Techno-economics of UTM Eco-Home: University-Industry Partners for Sustainable Build Environment

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The UTM Eco-Home is a project specifically designed for the competition at the Solar Decathlon China 2013 (SDC2013) held in Datong China.

The UTM Solar-Home team with the involvement of several research groups in UTM was participated by students and staffs from several disciplines and also demonstrates University-Industry collaborative effort.

This paper presents concept, process and development of the UTM Solar-Home project and it’s current development as a new revised design of UTM Eco-Home to be build in UTM campus.
The first Solar Decathlon was held in 2002; the competition has since occurred biennially in 2005, 2007, 2009, 2011, and 2013.

SDC 2013 was held in Datong China and participated by more than 20 institutions all over the world including institutions from Europe, USA, Africa, Australia and Asia.

UTM is the first institution from Malaysia ever participated in SDC in Aug 2013.
In the design brief of the competition, the participants are asked to design Energy Balance single storey house. A land plot of approximately 576 sq.m. was given and the building should have an area of approximately of 65 Sq.m. of one bedroom house.

UTM Solar-Home team selected the concept of “Home-Suite Home” which derives the concept of a multifunction home which designated to be flexible arrangement as the working place as well as a house at the same time.
2.0 UTM Solar-Home Design Criteria

• The aim is to build a zero-energy home that is affordable and demonstrate solar and energy efficiency technologies in marketable applications, through technology development.

• The design also incorporates passive design measures such as daylighting optimisation and heat gain minimisation in the context of Datong climate condition.
2.0 UTM Solar-Home Design Criteria

- The UTM Solar–Home using modular coordination system where the construction materials are in accordance to the Industrialised Building System (IBS).
- The overall project also demonstrates **University-Industry collaborative effort**, where some building components were sponsored partially or fully by the manufacturers.
2.0 UTM Solar-Home Design Criteria

Building System Structure (wall, floor, roof, window)

- Almost all of the structural system for this building are using cold-formed steel with special design and joints to achieve required dead and live load as well as to fulfill required strength in compression and tensions of overall building.

- Since the overall building were assembled temporarily in UTM site before it was dissembled and transported to Datong China using two 40 footers container, the selection of dry construction are the most appropriate.

- For example, steel joists are dry, stable and do not suffer the long term problems of drying out, creep or shrinkage and termite attack. The galvanizing layer on the joists also provides sufficient protection against corrosion.
2.0 UTM Solar-Home Design Criteria

Building System Structure (wall, floor, roof, window)

- Wall structural are also cold-formed. The inner skin, which has a plasterboard lining to the room face, uses C-section studs in single lengths between floors, at regular centres of typically 500 or 600 mm. These spacing are chosen to ensure the efficient use of plasterboard linings and other cladding materials. Multiple studs are used in heavily loaded applications, such as adjacent to openings or in braced panels.

- The structure of roofs is also using light weight cold-foamed C section roof trusses, where they are designed for long span applications with greater potential for usable roof space and transfer the vertical load from the roof into the wall.
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2.0 UTM Solar-Home Design Criteria

- The Grid Connected PV (GCPV) installed on the rooftop of the building generated excess energy, which fed into the grid and UTM Solar-Home was awarded as Energy-Balance Building.
2.0 UTM Solar-Home Design Criteria

• UTM Solar-Home were installed with the *Wiser Home Controller* which gives the ability to control lighting, climate, security, blinds, curtains and multi-room audio, while offering the ability to view cameras. All of this were done locally or remotely.
3.0 UTM Solar-Home: Summary
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• The UTM Solar-Home was successfully designed, constructed on SDC2013 site in Datong and visited by experts in building industries, jury and public at large.

• At the end of the SDC2013, UTM Solar-Home has been sold to interested party in Datong.
4.0 UTM Solar/Eco-Home Further Design Development
• UTM solar-Home (V 2) is now in the revised design progress, based on the original design concept and to be reconstructed in UTM Johor campus.
• Further development of the project through improvising the design is currently in progress.
• The new proposed UTM Eco-Home will be demonstrating several important sustainable and green concepts of building design, construction and operation which will highlight strategies and solutions appropriate to our local climatic conditions.
4.0 UTM Eco-Home Further Design Development

- Home of 3 bedroom with living room, kitchen & dining
  Floor Area : 115m² (excluding balconies)

- Master BR with attached Bath & WC
- Bedroom 2&3
- Terraces
- Kitchen
- Toilets
- Lounge
- Dining
- Switch rm

Ground Floor Plan
scale 1:100
Floor Area : 982.27 ft²
: 91.256 m²
4.0 UTM Eco-Home Further Design Development

- Showcase of UTM Eco-Home.
- Flexible space to be converted as small office / workplace.
4.0 UTM Eco-Home Further Design Development

Architectural Design Concept;

1. Design;

- Showcase of UTM Solar-Home.
- Flexible space to be converted as small office.
- Domestic scale building appropriate for site setting.
- Represent both residential & office building image.
- Considering site context with green setting.
• Design Response to Climate; Low Heat Gain; Low Carbon Building Material; EE Electrical Appliances; Renewable Energy; Intelligent Building control; Building Certification; Commercial Value and Market Appeal.

• Aiming to be a Zero-Energy Office (ZEO), the proposed UTM Eco-Home would provide indoor comfort for the occupants as a research building and as prototype eco-home.
4.0 UTM Eco-Home Further Design Development
Architectural Design Concept;
2. Design response to climate;
  • Sun-path analysis to minimise direct solar radiation.
  • Optimising Passive Design Approach & Selecting EE equipment where necessary.
2. Design response to climate;

- To provide thermal & visual comfort;
- Temperature: 25.5 - 28 deg C.
- RH: 50 - 60%.
- Air Flow: < 0.5 m/s.
- Radiation: 100 W/m².
- WPI: Approx 400 lux
- Avoid Glare.
4.0 UTM Eco-Home Further Design Development

Architectural Design Concept;
2. Design response to climate;

• To provide Large overhang / balcony / Terraces where appropriate.
• Installing thermal insulation to minimise heat transfer from outside ambient & solar radiation.
Architectural Design Concept;
Optimise **daylighting**, reduce artificial lighting / electricity.

- Utilisation and maximise daylighting for the interiors.
- Daylighting enter from both side of the walls into the building, expected WPI of 400lux.
- Pergola and shading devices on both side of walls to control amount of heat and excessive sunlight as well as to prevent glare problem by occupant.
Architectural Design Concept;
Optimise natural ventilation, reduce dependency on A/C and electricity.

- Raised floor to allow air-flow under the floor creating cooling indoor environment.
- Integration of the natural ventilation innovative design system to allow air-flow and provide indoor thermal comfort.
- High roof/ceiling at the lounge to create stack effect to increase natural air-flow for cooling purposes.
4.0 UTM Eco-Home Further Design Development

Architectural Design Concept;
Creating surrounding micro-climatic **natural cooling**, reduce dependency on A/C and electricity.

- landscaping surrounding the building / underneath pergolas.
- water element & water fountain to create cooling environment.
- Creepers / green wall as cooling elements.
- Tree plantings to create shading for the building.
- PV street lamp.
Selecting building materials that contained low embodied energy (low CO2 content) means avoiding negative impact on environment. Every building material contain embodied energy (GJ/m² or m³) i.e energy that were consumed for the production, transportations and installation of the building component. Less embodied energy can be achieved by selecting building materials produced locally, produces through bio-renewable resources or recycle-based building products.

- Constructions and installation of the building components with less waste. This can be done by selecting appropriate building material size and design during purchasing.

* Embodied Carbon
* 0.62kg CO2/kWh
Other Design Concept;
Innovative & EE Electrical Appliances;

- All fixtures (i.e. lighting, AC, etc) should be EE equipment / Energy Star Rating (High EE).
- Home/Office Electrical appliances should be Energy Star Rating.
- Installation of smart indoor control system.
The Grid Connected PV (GCPV) installed on the rooftop of the building generated excess energy, which fed into the grid.

- Solar water heating system.
- Rain water harvesting system.
Other Design Concept;
Commercial value & Market appeal;

- Comply with current market demand and competitiveness.
- Integrate innovative furniture design to suite with the overall design objective.
- Appropriate and impressive design (exterior & interior).
Conclusion

- UTM Eco-Home will function not only as a prototype eco-home, but also as an office, show case building and research laboratory.

- The building is open for University-Industry collaboration opportunities where industry may involved by installing their products for further study and improvement.

- Continuous research on the aspect of indoor environment such as thermal comfort, visual comfort, daylighting, sun shading, IEQ, ventilation, EE equipment, Building Automation System, RE (GCPV, Solar heating), RWH, Building materials and other areas will be carried out in this building by our researchers and postgraduate students.

- Our research groups and research students welcome industries to participates and take benefit from this project.
Thank You

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