# Earthship Communities Research Project
# October 2004

## Is the Earthship model viable as affordable eco housing in Scotland?

## A collaborative project between

sustainable communities initiatives

earthships moray
HOUSING and ENERGY
in the hands of the community

south AYRSHIRE COUNCIL

**Funded by The Innovation Programme, Energy Saving Trust**

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## 1.0 Executive Summary

The Earthship Communities Research Project is a collaborative project between Sustainable Communities Initiatives (SCI), Earthships Moray (ESM) and South Ayrshire Council (SAC) and investigates whether the Earthship model is viable as affordable eco housing in Scotland. The study also set out to ascertain whether there is a demand for the Earthship concept, what barriers are perceived in preventing any demand be converted to actual buildings, what support would be required to remove those barriers, and what number of Earthships could be realistically built in the next 2 to 3 years.

With their experience of building Earthship[1] Fife, SCI presents their findings as a case study, which comprises building design, materials, labour, cost, and planning and building control issues – all of which were addressed in building Earthship Fife, the first Earthship in the UK. ESM provides results from a market research survey, which explored the market demand for Earthships and any perceived barriers people may have in building them. Both SCI and ESM also share their understanding of the partnership potential of Earthship developments following their research into Housing Associations and Local Authorities. ESM also present background for the need for eco housing in the context of polices, which can be found in Appendix 2.

The lead partner in the study is South Ayrshire Council, who managed the project throughout.

The case study results for Earthship Fife has shown that the Earthship is viable in terms of cost, design, building methods, labour requirements, and building control and planning requirements as an affordable housing option in Scotland.

Earthship Fife cost £26,034 in materials to build the 31.5m$^2$ building. Scaled up to an average house size this relates to a projection of £43,000 for a highly energy-efficient house that will provide a family of four with autonomous systems of power, water and sewage treatment, and therefore be extremely inexpensive to run.

Labour costs are not reflected in the above figures as Earthship Fife was built by volunteers. The building methods employed in building Earthships in Scotland are clearly easily transferable to an unskilled labour force and will contribute positively to training and employment potential for people interested in building their own eco-home.

The case study also demonstrated that after 2 winters in the Scottish climate the building is functioning well in terms of being energy efficient and waterproof with no mains services and no significant back up heat source. A monitoring programme over the next 3 years will enhance observations made on, for example, temperature, humidity and renewable energy generation and provide real data on the buildings performance. Although currently the concept is not perceived by building control and planning as non-viable such data will assist in generic acceptance of the concept across all Scottish Local Authorities.

The market research survey element of the research project illustrates a demand for the concept as a self-build method of providing people with homes does currently exist, and a high level of interest was expressed. The survey also clarified the need for more information on the concept, which is currently either not known about, or not easily accessible to people due to the limitations of the two organisations working in Earthship development. Such expertise in Scotland is limited to SCI and ESM, both of whom are under-resourced to adequately provide the levels of support needed for self build projects.

As well demonstrating its viability as an affordable house that people can build themselves, the Earthship as an innovative concept in early stages of development in Scotland, provides communities with economic benefits by way of tourist revenue. Developments incorporating rental buildings with overnight accommodation and/or public buildings, such as a visitor centre could

[1] Appendix 1 provides comprehensive background information on the Earthship concept.

receive significant income streams from these enterprises. The Earthship Visitors Resource Centre in Fife is currently catering for a projection of 6 – 10,000 visitors per year (the centre has only been open 2 months at the time of writing).

The study concluded that in order to research further the costs for larger residential Earthships, and finalise planning and building control issues, more Earthships need to be built. Furthermore it is clear from the market research analysis that in order to realise the anticipated potential for Earthship developments a system needs to be implemented whereby people receive support through all stages of their building project from the provision of initial information to practical training in building methods. It is thus recommended that the implementation phase, as Phase 2 of the study, would be two-fold and incorporate:

1. A self-build housing project of 12 houses based on Zero Waste Zero Energy principles demonstrating Earthships as low cost social housing
2. And a Scottish-wide Earthship national development and support network to, amongst other aims: support new and existing Earthship initiatives; disseminate accurate and accessible information about the concept; and to ensure the cohesive development of the Earthship concept in Scotland.

## 2.0 Background on the Study Partners

South Ayrshire Council led the partners and provided in-kind support in the form of Officer time to manage the project and monitor its progress in line with the action plan. SCI headed the delivery partners based on their 4 years experience of developing the Earthship concept in the UK. ESM was employed as sub contractors to SCI to help deliver the project.

SCI is a registered charity (SC 034819) that works to demonstrate and encourage zero waste zero energy communities. SCI works with waste as a resource to be valued and utilised, whilst enhancing peoples' lives by providing creative solutions to global problems. The organisation has two main projects through which it makes zero waste zero energy lifestyles real and tangible; Creative Waste Workshops and Earthship Fife. Creative Waste Workshops provide fun and creativity with waste, where community members transform plastic drinks bottles, for example, into greenhouses and sky rockets, thus practicing waste reuse and experiencing positively what it means to have a different attitude to waste. Earthship Fife is the first completed Earthship in the UK and demonstrates a holistic approach to living a zero-waste, zero energy, low impact lifestyle by using waste as its main building materials and operating without the use of fossil fuel.

Earthships Moray (ESM), which works closely in association with SCI, is a voluntary organisation, that was set up in the summer of 2002 to actively support and encourage the building, as well as to raise the profile of, Earthships in Moray and to find innovative, practical ways to bring these energy-efficient, self-sufficient homes within the financial reach of all sectors of the community with a view to making sustainable and ecological lifestyles accessible to everyone.

ESM have run several Earthship-promoting and educational events for their members and their work to promote Earthships as affordable housing has led to an ongoing dialogue with Moray Council and approaches to Housing Associations and organisations such as Community Self-Build Scotland.

## 3.0 Rationale/Methodology

As explained in Section 1 above the purpose of this study was to determine whether the Earthship model is viable as affordable eco housing in Scotland, whether there is a demand for it, what barriers are perceived in preventing any demand be converted to actual buildings, what support would be required to remove those barriers, and what number of Earthships could be realistically built in the next 2 to 3 years.

Earthship Fife was built by SCI and serves as the first fully functioning UK Earthship, complete with autonomous power, water and sewage systems. Earthship Fife was used as the case study for the feasibility study and assessed on practical issues to conclude whether or not the Earthship model is viable.

The potential for Earthship developments was determined through both SCI and Earthships Moray approaching certain Local Authorities and Housing Associations.

Market demand, perceived barriers and level of support required were determined by undertaking a Research Survey and reviewing and analysing a 25% selection of enquiries, feedback and requests for support received from members of the public, groups, organisations and individuals and families on both SCI's and Earthships Moray's databases.

### 3.1 Earthship Fife

Earthship Fife provided the opportunity to assess practical areas of the viability of the new concept to the Scottish climate by examining:

- Earthship design and adaptations for Scotland;
- Building methods, such as earth-rammed tyre building and can wall masonry;
- Building materials using reclaimed and recycled sources such as car tyres;
- Material costs and labour;
- Planning and building control issues particular to Scottish Regulations;
- The associated autonomous systems; rainwater catchment, greywater recycling; blackwater botanical cells, and renewable energy production;

### 3.2 Earthships as Affordable Eco Homes

In the course of a carrying out the aims of their respective groups, as well as specifically for this research project, both SCI and Earthships Moray have approached certain Local Authorities and Housing Associations with a view to:

- Introducing the Earthship and, in the case of SCI, the Zero Waste Zero Energy community concept;
- Exploring the potential for Earthship communities with development partners;
- Finding a possible site for an Earthship housing development/community;
- Discovering what level of support and/or funding for an Earthship housing; development/ZWAZE community might be available;
- Illustrating the problems, advantages and opportunities in implementing a project of this nature;

### 3.3 Market Demand for Earthships & Perceived Barriers

Both primary and secondary data were used to ascertain the market demand for Earthships in Scotland and the perceived barriers to the actual building of Earthships.

A questionnaire was distributed both in hard copy and over the Internet and placed on a number of different websites with an option to print off and send in, or to submit electronically.

The questionnaire contained 17 questions and a section for adding comments, which were designed to assess the market demand for Earthships and any barriers to the future development of Earthships in general.

#### 3.3.1. Primary data – Questionnaire Survey

The market research approach in the form of the questionnaire survey was used to assess:

- The market demand

- Any barriers that are currently perceived as prohibiting future developments
- The level of support and information required by individuals and groups to implement their plans to build Earthships

The Questionnaire was sent out to:

- 10% (300 of 3000) of the addresses on the South Ayrshire Council Housing waiting and transfer lists
- Members of the public who responded to newspaper adverts in the Ayrshire Post, Leader and Ayr Advertiser
- 47 individuals ands families on the Earthships Moray database
- 300 individuals ands families on the SCI mailing list

In addition, the Questionnaire was posted onto the following websites:

- South Ayrshire Council
- SCI
- Earthships Moray
- Community Self-Build Scotland

### 3.3.2 Secondary data – Review and Analysis of enquiries and requests for support for implementing Earthship projects received by SCI

A selection of enquiries, feedback and requests for support received from members of the public, groups, organisations and individuals and families on SCI's database were reviewed and analysed.

All of the above areas were researched, analysed and documented to provide the results presented in Section 5.3.

## 4.0 Results of Feasibility Study

The assessment methods described in Section 3.0 above were used to generate the results presented in this section.

### 4.1 Earthship Design, Adaptations for Scotland & Material Costs

The Earthship concept is demonstrated in many different designs all around the world, determined by people's tastes, budgets, the climate and planning criteria. Regardless of the design the fundamental principles remain the same:

- Thermal mass;
- Passive solar gain;
- The utilisation of locally available and waste materials wherever possible;
- And autonomous water, sewage and power systems;

After considering designs across the globe research was carried out into what would work best in the Scottish climate. Climatic adaptations were incorporated into the proposed design and then implemented during construction of Earthship Fife. (Please see Appendix 3 for more details). A short discussion and breakdown of the costs are presented below.

The material costs involved in building Earthship Fife are presented below in Table 1.The costings are broadly broken down into building elements categories, which are based on, but don't follow entirely, those used in standard quantity surveying. Categories such as roof construction, wall construction, and floor construction are used.

Earthship Fife is 31.5 $m^2$ /315$ft^2$ in size. Given that the building was built almost entirely by volunteers, most of them unskilled, the costs do not include labour costs. Please see Appendix 4

for more details, which explores some of the issues around the labour required to build Earthship Fife.

The overall cost of materials to SCI for the Earthship was £26,034. The thermally dynamic "U" cost £8,770, the autonomous water system cost £3,678, the autonomous sewage system cost £926 and the renewable energy/power system cost £12,660. These figures are broken down further in the table below.

**Table 1 Material Costs**

| **Thermal dynamic "U"** | | **Water system** | | **Sewage system** | | **Renewable energy/power system** | |
|---|---|---|---|---|---|---|---|
| **£8,770** | | **£3,678** | | **£926** | | **£12,660** | |
| | | | | | | | |
| Excavation & Earthworks | £991 | Water Organising Module | £1920 | Botanical cells/ blackwater beds | £386 | Wind turbine & equip. | £4,265 |
| Wall Construction & Finishes | £480 | Filters | £311 | Greenhouse structure | £540 | Solar panels & equip. | £1,300 |
| Roof Construction & Finishes | £3,349 | Tanks & plumbing materials | £1447 | | | Hydro turbine & equip. | £2,500 |
| Floor Construction & Finishes | £337 | | | | | Control equip. | £3,344 |
| Windows & Doors | £1,440 | | | | | Battery bank | £1,250 |
| External Works | £428 | | | | | | |
| Internal Works | £100 | | | | | | |
| Miscellaneous/ Hardware | £1066 | | | | | | |
| Haulage of materials | £578 | | | | | | |

The above costs are the actual costs to SCI with charity discounts and sponsorships already deducted. It is estimated that the discounts and sponsorships are worth a total of £5,000. It is important to note that this figure includes the more expensive ecological materials such as *Voltex,* which our budget would have prohibited had it not been a sponsored material.

The sewage and power systems of Earthship Fife are adequate in scale to provide a family of four with their needs and the costs would not increase if the building was scaled up.

Appendix 5 provides more information on the autonomous systems.

### 4.2 Planning & Building Control Issues

Planning permission was required to build Earthship Fife and erect the 5.5 metre high wind turbine that is part of the buildings autonomous power system. The permission took no longer than the maximum statutory 2 months.

The permit granted was for a research/education building as the site the Earthship was built on is classified as agricultural as strictly non-residential.

Building Control (BC) have to take their lead from the Planning Department in classifying buildings, so because the Earthship was defined as non-residential by the Planning Department a residential building warrant could not be requested. The Building Control Department did however agree to take housing standards into consideration during the application process, with a view to testing the

concept for residential dwelling use in the future. The actual evaluation, however, was made on the proposed use of the building as an experimental limited life office building.

The outcome of the evaluation was thus a temporary building warrant of 5 years. BC also provided feedback on the issues that they consider need to be addressed before permanent residential status for Earthships may be granted. This decision was reached in consultation with the Building Standards Division of the Scottish Executive.

The issues raised by BC from the perspective of meeting the housing standards were as follows:

- Fitness of materials – tyres;
- Daylight;
- Flat Roof construction & Interstitial Condensation;
- Ventilation;
- Heating;

Fitness of materials - tyres refers specifically to the durability of tyres in a buried situation as in the Earthship walls. The lack of proof of longevity of tyres is used as justification for the limited life status granted to the first Earthship, Earthship Fife. This is therefore an important issue for us to resolve for the future of Earthships in Scotland.

Daylight refers to the interior glass wall that is integral to the design of a Scottish Earthship. Because this wall is not on an external wall it is considered a screen (on which curtains or shades could be fitted for example, and closed by the occupants and therefore obstruct the light), and therefore renders the external glass covering the entire south face of the building as invalid in meeting the required fifteenth of the floor area of each apartment[2] as windows to permit daylight. In actual fact the south facing glass permits more than 6 times the daylight requirements.

BC therefore could only consider the roof light in the main room as a means of providing sufficient day-lighting requirements. Measuring 0.16m2 this proved to be inadequate. Installing larger roof lights would have resulted in more heat loss.

The issue with the flat roof construction is interstitial condensation due to the combined warm and cold roof design. Commonly all insulation would be above the roof on a flat roof construction to avoid condensation within the roof structure (i.e. the warm roof method). BC suggested this combined design is avoided in future and requested that moisture levels are included in SCI's proposed monitoring programme.

Ventilation concerns over whether or not the building has enough ventilation refer to the current technical standards which require that a thirtieth of the floor area of each apartment[3] should be converted into operable ventilation mechanisms to permit fresh air. Earthship Fife is 31.5 m2 /315ft2 and should therefore have 1.05m2 of operable ventilation. The roof lights fitted in the roof are 0.16m2 each providing a total of 0.32m2, or approximately a third of the required operable ventilation. The mechanical fan fitted in the kitchen area is considered adequate to provide the additional amount of ventilation required. An operable vent has also been fitted above floor level, approximately half a metre square.

Over and above operable ventilation the technical standards state that 4000mm2 of trickle ventilation is required per apartment in a house. This is provided in the Earthship by vents fitted on the sides of the roof lights. BC stated that if the Earthship was a dwelling it should have trickle vents added to the windows.

Heating. The current technical standards state that one living space per building should have a heat source. In the case of the energy efficient design of the Earthship this may not be necessary.

[2]Apartments are rooms that are lived in or slept in.
[3]Apartments are rooms that are lived in or slept in.

Following the response of BC to Earthship Fife Gaia Research of Edinburgh were commissioned to make an assessment of the Building Control issues, and any need for monitoring, as well as investigating the Type Approval system as a way forward.

SCI's interpretation[4] of Gaia's Research's finding can be seen below. For the original work please see www.gaiagroup.org

### 4.2.1 Planning & Building Control Assessment

On the subject of durability of tyres Gaia Research reiterates the point that tyres are banned from landfill sites because they represent a long-term waste problem in the ground. This in itself suggests they are a durable waste material. Following approximately 20 conversations with tyre experts Gaia Research are convinced that tyres are durable in the ground and pose no risk of degradation. They support their assertion by discussing various projects that have used tyres in the ground or in water, for example the artificial tyre reef structure in Poole Bay, and the tyre bales manufactured and used by Northern Tyre Recycling Ltd.

Furthermore Gaia Research's research concluded that tyres are not combustible when buried in the ground, nor when rendered with thick layers of non-combustible earth plaster, as in the case of the Earthship.

After reporting back to the local BC officer on Gaia Research's conclusions on the suitability of tyres as a building material the response was an, in principle, agreement to the majority of their findings. The only specific response made was to the issue of fire resistance and the need for recognised methods of testing fire resistance for Earthships of more than one storey was emphasised.

Gaia Research concluded that with a little more time spent on research the necessary information could be elucidated and would prove conclusively that tyres are durable in their role as a main building material in Earthships.

Gaia Research considered the issue about daylight as an anomaly and a limitation of definition on the part of Building Control. They feel the internal glass screen should be recognized as allowing the necessary amount of light into the living space. BC's response to this was to reaffirm that the technical standards are prescriptive and as such the choices available to deal with this anomaly are to apply the standard, apply for a relaxation[5], or ignore the standard.

Gaia Research agrees that the combination warm-cold roof deck is unusual and a design that could have been improved upon. However, given that a vapour barrier was used they are unclear why BC is concerned about interstitial condensation. BC's response to Gaia Research's comments on the roof structure was that more evidence in support of the construction, which is avoided in Scotland, would help. Furthermore, a dew point calculation would help and they were unsure whether the vapour barrier was suitable.

Gaia Research did not consider trickle vents on the windows to be an ideal solution as they are so uncontrollable and potentially a large loss of energy. BC's response to this was to state that how the ventilation methods are used is down to the occupants of the dwelling.

On the issue of heating it was felt that a controllable heat source, such as a wood stove, would provide Earthship occupants with an attractive feature whilst removing an obstacle to acceptance in the current technical standards. Another option is to prove the case for passive solar heating through monitoring internal and external temperatures. This may demonstrate that the sun could

[4] Gaia Research is supportive of the work in developing the Earthship. However, they cannot confirm that SCI's interpretation of their findings is accurate in all details. They refer readers to the original report at www.gaiagroup.org

[5] The number of relaxations that can be granted are at the discretion of the BC Department

be considered a heat source in the terms of the technical standards, and is adequate to maintain a dwelling at a comfortable temperature throughout the year. The zero energy house in Aberdeenshire was not investigated as part of Gaia Research's research but does provide a potential useful source of information on this matter.

BC's response to the heating assessment was to reaffirm that the standards are prescriptive and as such the choices available to deal with this anomaly are to apply the standard, apply for a relaxation, or ignore the standard.

### 4.2.2 Type Approval

It is recognised that the achievements of Earthship Fife in testing Scottish Planning and Building Control systems have gone a long way towards preparing for their generic acceptance. However, residential Earthship dwellings need permanent building warrants if they are to become more mainstream and widely used as an affordable low impact housing model.

Type Approval[6] is one way towards achieving generic acceptance of the Earthship concept in Scotland. Type Approval is a generic approval for a given construction type that renders all subsequent applications simpler and quicker to put through the planning/building control system.

The Scottish Type Approval Scheme procedure requires that design specifications, drawings and supporting information are submitted with an application form to 3 Building Control Divisions in 3 different Scottish Local Authority areas. The respective Divisions assess the application and report on any pertaining issues.

If Type Approval is gained any subsequent submissions for building warrant approval should be simpler as the majority of the technical issues have been agreed. Each Local Authority will still charge for an application and consider any site-specific issues.

In Scotland the Type Approval System has only been used by relatively few designs so it difficult to judge the likely outcome of this approach as applied to the Earthship. However, the initial response from the Secretary of the Type Approval Scheme was that there would be a number of site-specific issues in the case of the Earthship.

Gaia Research was, however, of the impression that, given the modular fashion of the Earthship, any type approval gained for one module, or "U" as they are called, would easily be applicable to other "U's".

### 4.2.3 Other Regulatory Issues to Consider

Tyres are considered a priority waste by the government and pose a huge environmental problem. Fifty million tyres are discarded in Britain every year, which amounts to 134,000 per day. The EU Landfill Directive banned the disposal of whole tyres from landfill sites in 2003 and as of 2006 shredded tyres will also be banned. Illegal tyre disposal is of growing concern and tyre mountains do expose the public to risk from fire and pollution.

All tyres have to be disposed of legally and the cost of this to the public is an estimate £3-5 per tyre at your local tyre fitting company. Many of those tyres are transported long distances to be added to the ever-increasing tyre mountains. For the most up-to-date UK statistics on tyre disposal please see those of the Used Tyre Working Group: http://www.tyredisposal.co.uk The breakdown of tyre disposal methods for Scotland in 1999 was 32,000 tonnes (approx 3.3 million) of which 45% were landfilled and the rest were reused or recovered in some way. The estimated annual figures for 2005 are expected to reach almost 4 million used tyres for Scotland alone.

[6] For further information on the Scottish Type Approval Scheme The Secretary of ***STAS*** can be contacted through PO Box 13617 Newtown St Boswells

In order for SCI to reuse tyres in Earthship Fife the Scottish Environment Protection Agency (SEPA) were formally notify in May 2002 of a recovery activity using waste tyres. This was then registered as an exempt activity under Schedule 3, Paragraph 15 of the Waste Management Licensing Regulations 1994 (As Amended).

Anyone handling waste tyres has a legal responsibility over their disposal. There is a legal requirement known as “a duty of care” for businesses to follow under the Environmental Protection Act 1990.It applies if you produce, import, carry, keep, treat, or dispose of waste tyres. It requires that companies take responsibility to ensure that waste tyres are not handled illegally and that they are only transferred to an authorised person together with a waste transfer note (in SCI’s case this was the exemption certificate authorised by SEPA).

The exemption certificate is exempting you from having to have a waste management license to handle waste. It follows the Environmental Protection Act 1990, Waste Management Licensing Regulations 1994 and comes under Schedule 3 Paragraph 15 of the Regulations which permits the exemption for the beneficial use of waste if it is put to that use without further treatment and that the waste is not disposed of. You are required to protect and store your waste tyres safely, preventing any escape. The maximum storage limit, under an exemption from waste management licensing, is 1000 tyres.

The Environment Agency (EA) in England are taking a different view of the use of tyres in building projects and are currently not in agreement with this exemption clause. The current situation in England means that any use of tyres should have a waste management license. Obtaining a waste management license is an expensive and onerous business. SEPA have stated that in the future they will examine future similar notifications on a case by case basis as they do with all notifications of exempt recovery activities.

## 5.0 Findings

The results generated in Section 4.0 above are discussed in this section with the conclusions and suggestions for Next Steps presented for consideration in Sections 6 and 7 respectively.

### 5.1 Earthship Fife – the Case Study

Earthship Fife was used as a case study and assessed on practical issues to conclude whether or not the Earthship model is viable as affordable eco housing in Scotland.

The design aspects used to build Earthship Fife provide a clear and replicable model to implement in future Earthship building projects. The design has been approved by a structural engineer and scrutinised by both the Planning and Building Control Departments of Fife Local Authority. Aspects of the design were also discussed in consultation with the Scottish Executive Building Standards Division, which means the concept has been introduced at a higher level within the Building Control system.

In the main, the concept has been accepted as viable by these authority bodies, although there are still some technical details to resolve, e.g. the durability of tyres and hence their suitability as a building material. In consultation with Gaia Research of Edinburgh, a reputable architectural firm in the field of eco housing and design, the technical details to be resolved with Building Control are all surmountable.

The experience gained by those involved in building Earthship Fife has resulted in the ability for Scottish self-builders to amend some designs aspects, i.e. the roof, with confidence.

The design of the building is now proven as far as the viability of it in the Scottish climate is concerned. A formal monitoring programme will start in September 2004 to ascertain finer details of temperature, air quality and condensation and will enable accurate predictions into future design considerations, e.g. how much back-up heat, if any, is required in Earthship houses.

The building methods used to construct Earthship Fife are all considered low-tech and easily taught to unskilled people. The methods proved to be relatively labour intensive, compared to e.g., a timber frame house, but the evident advantages were seen to compensate that fact. As low-tech building methods they are easily learnt by people from all backgrounds and offer individuals an empowering route in building, or contributing to building, their own homes.

The basic building materials used to build the walls of an Earthship are readily available almost anywhere in Scotland, and are contributing to the reduction of tyre mountains – a priority waste stream across the UK. Following responsible and legal routes to acquire the tyres people building Earthships will furthermore gain financially and help pay for some of the building costs of their project. This is due to the disposal costs normally borne by the tyre fitting company, which the builder is alleviating by taking responsibility for "disposal".

Earth from the site excavation is also freely available for plastering and burying the walls of an Earthship. All the skills required for this process are again, low-tech and easily learnt by unskilled people.

Other reclaimed materials can be used in many other areas of building an Earthship, many of which can be used in any house design. Timber for the roof and internal walls and fittings, cans and bottles for non-load bearing walls and aesthetic finishes are some of the examples.

Using reclaimed materials reduces building costs but can increase labour time, a scenario that is commonly seen in self-build projects. Labour intensive building methods generally make less of an impact on the environment, which fits well with the ethos of eco-housing at the construction phase.

The material costs accrued in building Earthship Fife have not yet, in practise, been scaled up to present costs for an average house size. If Earthship Fife was scaled up for a family of four and was 950 ft2/88$m^2$, 150 $ft^2$/0.93$m^2$ larger than the average size of a 3 bedroomed modern 20$^{th}$ Century villa, (Earthship Fife is 315 $ft^2$/31.5$m^2$) the costs could be trebled. This would result in a thermally dynamic building with very minimal heating and running bills costing £26,310. On top of that approximately £17,000 could be added to the build cost to provide the family of autonomous water, sewage treatment and power systems – again creating systems with very minimal running costs. The total material costs to build, and the majority of the running costs for the lifetime of the building, is then approximately £43,000 for a three-bedroom house for a family of four. This is not taking into consideration fittings such as kitchen units but neither would any other self-build project. Earthship Fife used reclaimed kitchen units and self-builders could do the same at very little cost.

The cost per square metre for the Earthship is £488/$m^2$ in the above scenario. A recent example of a self-build eco house in Wales was costed at £683/$m^2$ but did not provide all of the renewable energy required. A straw bale office built in Perthshire a few years ago is estimated to have cost £888/$m^2$, built by contractors and connected to mains services.

The above costs are presented with some caution as it is not clear at this stage whether trebling the size of Earthship Fife would necessarily treble the material costs. The existing power and sewage systems are already set up to cater for a family of four. More Earthships need to be built and further research carried out into the cost aspects of building them before this information can be considered accurate.

In postgraduate research carried out in 2000 at Stirling University the running costs of an American Earthship in a similar climate to Scotland was compared to 3 conventional Scottish houses. The research showed that an annual saving of between £900 and £1500 could be made in the Earthship through not requiring conventional services, i.e. water, sewage, mains electricity and gas.

The response to Earthship Fife from the Planning Department strongly suggests that the visually low impact nature of the building type would be welcomed in rural Scotland. As for planning permission for all building types, it seems crucial that provision for low impact dwellings/eco buildings be made in Local Authority Local and Structure Plans to enable Earthship developments.

Affordable housing is, however, another category that Earthships can conceivably fit into and is a high priority for the Scottish Executive and Local Authorities across Scotland.

Building warrant status is currently temporary for Earthship Fife and it is clear that permanent status for that particular building will move generic acceptance for Earthships in Scotland forward. Earthship Fife is however not classified as a residential building and the option of attempting to achieve Type Approval for the Earthship concept to gain residential status and generic approval is worth considering as a way forward and should be explored further in the light of the completion of Earthship Fife.

The report presented by Gaia Research, which investigated Building Control's concerns regarding the technical aspects of the concept is encouraging and suggests all concerns can be ameliorated. It is the view of SCI in their experience of testing this concept against the Technical Standards that residential building warrants will be achievable in the next project/developments.

With regard to the Earthship Fife's concept's autonomous systems the only development work that needs to be carried out by SCI is that of the water system. Earthship Fife has not yet achieved approval from Environmental Services simply because free-ranging peacocks roosted on the roof for a long time and caused faecal contamination. It is not foreseen that achieving drinking quality water with a filtering system similar to that of Earthship Fife will be a problem for other Earthship builders. It is the view of SCI that this achievable with no major cost or inconvenience. Filters are readily available in this country at no major cost to deal with such bacterial problems and shouldn't be difficult to find for self-builders.

### 5.2 Earthships as Affordable Eco Housing

The meetings with The Moray Council, Fife Council and Perth and Kinross Council, as well as the meetings with Albyn Housing Society and Kingdom Housing Association, showed that although not all factors have been resolved, that an affordable Earthship Zero Waste Zero Energy (ZWAZE) housing development could go ahead in the next 2 years. The meeting notes for these meetings can be seen in Appendix 6.

One common factor remaining unresolved, however, is the official opinion or stance of Communities Scotland on a project such as this and if they would allocate funds towards it. This is felt to be important so that the pilot project may be replicable in the future for other groups, Housing Associations or individuals who wish to build Earthships as affordable housing.

In addition, Communities Scotland support would help to gain political backing within Local Authorities for the Earthship concept, which would help to speed up the building of actual Earthships.

The contact with the various Local Authorities also showed that the Earthship concept was more acceptable to those LA's that had sustainable housing policies as they could justify a development of this sort more easily. The more developed those policies, the more attractive the Earthship and ZWAZE community ideas as they fit so many criteria of government policy which has eventually filtered down to LA level.

One of the biggest barriers is to find a site for an Earthship/ZWAZE development. This would be much ameliorated if LA's had clear policies that supported sustainable communities and had clear guidelines for these communities or developments to adhere to. This is backed up by SCI's experience with Perth and Kinross Council who were keen to have demonstration sites for sustainable communities because they were developing a sustainable construction policy. This shows that LA's and sustainable Earthship housing developments can be mutually beneficial as well as achieving environmental and social benefits.

All of the LA's mentioned in section 4 put the onus on the Earthship-promoting group to draw up a proposal of partnership working with the Council. However, both Fife and Perth and Kinross Councils responded well and very specifically to proposals put forward by SCI. Similarly, The

Moray Council responded much better to a specific proposal that involved an already reputable organisation, in this case, Albyn Housing Society.

It is therefore recommended that any future Earthship initiatives draw up clear proposals for their projects before approaching the Local Authority, as this would speed up the process enormously. The LA's then have something specific to respond to and can help the groups to see how their projects fit the LA's criteria.

The existence of Earthship Fife and the meticulous care taken in conforming to planning building control regulations made an enormous difference to the way The Moray Council viewed ESM's proposals. ESM made even more progress with gaining credibility for their projects and ideas when ESM had access to information from SCI concerning the questions being asked by TMC. This suggests that any future initiatives should have access to an updateable bank of information concerning other Earthship developments in Scotland as well as support staff, who have the bigger picture of national Earthship development. It is suggested in Section 7 that this support and information take the form a Scottish-wide national development and support network.

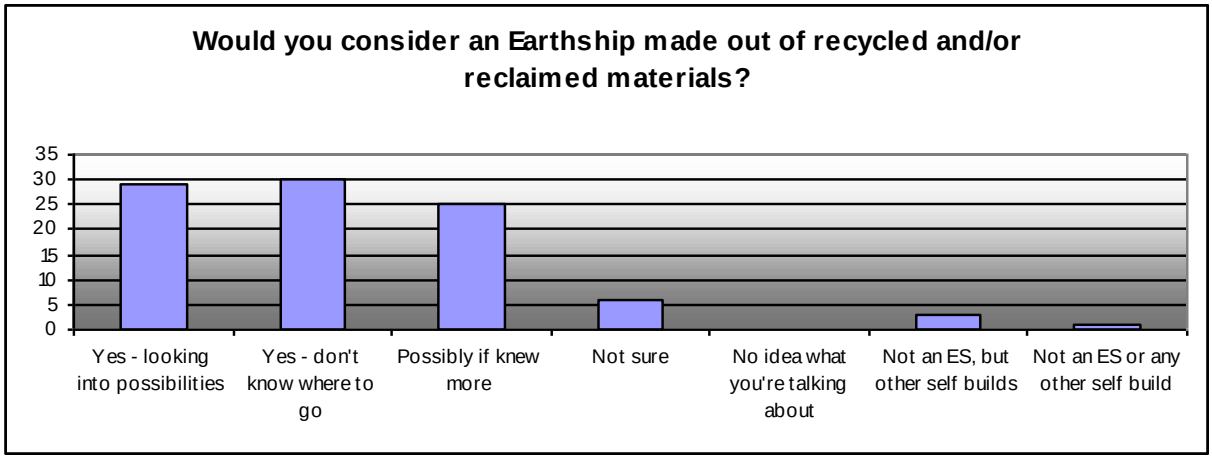
### 5.3 Results *and* Findings - Market Demand for Earthships & Perceived Barriers

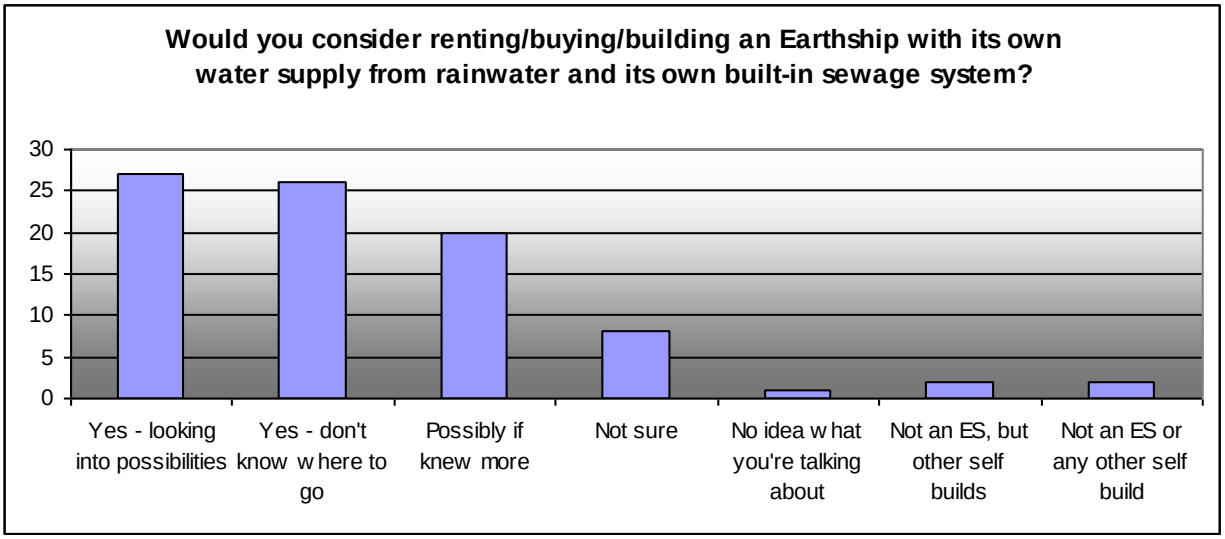
This section discusses the results of the questionnaire, copy of which can be seen in Appendix 7. Appendices 8 and 9 also show a copy of the covering letter sent with the questionnaire and accompanying background information. This section also highlights the high number of respondents interested in living in an Earthship, and the concept in general. It is worth noting that the 15% response rate from people on the South Ayrshire Housing waiting list was above average, reinforcing the high interest level in the concept. This section also shows the lack of information available to the respondents. Appendix 10 contains details of the results of the survey, while the conclusions of the survey are presented in Section 6 below.

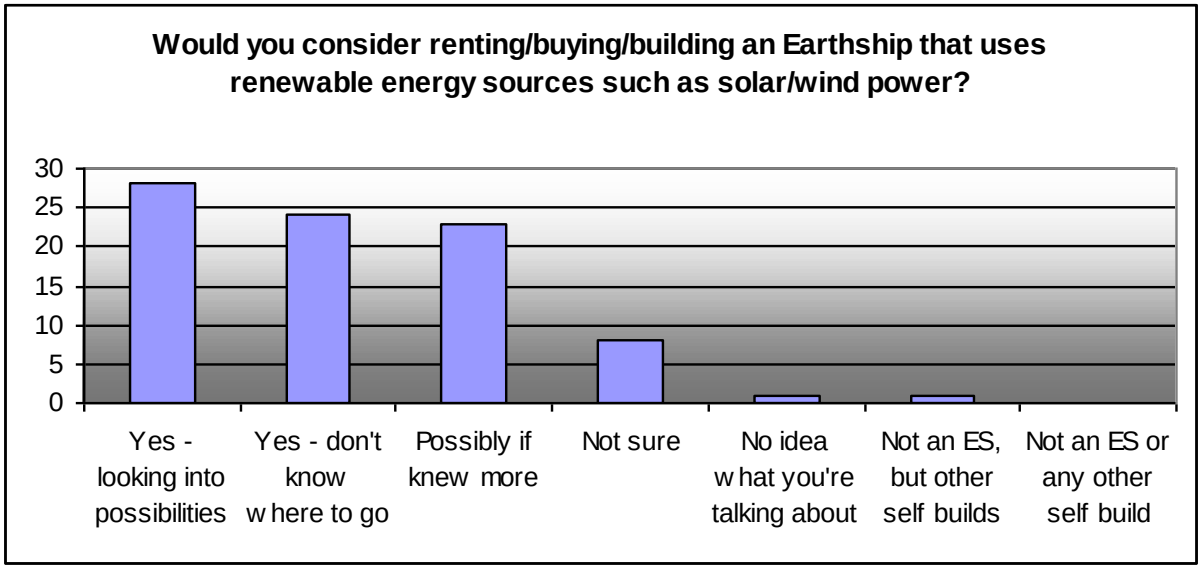
A total of 94 completed questionnaires were received. Despite the fact that 35% of respondents had never heard of an Earthship before they received the questionnaire, 73% of the respondents indicated that they would be willing to be put on a mailing list to continue to receive Earthship information, which further shows a strong interest in the concept. In addition, the comments received by the respondents were also very supportive (see Appendix 11).

The high level of interest in Earthships is reflected in the following percentages: 18% of respondents stated that they were definitely interested in renting an Earthship; 9% stated that they might be interested in renting and Earthship if they knew more about it; 33% would definitely be interested in building and Earthship if funding were available; 32% would possibly build or buy an Earthship if thy knew more about it; 19% were interested in building an Earthship with or without funding; 32% would consider sweat equity (giving their time and energy to help build an Earthship in exchange for part ownership of it); however, 17% didn't believe that they qualified for any funding/didn't have enough capital to build an Earthship.

The graphs below indicate that although 28% of respondents would consider renting/buying/building an Earthship made out of recycled and/or reclaimed materials, yet 30% would consider it but didn't know where to go for information. Similarly, 27% stated that they would definitely consider building/buying/renting an Earthship that used renewable energy sources such as solar and wind power, while 25% would definitely consider it but didn't know where to go for information. Lastly, 26% of the respondents would consider renting/building/buying an Earthship with it's own water supply from rainwater and it's own built-in sewage system; yet a further 27% would but didn't know where to go for information. Only 4% of respondents were currently going to Sustainable Communities Initiatives for information; whilst 3% went to Earthships Moray; 3% to Earthship Biotecture's website and less than 1% to Low Carbon Network's website (builders of Brighton Earthship). These figures show a clear need for information about Earthships to be accessible.


Would you consider an Earthship made out of recycled and/or reclaimed materials?
35
30
25
20
15
10
5
0
Yes - looking into possibilities
Yes - don't know where to go
Possibly if knew more
Not sure
No idea what you're talking about
Not an ES, but other self builds
Not an ES or any other self build


Would you consider renting/buying/building an Earthship with its own water supply from rainwater and its own built-in sewage system?
30
25
20
15
10
5
0
Yes - looking into possibilities
Yes - don't know w here to go
Possibly if knew more
Not sure
No idea w hat you're talking about
Not an ES, but other self builds
Not an ES or any other self build


Would you consider renting/buying/building an Earthship that uses renewable energy sources such as solar/wind power?
30
25
20
15
10
5
0
Yes - looking into possibilities
Yes - don't know w here to go
Possibly if knew more
Not sure
No idea w hat you're talking about
Not an ES, but other self builds
Not an ES or any other self build

## 6.0 Conclusion

### 6.1 Earthship Fife – The Case Study

This study set out to determine whether the Earthship model is viable as affordable eco housing in Scotland, whether there is a demand for it, what barriers are perceived in preventing any demand be converted to actual buildings, what support would be required to remove those barriers, and what number of Earthships could be realistically built in the next 2 to 3 years.

The study now completed on Earthship Fife as an actual case study constructed in Scotland provides evidence that the Earthship is viable in the following ways:

- The building design used is accepted by structural engineers and Planning;
- The building design works in the Scottish climate;
- The building methods lend themselves well to self-build, or part self-build building projects;
- The building methods are easily taught to unskilled people;
- A significant amount of the building materials are readily available as waste products and can help reduce a major waste problem;
- Reclaimed materials can be used in many aspects of the building;
- More than average labour time in building is compensated by the low-tech and easily taught techniques, as well as reducing the environmental impact of more technical building methods;
- Earthships are affordable as family homes as a self build model;
- Earthships provide families with houses that cost very little to run and operate in their lifetime;
- Residential status for Earthships is achievable in the short term for future developments;

### 6.2 Earthships as Affordable Eco-homes

The results and findings show that although not all factors have been resolved, that an affordable Earthship ZWAZE[7] housing development could go ahead in the next 2 years. Whilst it can go ahead without support from Communities Scotland, ideally this type of development would be supported by Communities Scotland, which would make the project replicable in the future by others much more easily.

The results and findings also show a need for clearer sustainable construction policies by LAs and the allocation of land for these types of sustainable communities and low impact dwellings. The clearer the sustainable construction policies, the easier an innovative ZWAZE Earthship housing development proposal matches those policies.

From the experience of ESM and SCI, and notwithstanding that the production of this report, the completion of Earthship Fife and the production of “The Earthship Toolkit, Your Guide to a Zero Waste Zero Energy Future” will save both groups a lot of time and resources in dealing with enquiries, it is still felt that the setting up of a National Development and Support Network is necessary.

### 6.3 Market Demand for Earthships & Perceived Barriers

#### 6.3.1 Primary data – Questionnaire Survey

The results of the quantitative data along with the qualitative data received in the comments would indicate that there is a real market demand for Earthships and that this has not been fully revealed to date. The lack of information about the possibilities and the lack of awareness on the part of the

[7] A draft proposal of the ZWAZE development can be seen in Appendix 12

general public must be seen as a barrier to the future development of Earthships as if awareness was increased, it is inevitable that the market demand for Earthships would increase.

The respondents came from a variety of backgrounds and personal circumstances but they seem to want to have some choice about what location they would prefer to live in and to share that with people who share similar community values. They also don't know where to go for information or in some cases, where to start looking for it. Thus, the main barrier appears to be lack of awareness. 35% of respondents hadn't heard of Earthships before completing the questionnaire and 78 out of the 94 (73%) in total have stated that they want to be kept on a mailing list to be kept informed about Earthship developments. This would suggest that if people were aware and information available there would be greater interest and involvement from members of the public. However, please see section 6.3.2 below for implications of this.

In conclusion, the research has shown that the market demand for Earthships is currently high and potentially very high, and the main barriers to the future development of Earthships appear to be twofold - lack of awareness and information, and lack of funding. With these addressed, Earthships are viable as affordable eco housing in Scotland and as low cost social housing.

### 6.3.2 Secondary data

As shown in Section 4, whilst the breakdown of the selection of enquiries to SCI was informative and interesting, it was the story behind the enquiries that may be more relevant to the future. It is clear that to progress Earthship development in Scotland, the concept has to be coherently marketed in a number of different ways. However, with marketing come enquiries and with enquiries comes a need for staff and resources to deal with those enquiries. From their own experience, the author groups are suggesting that any new Earthship project, particularly a real housing development will be met with a storm of enquiries and unless that project has enough resources to deal with them, the results will be the same as what SCI experienced i.e. not providing an adequate level of support to enquirers. Earthships Moray, as a small community group run by volunteers has had a similar experience to a lesser but relative degree.

## 7.0 Next Steps

In light of the above results it is now recognised that the Implementation Stage of this research project would consist of 2 distinct components:

1. **A Zero Waste Zero Energy Earthship Housing Development** of 12 Earthships that would demonstrate the effectiveness of the Earthship model as affordable eco housing and its potential to reduce carbon emissions and waste, which could be replicated in future, and surmount perceived barriers.
2. **Scottish Earthship Development & Support Network**[8] There is a need for a supportive network to enable Earthships to be developed as affordable eco-homes. It is thus recommended that in conjunction with a self build eco housing project using Earthships as the Zero Waste Zero Energy model should be the establishment of a national network that would fulfil a number of aims not easily achievable by individual projects trying to focus their energy and resources on the project at hand.

   This development and support network would not replace individual Earthship projects' freedom and ability to provide an information resource to enquirers, but would rather take the pressure off groups by supporting them in a way that suits each individual project. It is envisioned that each Earthship project would be a resource centre in its own right if that group felt that were appropriate to their needs. The Network would be more than a resource base and it would seek high level support for Earthship projects as well as policy change to enable them to occur. The Development and Support network would be a discrete part of an expanded SCI as a natural progression of its activities.

[8] A draft description of the Network can be seen in Appendix 13