GDPCAPITAL

The Nottingham H.O.U.S.E. Project:

Home Optimising The Use of Solar Energy

"This is one of the few houses attempting to push boundaries of passive design…(resulting) in a very competent and simple proposal for a liveable, market-ready family house that introduces sustainability by stealth, rather than flashy technologies" **International Jury at the Solar Decathlon 2010.**

The Nottingham H.O.U.S.E. project came about as a proposal for the Solar Decathlon 2010 held in Madrid. This competition, originating in the USA, involves 20 Universities from all around the world competing in the designing and construction of an innovative and sustainable household that utilizes Solar Energy as it's sole power resource and combines it with efficient technologies to reduce its carbon footprint and maximize its energy-efficiency.

Aims and Ambitions

Working in association with Saint-Gobain and other important players in the construction industry, the University of Nottingham's school of the Built Environment aimed to design a house that would work in the UK as a mass-market affordable solution to UK housing. Priorities included working to the zero carbon agenda where all the energy used by the home is produced on-site by the solar systems on the roof of the house, while at the same time, retaining all the aesthetic qualities a home should have.

Consequently, this could trigger the start of a more fully sustainable urban fabric where family homes will sit side by side to create a more efficient and sustainable community.

The successful implementation of the project would show how a home could provide its own energy in a real life context, while adhering to the conventional aesthetic qualities of two-story terraced/semi-detached housing that is typical of the UK housing market. Ultimately predicting strong market viability.

Design

The design followed a two year development in accordance to the world's most stringent design codes - German PassivHaus Institute Design, the UK Government's Code for Sustainable Homes

Level 6 (Zero Carbon standard), Lifetime Homes compliant, Secured by Design compliant and finally adhering to the UK building regulations. It was designed to target "starter" families of 2-3, which happen to be a major requirement in the UK today.

Although primarily designed for Madrid weather over the Solar Decathlon competition, measures have been taken to account for its use in a UK context such as Air-tightness, Passive Stack Ventilation, Passive Solar Gain as well as its off-site construction. These technologies have been estimated to amount to annual savings of £920 (£640 in savings, and £280 for feed in), and a payback time of 11.6 years on electricity costs alone (for a more comprehensive breakdown of facts and figures see Sustainability on pages 4-6)

Funding of the project

- UK Zero Carbon Hub
- U.S. Department of Energy (USDOE)
- Solar Decathlon Europe
- The University of Nottingham
- Faculty of Engineering
- Industry Partners – Saint-Gobain (for full list see pages 6-8)

Project Recognition

Awards

- International Award for Sustainability - For providing a truly sustainable house that is market-ready and market-appropriate.
- Awarded the top prize in the inaugural Timber at Ecobuild Awards for best use of Timber from sustainable sources at Ecobuild 2010 – the world's biggest event for sustainable design, construction and the built environment.
- The Nottingham H.O.U.S.E. team were also shortlisted for the Sustain Magazine 2010 Construction Award.
- Recently nominated in the prestigious Housebuilder Awards 2011.

Following this, under the theme *Zero Carbon, Zero Waste*, Nottingham H.O.U.S.E. project in partnership with ZEDfactory was exhibited at the Shanghai Expo 2010 which promulgated the idea of *Better City, Better Life.* The exhibition boasted over 73 million visitors with 246 countries taking part.

Stakeholders/Investors

Saint-Gobain:
Saint-Gobain is a world leader in design, production and distribution of construction materials, delivering innovative products and services with tomorrow in mind.

UK Zero Carbon Hub:
The UK Government has agreed that the Zero Carbon Hub has a lead responsibility for delivering homes to zero carbon standards by 2016.

US Department of Energy:
After more than 30 years in existence, the Department now operates 24 preeminent research laboratories and facilities, four power marketing administrations, and an energy information administration, as well as managing the environmental cleanup from 50 years of nuclear defense activities that impacted two million acres in communities across the country.

University of Nottingham
The Department of Architecture and Built Environment is a leading centre for teaching in architecture, urban design and sustainable energy technologies. The department is particularly noted for it's innovative work in green issues and sustainability, and attracts leading experts from practice and industry.

The faculty of Engineering
Aiming to enable the transition towards a more sustainable, low carbon society that will bring with it improved economic and health benefits.

For a full list of sponsors see pages 6-8.

Benefits to both parties

For the University of Nottingham, the value of the project consisted in their chance to compete in a worldwide competition. Being the first UK university ever to take part in the Solar Decathlon, it proved a great privilege and opportunity to propose a student-designed house that would help lead the incentive towards sustainable housing in the UK and beyond.

The value of the project to the stakeholders was the exposure of their own products embodied in a successful example of sustainable housing. This meant that through sponsorship and resourcing of the materials used on the Nottingham H.O.U.S.E. project, they would be able to demonstrate their close participation towards the future of sustainable buildings and hence, be at the forefront of the future in construction.

Viability and future potential

In the Solar Decathlon 2010 The Nottingham H.O.U.S.E. project was rated in the top 3 for the sustainability criteria. Unfortunately several complications deterred its success at the competition:

- **Lack of proper experience** – although it was one of the main objectives to present a house designed and built by students, this meant that the vast majority of the students involved had little if any experience about the process of building and construction. Those with the proper experience were limited and were being stretched across a huge workload.
- **Compromised Design** – at the last minute, Saint-Gobain insisted more Isova materials be used in the design, therefore altering time and expectation of construction and design.
- **Transportation of materials** – in order to decrease construction time and cost, the house is constructed into 8 modules off-site. These get transported onto the site where they are assembled; some of the materials along with the roof of one of the modules broke during transportation.
- **Little preparation time** – students began working on the project in January 2010 thus giving them a very short time to familiarise themselves with the design, materials and construction of the project.

Despite these drawbacks, the project has had international recognition from some of the biggest players in the construction industry and is still being nominated for awards. The sustainability and market viability of the house arguably remains successful and is currently awaiting funding from collaborators to invest £25,000 before July 2012. This will be combined with the other £25,000 the UK government has offered in order to build one of these houses in The University of Nottingham's Built Environment.

Collaborators will gain access to IP (Intellectual Property) of the technologies used in the project will be directly supporting a student project to leave a fantastic legacy on the campus for 1000's of visitors to see in years to come.

"It is the only entry that is an example of medium-density housing from the word go and allows for the possible expansion of the family without having to add modules or move to larger accommodation. Its simple and familiar form and affordability presents no barrier to entry and the house is ready for large-scale implementation" **International Jury at the Solar Decathlon 2010.**

Sustainability

- Sustainably sourced timber for exterior walls and interior furniture.
- Membrane covering insulation to achieve air-tightness and avoid leaks and drafts.

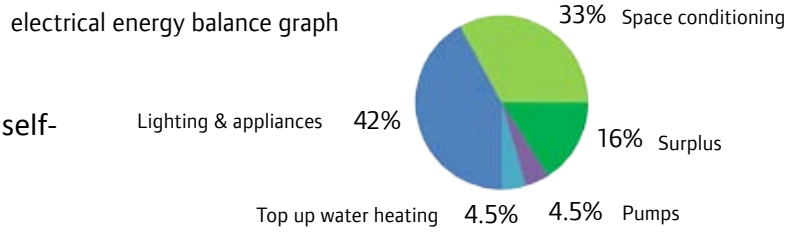
- Water recycling - fresh water for shower that then gets treated and cleaned to be used in the toilet for flushing.
- Zero carbon decking around the house designed by the students.
- Landscaping involves carefully selected plants that can be harvested as home grown produce.
- Passive solar gain - using the sun's energy to heat spaces.
- Rapid volumetric assembly consisting in 8 modules.
- Passive downdraft evaporative cooling technology (first time being used in a domestic situation) – used in warm climates (South Europe)
- Passive stack ventilation – used in colder climates (North Europe)
- Photovoltaic Panel (PV) technology for the production of electricity.

Two types of solar energy systems have been developed in order to meet the house's full energy demands:

- Solar Electric Energy Demand
- Solar Thermal Energy Demand

The energy balance analysis illustrated in the graph shows a surplus of electrical energy generated by the PV array when compared to the electrical energy demands of the house.

This surplus will be exported to the grid, allowing energy demands to be offset when they are not met by the PV array. As a result, the house achieves full energy self-sufficiency.



Solar Thermal Energy Demand:

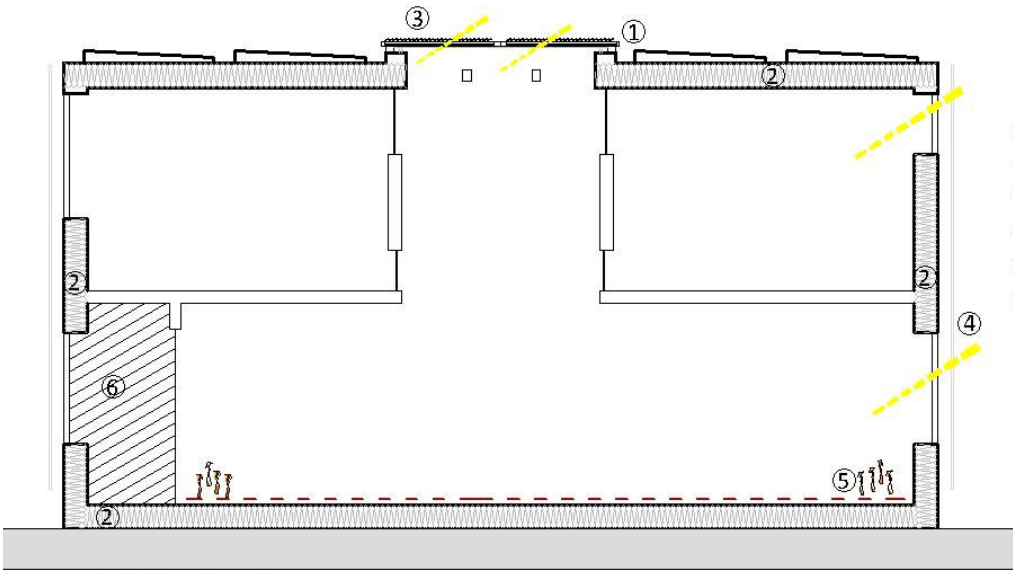
Using a water budget that is specific to two people living in a house, it has been calculated that each person will require 50 litres of water at 60^{o}C per day (which will be mixed with cold water afterwards). To obtain this, 9.45KWh/day will be required.

This requirement will be met using solar thermal energy technology. In this case, a Vaillant auroTHERM 5m^2 horizontal solar collector has been integrated into the roof. The system has been generally predicted to provide around 50-60% of the annual domestic hot water requirements. In Madrid summer, simulations run for the competition week, predicted initial efficiency is approximately 80%

The system uses indirect solar radiation, not just direct sunlight, which guarantees the system to work efficiently in the UK as it does in other countries of similar climates. However, it should also

be considered that an excess in solar thermal energy may damage the system. It was decided to dimension the system to have an optimum summer performance. It is therefore assumed that efficiency will be reduced during winter.

The high performance envelope will minimize fabric heat losses, and a combination of fabric air tightness and the provision of a lobby 'airlock' will minimize infiltration heat losses. Most of the glazed openings (53%) are oriented to the south, and 25% of the south face is glazed, promoting passive solar gains.

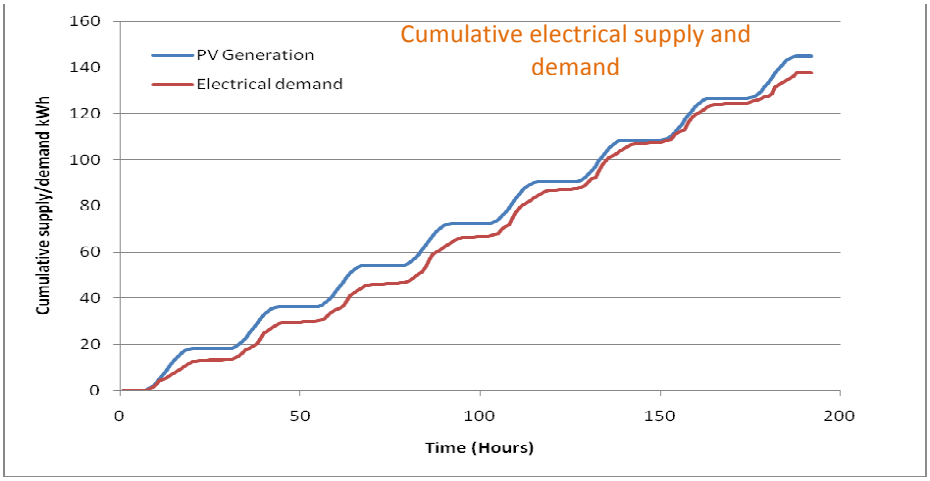


1) Roof vents completely closed.
2) High Performance thermal envelope.
3) Shading platform designed to allow solar gains
4) Mesh allows solar gains
5) Exhaust air source heat pumps uses exhaust warm air to preheat air intake.
6) North facing buffer space for living areas

The combination of passive solar gain and internal heat gains couple with a high performance (well insulated) building envelope, are likely to reduce the heat residual heating requirement to well below 15kWh/m^2 (the 'PassivHaus' standard for heating energy). Top-up heating for this residual load will be provided by the air source heat pumps when required.

Solar Electric Energy Demand

The house has been fitted with a 24m^2 PV array located in a horizontal plane above the roof surface. The system was designed using the Detailed Design function in PVsyst Software, loaded with the Madrid weather data set for the week of the competition as stated in the Project Manual.



The system has considerably lower cost than average, of £0.413 or €0.46 p/KWh.

(Considering current rate of £1 = €1.106). The PV's and their installation, sum up to £10,690 or €11,822. The suppliers estimate an annual generation of 4000 KWh. The energy analysis for the house estimates energy consumption of approximately 3200 KWh per annum. If we consider 2010 domestic electricity tariffs in UK were £0.20 p/KWh and feed tariffs could potentially reach £0.35 p/KWh, this can amount to annual savings of £920 (£640 in savings, and £280 for feed in @0.35 p/KWh), and a payback time of 11.6 years.

All Parties Involved

Institutional Sponsors

- Solar Decathlon Europe
- The University of Nottingham
- Faculty of Engineering

Corporate Sponsors

- Saint-Gobain

Saint-Gobain Sub-Sponsors

Avancis	Photovoltaic Systems
British Gypsum	Rigidur H Lining
Ecophon	Acoustic Ceiling & Wall Panel Systems
Graham	Sanitaryware and fittings, solar panel (Avancis)
International Decorative Surfaces	Work surfaces & bamboo floor
International Timber	Thermowood cladding & external decking
Isover	Thermal and Acoustic Insulation
Jewson	Kitchen, general building materials, tool hire and PPE
Pasquill	Engineered Timber cassette structures
Saint-Gobain PAM	Soil and drain, and rainwater systems
Saint-Gobain Performance Plastics	PTFE covering
Solaglas	Windows and doors + Gull wing skylight & balustrades

Logistics & Other Construction Sponsors

DHL Supply Chain	Logistics, transportation of the house
Roger Bullivant	Crane operations in association with Crane Hire Solutions Ltd
HSS	Skates and equipment hire

Marley Alutec	Aluminium downpipes
Netta	FSC Timber, 6x12mm BB grade birch ply
Microwatt	Control Systems & monitoring
Photonstar	Low Energy Lighting
Ecoplay	Grey water recycling system
Greenwood Airvac	MVHR unit
Vaillant	Equipment
SIKA	Sarnafil single ply PVC roof membrane
Roger Bullivant	Foundations for house on final location
Birmingham Powder Coaters	Polyester Powder Coating to aluminium flashings and copings
Crown Aluminium	Fabrication of aluminium flashing details
ECOS Organic Paints	Interior finishing for Rigidur boards
AM Profiles	Aluminum profiles

Consultancy Sponsors

Saint-Gobain	Building technologies and materials consultant
Marsh & Grochowski Architects	Architecture detailing and building control
Dewhurst MacFarlane and partners	Consulting structural and façade engineers
Max Fordham Consulting Engineers	M&E engineering
Davis Langdon	Quantity survey and cost estimation
Evoenergy	Photovoltaic systems
MicroWatt	Consulting microelectronics and software engineers
Inbuilt	Performance assessment consultancy
Nick Whitehouse MBE	Engineering consultant

Communication Sponsors

Ecobuild	Stand
Sat Bains	Menu design & Executive Chef
Lime Orchard (Ian Dexter)	Landscaping design
Philip Lee	Food technologies
CG Vision (Ed Collard)	Video
Eight days a week printing solutions	Brochure printing
John e Wrights printers	Posters printing