installation of a key element in the homes low energy strategy. The manufacturing methods of these panels also allowed the development to continue at a steady and accurate pace.

However issues linked to the placement and number of sensors installed to monitor various components and post occupancy evaluation criteria was noted. Attention was drawn to both a lack of sensors in some areas, as well as, an over allocation in others. Knowledge learnt from this experience has now been accumulated to avoid similar problems in future developments.

Minor issues were also identified with operation of the homes SolarWall MVHR system, where consistent checking of filters was not regularly undertaken after the commissioning stage, resulting in a build up of foreign materials reducing the systems effectiveness, although reversible this issue re-emphasises the need for energy efficient systems to be operated correctly with robust maintenance processes in place.

POST OCCUPANCY EVALUATION / DEMONSTRATING PERFORMANCE

PERFORMANCE

Since construction the Solar House has been monitored through two winters and a summer period. The observations made in this period indicate that all the systems in the home seem to be performing well.

- The year-on-year performance has been remarkably consistent with only a 0.3ºC difference for any period over the two winters. Showing that even in varying conditions the EBB is able collect and store energy effectively for use in colder periods.
- Monitoring of the home has also shown the EBB to be robust, with peak ground temperatures (9ºc) being maintained for use throughout the winter period. This allows the home to continue to withdraw energy from the EBB for use in the house despite surrounding ground temperatures dropping below 0ºC.
- The electricity generated over the first 12 months was 6,400 KWH equivalent to 1,185 KWH per 1KWp of capacity, confirming the beneficial effect of cooler PV operating temperatures. This also amounts to around twice the energy needed to run the heat pump.

In order to guarantee the performance of the Solar House occupant controls were also limited to a single display where only room temperature could be altered.

OCCUPANTS COMFORT/PERSPECTIVE

Only one area of concern was noted with the performance of the Solar House. This was associated to a number of large unshaded windows on the south side of the home, which caused overheating prior to occupation of the building. In order to increase resident comfort and choice the method of rectifying this issue was ultimately left to the future occupiers, who eventually, with the help of the developer, chose to fit automated internal blinds with a high reflective rating.

Lessons relating to solar gains and the risk of overheating in highly energy efficient homes were taken onboard and applied to the design of future homes.