56 Howden Hall Road is a 1930s Bungalow which has been completely re-modernised, environmentally enhanced and extended employing offsite and modern methods of construction (MMC), renewable technologies, novel techniques and innovative products. The level of build quality, architectural improvements and low carbon credentials achieved represent an extremely high level of cost benefit. In addition the build itself has been an applied research project which undergraduate and postgraduate students have participated in via the Edinburgh Napier University, Institute for Sustainable Construction (ISC) Centre for Offsite Construction + Innovative Structures (COCIS). This ambitious renovation and retro project has therefore not only provided a new low carbon construction retro fit solution but has also provided a research into teaching student learning experience through collaboration with industry partners David Blaikie Architects, MAKAR Construction, Harley Haddow Engineers, Accsys Technology, NorBuild, Tree Craft and Blake Group.

Figure 1 Bungalow offsite fabricated extension

1) **Phase 1 Complete Modernisation and Reconfiguration** – The house was turned back to front to create a new South/West facing open plan living, dinning and kitchen area with the reallocation of the bathroom and utility space to the internal core with bedrooms to the front. This required a completely new plumbing and wiring infrastructure, the removal of walls and creation of new partitions as well as the installation of a new bathroom with velux window for natural light and kitchen. This part of the build was challenging as it required controlling a limited budget, project managing all trades and living in the house.

2) **Phase 2 Energy Rating** – The house was taken from the original E53 Energy rating to B82. Failing double glazing to the front elevation was replaced with modern high specification windows, additional insulation to the fabric including cavity wall, loft top up and under floor (installed by owners) as well as the installation of energy saving measures including LED light bulbs and renewable technologies in the form of a 2.5kW
solar PV array and a 4.8kW wood burning stove. To install the stove the existing chimney was opened back up from behind given the original fireplace was now bricked up in the bathroom area. The wall around the stove, which has been left as exposed brickwork, acts as a masonry radiator storing heat from the wood burner due to inherent thermal mass emitting this into the living area and bathroom after the fire has went out. **Note:** Solar PV was an Energy Saving Trust (EST) interest free loan.

3) **Phase 3 Contemporary Off-site Manufactured (OSM) Sitooterie with innovative Cantilevered Glass Box**

   a) **OSM Sitooterie:** The old sunroom was removed and the existing foundation was reinforced to carry an offsite fabricated “sitooterie” (sunroom) with a high specification of natural and breathable fabric. U-Values of the roof, wall and floor closed panels were 0.17, 0.19 and 0.14 (building regulation renovation target values are 0.18, 0.22 0.18) respectively. The closed wall, floor and rооd panels were lifted into position with a high level of tolerance adhered too and all joints and gaps filled for air tightness ensuring a high performing thermal envelope. The walls were internally lined with Birch Ply and clad externally with Scotspine Accoya Cladding. Accoya is a timber product that has been modified by an Acetylation process reacting the wood with an acetic anhydride, which comes from acetic acid (known as vinegar when in its dilute form). By essentially pickling the wood it greatly reduces the ability of the wood to absorb water rendering the wood more dimensionally stable and, because it is no longer digestible, extremely durable. Accoya is made from sustainably sourced softwoods (normally radiata pine and southern yellow pine) and this project piloted the use of Scotspine. Finally to connect the Sitooterie with the existing house the old external door way opening was extended with a Glulam support beam inserted and a glass link formed to ensure maximum light into the space and newly formed sitting room area.

   b) **Cantilevered Glass Box:** To eliminate the need for new foundations David Blaikie (architect) formulated the idea of inserting beams under the suspended floor of the house that would rest on to the existing external wall and be tied down to the under-building internal dwarf walls thus providing both bearing support and holding down restraint. These beams would then be capable of supporting an open plan kitchen and dining full height glazed extension with a highly insulated roof clad with zinc that would look out on to South West facing garden providing a natural source of light and solar gain (heat provided by the sun). Structural accoya sections were therefore re-engineered to form the beams from Glue-Laminated timber for enhanced strength, stiffness and durability. The beams were installed and the movement of them measured for instantaneous deflection (initial deflection due to the installation of glazing) and creep deflection (deflection over time). The final maximum deflection after 6 months was 3mm, less than half of the allowable 7.15mm deflections prescribed by the building codes of practice.