kingdom housing association
A Scottish Charity

The Kingdom House

A House for the Future

FIFE HOUSING ASSOCIATION ALLIANCE

Project Overview

6 Station Court

Pittenweem

October 2010

kingdom housing association
A Scottish Charity

THE KINGDOM HOUSE – PROJECT OVERVIEW

The purpose of this report is to provide an overview of the Kingdom Housing Association's Passivhaus – *The Kingdom House*, as built, and in particular the Modern Methods of Construction and Sustainability features incorporated into the design as part of the Fife Housing Association's Alliances ongoing research into appropriate systems for delivering affordable rented property.

One of Kingdom Housing Association's strategic objectives is to continually improve their products and services delivered to their customers. Through building this house the Association have contributed to this objective and are able to monitor for further development the approach and systems that will become part of the mainstream programme for the Fife Housing Associations Alliance projects.

In addition to being designed to Housing for Varying Needs, Secured by Design and Passivhaus Institute Standards, Kingdom Housing Association are working towards Ecohomes and Code for Sustainable Homes accreditation.

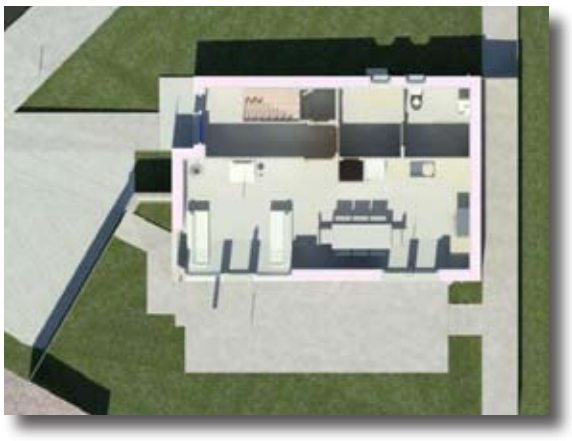
Before commencing the design it was necessary to understand the energy usage in the typical home so that the areas of highest usage could be targeted. The Midlothian Innovation Centre has collected such data over several years and have reported the following:

Space Heating	60%
Water Heating	24%
Light	13%
Cooking	3%

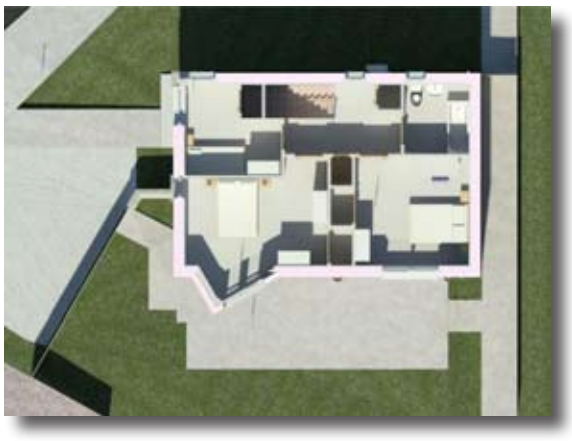
White Goods	Minimal
Leisure Appliances	Minimal
IT and Communication	Minimal

The Project

The dwelling is a 5 person 4 apartment two storey family home located on the northern side of Pittenweem, one of the idyllic East Neuk of Fife villages. It has a gross indicative floor area of 104sqm including 4.5sqm of storage. Benefitting from a southerly aspect the plot is within a development where a mix of tenures has already been provided. There is an eclectic mix of styles of varying heights.



Ground Floor Layout



First Floor Layout

kingdom housing association
A Scottish Charity

The Benefits of Passivhaus

Why use the Passivhaus standard for the basis of the design? A Passivhaus is a design methodology and rigorous, voluntary performance standard for energy use in buildings. It results in a building that requires little or no energy for heating or cooling, has excellent levels of internal air quality and minimises overheating through advance thermal modelling. By providing a constant level of comfort through summer and winter and supplementing primary energy use with renewable energy technology, the Passivhaus has an ultra low heating demand meaning that the space heating costs are greatly reduced. A Passivhaus can protect tenants against fuel poverty.

Passivhaus have basic parameters. For the Kingdom House the following have been achieved (Passivhaus minimum standards in brackets):

- Space Heat Demand 14kwh/m^2 per annum (≤15kwh/m^2 per annum)
- Primary Energy Demand 85kwh/m^2 per annum (≤120kwh/m^2 per annum)
- Air Change Rate n_{50}≤ 0.58h^{-1} (≤ 0.6h^{-1})
- Thermal Bridge Free Design
- Efficient Mechanical Ventilation and Heat Recovery System with efficiency of 90% (≥ 75%)

The Approach to the Design

Optimising the Design

The building form has been kept deliberately 'compact' which minimises surface to volume ratio that in turn increases the thermal efficiency of the envelope. It has been orientated so that all the habitable rooms are located on the southern side, each with a large opening to maximise solar gain and to allow daylight penetration deep into the floor plan. On the north, east and west elevations openings are minimised to reduce overheating and heat loss.

Super Insulating the Building Fabric

Extremely low wall and roof U-values of 0.09 w/m^2K are achieved using Scotframe's Supawall System, which is a BBA Certified closed timber frame panel system comprising of 140mm timber studs sheathed both sides with Oriented Strand Board and factory filled with Polyurethane which itself has a BRE Green Guide 'A' Rating. This kit was erected, wind and water tight within one working day and is supplemented by a mechanically and adhesively fixed JUB Jubizol S External Wall Insulation System that provides an additional 160mm insulation. The render contains the latest nano technology that provides a self cleaning surface with high resistance to the effects of ultra violet and other modern atmospheric factors. The insulated concrete ground floor has a U-value of 0.12w/m^2K. The building has been carefully detailed and constructed to ensure that it is thermal bridge free.

Windows are often the weak point in any building. Nordan N Tech Passive windows with a triple glazed argon filled cavity system have been installed. The complete window has a combined U-value of 0.7w/m^2K with no trickle ventilation providing an installed u-value of 0.8w/m^2K. The high thermal performance ensures that draughts and cold spots often associated with conventional windows are eliminated.

Reducing Ventilation Heat Loss with an Airtight Fabric

The air permeability through the fabric of the building has been designed to below 0.6ach^{-1} @ 50Pa. This performance is 6-10 times better than standard UK Construction and is guaranteed by an air pressure test on completion of the construction. Without good air tightness the effectiveness of thermal insulation can be reduced by up to 70%.

kingdom housing association
A Scottish Charity

Quality Indoor Air

Continuous fresh air is provided by a Paul Novus 300 mechanical ventilation heat recovery unit. The unit conserves energy by recovering 90% of the heat from the extracted air and transferring it to the incoming fresh air without contaminating it. This works both ways so if the outside temperature is higher than inside the exchanger will cool the incoming air and help maintain a comfortable internal environment. The fresh supply air is distributed to the rooms by ductwork and similarly the stale, moist air is extracted by ducts from areas such as the bathrooms and kitchen. The carefully balanced system and positioning of grilles ensures that there is adequate cross ventilation throughout the house. This system still allows windows to be opened should the tenants wish to do so.

Greatly Reduced Heating Demand

The heating load required for this house has been reduced by c. 90% compared to a standard house of the same design. Combined with the elimination of draughts and cold spots next to windows this means the capital cost of the heating system can be significantly reduced. To cater for the vagarities of their tenants, Kingdom Housing Association opted for proprietary water borne low temperature under floor heating with insulated track system to both ground and first floor. This provides a constant heat source throughout the room and avoids cold and hot spots traditionally associated with radiators. Usable wall space is also maximised. To further enhance the efficiency and ensure a quicker response time to tenants demand the underfloor heating is set in a Fermacell dry flooring system as opposed to a conventional wet screed.

Renewable Energy

Due to the ultra low heating demand of the Passivhaus renewable energy technology is not strictly required though it can be used to compliment the thermally efficient design. Kingdom Housing Association have explored the further benefits that renewable technology provides and also the associated tariffs, newly introduced by the Scottish Government.

Photovoltaics

An estimated 2.16KW of electricity will be produced by 12 Yingli Solar semi-integrated Photovoltaics modules, which are less obtrusive than the more commonly used ‘above roof’ solutions . Any electricty generated will be used by the house with excess being sold back to the National Grid. In addition to this ‘export tariff’ the Scottish Government have introduced a ‘Feed in’ Tariff which came into effect April 2010. This creates an opportunity for the owner of the panels to generate an income.

In conjunction with the Energy Saving Trust, it has been estimated that a total saving of £839 per annum can be achieved from the Photovoltaics alone. This is broken down as follows:

Estimated Solar PV generation	**1800 kwh per year**
Estimated Income from generation FIT tariff	**£650 per year**
Estimated Income for export	**£ 14 per year**
Estimated Fuel Bill Savings	**£175 per year**
Total estimated saving	**£839 per year**

kingdom housing association
A Scottish Charity

Air Source Heat Pump

As the domestic space heating demand is lower the whole system can be heated by a Mitsibushi Ecodan W50 air source heat pump. With conventional boilers 1KW of input energy provides less than 1kw of output energy or heat. With Ecodan, every 1KW of input energy is converted into an average of 3.6kw making it over three times as efficient. The system is also supplemented by water heated by the solar thermal panels. This highly effective and efficient system means that the house does not require a conventional gas boiler. As a direct requirement of having no gas, an induction hob and an A rated electric oven have been provided.

Estimated savings calculated from the MCS Scheme formula/SAP 2005 Calculation would suggest the following:

Estimated Air Source Heat Pump generation	**3408 kwh per year**
Estimated Income from proposed RHI tariff	**£255 per year**

Solar Thermals

To further reduce the primary heating demand 4.6 sqm of Wagner Euro C20 'in roof' mounted solar thermal modules have been installed. These are connected directly to a twin core Geldhill 300 litre stratified solar cylinder and is used as the prime source for heating domestic and hot water. This is supplemented when required by the air source heat pump and as a last resort by a 3kW immersion. In April 2011 the Government will be introducing the 'Renewable Heat Incentive' which will pay a fixed amount to those who install renewable heat equipment such as solar thermal heating panels, heat pumps etc.

Estimated savings calculated from the MCS Scheme formula/SAP 2005 Solar Water Heating Calculation would suggest the following:

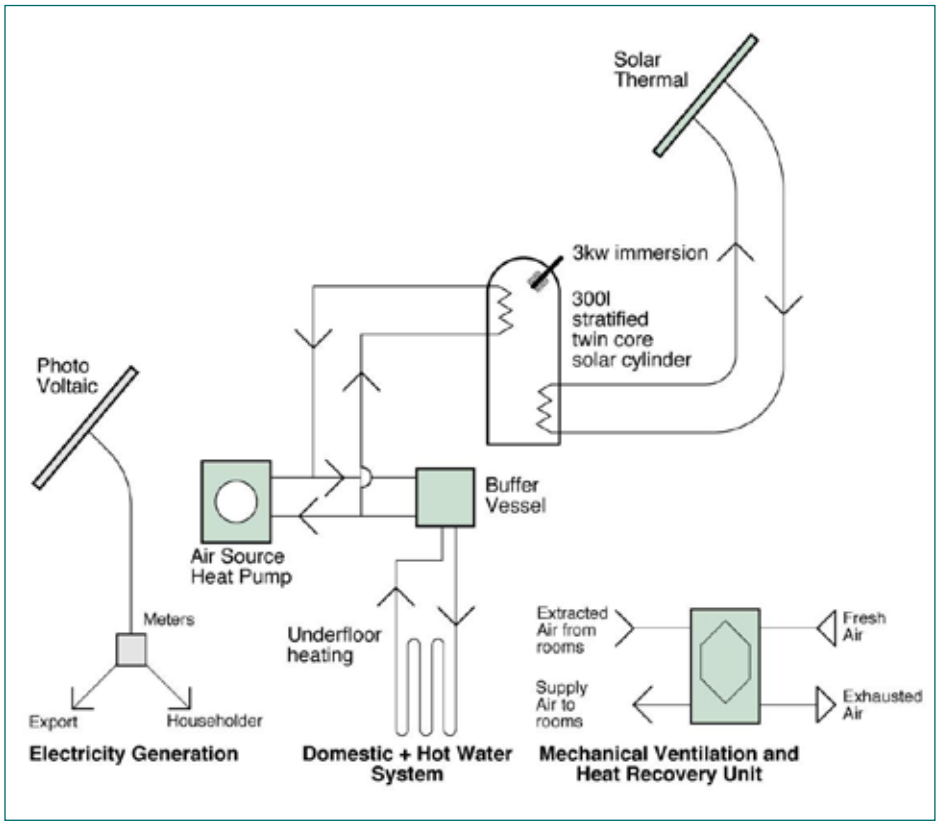
Estimated Solar Energy captured	**1137 kwh per year**
Estimated Income from proposed RHI tariff	**£205 per year**

Renewable Control Strategy

The Association has implemented a Control Strategy to make best use of the renewable energy sources and therefore minimise the use and cost of the non renewable carbon energy sources.

Governments Tariffs

To ensure eligibility for the FIT and RHI tariffs, the installers of the air source, photovoltaic and solar thermal systems are accredited with the Microgeneration Certification Scheme, the products themselves are also MCS / Solar Keymark certified.



Renewable Control Strategy Diagram

Tariff rates and lifetimes are as follows (note: the RHI tariff and lifetimes are subject to confirmation by the Government):

Solar Photovoltaic (<4kW new build)	36.1p per kwh	Tariff lifetime 25 years from 1 April 2010
Air Source Heat Pump (<45kW)	7.5p per kwh	Tariff lifetime 18 years from 1 April 2011
Solar Thermal (<20kW)	18p per kwh	Tariff lifetime 20 years from 1 April 2011

The Outcomes

A comparison study of the energy performance using SAP 2005 calculation has been made between the as built Kingdom House, the Kingdom House with no renewable and gas boiler as primary source and the standard specification used in Kingdom Housing Association's new build programme.

The outcomes are as follows:

	Standard	Passivhaus with gas only (no renewables)	Passivhaus with renewables
Energy Efficiency Rate	B(83)	B(87)	A(98)
Environmental Impact (CO2) Rating	B(82)	B(88)	A(101)
Energy Use	117kwh/m^2 per annum	81kwh/m^2 per annum	14 kwh/m^2 per annum
Estimated Fuel Costs	£451 per annum	£377 per annum	£91 per annum
Carbon Dioxide Emissions	2.2 tonnes per annum	1.4 tonnes per annum	-0.1 tonnes per annum

The estimated fuel costs for the Kingdom House of £91 per annum assumes a reduction of £175 from that determined as a fuel energy saving in the SAP 2005 calculation, and which is derived from the Energy Saving Trust calculation.

Therefore it is clearly demonstrated that the Kingdom House reduces energy consumption by over 88% and is carbon neutral. Fuel costs are predicted to be reduced by c. 41% but this will be dependent upon the tenant's life style. Further cost reductions are possible if the Government's 'Feed In' and 'Renewable Heat Incentive' tariffs are realised.

From the Passivhaus PHPP calculation it has been verified that the design achieves the Passivhaus Standard.

Ecohomes / Code for Sustainable Homes

The house is more than an exercise in thermal envelope and renewable energy, Kingdom Housing Association have taken on board both the BRE's Ecohomes and Code for Sustainable Homes environmental impact rating systems. From an initial assessment of the Eco Homes submission a *Very Good* rating has been achieved, this has to be confirmed by the BRE. The Code for Sustainable Homes rating has yet to be verified.

Over and above the excellent thermal performance of the building and the adoption of renewable technologies the *Kingdom House* also includes the following features:

- Internal and external recycling provision.
- External water storage in the form of a water butt connected to the rainwater system.
- Provision of covered and secured cycle storage for two bicycles.
- Dedicated low energy light fittings internally and externally. The former will only take a 4 pin PL low energy lamp which in this case 18w fluorescent bulbs are used which is equivalent to a 100w traditional bulb.

Due to the construction method higher ceilings are achievable creating light, airy spaces. This in itself has allowed fanlights to be introduced above doors allowing borrowed light to be brought into the hallway, reducing the need for artificial light to these areas.

kingdom housing association
A Scottish Charity

Typical Section

Summary of U-values

Roof (pitched)	0.13 w/m²K
Roof (flat)	0.07 w/m²K
Wall	0.09 w/m²K
Ground Floor	0.12 w/m²K
Windows	0.7 w/m²K
Windows (installed)	0.8 w/m²K
Door	1.0 w/m²K

Monitoring Strategy

The two main objectives that require to be accurately monitored are:

a) Space heating demand of less than 15 kwh / m² / year

b) Primary energy use of less than 120 kwh / m² / year

In order to ensure that the Trial House concept is fundamentally successful, both the space heating energy requirements, and the overall energy use require to be accurately monitored over a minimum two year period. This will be achieved by the use of individual energy monitors for each of the following systems.

- Incoming Electricity Meter
- Solar PV System
- Solar Thermal System
- Electric Immersion Heater
- Air Source Heat Pump System

The Association has arranged for all the monitoring to be done remotely. The data will be sent via modem to the Meter Manager Internet site where the data will be collected for analysis.

Conclusion

The ultimate test will be how the building performs when it is occupied by the tenant and how that tenant manages the renewable energy sources within. The Project Team will also have to review the design and construction phases of the project and, through Kingdom Housing Association, monitor the performance of the building in relation to the materials selected, energy consumed and any ongoing cost items such as maintenance. Once this exercise has been completed Kingdom Housing Association will have a sound basis on which to take forward selected technologies to their mainstream developments.

Kingdom Housing Association Limited

Saltire Centre, Pentland Court
Glenrothes, Fife, KY6 2DA

Phone: 01592 631661
Fax: 01592 631991
Email: kingdom@kingdomhousing.org.uk
Web: www.kingdomhousing.org.uk

Registered Scottish Charity Reg. No. SCO00874

kingdom housing association
A Scottish Charity

The Kingdom House – A House for the Future

Partnering Team

CAMPION HOMES

Hardies PROPERTY & CONSTRUCTION CONSULTANTS

ora
Oliver + Robb Architects

Scott Bennett Associates Ltd
consulting civil and structural engineers

LANGMUIR & HAY CONSTRUCTION CONSULTANTS

Funded by

Housing Association Grant
Renewable Construction Programme
CARES Funding

Community Energy Scotland
Cumhachd Coimhearsnachd na h-Alba

The Scottish Government

Main Suppliers / Products

- **Scotframe** MMC Closed Panel System
- **Nordan** Windows and Doors
- **JUB** External Insulation and Render System
- **ROK** Yingli Solar Photovoltaic System
  Wagner Euro C20 Solar Thermal System
  Mitsibushi Ecodan W50 Air Source Heat Pump
  PAUL Novus 300 Mechanical Ventilation Heat Recovery
  Myson Underfloor Heating