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Scott M. Dwyer

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"*An Investigation of the Barriers that Exist for Building Integrated Renewables and their Implication for Sustainable Development*"

Department of Mechanical Engineering

Faculty of Engineering

University of Strathclyde

BIBLIOGRAPHY & REFERENCES:

APPENDICES:

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“*If you can find a path with no obstacles, it probably doesn't lead anywhere*.”

Frank A. Clark

ABSTRACT

The UK has proposed a significant amount of its electricity will come from renewable sources within the next decade while Scotland has submitted a more ambitious figure. Building integrated renewables offer an additional pathway to achieving these targets but barriers exist which may hinder their development.

The Scottish Executive has proposed that 17-18% of electricity should come from renewable sources by 2010 in an attempt to reduce carbon dioxide (CO^2) levels. The use of renewable energy systems such as wind farms has a number of inherent difficulties. Due to the nature of the UK electricity and distribution network, a number of problems have been predicted if a large amount of intermittent electricity is accepted onto the Grid (Butler 2001, Wallace 2003). Building integrated renewables could suppress these difficulties while alleviating the planning issues and environmental impact of large-scale renewable projects. Energy use in buildings represents 45% of the CO^2 emissions in the UK (BSRIA 1999) so addressing the building sector with CO^2 reduction in mind would have a substantial impact.

A significant amount of funding and effort has been contributed to encouraging renewables into the built environment. However, if the same barriers repeatedly obstruct BIR projects then both these valuable resources will be wasted, driving up the cost and slowing the development of this branch of renewable energy systems.

In this thesis, the barriers that exist for those trying to incorporate building integrated renewables in Scotland are investigated and their implications for sustainable development discussed. Building integrated renewables possess a distinct lack of environmental and planning obstacles normally associated with certain renewable energy systems. However, they do have a wealth of other issues created by a lack of the essential skills and experience, and also the high degree of multidisciplinary interaction that is required to ensure the success of a project. These barriers are bridgeable if past experiences of BIR

projects are drawn from in addition with a raised awareness of the potential obstacles.

INTRODUCTION

This thesis investigates the barriers faced by those involved with building integrated renewables (BIRs) in Scotland and how these barriers can pose a threat to achieving sustainability at a number of levels. The views and experiences of those involved in each sphere of the BIRs process was explored and the implications for the technology's future development discussed.

The 1997 Kyoto Protocol on Climate Change formed for the United Nations Framework Convention on Climate Change was introduced as a legally binding agreement to stabilise then reduce greenhouse gases to 1990 levels. As part of the agreement, the UK government agreed to CO^2 emissions reductions by 2008-2012 of 12.5%. The UK government now aims to reduce emissions of CO^2 by more than is required by the EU agreed target of 20% below the 1990 baseline before 2020.

The Renewables Obligation was an important instrument in achieving the Government's proposed reduction. Currently in Scotland, 11% of energy demand is satisfied by renewables (Scottish Executive, 2003) and with the gradual decommissioning of nuclear power stations, a substantial short fall could exist. The Scottish Executive has recently proposed a further increase to take the total of electricity supplied by renewables to 17-18% by 2010 (DEFRA, 2000). Much of this extra renewables generation is expected to come from large wind farms, although there are complicated technical and planning issues to be considered. Among these concerns is the question over how much additional power is the Scottish electricity Grid able to absorb.

In 1987, the World Commission on Environment and Development (WCED) published a report called '*Our Common Future'*, also known as the Brundtland Report. It proposed long term environmental strategies for achieving sustainable development in the future. Among the critical objectives of the report included meeting the essential needs for energy, conserving and enhancing the resource base and reorientating technology.

Building Integrated Renewables (BIRs) are technologies that work on the same principles as other renewable energy systems. However, they are built into the fabric of the building so that the building envelope and its surroundings are capable of generating useful heat and electricity. Energy use in buildings accounts for nearly 50% of the carbon dioxide (CO^2) emissions in the UK (BSRIA, 1999). However, unlike other sectors of the economy (e.g. car manufacturers) that have had to address environmental issues in the past due to resource availability issues, the housing sector has been slow to react in comparison.

There are many benefits of integrating renewables into building. BIRs are able to exploit renewable energy sources in the area where the demand is to be met. Renewable energy is a low density, diffuse energy source and buildings provide a large collector area for which to capture this energy source without intrusion on the environment. This avoids the application of energy transmission infrastructure that has economic, environmental and even health implications. Within an urban context, BIRs can offer the chance for cities to disassociate themselves from their traditional patterns of high consumption and reliance on resources from rural areas. Also, a new market can be created by nurturing the further development of BIRs. Even though the technology has been in existence for a relatively long time, new and innovative ways of incorporating renewable energy systems into building design still remain. In addition, BIRs may be able to address many sustainability issues as energy is paramount in ensuring economic development; necessary for powering the manufacturing industry to providing lighting and heating for schools. Inequality is also an issue as poor energy efficiency and low incomes contribute to fuel poverty imposing wide-ranging costs on communities.

The installation of BIRs is becoming more common in Scotland as grant programmes like the £20m PV Demonstration Programme and the Community Renewables Initiative close the economic gap. However, many other barriers, economic and otherwise still exist. As long as they go unrecognised, they will continue to hamper the development and drive up the cost of BIRs.

The barriers that can be encountered when developing a project involving BIRs are like those that could be encountered in any traditional construction project. There are many uncertainties and risks that must be managed and in addition, the deployment of often new and untested pieces of equipment. These experimental projects are necessary if BIRs are to be eventually considered effective and mainstream but this is not to say that the same obstacles and errors should be repeatedly encountered. By highlighting the common and often stubborn barriers and drawing on those projects that have been successful in overcoming certain obstructions, it is hoped that the development and acceptance of BIRs will be expedited.

While there are many individuals that identify certain barriers and discuss the need for their removal, many key organisations agree that barriers which oppose BIRs as a whole must be removed. The Organisation for Economic Co-operation and Development (OECD), a group that "*discuss, develop and refine economic and social policies*" , believe that a comprehensive approach must be used for climate abatement by "*supporting research and technology projects that remove barriers to the uptake of more energy efficient technologies and less carbon intensive energy sources*" (OECD 2001a). INREB (Integration of New and Renewable Energy in Buildings), a partnership of organisations that aims to exploit the business opportunities offered by BIRs, believe that the obstacles are diverse, stating that its a "*key challenge…to remove the barriers to the successful deployment of new and renewable energy technology in the built environment*." (INREB 2003)

It is important that the development of BIRs is furthered and their place in the built environment secured. The implications if we don't extend beyond that of ignoring a simple whim for 'green electricity' and are routed in equality, health, resource conservation and protection of the environment. It is essential that the obstacles that exist for BIRs are not ignored and that new projects lead the way with new innovations, rather than with new barriers.

1.1 Aims

There were a number of aims that were established at the beginning of this thesis. The purpose of developing these aims was to ensure that each stage of the project was focussed towards achieving the specific goals. The aims of this project were to:

- Explore the views of those involved with BIRs and how the current process might be improved
- Find the most common barriers are identify those that are persistently being overlooked
- Identify the barriers that are the most difficult to overcome
- Suggest possible remedies to the problems encountered by those involved in working with BIRs
- Investigate the implications for sustainable development with regard to the obstacles posed by BIRs.

1.2 Study Goals

The two main accomplishments that this study and resultant conclusions intended to achieve were that:

- Barriers would be prevented from repeatedly obstructing the further development of BIRs, driving up cost and delaying sustainable energy use within the built environment

- A clearer and more straightforward path would be paved for those considering integrating renewables into buildings

2.0 STRUCTURE & SCOPE

2.1 Scope

The scope of this thesis is, primarily, to describe and categorise specific and significant barriers that exist for the further development of building integrated renewables within Scotland. It tries to ascertain how these barriers have been, and are being overcome. Where solutions have not been applied or suggested, the development needs related to building integrated renewables in general will be proposed.

2.2 Building Integrated Renewables

These are renewable technologies that are integrated into the fabric of buildings, displacing some of the traditional building materials, and drawing energy from its immediate environment. Building integrated renewables can either make use of its energy source directly for electricity generation or heating, or passively in areas such as wind induced ventilation, transparent insulation or natural lighting.

By integrating the renewable features into the building itself, it is hoped that the buildings efficiency and performance is improved beyond what could be achieved if the technologies were simply employed as "add-on" features.

2.3 A Scottish Context

The decision to consider only Scottish projects rose due to a number of factors. One reason was that due to the nature of the project requiring one-to-one interviews, to have included the whole of the United Kingdom would have stretched the resources of the author beyond what was realistic. Also, by studying Scotland alone meant that a workable sample of data could be analysed and compared with parts (or the whole) of the UK at a later date. This could be crucial in identifying issues such as skill shortages in certain parts of the country.

2.4 Barrier Categories

The term “ barrier” is meant to relate to any obstacle or impediment that has been encountered during a project and this definition is the same one used by Turvey (1999). It was important to categorise any barriers that were known to exist for building integrated renewables before carrying out the study. Some of the barriers had already been classified in the relevant literature while others had yet to be grouped. Seven barrier categories were formulated:

ECONOMIC – This type of barrier refers to any impediment that affects building integrated renewables by obstructing the economic case for its application.

EDUCATIONAL – This barrier relates to any obstruction that is caused by any missing component or any encumbrance to the education that restricts the performance of those involved with building integrated renewables.

ENVIRONMENTAL – This category of barrier identifies any restriction caused to building integrated renewables due to a negative impact on the environment.

INSTITUTIONAL – This barrier refers to any obstruction that is created by the existence of local planning constraints or the effect of company policy with regards to building integrated renewables.

LEGISLATIVE – This type of barrier identifies any impediment that is rooted in the legal codes and practices that relate to certain aspects of building integrated renewables.

SOCIAL – This category of barrier relates to any restrictions that are caused due to issues relating to society and its attitudes towards features of building integrated renewables.

TECHNICAL – This barrier refers to any obstruction that affects building integrated renewables due to issues relating to mechanical problems or technological inadequacies in its inherent design.

2.5 Considered Projects

The type of projects considered for the study included many different types with a variety of end uses. ‘New-builds’ were one type of development that was examined and they are essentially those constructed from the foundations. This type of project will have the advantage of including all the necessary wiring/piping/etc. from the beginning with the rest of the building growing up around it. ‘Retrofit’ projects were also considered and this is where perhaps a refurbished building is re-designed with the idea of integrating renewables into its fabric. Alternatively, would not be considered is the simple ‘strapping on’ of a PV array or similar. An element of integration must be evident before the project was considered.

How the building was used was not instrumental in deciding which projects were considered but it was important to evaluate a diverse range of buildings. This meant including properties with commercial, industrial or domestic use, where possible.

3.0 BACKGROUND

3.1 Introduction

Renewable energy has increasingly seen its profile raised over the past 10 years, with the debate that has been generated generally clarifying its position with regards to the amount of misinformation on the subject. The result is the impression that renewable energy is being increasingly more accepted into the mainstream with usually positive, periodic appearances in the media that mostly verge on the positive. Much of the emphasis has admittedly been on large-scale wind projects with these larger projects sparking debate and controversy in some instances. Photovoltaic projects also tend to have a raised profile among the public and developers alike. Scooned (2002) believes that these more discernible forms of renewable energy offer more of a "*strong visible image*" so these are often the first technologies to enter the mind of someone contemplating renewables. There are however, many less fashionable, less visible technologies that are more effective than photovoltaics and wind power.

3.2 Embedded Generation

Embedded Generation is where small and micro generators are directly connected to those that demand the electricity, such as homes, offices or factories. Electricity not required by the directly connected customers is fed back onto active distribution network to be utilised elsewhere. Storage systems may be used in the case where there is no demand or an excess.
An inherent negative aspect to renewable energy is that often where the renewable resource is most abundant; the population density and therefore energy demand is at its lowest. This necessitates the need for the construction of substations, transmission towers, and (especially in city areas) underground cabling which is a necessity and is more expensive than overhead lines.
The long distances that the electricity must travel from isolated renewable locations also has the effect of inducing transmission losses, which can be in

the range of 5-7% (University of Strathclyde, 1998). This is another disadvantage to the nature of renewables, such as remote windfarms.

By using integrated renewables in buildings there are a number of aspects which help to quell some environmental concerns about the traditional electricity transmission network. The 'corona effect' is an occurrence with overhead lines that can cause noise disturbance and transmission interference to the surrounding population. Another obvious environmental impact is the clearing of land and trees to facilitate the construction of the various necessary infrastructure (transmission towers, substation buildings). Another issue which embedded generation would improve upon is that of stability and reliability of supply. By choosing to not supply electricity over the distance of many miles, shorter response times and better controls are experienced with embedded generation (University of Strathclyde, 1998). Embedded generation through the use of building integrated renewables would help avoid supplying excessive amounts of electricity to the Grid that were not needed and thus being wasted as heat. This would especially be the case with the extra addition of renewable energy generators onto the Grid and Wallace (2003) discusses the way in which this is due to the way the distribution network is historically designed "*to supply demand that reduced with distance from the transmission system*" . It would be more beneficial to use an embedded scheme where total energy consumption could be reduced at the point of demand.

As the demand profile of an embedded scheme is better defined because of its smaller scale compared with the load for supplying a whole region using the Grid, it would be more beneficial to use an embedded scheme. By doing this it would reduce unnecessary wastage.

By encouraging building integrated renewables the incidence of embedded generation is likely to increase. This will result in all the benefits of renewable energy without the risk of having to severely alter our electricity distribution network to cope with them, having instead a positive impact.

3.3 Energy Use in the Built Environment

Energy use in buildings accounts for nearly half of the carbon dioxide (CO^2) emissions in the UK (BSRIA, 1999) but this sector has traditionally received less attention than some of the more obvious pollution contributors such as road transport and industry. Buildings consume a large percentage of most nations energy budgets and for this reason it is extremely important to promote energy efficiency and the substitution of renewables where possible in this sector.

One way that this is trying to be achieved in the UK is via the Climate Change Levy (CCL). This is the UK legislation that directly addresses renewable energy. It is a tax on energy use in industry, commerce, agriculture and the public sector which was introduced in April 2001. Organisations are exempt if they buy their energy from a renewable source or generate their own energy. The CCL is a direct result from Britain's commitments to the Kyoto Protocol, which if Britain is to meet, must reduce its greenhouse gas emissions 10% by 2010.

It is acceptable to expect that by targeting the built environment sector a large leap forward in terms of sustainability will be possible. By integrating renewables into buildings, increasing the energy efficiency and energy performance of offices, homes and businesses, it is hoped that this will become one of the major steps towards achieving this.

3.4 The Built Environments Contribution Towards Sustainability

Many feel that housing has the ability as a whole to satisfy all the needs for addressing sustainability. With regards to housing, local sustainable development involves "*improving the quality of life of the local community through the prudent use of local resources*" (Oktay, 2002). However, when considering every aspect of the built environment it can be seen that this involves more than just local sustainability. Currently, 70% of the UK population live in urban areas, relying on rural resources for many of their basic necessities such as food, water and energy (Elliott, 2002). By contributing, even in part its own energy demand, cities will take a step closer to realising sustainability

3.5 Urban Energy Use

Urban centres are predominantly densely populated environments with an abundance of service and a high consumption rate for water, food and energy. These resources come usually from rural areas and the demand is only going to increase as migration to urban centres rises and consumption increases. The current demographic increase of 50 million urban citizens per year is the equivalent to adding another Paris, Beijing, or Cairo every other month (UNICEP, 2002b). Providing energy for all these extra urban residents will be a challenge if it is to be done without destroying the environment. A city's' ecological footprint is the area of land required to sustain its populations' consumption and London's is 125 times the city's area and equivalent to nearly all the UK's productive land area. (Elliott, 2002). Building Integrated renewables could help urban centres, not by allowing total self-sufficiency, but by providing more effective supply and demand matching. This works best on an urban scale and is where local heat and power networks can integrate renewables into a highly efficient distribution system. By harbouring integrated renewables within their buildings' fabric, cities could meet part of their energy needs themselves instead of acting entirely as an energy drain.

3.6 Development of a New Market

Windfarms are progressively becoming a more familiar sight in the UK today but the majority of these wind turbines and the manufacturing expertise to build them derives from Denmark. This is due to considerable investment and government backing at the early stages of their development in the 1970s. Now the technology is mature the country is reaping the rewards of a huge export trade in the technology and a large market share. As similar advancements are made with building integrated renewables, it is important that UK companies can simulate the Danish experience. Otherwise, by failing to develop new and renewable energy technologies and expertise the UK will be forced to buy from overseas. UK companies will then lose the chance to meet home demand and the opportunity to create a thriving export business will be missed. Businesses could also lose out on the chance to get one step ahead of their competitors by installing integrated renewables and reducing their energy bills. Energy running costs are a similar proportion of overall business cash flow as profit margins (BRE 2002), Scooned (2002) stating how offices that benefit from renewable energy sources are far more common on the continent than here. For businesses they could provide highly visible corporate social responsibility, in situ inflation resistant power supply, and a market in Renewable Obligation Certificates (ROCs).

3.7 The White Paper on Energy

The recently delivered Government White Paper on Energy delivered four main goals; the first three offering particular poignancy with regards to building integrated renewables. The first aim was to cut greenhouse gas emissions and is a feature that building integrated renewables can help contribute as they have zero emissions and come from an inexhaustible source.

Secure and reliable energy supplies was the second goal that was featured in the Energy White Paper and one that is also relevant for building integrated renewables as they help maintain the quality of the power supply without interfering with public electricity supplies (Strong, 2001)

Ensuring that every home is heated adequately is the third of the four objectives and this serves to eradicate fuel poverty ensuring that this important socio-economic criteria of sustainability is fulfilled.

The government has introduced this White Paper to increase the sustainability of our current energy supply and add more forethought and planning to the process. As renewable energy resources are a key to a sustainable energy supply, it can be said that building integrated renewables will certainly help achieve these goals.

4.0 BUILDING INTEGRATED RENEWABLES

There are many different types of BIR technology in existence and each one, when used in the correct circumstances, can go towards successfully fulfilling part or all of a buildings energy demand. This section outlines the principles behind the technology and provides an assortment of examples for illustrative purposes.

4.1 BIPV

Solar remains to be one of the most popular technologies and when utilised in an 'active' system, it can provide electricity for a range of applications. The PV cells themselves convert a small portion of the incoming radiation directly into electricity with the rest being reflected or lost as heat and light (UNICEP, 2002a). BIPV use photovoltaic surfaces that can be integrated with standard roofing, glazing or cladding products. Because the electricity is generated at the place where it is consumed, energy distribution losses are minimised (Bazilian *et al* 2000). BIPV also has advantages over traditional ground-mounted PV systems such as the support structure already being in place (i.e. the building), the electrical connection already existing, and without the cost of extra land. Also, for organisations that require prestige architectural features, some may regard PV as the ideal solution; communicating a company's' green credentials while giving the building a unique appearance. It also offsets the cost of other building materials such as roof tile or facades that may be expensive materials when used on prestige buildings, offering no additional benefits of power supplementation and no comparable payback period (Hanel 1999).

4.1.1 The Installed PV Capacity

In 2001, the UK installed PV generation was an estimated 1.4 GWh to UK total energy supply in 2001; less than 0.0005% compared with total annual electricity supply of around 340TWh (OJA, 2001). However, PV is highly favourable in a growing number of niche applications and can become more cost effective where mass production of standard components, simplified engineering, higher availability of grants, and co-generation are utilised (NWPPC, 2000).

4.1.2 PV Hybrid Systems

A PV hybrid system is one where the waste product (heat) is utilised. This solution allows the PV system to work more efficiently as PV systems efficiencies drop with increasing temperatures. 'PV cogen' systems can therefore increase the economic viability of BiPV (Bazilian et al, 2000) which can have questionable economics (i.e. long payback period) when used in singular systems (Bahaj, 2001, Bazilian et al 2000, Hanel, 1999). (For further info. 'Hybrid Energy Systems')

4.1.3 Solar Thermal

Like PV, solar thermal is used for purposes such as comfort heating, cooking applications and heat for technological uses. Heat from solar thermal applications can be applied to structural materials, water or air. There are two ways in which the light to heat energy conversion process can take place and these are either passively or actively (UNICEP, 2002a).

4.1.4 Passive Systems

A passive system is where heat is transferred without the use of moving components. Large glazed areas, building materials with a high thermal mass (which stores heat), and good insulation can all work to increase a buildings capacity to capture and retain heat (Elliot, 2002). For these passive systems to be successful it helps to have features for distributing the captured heat energy evenly throughout the building. There should also exist the ability to control the intake of the heat to prevent overheating while any large glazed areas should face the sun to maximise the solar gain. Natural ventilation is another version of a passive system and the concept involves air that is heated by solar means and is used to assist natural convection. This reduces or eliminates the need for the use of mechanical, energy consuming ventilation components. Daylight deflection is another passive technology and is suited to tackling issues of restricted daylight within buildings. Innovations in this technology range from a reflective " light-shelf" to the use of laser-cut acrylic panels (Bazilian et al 2000). These transparent sheets reverse the concept of shading devices used in glazing units in Australia and work by using a grid of fine precision cuts angled to reflect light deep within a buildings interior. Passive technologies are useful where solar energy can be utilised to provide part of the capacity for heating and lighting for buildings and to assist with the provision of clean air.

4.1.5 An Active System

An active system is one where heat is transferred mechanically by use of a working fluid such as air, or a fluid that is typically water, or water based. An anti-freeze solution may sometimes be added to prevent freezing during winter months. Pumps or fans are often used as the active components of these solar heating installations.

An active solar thermal system typically constitutes three different elements: the solar collector, the circulation system including a unit for storage, and a control system, which ensures efficient operation of the system (OJA 2001). There are many different types of collectors such as glazed and unglazed, flat plate, and evacuated tube collectors and each one is suited a different application.

4.2 Biomass

The sustainable use of biomass gives a renewable source of electricity with low or zero emissions of SO^2 and CO^2 for electricity generation. Biomass energy systems are based on the combustion or more efficient conversion of wood-fuel or other agricultural by-products to supply heating.

Although biomass generates about the same amount of greenhouse gas when burnt as fossil fuels, every time a plant grows CO^2 is taken out of the atmosphere (NREL 2003b). This results in ‘ zero emissions’ of net CO^2 emissions while the organic matter is continuing to be replanted for its biomass energy purposes.

The simplest way to utilise biomass is to use it to generate heat in the same way traditional fires and boilers generate it. Biomass can be traditionally split into 3 different categories: Solid biomass that includes the use of trees, crop residues, animal waste, household or industrial residues, which are all burnt directly to provide heat. Biogas is obtained anaerobically (in an oxygen absent atmosphere) from organic material to produce the combustible gas, methane. Typical organic feedstocks are those of animal and municipal waste. Liquid biofuels are obtained by performing physical or chemical processes to produce a combustible liquid fuel. Feedstock's that can be used for these processes include vegetable oils or ethanol. Biomass can also be used to generate electricity also but this usually occurs on a larger scale, involving the production of steam and use of turbines (NREL 2003b).

Biomass systems can be incorporated in district heating networks where a number of neighbouring buildings share the heat supply through a number of distribution pipes and heat meters. Biomass application within urban areas has an inherent problem with the transportation of feedstock to urban centres. There is the sustainability issue of transporting the fuel over distance (emitting transport fumes and adding to congestion) while also consuming resources which are not likely
to be localised.

4.3 Fuel Cells

4.3.1 Hydrogen

Hydrogen systems are a relevant addition to the list of building integrated renewable technologies and used in a fuel cell are considered to be a useful energy conversion device to be powered by renewable sources. It is not singularly available to the building sector but has applications within transportation, utilities and industry. Elam et al (2003) discusses how a number of barriers (economic and technical) still exist for hydrogen before it can become a "*competitive energy carrier*". However, besides this point it is felt that hydrogen holds an important future role in reducing environmental impacts linked to energy use. Hydrogen has an intermediary role also as it will be able to aid the development of renewable energy sources by acting as a means of storage, distribution and conversion. It is considered by Elam et al (2003) that in the near-term, hydrogen production will not be cost effective and also the institutional barriers of safety (real or as perceived by the public) are overcome.

4.3.2 Wood-fired Fuel Cells

This system benefits from the positive aspects of both fuel cell and biomass. The latter is advantageous because it is not site specific, intermittent, or difficult to store. The former has the benefit of high efficiency power generation at any scale. The combination of the two technologies produces a synergistic effect that's outcome is clean and efficient power generation that is ideal for use "*at small scales in such applications as domestic or commercial buildings*" (McIlveen-Wright et al, 2003). In this instance, waste heat is used to dry the wood-fuel before incineration while also heating water for the CHP application. The gas then leaving the gasifier preheats the air used in the fuel cell while the overall systems efficiency is improved by using waste heat from one process to benefit the other. However, McIlveen-Wright *et al.* admit an inherent problem with the system is that the raw material that it requires (wood) may not be suitable for transportation through highly populated urban areas, although this does not rule out its application in smaller towns or villages. However, other barriers to this technology do exist, such as the high cost of the fuel cell stacks and their short lifetimes.

4.4 Geothermal

Geothermal systems utilise heat energy from the earth and can be exploited in areas where there is the presence of underground hot water springs or reservoirs. Boreholes and pipes bring hot water to the surface using mechanical pumps and a heat exchanger extracts the heat while the cooled water is either returned to underground or disposed of on the surface (NREL 2003c). However, as geothermal is site specific this limits the number of instances in which it can be applied.

4.4.1 Ground-source heat pumps

Like geothermal systems, ground-source heat pumps take their heat from boreholes drilled in the ground. However, as the upper 10 feet of the earth's surface maintains a nearly constant temperature of between 10 and 16 degrees Celsius, it is consistently warmer than the air above it (NREL, 2003a). Heat pumps work more efficiently with this constant temperature heat source that even the shallow ground source provides (Rimmington 2002) so their application can be quite universal. These systems are better suited to delivering moderate levels of heating so one good example of an application may be under-floor heating. The process can also be reversed to withdraw heat from a building during warmer months.

4.5 Combined Heat & Power (CHP)

Combined Heat and Power (CHP) is the simultaneously generation of useable heat and power in a single process. The basic elements of a CHP plant are one or more prime movers usually driving electrical generators, where the heat generated in the process is used through suitable heat recovery equipment. In centralised electricity generation a large amount of this heat is wasted, dissipated to the environment from power station cooling towers The heat that is generated in CHP can be used for space heating, communal heating, or for industrial processes. CHP units (like fuel cells) are considered energy conversion devices and are utilised in a sustainable way by being powered by renewables sources. They are sometimes referred to as co-generation devices, powered by wood chip biomass, and are currently one of the most rapidly expanding technologies (UNICEP 2002). CHP systems can run on many different fuels including domestic refuse, gas or oil. Strictly speaking these two latter fuels are not renewable, although CHP does offer a more efficient way of electricity generation than traditional fossil fuel use. However, CHP may present itself as a suitable method of power generation for the transition period between fossil fuels and renewables.

4.6 Building Integrated Wind Solutions

A number of building integrated wind solutions exist and described here are two models to illustrate the diverseness of the designs available. The first kind described here is the ducted wind turbine.

4.6.1 Ducted wind turbines

This system developed at Strathclyde University and first described by Clarke et al. (1998), uses the concept of a small, modular, ducted unit able to be integrated into the roof structure of large buildings. Its advantages are its compactness, simplicity and low cost, while the addition of the ducting damps out any turbulence in the air-stream caused by densely packed buildings. The disadvantage of this system is that it is directional and requires a site with a prevailing wind direction. However, Clarke et al. do point out that while this " directional sensitivity" will see an impact on performance, "*a wind which is nominally favourable in direction may produce slightly less energy than expected over a period of time, while a nominally unfavourable wind might deliver more than anticipated*." An effect which overtime will reduce the directional sensitivity of the system.

4.6.2 Aeolian Roof

This design of wind solution for a building integrates the entire design into the roof structure. The concept developed by Taylor et al. of the Open University uses a series of cross flow turbines on a horizontal axis mounted in sections under an aerofoil which then increases the airflow. It is recommended that those buildings fitted with the system should be appropriately orientated with *dual pitch* or *vaulted roofs* while the ridges are curved and enhanced with a two-directional aerofoil section. When used together with the curved roof, a *venturi* slot is created and this accelerates the airflow further. The benefits of this system are said to be the low visibility and a small diameter turbine that can be directly connected to the generator without the needed extra of a gearbox. This allows a quieter system with fewer moving parts. A potential disadvantage to this system is perhaps the limited applications with which it would be suitable.

4.7 Hybrid Energy Systems

The majority of buildings using renewables will be using them in conjunction with conventional building services utilising mains electricity or gas. By taking a more sophisticated approach towards the integration of renewables into buildings, the impact on reducing carbon dioxide will be amplified.

One type of integrated energy system is a ‘hybrid renewable energy system’ which is able to fill a number of roles. One example could be PV panels with integrated phase change material to maintain low cell temperatures thus improving efficiency while storing enough thermal energy for space or water heating.

Another type of strategy for hybrid integration is using a ‘hybrid renewable/energy efficient system’. The aim of this system is to enhance the effectiveness of the renewable technology being utilised. Using a renewable technology with a high coefficient of performance (e.g. ground source heat pumps) would produce a synergistic effect when combined with a hybrid PV system, making use of the full effectiveness of the PV derived electricity.

Hybrid energy systems can also benefit from being used in conjunction with passive applications. They are useful for applications in environments where daylight is restricted and there is perhaps poor ventilation also. Using natural ventilation with natural day-lighting, super-reflective chimneys or ‘light pipes’ with integral ventilation can be benefited from. Lighting levels can be doubled (Hill 2002) and this effect can then be enhanced by coating the pipes with ‘dichoric’ coatings to absorb increased levels of solar thermal energy to improve performance of the stack effect. The stack effect draws in fresh air without the need for mechanical ventilation equipment.

5.0 FINANCING BUILDING INTEGRATED RENEWABLES

5.1 Available Financing Options

Cost is certainly an important factor when considering new and renewable technology as currently a major financial gap exists for many of them. At current costs, building integrated renewables are marginal however, the benefits of developing and gaining experience with BIRs is invaluable as it will eventually lead to the more widespread application of these technologies. However, an important consideration is that it is not always going to be cost effective. Bellew (2002) believes that "*investment in renewables requires experimentation, change and a long-term viewideally stimulated by subsidy or regulation*"

5.2 The Need for Investment

There is a definite need for investment for BIRs and Grob (2003) points to the book " Changing Course" by Dr Stephan Schmidheiny (Chief Editor and Chairman of the Business Council of Sustainable Development), which discusses the huge task of investing on a larger scale where sustainable systems are concerned. It highlights how energy is one of the largest investment sectors and therefore requires a large amount of investment to place it on a sustainable level. Some believe that the time for investment is now, as the financing options for building integrated renewables has never been greater (Hough, 2002). Currently, the amount of Government grants available for renewable energy has been put at £200m in total with a number of these available for building integrated renewables.

5.3 Major PV Demonstration Programme

For PV installations there seems to exist the greatest opportunity for attaining financial aid. Currently, a Major PV Demonstration Programme is being conducted which is worth £20m for the 1st phase of a 10-year programme to boost solar PV in the UK. The demonstration programme was launched by the DTI in March 2002, with the first phase conducted over a three-year programme. Grants are available for between 40-65% and are available to businesses, public bodies, and householders. The Government expects this programme to increase the number of PV installations in the UK by a factor of 10 by 2005 and this is equivalent in scale to the start-up phases started in the Netherlands, Germany and Denmark. There are 3 different types of grant available (all include all installation costs including Grid connection and the capital cost of the equipment itself):

1. Commercial organisations and large businesses get up to a 40% 'fixed' grant funding for large-scale applications (5kWp – 100kWp). For this grant to be awarded, an independent panel must consider the application and if approved there is 12 months in which to complete the installation. Payment of the grant is completed in two stages: up to 70% pending approval and 30% due on completion.
2. Social Housing Groups and Larger Scale Public Authority Building Projects is eligible for up to a 65% grant available to large-scale applications (5kWp – 100kWp). Again, an independent panel considers any applications and as before, the grant is payable in two stages: up to 70% pending approval and 30% due on completion.
3. Domestic Householders, small to medium enterprises (less than 250 employees, less than £25m annual turnover) and small-scale building projects (schools, community groups, etc.) are eligible for up to 50% 'fixed' grant funding for small-scale applications (0.5kWp – 5kWp). Approval for these grants is provided on a rolling basis and the awards are fairly automatic provided certain criteria are met. Six months is the time within which the building work must be completed, then once the necessary paperwork is completed the grant is awarded.

For further information go to:
www.dti.gov.uk/energy/renewables/support/capital_grants.shtml
www.est.co.uk/solar/

5.4 Plugging the Financial Gap

Aside from large, national grant schemes there are other ways of funding projects that encompass BIRs. In guidance developed by Energy for Sustainable Development (ESD) for use by social housing energy managers, five options were identified for "*plugging the PV financing gap*" (Hough, 2002).

Concessionary Finance is one method and would include lower rates for loans. It allows for increased flexibility in repayments with less security required on loans. Availability relies upon a small number of banks that are willing to offer these preferential measures to certain organisations.

Small-scale top up grants is another method and this makes use of 'Renewable energy funds' established by electricity suppliers as part of a 'green tariff' deal. This operates by placing a premium paid by the consumer into a fund that is then used to award grants – usually to schemes that will bring value to a particular community.

Assessing full renewable electricity market is another method of financing BIRs and this considers renewable electricity as a commodity which can be sold. Small scale PV electricity has market value defined by a number of components such as the type of electricity, and the Renewable Obligation Certificates (ROCs), which harbour a value due to the Renewables Obligation (See Section 6.7). The ESD guidance recognises that calculating the value from all these components "*not straightforward*" but they estimate as being capable of creating an income of up to £4500 pa for a 100kWp system.

Equipment leasing provides an opportunity to transfer the payment of the full capital cost of the system to a third party (a bank, energy service company, etc.). However, the ability to lease depends on the ability of the lender to be able to take ownership over the PV equipment. If any of the PV technology is integrated within the fabric of the building and become ‘fixture and fitting’, then ownership will lie with the property owner so leasing may be ‘precluded’.

This necessitates that for the leasing option, only removable modules could be used excluding the option of fully integrated renewable systems.

5.5 The Community and Household Renewable Energy Capital Grants Scheme

Unlike PV, solar water heating has no dedicated government grant programme. However, grants are available for systems installed in community and public buildings. A £10m Community and Household Renewable Energy Capital Grants Scheme was launched by the DTI in January 2003 and makes grants available to renewable energy projects that display a “*strong community or household interest*”.

For further information go to:
www.dti.gov.uk/energy/renewables/support/capital_grants.shtml
www.est.co.uk/solar/

5.6 The Bioenergy Capital Grants Scheme

Biomass boilers schemes were applicable to a £66m Bioenergy Capital Grants Scheme that offered funding on an equivalent scale to the PV demonstration programme. Unfortunately, this grants scheme ended in October 2002 although further rounds of funding may be contemplated if they find that the scheme was a success.

5.7 The Community Energy Programme

The £50m Community Energy Programme would be applicable to a biomass-heating scheme if it supplied to a public building and involved a district-heating network. However, while £33m goes to fund project generating electricity from energy crops, and £10m to offshore wind projects, only £3m goes to small-scale biomass heating schemes (DTI 2002b) which is a significantly lower figure than was offered previously. Under the community energy programme capital grants of up to 40% are available along with grants for feasibility assessments which cover the cost up to 50%.

For further information go to:
www.dti.gov.uk/energy/renewables/support/capital_grants.shtml
www.nof.org.uk

5.8 Enhanced Capital Allowances

Enhanced Capital Allowances (ECAs) are also available for businesses on some technologies, such as solar water heaters, biomass boilers, and ground source heat pumps. These enable businesses to write off the whole of the capital cost of their investment in these BIR technologies against their taxable profits over the time during which they make the investment. This can shorten the payback period and provide a monetary boost for the company.

For further information go to: http://www.eca.gov.uk/

6.0 RENEWABLE ENERGY

6.1 The Growth of RE

Interest in Renewable Energy Systems has grown considerably over the past two to three decades with few people willing to argue that there is not a place for renewables in our future methods of energy generation. Renewable energy is relevant to more than just environmentalists as it has social and economic ramifications; fossil and nuclear fuels are at the centre of industrial societies everywhere and therefore have wide reaching implications for everyone.

Renewable sources have the additional advantages over traditional fuels as being secure and inexhaustible. This means there is little chance of them being depleted causing a potential fuel crisis's similar to the one experienced in the 1970's. They can also be generated locally and with a diverse range of energy sources withdrawing the political power certain countries can exert due to their own substantial supplies.

6.2 Renewable Sources

Most renewable energy sources are derived from solar radiation whether it is in a direct or indirect form. A direct form of utilising the solar radiation would be to use it for electricity generation or heating. An indirect way is using the energy is from plants, animals, wind, waves or running water to produce power. Tidal energy is slightly different as it is a cause of solar or lunar forces while geothermal energy utilises heat retained within the earth's core. Energy from waste is another renewable form of energy.

6.3 Environmental Impact

Fossil and nuclear fuels have a detrimental affect on air, water, land, flora and fauna. Considered by many to be among these detrimental impacts are acid rain and global warming.

Acid rain is a side effect of the burning of fossil fuels and is created when sulphur dioxide (SO^2) and nitrogen oxides (NOx) are produced. These gases combine with water in the atmosphere to form sulphuric acid and nitric acid. This falls to earth as slightly acidic precipitation with the effect of damaging plant life, poisoning bodies of water, while eroding land and manmade structures.

Global warming is the effect many scientists believe is heating up the earth and could cause problems for many different species of animal and plant life. Without natural global warming the earth would be too cold to inhabit and a fine balance between incoming and outgoing radiation exists. The balance itself is affected by absorption or reflection which occurs in the atmosphere. Molecules of oxygen and nitrogen, which make up most of the atmosphere, do not absorb the relatively long wavelengths of the infrared radiation. However, more complex molecules such as carbon dioxide, water, methane and chlorofluorocarbons, and other chemicals that are more complex, all absorb the infrared radiation. These more complex molecules are generically known as ‘greenhouse gases’. CO^2 is the most prominent of these gases, the cause of which is released by the burning of fossil fuels (Boyle, 1996, Houghton et al., 1990, 1992)

6.4 History of Energy Use

For half a million years humans have used biomass as a source of energy. Wood material was used to fuel fires to keep warm, give light and cook food. Later it was also used to extract and work metals providing tools.

Humankind’s dependence on fossil fuels began to grow; a direct result of the industrial revolution (Boyle, 1996). At first it were watermills that were relied upon but with the invention of steam power, which utilised the energy gained from the burning of coke and coals, fuels began to displace running water as the main energy source.

In the nineteenth and early twentieth century, electricity generation, development of the chemical industry, the internal combustion energy, and the exploitation of oil and gas were mutually beneficial to each other in bringing on a rate and level of development never before seen. The combination of more sophisticated materials (plastics and metal alloys) and transport spread and enhanced the process of industrialisation.

The middle of the twentieth century saw an increase in the number of electricity distribution networks. The discovery of major oil fields in North Africa and the Middle East and the development of nuclear power post-World War II went further to cementing the industrialised worlds' dependence on the use of environmentally impacting fuels. Environmental effects and unsustainable energy use were ignored as development proceeded at a pace never before witnessed, as fuel seemed to be cheap and plentiful
As the twentieth century ended a new era had already been accepted. Growth in areas such as science, information and technology was paramount and so values that were once central to the industrial revolution now seem dated and old fashioned. This has heralded the inception of renewables and against many barriers, has established it in the future of our energy needs.

6.5 Key Characteristics of Renewable Energy

One of the key characteristics of renewable sources of energy is its intermittency. This is where the output from sources such as wind, and solar is considered to be variable in timing and power and thus unfavourable in certain circumstances. The effect of the variability of the energy source on the energy Grid is often used as an argument against renewables. However, studies have shown that up to 20% of the Grids supply could be taken up with renewables (ESTU 1996). With BIRs, much of the sources need not even be connected to the electricity supply network, instead providing thermal heating or storing the energy in batteries or other devices.
Another key feature of renewables is that they are remarkably versatile in their method of capabilities. Wind turbines and hydro schemes can offer the supply of a few kilowatts or multi-megawatts. Most other technologies (and this now includes wind) can be considered as modular. This means that they can easily be integrated into larger systems, providing increased manufacturability and making them easier to transport and service. Due to this versatility, renewable technologies can be tailored to suit the requirements of a variety of resources and markets.
Renewables tend to have an inherent high initial investment cost that is offset by low operating and maintenance costs. Another trait of renewables is their

lack of economic appeal within the current system. However, where subsidies and grants are offered, the economic case becomes more attractive.

6.6 Evolving UK and Scottish Energy Policy

During the 1997 United Nations Framework Convention on Climate Change the Kyoto Protocol was agreed upon as a legally binding agreement to prevent the current trend of rising levels of greenhouse gases. The UK's contribution would be to cut CO^2 emissions of 12.5% by 2008-2012. However, the UK government plans to go further than the reduction agreed by the EU and now aims to reduce emissions of CO^2 by 20% below the 1990 level before the year 2020 (ODPM 2002).

Scotland already contributes a reasonable amount of renewable energy due to its geography and climate and currently 11% of energy demand is satisfied by renewables (Scottish Executive, 2003). The Scottish Executive has recently used its devolved powers to propose a further increase of electricity supplied by renewables to 17-18% by 2010 (DEFRA, 2000). The majority of this increase is expected to come from large-scale wind farms, although there are a number of technical and planning issues to be considered.

Government energy policy has suffered a lack of visibility over the past few decades, although recently this was all set to change. Energy policy has not been completely absent however, as rises in the price of oil in 1973 and 1979 took the value of a barrel of oil to around 5 times what it was in previous decades (RCEP 1998). The price eventually fell but the initial increase was enough to spark a fuel crisis around the world. It was enough to prompt the development of the UK's first energy policy in 1979 which Britain's position with regard to its available resources and led to Margaret Thatcher declaring that a new nuclear power station should begin construction every year. This declaration only resulted in the construction of one nuclear power plant (Sizewell B) by 1990 due to the public sectors refusal to buy nuclear power stations when the electricity supply system was privatised (SDC 2001).

The UK Government's Energy White Paper "Our energy future – creating a low carbon economy" was published on the 24th February 2003 (DTI 2003). It outlined the need for carbon dioxide emission reductions along with a long-term view of addressing the important issues for achieving a sustainable energy infrastructure. Goals and individual contributions were outlined and a " Sustainable Energy Policy Network" (SEPN) was created which intended to ensure *" close integration across departments and much wider*" (DTI 2003).

Historically, Britain's resource mix of coal, gas, hydroelectric power, and nuclear power has meant that energy policy could be absent from the forefront of the government of public's with the odd exception (British Energy, 2002). However, this has had to change. Coal and oil is no longer environmentally acceptable; British oil and gas supplies are set to run out; existing nuclear power stations have reached the end of their lifetime while substantive opposition exists towards the construction of new ones. Even renewable energy generators such as large-scale windfarms, cited as the solution to our energy problems, poses problems as they cannot be relied upon to generate bulk quantities of power needed to ensure a secure and diverse electricity supply.

6.7 The Renewables Obligation

As a way of stimulating growth of the renewable energy market in the UK, the Non-Fossil Fuel Obligation (NFFO) Orders for England and Wales, and the Scottish Renewables Order (SRO) were introduced. The Secretary of State was handed powers by The Electricity Act 1989 that allowed him to make orders obliging the Regional Electricity Companies (RECs) to ensure that a specified amount of their electricity was generated by renewable sources; Renewables Obligation Certificates (ROCs) were introduced as a measure to aid this. ROCs are issued to generators to represent every unit of energy generated and the certificates themselves can be traded separately (SolarCentury, 2001). This will ensure that suppliers meet their obligation through the purchase of ROCs from renewable energy generators.

6.8 Local Effects of RE

The local impacts of Renewable Energy vary. All energy technologies have a physical presence that can prove to be a contentious point with regard to opposition to certain projects as well as planning issues. Smaller, more inconspicuous plants offer less opposition but to fulfil the same demand the generators would need to be more widespread. However, by using BIRs, much of the local effect can be marginalised. Waste and biomass combustion technologies do have local impacts such as atmospheric emissions, fuel transportation, handling activities such as ash disposal and thus may prove unfeasible for integration within an urban context, at least.

6.9 Regional Effects of RE

While fossil fuel plants transpose their emissions over regional boundaries, causing environmental and health problems such as acid rain, renewables (with the exception of waste burning ones which are subject to stringent EU legislation) have no notable negative regional effects.

6.10 Global Effects of RE

Most renewable technologies produce no CO2 or other greenhouse gases in its operation. Biomass and crop wastes do produce CO2 but as it was absorbed and fixed while the plant matter was alive during photosynthesis, there is effectively no net addition of CO2.
By using renewable energy sources, the finite and environmentally damaging fuels are displaced reducing the ill effects caused by a century of industrialisation

6.11 The Case for BIRs

BIRs can match all the benefits of large-scale wind farms and exceed them – providing the perfect complimentary technology. It is true that they could not match the kind of output generation that can be achieved by a number of large wind farms. But by increasing the number of buildings that generate heat by electricity on site, the number of windfarms required could be reduced. This could help mitigate the environmental impact of hundreds (perhaps thousands) of wind turbines as planning obstacles dissipate proving no longer valid within the built environment. Questions about renewables inherent negative effect on the transmission network due to intermittency could be answered due to the way BIRs could suppress this through embedded generation. Security of supply can also be increased for renewables on the Grid by offering suitable backup. BIRs could also offset the expenditure of network upgrades that would be required if the UK was to accept a large proportion of its electricity from renewables (ETSU 1994, RCEP 1998).

7.0 SUSTAINABLE DEVELOPMENT

A Definition*: " Development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* Brundtland Report, WCED, 1984

7.1 Historical Perspective of Energy

Historically, the technology that was available to mankind initially to harness scarce and costly energy supplies simple and inefficient and was met mostly by biomass and human/animal power. The production of energy on a large-scale commercial basis was to arrive later initially through water mills, wind, then later with coal. Generating energy in this way enabled industrial growth but was only individually available in a limited capacity while environmental issues were of no concern. With the arrival of new technologies after World War II, such as hydroelectric power and nuclear power, the cost of electricity fell for the individual while its availability rose.

Today, the energy sector is characterised by large-scale projects of which the planning, operation and, and decommissioning takes an excessive time to execute. There is an element of inflexibility in being able to provide a choice to the consumer as to the type of electricity and the way in which it is generated. "*The slow turnover of energy specific capital stock (creating) rigidities once a decision has been made*" (OECD, 2001b). The OECD believe that offering this choice is an integral part to sustainable decision making in the energy sector.

7.2 Earth Summits

In 1992, an Earth Summit in Rio de Janeiro intended to bring together governments, NGO's and business leader to discuss the importance of sustainable development and how it could be achieved. It was at this meeting that Agenda 21 was adopted as a global plan of action for achieving sustainable development in the 21st century. In Agenda 21 attention was brought to the fact that the current level of energy consumption and production were unsustainable and stressed the significance of using energy in a way which is not detrimental to human health, the natural environment and the atmosphere.

Since Agenda 21, the difficult challenge of integrating sustainability and energy use was a main topic of discussion at the Ninth Session of the Commission of Sustainable Development (CSD-9), while also being highlighted at the World Summit on Sustainable Development (WSSD). At these two conferences, countries agreed that there should be more emphasis on " *the development, implementation, and transfer of cleaner, more efficient technologies and that urgent action is required to further develop and expand the role of alternative energy sources*." (UN, 2003)

In 2002, the next Earth Summit in Johannesburg intended to adopt more concrete measures for how to better implement Agenda 21. However, many expected there to be lack of commitment and substantial initiatives and there was; only a third of the expected participants turning up (BITC 2002**)**

However, even groups supposedly on the same side were in disagreement. Greenpeace considered that despite the lack of outcomes it was still useful as it got sustainable development and the environment back on the agenda (Greenpeace 2002) while Friends of the Earth (FoE) felt that the conference was industries "*first corporate Greenwash offensive"* (FoE 2002*,).* However, positive actions did occur with regards to climate change and energy, with Russia and Canada agreeing to ratify the Kyoto Protocol.

7.3 Energy & Sustainable Development

Balancing economic growth against the detrimental effect it has on the environment is one of the main challenges of sustainable development. Energy is crucial for economic development as it provides services for basic needs such as food and shelter while also contributing to social development by improving public health and education. However, certain forms of energy production and consumption can diminish environmental sustainability. Many refer to the way in which energy and sustainable development have many intertwined relationships. The OECD (OECD 2001b) states how *" energy has deep and broad relationships with each of the three pillars of sustainable* *development – the economy, the environment, and social welfare*" , while Reid (1995) points to the Brundtland report (WCED O*ur Common Future*, Oxford, Oxford University press 1987), which remarks that "*the various global crises…are not separate crises: an environmental crisis, a development crisis, an energy crisis. They are all one*"

Sustainability at the national level (i.e. for Scotland) is important, as a nation that consumes resources faster that they can be regenerated is not acting sustainably. This is also the case when a country draws on the natural capital of other nations. Examples of how countries can use others resources unsustainably can be by either importing resources (e.g. oil, coal, etc) or by exporting toxic wastes (e.g. spent nuclear fuel). Reid (1995) says such a country is " imp*orting sustainability from others that are exporting theirs*" .

7.4 The Social Dimension

The social dimension for sustainable development with regards to energy is extremely diverse. It includes access to energy services, energy security, energy sector employment, disruption to societies resulting from price shifts in the energy sector, and the social implications of energy related land use. Each must then be considered as possessing economic and environmental implications as well.

Another unsustainable trend that derives from the social aspect is the inequality between rich and poor. At the beginning of the 1990's the richest fifth of the worlds' population receives 82.7% of the total world income, while the poorest fifth receives 1.4% of the total worlds' income (Reid, D 1995 – Source UNDP (1992)). This disparity in income is matched by other inequalities such as the distribution and consumption of resources.

This unsustainable trend is not only confined to those that inhabit the worlds poorest nations. Fuel poverty is an effect that it is very relevant in places like Scotland today.

The most common and widely accepted definition of Fuel Poverty is " *one which needs to spend more than 10% of its income on all fuel use and to heat its home to an adequate standard of warmth*" (DTI 2001). The main cause of fuel poverty in the UK is the combination of poor energy efficiency in homes and low incomes. In 1996, around 5.5 million households in the UK had difficulty with keeping warm over winter (The Scottish Executive 2000). The destructive effects of fuel poverty are the lowering of the quality of people's lives, inflicting wider costs on to communities, and affecting people's health. Those that can be affected includes everyone but most at risk are those that need the most protection: the young, elderly, disabled, or those with long term illnesses.

The UK Fuel Poverty Strategy was published in November 2001 and in it sets out a framework for eradicating fuel poverty in the UK. New features of the strategy include the £10 million micro-scale CHP pilot which involves 6000 homes in England and Wales, and a £5 million pilot to test the potential for renewable energy in homes that are not connected to gas mains.

7.5 Energy Security

Energy security requires efficient markets, secure frameworks for investment, undistorted pricing, integration of environmental concerns, and stable and transparent relations between consumers and suppliers. Energy diversification provides one element of supply security. Non-fossil energy services, such as BIRs could make a substantial contribution to this.

OPEC Middle East accounts for 26% of oil supplies (WEO 2000) – could grow to 50% in 2020 (OECD, 2001b)

7.6 Addressing Science and Technology

Some believe (Liddel et al., 2002) that "*technological fixes*" such as BIRs are not the answer to achieving sustainability in the built environment. However, the Organisation of Economic Co-operation and Development (OECD) state that "*scientific progress and technological development are major forces underlying improvements of productivity and living standards*" (OECD 2001a). They feel that the new technologies " offer considerable promise" for decoupling economic growth from long term environmental degradation.

It is therefore important that research and development is continued as there is still a lot of scope for further progress. Relative to other energy sources, renewable energy has only received a small share of government or private R&D budgets. In 1994, renewable energy only accounted for 8.1% of IEA government funding for energy R&D in 1994, compared with 54.9% for nuclear power and 11.3% for fossil fuels (OECD, 2001b). This shows how only a few years of investment can not realistically bring renewable energies to the forefront of energy generation and there is still a lot of room for further progress with BIRs.

8.0 METHODOLOGY

8.1 Development of the Project

Barriers for renewables were continually being referred to and used to galvanise the arguments of individuals and groups with various vested interests. Many obstacles were announced but few solutions were being offered.

Many of the barriers discussed in the previous research of past-BIR renewables projects only seemed to be classified loosely and variably from project to project. Having read all the information on the subject, it appeared relatively easy for an individual to proceed with a BIR project and be none the wiser as to the realistic barriers that they would be likely to encounter.

Turvey (1999) examined the barriers that were likely to face developers of renewable energy projects in Scotland. This focussed on large-scale projects that were a result of the SRO, many of the main issues centring around issues of planning and environmental impact. It seemed interesting to see if these issues were relevant for BIRs or if they varied in anyway, given that BIRs utilise an environment already altered by man.

There appeared to be a lot of information on past-BIR projects for the UK in general but not for Scotland where different factors could exist. There turned out to be a reasonable number of individuals involved in various BIR projects in Scotland from which a clear picture of the Scottish BIRs situation could be gained from a variety of different perspectives. Not just the one or two views that were common from the literature search.

✍✍ Project Aims Established

Firstly, the aims of the projects would be established to clearly define its parameters. Also identified would be what the project hoped to accomplish. This would be done to ensure the project accomplished in its goal once completed.

✍✍ Literature Search

A literature search was conducted that examined all the information that had looked at building projects that incorporated BIRs. While the information was being gathered any mention of potential barriers', barriers' that occurred or barriers' that were overcome were listed.

✍✍ Categorising Barriers

Categorising these barriers was the next important step and this was done by again examining past literature on the subject as those barriers that were listed were often categorised by the authors themselves. Those barriers that were not categorised in the literature were done so by the author in the most appropriate way possible.

By classifying the barriers early on in the project, it will help make it easier when designing a suitable questionnaire. It will also make it easier to quantify the responses given by the interviewees and also aid when the time comes for analysing the data.

✍✍ Questionnaire

The first thing that was done prior to designing a suitable questionnaire was to decide on its aims and the type of information that needed to be extracted. This kept the study's focus and ensured that when the questionnaire responses had been collected all the required information was contained within them.

The questionnaire aimed to highlight which of these barriers were actually occurring with BIRs projects in Scotland while also intending to uncover any barriers not previously mentioned in past literature. This helped create a picture of the most common BIRs barriers in Scotland. The questionnaire was also intended to find ways in which other methods had been successful in overcoming certain barriers. This aided in identifying solutions that had been proven to be successful.

✍✍ Cover Letter

A cover letter was designed and posted to the interviewees which gave the background to the project, including information on the author, the aim and purpose of the study, and also the intent of making contact by telephone within the coming weeks.

It was intended that this would introduce the interviewee to the project whilst providing all the necessary information, allowing them to reflect on the project at their own leisure.

- Telephone call

A telephone call was made a week after the cover letter was sent. The background to the project was again summarised and the author introduced. An appointment for an interview was then arranged within the next few weeks, where possible, for the delivery of the questionnaire. The aim of the questionnaire was to add a personal aspect, allowing the interviewee to ask any further questions they had about the project while the interviewer could ensure a definite time and date for the interview.

- Interview

The interview was conducted at the premises of the interviewee. The author conducted the questionnaire orally. For the reasons why an interview style questionnaire was selected see section 8.2.7.

- Data Analysis

The data analysis was conducted once all the interview responses had been collected. This information was then transferred into data tables to make it easier to analyse. The data in the tables was then converted into graphs using EXCEL. The aim of this was to make it easier to identify any trends, patterns, or anomalies in the results.

- Write-up

The final write-up of the project would include all background information relevant to BIRs. This would show benefits of BIRs and its importance to sustainability and for furthering the development of renewables. All barriers encountered in other projects in the literature review would be presented along side those barriers encountered by those interviewed. This would reveal those barriers most likely to occur in Scotland.

Any conclusions will then be formed based on all the information gathered. This can be used as a point of reference to anyone in the future intending to utilise BIRs by making transparent all potential barriers and possible solutions.

8.2 Development of the Questionnaire

The development of a questionnaire is a complex process with many common pitfalls. A considerable proportion of the time spent on the project went towards refining this useful tool. The following contains the justification for the use of questionnaire as well as other related methods.

8.2.1 the reason for a questionnaire

A questionnaire was decided upon as the best way to gauge how those actually involved in building integrated renewables (BIRs) feel about the current process. There was sufficient information available from various sources from which one could draw conclusions about which barriers existed to those trying to integrate renewables into buildings. However, the information was often published from an academics perspective and although the author's background could originate in mathematics, social science or architecture, this could still give a skewed interpretation of the overall process of integrating renewables into buildings. The implication of this was that it may not take into consideration, for example, the installer's, utility manager's, or planning officer's view. It was therefore decided that the only way to obtain a realistic view of the BIRs process was to secure the opinions and experiences of people involved at every level of its development within Scotland.

8.2.2 the small sample size

The sample size of the questionnaire was an important consideration as much of the literature stated that although the limit for the minimum sample size relies on a number of factors, it is likely that the number taken for this particular survey would usually be regarded as too small. However, as the study was investigating only those projects based in Scotland then this limits the size of the sample to below what is generally regarded as acceptable, although Berdie *et al.* (pp11, 1984) regard this as one way of achieving a higher response rate. The decision to not widen the parameters to include the rest of the UK was due to the increased difficulty with which it would have been to conduct the interviews in person. Also, by performing a small study it was possible to be more specific in the questioning, take longer with the interviews and thus extract more detailed information. It was therefore decided that a small, specific and detailed survey would be the best approach.

8.2.3 the reason for an interview

Conducting a mail questionnaire or a telephone interview were considered as methods of extracting the views from those involved with BIRs but the decision to conduct a face-to-face interview was based on a number of factors.

As the interviewees' profession could range from involvement with the financial aspect to involvement in the wiring of the system, designing a questionnaire that suited each individual could prove extremely difficult. By being present at the interview it was possible to guarantee that the questions being asked were fully understood, while also ensuring the ability to explore further the answers to the questions if required.

Another reason for conducting the interview in person was to ensure that a high response rate was achieved. Due to the size of the sample, it would be disastrous if only a fraction of the questionnaires were returned as occurs with large, unspecific, " blanket" style surveys. By appearing in person it was felt that the chances of the questionnaire being filled out correctly and on time were increased.

It was also felt that this particular method might prove useful for gaining further contacts in other areas of expertise for BIRs who may be eligible for interview.

8.2.4 the reason for a cover letter

A cover letter was produced and posted (See Appendix A) that was intended to introduce the author and project title, explain the aim of the project, describe the benefits of taking part, and also to give a time period in which they would be contacted to arrange a time for a one-to-one interview.

"*Cover letters…can be helpful in personal interview situations as means of introducing and legitimising interviewers*." (pp51 Berdie *et al*.)

It also contained a contact phone number and email address. The aim of the cover letter was thus to give the potential interviewee time to read over and consider the study with which they were to partake. This prevented the need to " cold call" and to increase the chances of securing a time for conducting the interview.

8.2.5 the reason for a phone call

After one-week phone calls were made to the individuals who had been sent cover letters. At this point the author reiterated the title and aim of the project, and why it was beneficial for them to give their views on the topic. At this point the aim was to simply refresh the memory of the potential interviewee of the aims of the study. Dates and times were then arranged for meetings at which the interview would be conducted.

8.2.6 the scope of study

The project study was to include anyone involved with BIR projects in Scotland. The reason for limiting the area to Scotland was due to the ability to travel to conduct the interviews in person. It also represented a workable sample of data that could be compared with other BIR projects situated in other parts of the UK for further work if desired.
The individuals that would be called upon to give their views on certain aspects of BIRs in Scotland were selected to represent as wide a cross section as possible. It was also felt that the usefulness of the study would be jeopardised if there were not representatives from every stage of a BIRs project. This could include anyone from the system designers, utility managers and installers, to the architects, project managers and builders.

8.2.7 the questionnaire format

The questionnaire began by first defining what “*a barrier*” means to ensure no misunderstandings over what is intended by the phrase: “*Barriers may include any impediment that has been encountered. For example: planning, financial, technical, or any other problem*” (Turvey, 1999).

1.) What technologies did your project encompass?

The question sheet then determined the technologies the interviewee had been involved with. The intention of this question is to ascertain the most common technologies used. It also intended to enable the author to link certain barriers with specific technologies as this could single out problems that consistently caused difficulties for a specific group. For filling in answers to the questionnaire, options were presented in the form of 8 categories of BIR technology, which could then be easily checked off. In a conventional mail questionnaire, the aim of this is to allow for the respondents to view how the question is to be answered. It also makes analysis of the filled in questionnaires less complicated. For a questionnaire that is conducted in person, it is the second reason that makes the answer options so important. It allows the interviewer to categorise the interviewees’ answers at the time thus saving complications later that could add extra time to the analysis stage of the questionnaire’s data.

2.) Was your project grid connected?

The next question intended to establish between grid connected and non-grid connected projects. The reason for this was that some barriers may be invalid if the project is one or the other. It may also explain the reasons why some projects choose grid connection while others don’t. The answer options in this case simply reflect a ‘Yes’ or ‘No’ response.

3.) What was your role?

The role of the interviewee is then ascertained and this was probably one of the single most important questions in the questionnaire. It was imperative that this question is asked, as it will explain later why they have certain views and also where exactly their experiences exist with regards to BIRs. There were 10 options given but there was also an option for individuals who do not fit into a particular role. This allows flexibility in categorising interviewees' personal job description.

4.) Which barriers were encountered during the first phase? (i.e. planning, building design, systems design)

The next question then enquires as to which barriers were experienced in the first phase. Seven different categories of barrier (*See Section 2.4) were given here to aid the interviewee as well as the interviewer. Examples were also given for each along with an option that could be checked if the barrier was a foreseen or unforeseen barrier. The reason for this additional option was that it could prove important whether those integrating renewables into buildings were actually aware of the barriers they were likely to face. It was also relevant for establishing how differently foreseen barriers are dealt with compared to unforeseen barriers.

It was considered that some of the interviewees might have no knowledge of a certain phase of a BIRs project and so an option of " don' t know" was given in this event. " None" was another important option as it could demonstrate how an individual fulfilling a certain role within a BIRs project might feel there are no obstructions at another particular stage of the project. An " other" option was also important as it allowed the interviewee to describe a barrier previously unrecorded.

5.) How were these overcome?

This was another very important question as it tried to use past experiences of BIRs to establish successful solutions to existing common problems. Bellew (2003) comments on his suspicion of how similar evaluation work of BIRs is being repeated and that this is driving up their cost. By revealing common barriers which reoccur in many similar projects and prescribing for them, it is hoped that this will prevent some of the same mistakes being repeated.

6.) Which barriers were encountered during the second phase? (i.e. construction, commissioning, installation)

This question is very similar to Question 4 but aimed to reveal the barriers that exist at further stage of development than previously. The reason for this was that it was felt if the BIRs process was split into more than just one stage, the barriers would be easier to identify then classify. Also, it would recognise the fact that many of the interviewees may only be aware of barriers at certain stages of the BIR project. This would thus reveal whether certain people were actually aware of the barriers that other individuals were encountering on other stages of a BIRs development

7.) How were these overcome?

(*See Question 5)

8.) Which barriers were encountered during the third phase? (i.e. maintenance, upgrading, repairs)

(*See Question 6)

9.) How were these overcome?

(*See Question 5)

10.)Please tick which of the following could be implemented to improve the overall process?

This question aims to identify a number of measures that could be installed to improve the process for which BIRs are developed in Scotland. The question is presented as a checklist and is different from the other questions in that the interviewees get a copy of the question and are free to read and comment on them. The reason for this was that the comprehensive nature of the list would allow the individual to take their time with the options, re-read them if necessary, and to fully understand their intention. There were twenty options including the "Don't know", "Nothing", and "Other" choices. The other seventeen options were measures that were suggested as ways to improve the development of BIRs in an earlier review of literature on the subject. It was therefore important to examine which were the most common among projects initiated in Scotland, what solutions were being applied, and which ones were proving successful.

9.0 GRAPH ANALYSIS

9.1 Graphs & Comments

Phase Definitions:

- *1st Phase* – the time from the point of the project's inception to the time before any physical work begins, i.e. planning, building design, systems design, fund raising, consultations, etc.
- *2nd Phase* – the time from the point of any physical work to the time before the system starts to become operational, i.e. construction, installation, connection to the Grid, etc.
- *3rd Phase* – the time from the point where the projects starts to become operational to the time up until when the questionnaire was conducted, i.e. maintenance, upgrades, repairs, routine inspections, etc.

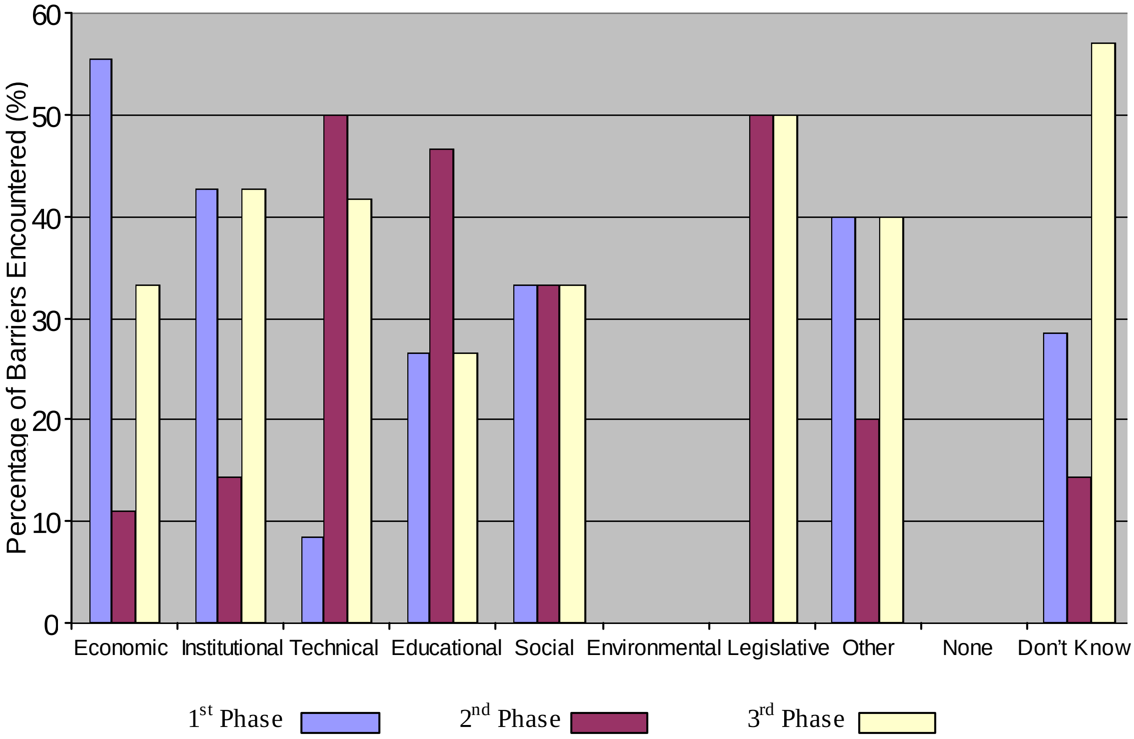

Fig 9.1: Barriers encountered at various stages

Figure 9.1 shows how economic barriers are most likely to occur in 1st phase with 50% of the total occurring then.

A reason for this could be that this is the time when any funding must be secured to ensure the go ahead for the project and therefore the time financial problems are most likely to occur.

Around a third of economic barriers are then likely to occur in the third phase. The reason for this may be that this is the time when unforeseen problems may occur with regards to maintenance or repairs and the cost for such things may have been underestimated. This is displayed in Figure 9.4 where it shows that the majority of Economic obstacles (55%) are unforeseen. Only around 10% of economic problems occur in the 2^{nd} phase.

Institutional obstructions are equally likely to occur in the 1^{st} phase as the 3^{rd} phase. The reason for a high instance in the 3^{rd} phase may be due to the fact that this is the time when most upset is likely to be caused with regards to visual or noise issues.
A high occurrence of institutional barriers in the 1^{st} phase may be due to this being the time when most planning issues are likely arise. However, it might have been expected that barriers occurring during the 2^{nd} phase might have been higher due to barriers arising from Grid connection and health & safety issues.
A more even spread across the various phases for institutional barriers might have been more expected. A reason for this distribution may be down to the comparatively low number of grid-connected projects (under 30%) shown in figure 9.3 and perhaps the relatively low overall percentage of institutional barriers occurring as shown in figure 9.14 (just over 10% - fourth lowest specific barrier).

Technical barriers are most likely to occur in the 2^{nd} and 3^{rd} phase which might be expected as this is the point in a project when installation, construction, maintenance, etc. occurs. It could also be related to the fact that most of the technical barriers being encountered are unforeseen and are simply being dealt with as and when they happen. This is reinforced by figure 9.4 which shows that two-thirds of technical problems are unforeseen. This in turn could be related to the fact that only around 25% of technical barriers are actually overcome as shown in figure 9.5 – the second least-likely barrier to be overcome.
Less than 10% of technical barriers are encountered in the initial stages of a project.

Educational barriers are most likely to occur in the 2nd phase with almost half of them occurring then. This could be due to the strong connection between technical and educational barriers – e.g. a technical problem arising due to an installer without proper training.
After the 2nd phase, educational barriers are then just as equally likely to occur in the 1st and 3rd phase with just under 30% of the total educational barriers each. This relatively high distribution for each stage could be due to the barrier identified as " lack of multidisciplinary interaction" . Although this problem could be placed as a barrier on its own, it was felt it fitted within the educational barrier category. This was because it was felt that multidisciplinary interaction could be improved upon by teaching the importance of this element during undergraduate, apprenticeship, or training course level, while Pitts (1996) supported this idea also. This is especially important for the case of building integrated renewables where many disciplines are required to make a project successful. Hence, lack of multidisciplinary interaction occurred at every level causing a high distribution across every level.

Social barriers were equally as likely to occur in one level as another. This shows that any social obstructions are not stage specific and attitudes towards BIRs do not change during the course of a project. However, social barriers were not the most prolific obstructers and were in fact the second least likely specific barrier to occur (See figure 9.18). This could also account for the even distribution.

Environmental barriers were non-existent in this study, although it was difficult to see how issues relating to the protection of the environment would be relevant within the context of BIRs. This category of barrier can prove instrumental in the decisions which affect large-scale power generators such as wind farms (Turvey, 1999). However, an inherent benefit of BIRs could be that any of these planning issues relating to the environment are simply annulled paving a smoother path for renewables than previously.
Legislative barriers are equally likely to occur in the 2nd phase as the 3rd phase (50% each). No legislative barriers were encountered in the initial

stages of any of the projects. One reason for this could be the fact that legislative barriers were the least likely to occur specific barrier with only 3% of the total (See figure 9.18). Another reason could be that almost all the relevant legislation referred to is that which is necessary for Grid connection (G77, G83, etc.). This legislation then may only be addressed once the project reaches the stages of the 2^{nd} and 3^{rd} phase where Grid connection is necessary so only identified as a barrier at this point. This is enforced by figure 9.4 which shows that 100% of legislative barriers encountered by projects were unforeseen.

'Other' barriers include those that were not considered prior to the project due to absence of it from the literature search. 'Other' barriers encountered in the 1^{st} and 3^{rd} phases were the most prominent with 40% of the total encountered each. The final fifth of the barriers were encountered in the 2^{nd} phase. Among those barriers encountered were those that referred to " Political Barriers" , barriers that mentioned a difficulty in obtaining the necessary equipment, along with other barriers that were difficult to categorise under one heading. 'Other' barriers represented a relatively small proportion of the overall total number of barriers at around 7% (See figure 9.18).

'None' was an option that was included in the questionnaire to allow individuals the choice to opt out if they felt there were no obstructions at any one stage.
It was an option no individual involved with a BIRs project decided to take, maybe demonstrating that barriers are universal to anyone fulfilling any particular role with any given technology.

'Don't know' was another option that the interviewee could opt for if they could not name a specific barrier. A reason for not being able to name a specific barrier could be due to uncertainty about a specific phase of the project because they only became involved with a project from a certain period. It could also be due to an individual only being involved in certain stages of BIR projects. Finally, it would also be a chosen option for an interviewee should they simply be unaware of any problems at certain phase, or if a project had not progressed to a certain stage of development.

'Don't know' was most likely to be chosen as an option for the 3rd phase at almost 60%. This was due to a number of the projects having been newly completed while also there existing an element of uncertainty in issues relating to maintenance, such as what kind and how often. Another reason given was that some felt it was still too early in the development of BIRs to tell what the barriers would be.

The period in which 'don't know' is second most likely to be chosen is the first phase. The reason for this could have been due to those individuals who were new to positions and were unaware of the full extent of the barriers at these earlier stages.

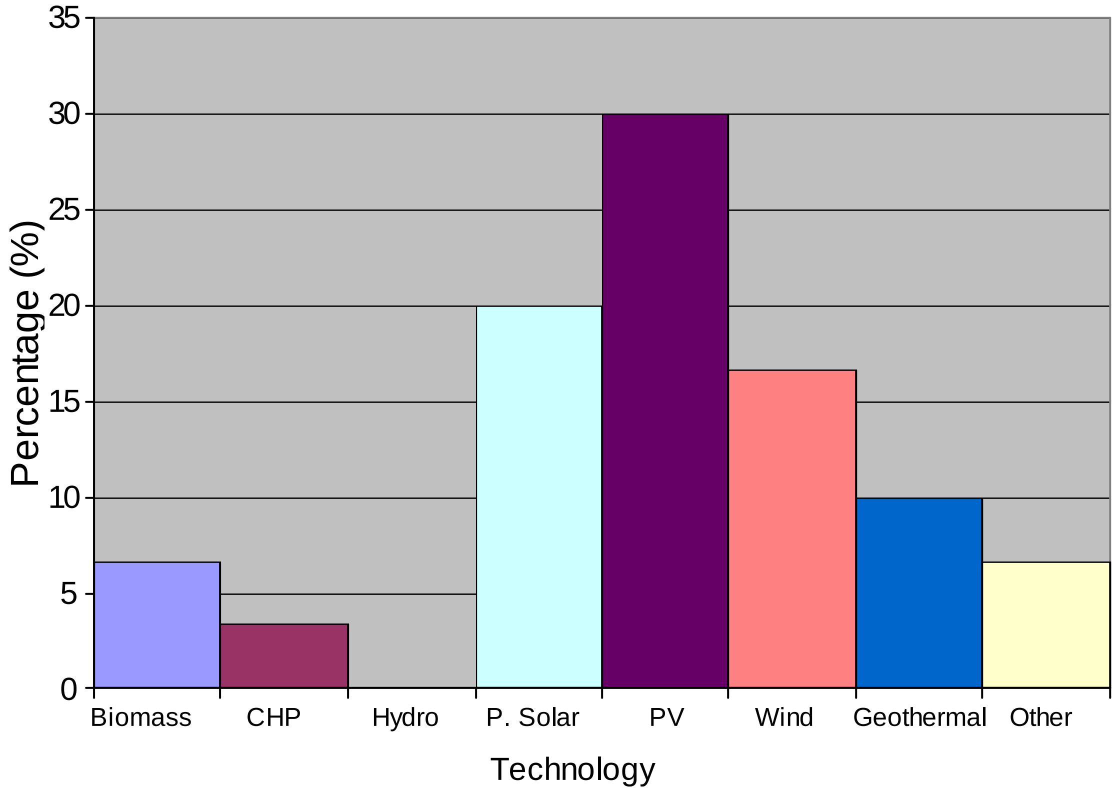

Fig 9.2: Technologies Used

As can be seen from figure 9.2 the most popular technology featured in the projects by those interviewed was PV. 30% of individuals interviewed had some form of PV installation incorporated in their building. The second most common technology used was passive solar and this was featured in a fifth of all projects. Slightly less than this was wind technology, that was featured in the projects of just over 15% of the individuals. The fourth most popular technology was geothermal with 10% of projects. Then was biomass and 'other' technologies not mentioned (they included hybrid installations and communal heating systems), with only around 7% featured for each one. CHP was only applied in around 3% of projects while hydropower was not featured in any of the projects.

The reason for the high incidence of PV systems could be due to the high availability of the funding (£20m PV Domestic Field Trials.). Passive solar also feature in funding options all be it to a lesser extent (£10m 'Community and

Household Renewable Capital Grants Scheme' and the £3m 'Community Energy Programme')
The popularity of wind use is however surprising but this could be related to those individuals to whom wind projects would be relevant given their position but this does not indicate fully functioning wind installations.

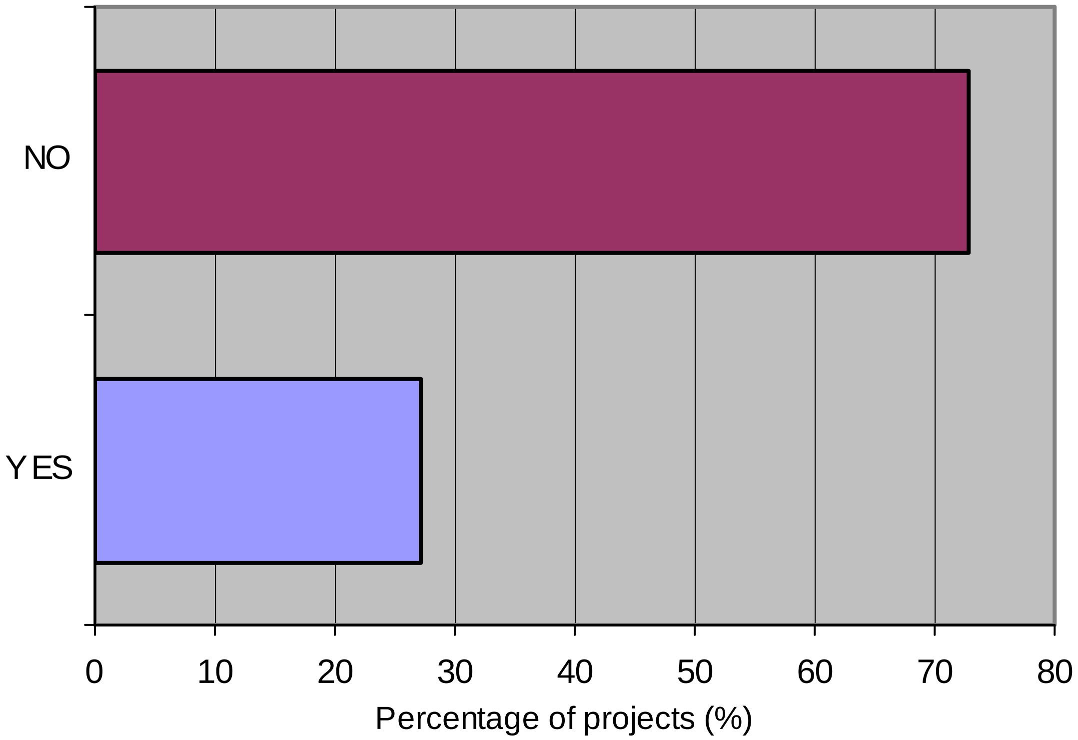

Fig 9.3: Projects that chose Grid Connection

Figure 9.3 shows the percentage of projects deciding on grid connection. As can be seen, slightly over 70% of projects decide to abstain from connecting to the Grid while slightly fewer than 30% choose to connect. Possible reasons for this could be the number of projects deciding on renewable technology that does not generate electricity, such as passive solar, geothermal, biomass, heat pumps, etc. Even the wind turbine system in this case generates (excess) electricity for storage in a battery. Another reason could be the potential difficulty with which grid connection poses. In a number of cases there were legislative barriers relating to Grid connection that none of which had yet been overcome (see figure 9.5). Those involved with these projects also expressed the difficulty which they found navigating the complex company structure of the DNO (Scottish Power), whilst others also discovered a sense of antipathy towards Grid connected renewables schemes in higher levels of the organisation.

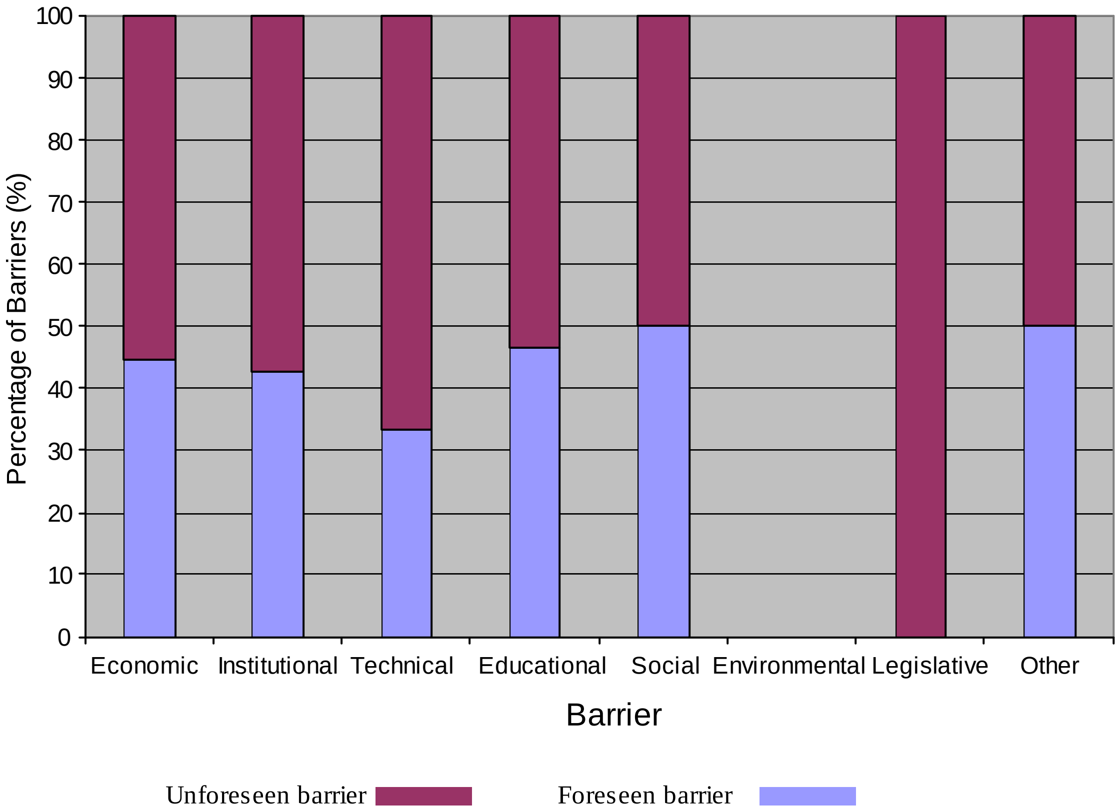

Fig 9.4:Comparison of barriers that were foreseen/unforeseen

Figure 9.4 shows the percentage of any specific barrier that is foreseen or unforeseen by those involved in the project. As can be seen, most barriers deviate around the underside of the halfway mark. The overall figure for barriers foreseen or not foreseen is: 58% - unforeseen, 42% foreseen (See figure 9.19).

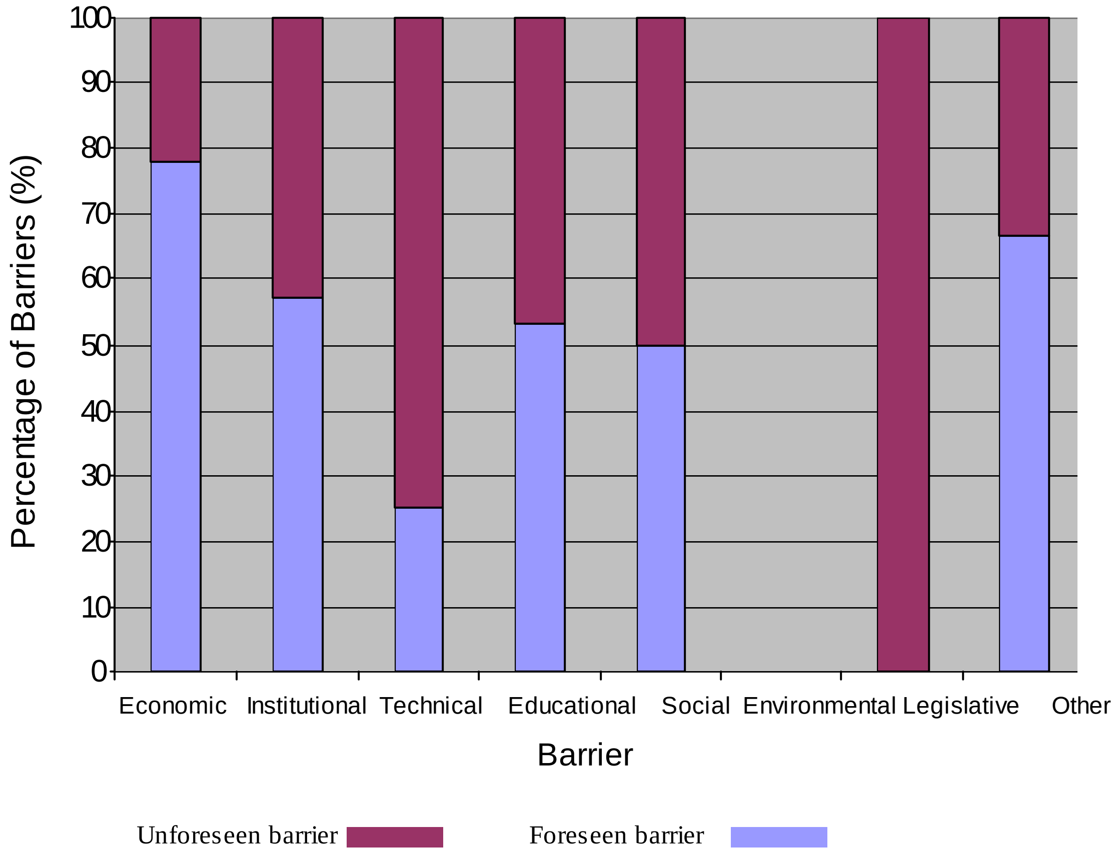

Fig 9.5: Comparison of Barriers that were overcome/not overcome

Figure 9.5 shows the percentage of any specific barrier category that is ‘overcome’ or ‘not overcome’ by those involved in the project. The distribution of barriers is more varied than that for barriers ‘foreseen’ or ‘unforeseen’. The overall figure for barriers overcome or not overcome is: 49% - not overcome, 51% overcome (See figure 9.18).

Legislative barriers are the least expected problem with 100% of them unforeseen. This could be due to the fact that legislative barriers only made up a small fraction (3%) of the total barriers (See figure 9.18). Another reason could be that almost all the relevant legislation referred to is that which is necessary for Grid connection (G77, G83, etc.). This legislation then may only be addressed once the project reaches the stages of the 2^{nd} and 3^{rd} phase where Grid connection is necessary so only identified as a barrier at this point. The fact that all the problems related to legislative barriers were unforeseen maybe explains why none of the issues were overcome (or had not been overcome at the time of interview).

33% of technical barriers are foreseen while 67% of them are unforeseen. This is the next most unpredicted obstacle after legislative barriers. Reasoning for this could be that due to the relative immaturity of the technology and lack of experience of those involved, many of the projects fulfilling a pioneering role. As technical issues are closely linked to educational ones, and because educational barriers make up the share of overall barriers (almost 25% - See figure 9.18), much of the educational issues (lack of training schemes, no best practice) could culminate as technical problems. Again, a barrier category with a high number of obstacles unforeseen has a high number of barriers not overcome (3/4 not overcome) perhaps showing a correlation between the two.

43% of institutional barriers are foreseen while 57% of them are unforeseen so this is the next most unidentified group of barriers. Again, because of Grid issues this probably features as one of the larger least expected barrier categories. However, despite this fact the majority of institutional barriers were overcome (almost 60%). A reason for this could be that schemes that opt for Grid connection rely upon the ROCs producing an income to help produce a more favourable economic case for the technologies employed. It could also be that the majority of schemes choosing Grid connection are social housing groups who possess the resources along with the commitment to ensure the completion of any project.

44.5% of economic barriers are foreseen while 55.5% of them are unforeseen. This was quite an unexpected position for economic barriers to come as it might be expected that most economic issues will have been made be relatively transparent due to the amount of interest and investment in this sector by the government and other organisations. However, it may be that due to the lack of knowledge of later issues regarding maintenance and repairs that leads to the uncertainty over certain costs. Despite the fact that the majority of economic barriers are still unexpected, almost 80% of these barriers are overcome (the most out of any barrier category). This could be a testament to the high availability of grants for certain technologies with this factor crucial in ensuring the majority of these obstacles (whether unforeseen or not) are overcome.

47% of educational barriers are foreseen while 53% of them are unforeseen. This particular barrier category encompasses obstacles such as lack of trained personnel, absence of best practice, or no official certification scheme for the industry. By less than half of these total barriers proving to be unexpected it shows that this is something that these issues are not well known by most individuals who decide that BIRs should be incorporated into their building. This figure is reversed for the issue of barriers being overcome with 47% of barriers not being overcome while a majority of 53% are overcome. This seems to go against the theory that if barriers are foreseen then this makes it easier for them to be overcome.

50% of social barriers are foreseen while 50% of them are unforeseen. The reason for this 50:50 split may be due to the low overall percentage of social barriers encountered – second least encountered specific barrier with fewer than 10% (See figure 9.18). The ratio for social barriers 'overcome' to 'not overcome' is again split evenly and could show that this is due to the low number of overall social barriers encountered.

Again, there was a lack of any suggested environmental barriers.

Among the barriers classified under 'Other' were those that referred to " Political Barriers" , barriers that mentioned a difficulty in obtaining the necessary equipment, along with other barriers that were difficult to categorise under one heading. 'Other' barriers represented a relatively small proportion (7%) of the overall total number of barriers (See figure 9.18) so this could be the reason for the even distribution. Two-thirds of the 'Other' barriers were overcome which was a surprising result given that it might have been expected that less well-known barriers may have proved more difficult to conquer.

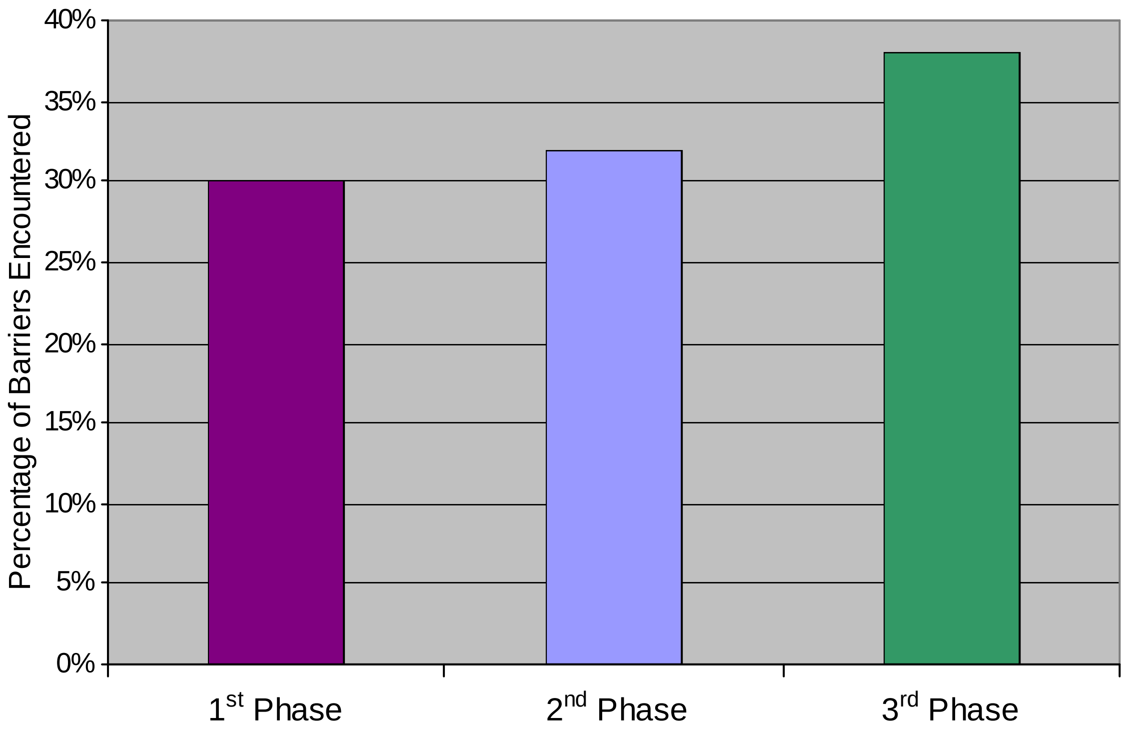

Fig 9.6: Barriers Present at each stage

Figure 9.6 shows the percentage of total barriers encountered at each phase of a project involving BIRs. As can be seen, the split is fairly even with barriers encountered at the first stage encompassing 30% of the total number of barriers; 32% of the total number of barriers taking place in the 2nd phase; while 38% of all the barriers existed in the 3rd phase. This was contrary to what might have been expected, where one particular phase might have proved exceptionally that it required the most attention as far as removing barriers.

By looking at figure 9.1, it can be seen that while the first and second stages do vary a lot with regards to how each specific barrier appears in them, a consistently high number of every barrier does occur in the 3rd phase. Out of all the stages of a BIR development, the third phase has obviously received the most attention so far in the form or grants and funding. By focussing more attention on removing the barriers from the second phase (i.e. construction, installation, connection to the Grid, etc.) a greater impact could be felt as this stage can determine the success of the third phase.

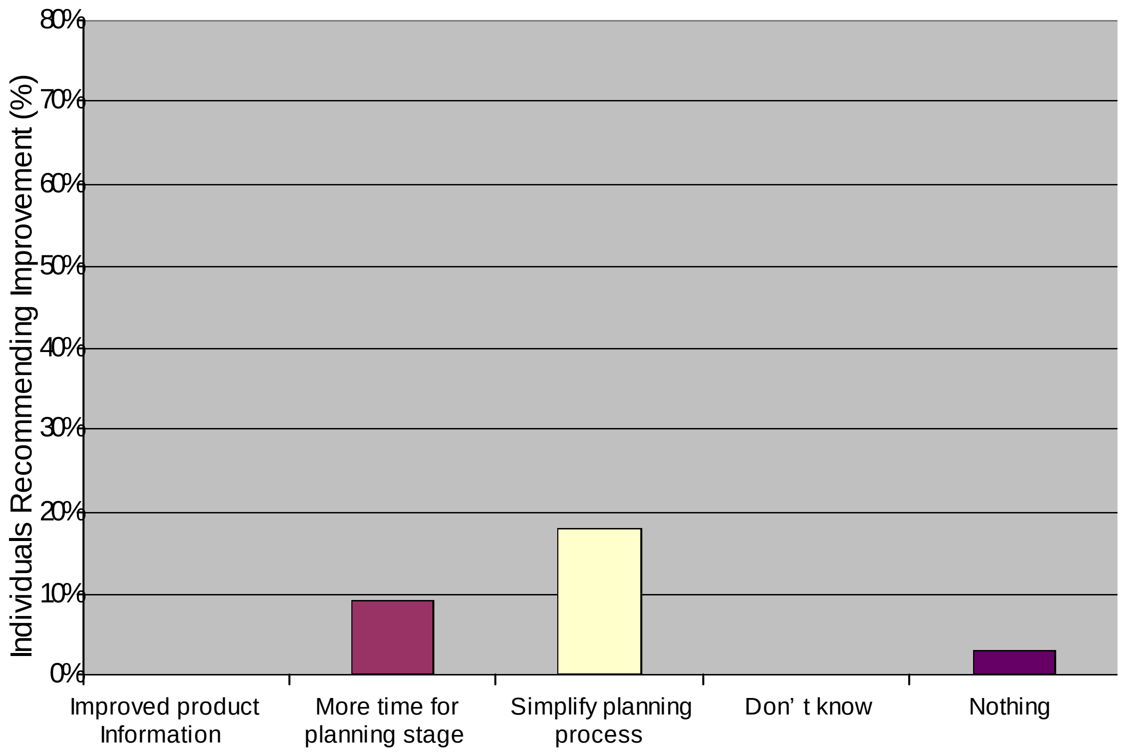

Fig 9.7: Recommended Improvements (low) Part I

Figure 9.7 shows the percentage of individuals that feel certain improvements should be made to better the current experience of BIRs. Figure 9.7 is the first section out of three (figure 9.7, 9.8 & 9.9) that makes up the entire list of improvements. It represents the improvements that were chosen with a low frequency.

None of the individuals felt that improved product information would better the BIR process. 9% of individuals felt that it would be an improvement to allow more time for the planning stage which is relatively low for an institutional barrier (11% of all barriers). Twice as many (18%) felt that by simplifying the planning process an improvement would have been made which again is classed as an institutional barrier. All of the individuals were able to identify some improvements they would like to see introduced. Only 3% felt that there was no action that could be taken to improve the process.

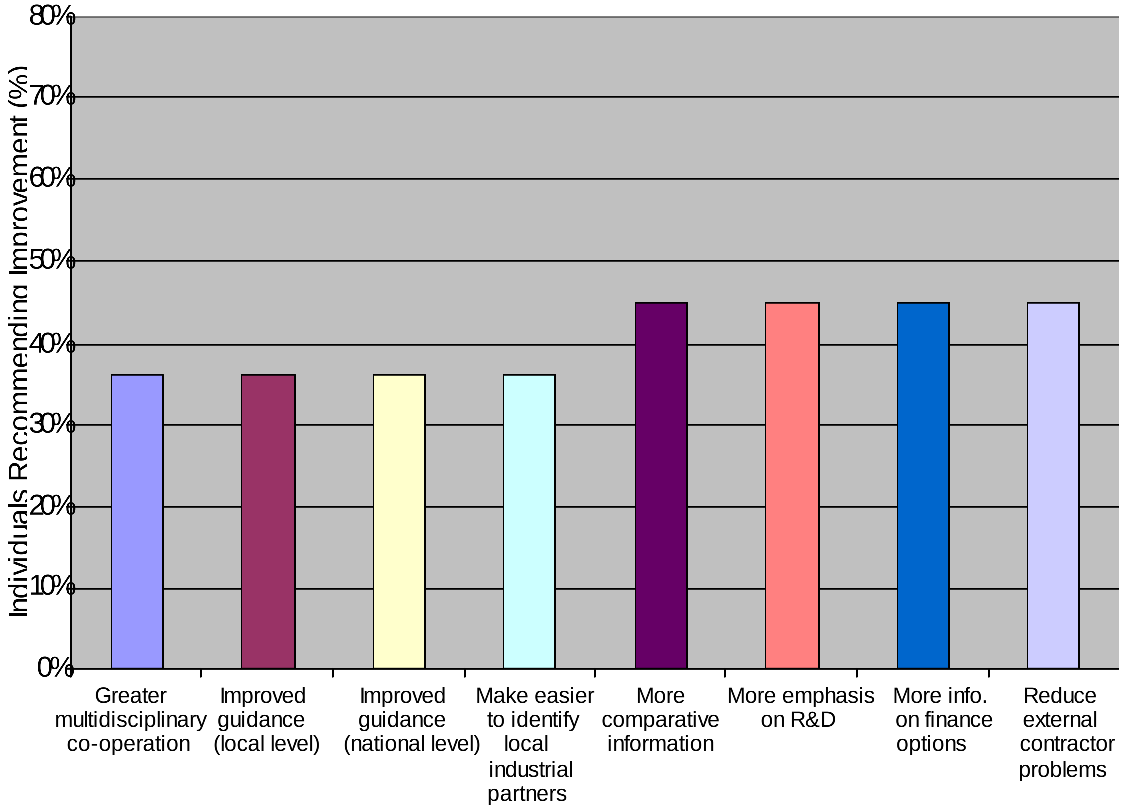

Fig 9.8: Recommended Improvements (medium) Part II

Figure 9.8 shows the percentage of individuals that feel certain improvements should be made to better the current experience of BIRs. Figure 9.8 is the second section out of three (figure 9.7, 9.8 & 9.9) that makes up the entire list of improvements. It represents the improvements that were chosen with a medium frequency.

Over a third (36%) of individuals felt that an improvement they would like to see was one of greater multidisciplinary interaction. It is slightly surprising as it belongs under the Educational barrier category (the most prominent barrier category) and might have been expected to have been recommended by more individuals. The same amount felt that they would like to see improved guidance at local level while 36% also felt that they would like to see improved guidance at national level showing little distinction between the two. The same amount also felt that they would like it to be easier to identify local industrial partners. 45% wanted more comparative information available on the various technologies which as a technical issue might also have been expected to be have recommended by more. The same amount felt that there should be more of an emphasis on research and development. 45% also wanted more information available on the different finance options which may show that the majority of those interviewed were fairly well informed about the financial side of matters relating to BIRs. The same number felt that they would like to see fewer external contractor problems which shows that more than half of the projects did not experience personnel problems.

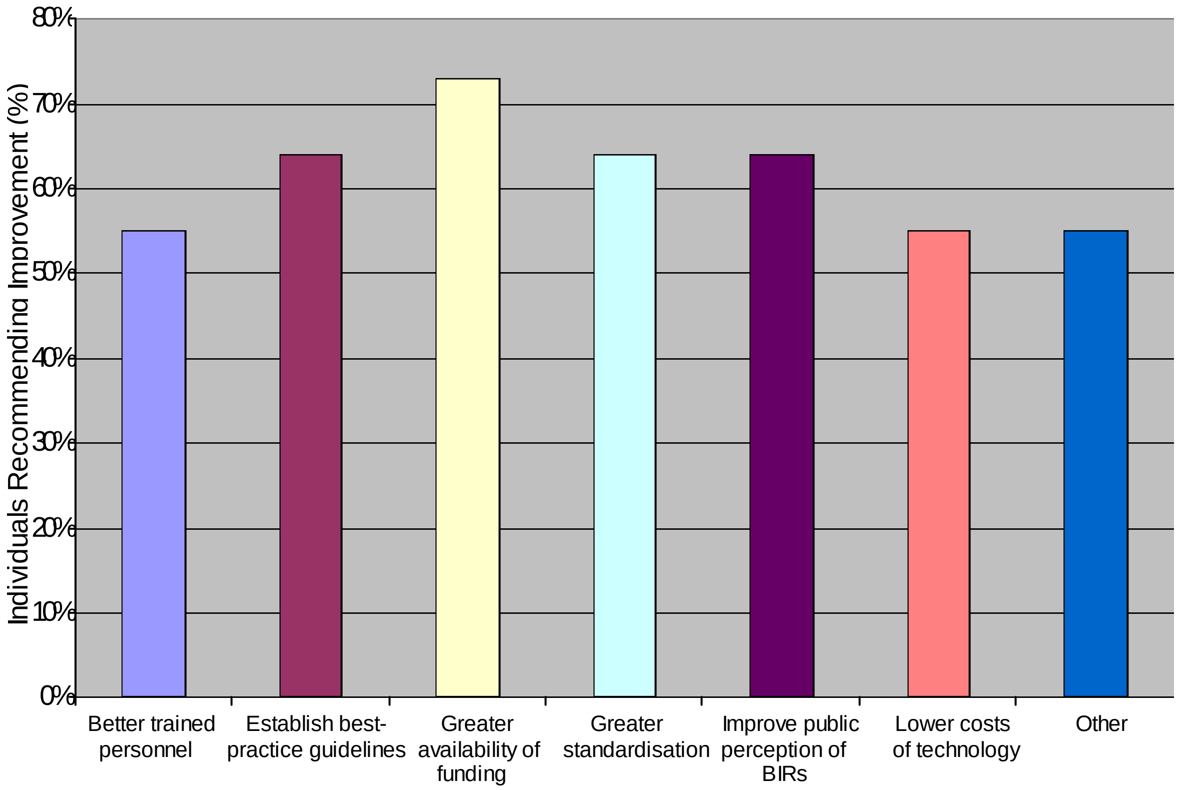

Fig 9.9: Recommended Improvements (high) Part III

Figure 9.9 shows the percentage of individuals that feel certain improvements should be made to better the current experience of BIRs. Figure 9.9 is the third section out of three (figure 9.7, 9.8 & 9.9) that makes up the entire list of improvements. It represents the improvements that were chosen with a high frequency.

55% of individuals' felt that they would like to see better-trained personnel, which as an educational barrier (almost a quarter of all barriers) is recommended by a number that one might expect. Almost two-thirds (64%) would like to see best practice guidelines established and available which is also an educational barrier. 73% of those interviewed felt that there should be greater availability of funding which as an economic barrier and third most abundant of all barriers (14%). It is also the improvement that most people would like to see happen and is maybe not all that slightly surprising even considering the amount of funding available (though it is obviously not enough). 64% would like to see greater standardisation occurring with regards to building integrated renewables technology. The same amount felt that they would like to see the public's perception of BIRs improve which is surprising given that social barriers' were among the least common barriers to be encountered (under 10%). 55% wanted to see the costs of BIRs technology lower which was a figure perhaps expected given the high emphasis on the issue of cost. The same number of people (55%) felt that there were other things not on the list that could be done to improve the overall process of integrating renewables into buildings. Among these included:

?? Increase ease of negotiating with electricity providers with regards to grid connection

?? Provide a BIRs guide which offers unbiased, up-to-date information on all the technologies

?? More consideration must be given to the user-friendliness of the systems at the demand side

?? Integrated RE systems should be sold as complete packages

?? More specialist companies starting out as 'installer' but then retreating to a role as 'provider'

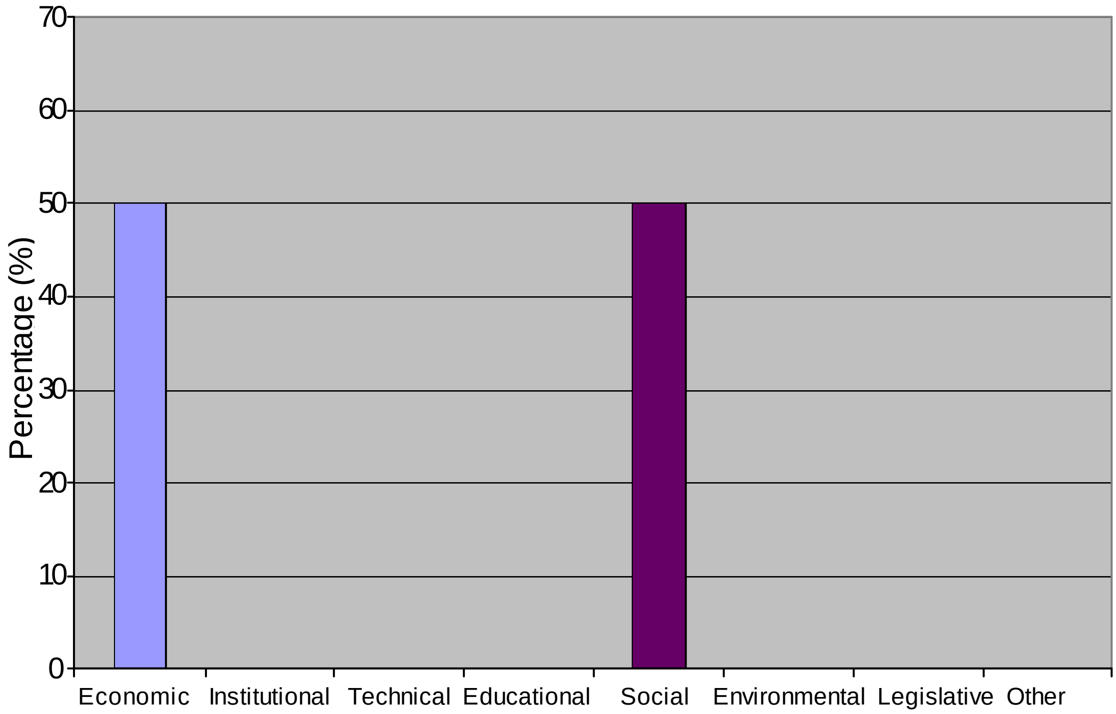

Fig 9.10 Barriers that are specific to Biomass projects

Figure 9.10 shows the barriers that are specific to projects that have involved biomass. As can be seen, the barriers are divided equally between economic barriers and social barriers. This could be a result of the low number of biomass projects included in the study, of which only 3% of the total number of projects included biomass installations.

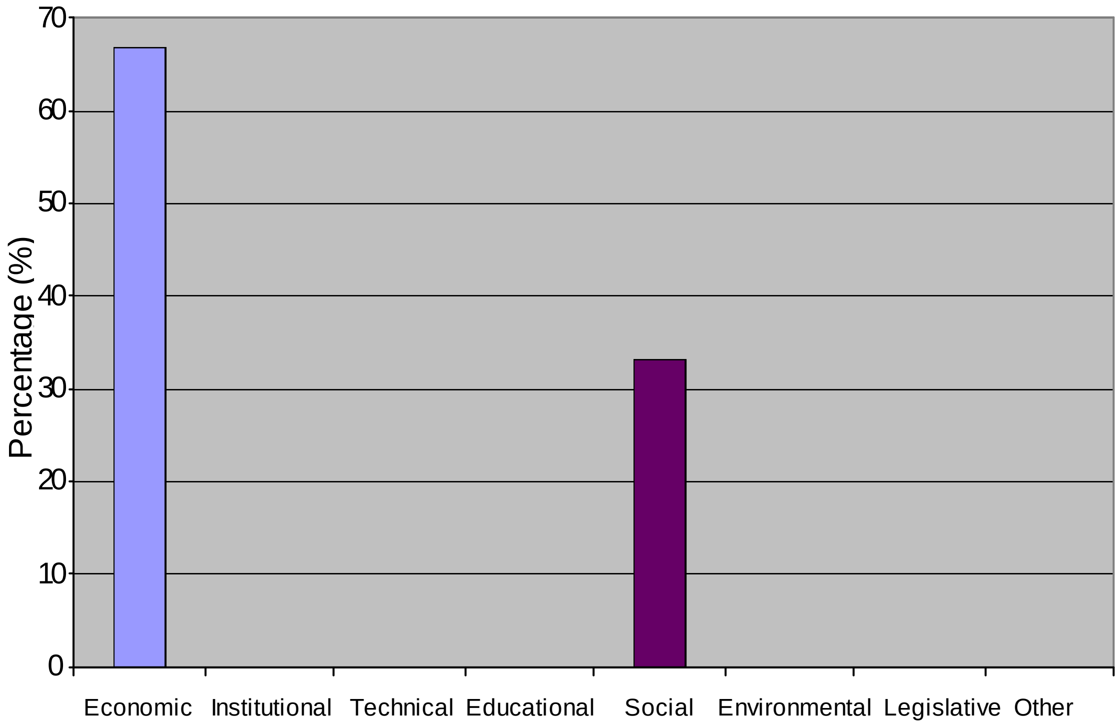

Fig 9.11 Barriers that are specific to CHP

Figure 9.11 shows the barriers that have been identified as being specific to CHP projects. The majority of obstacles for this type of installation are economic, while a third are related to social issues. However, CHP did account for only 4% of the total projects questioned about so this could account for the low distribution of barriers.

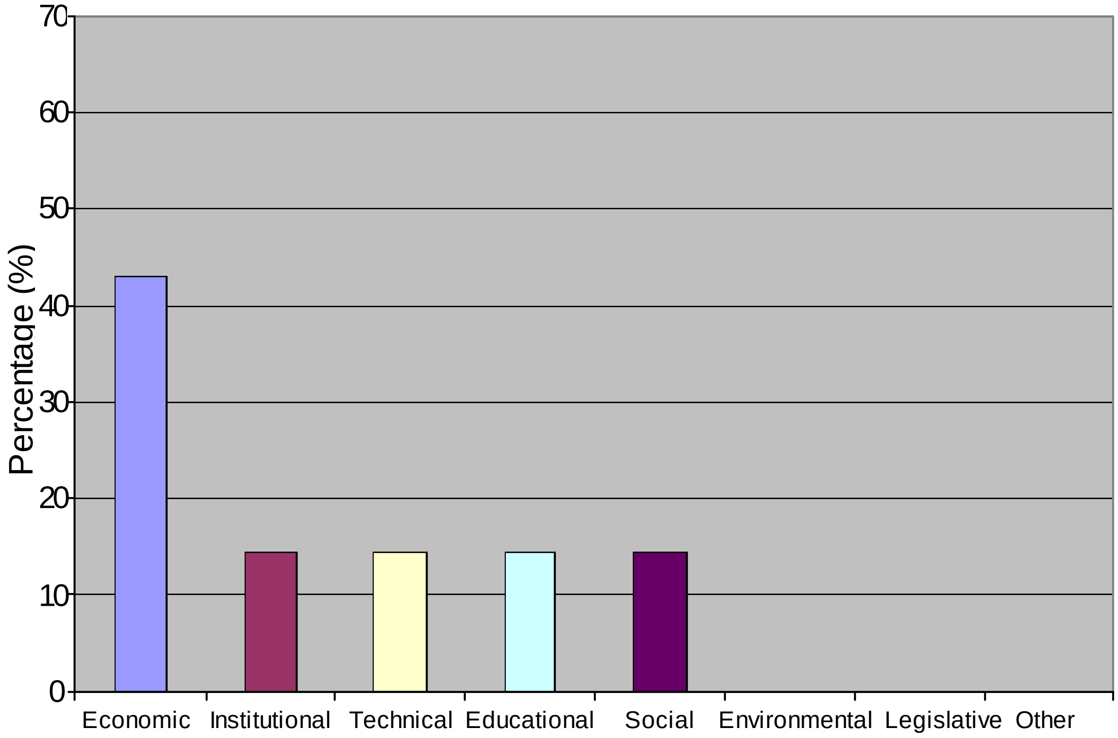

Fig 9.12 Barriers that are specific to Geothermal

Figure 9.12 represents all those barriers that are likely to occur during a project encompassing geothermal technology. Economic is the most experienced obstacle with over 40% of the total number of barriers relating to these issues. Institutional, technical, educational and social barriers are then all equal on almost 15% each.

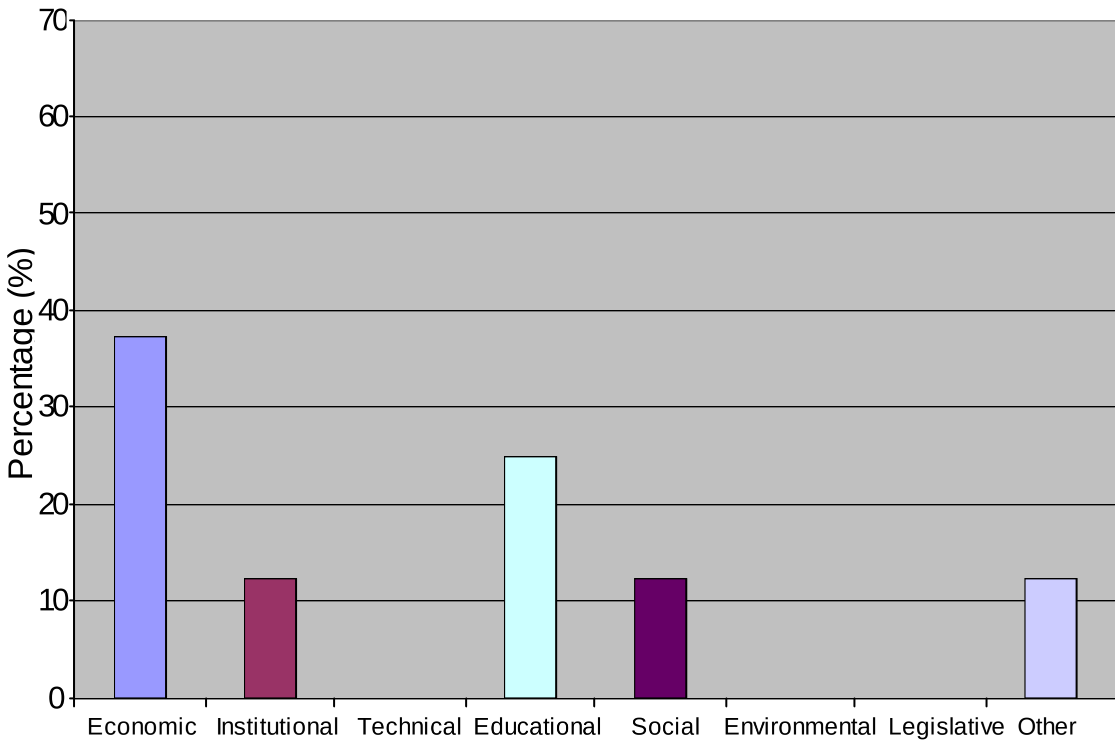

Fig 9.13 Barriers that are specific to Passive Solar

Figure 9.13 represents all those barriers that are likely to occur when employing passive solar technology. The distribution of barrier is quite even although economic barriers are the most abundant at almost 40%. Educational barriers are the next most prominent with a quarter of all obstacles experienced in passive solar projects relating to these. Institutional, social and ‘other’ barriers are all quite even with an eighth of the total number of barriers each

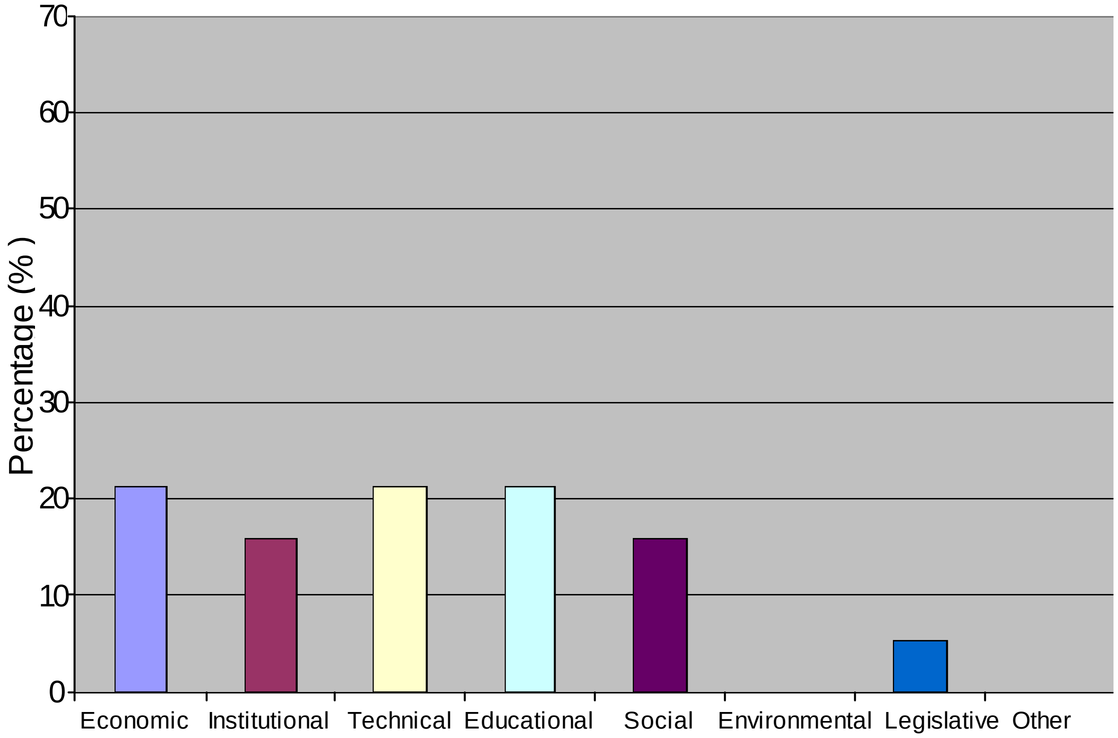

Fig 9.14 Barriers that are specific to PV

Figure 9.14 shows the type of barriers that are likely to occur when using PV technology integrated into buildings. As can be seen from the chart there is quite an even spread of barriers for PV. Around a fifth of overall PV barriers belong to the economic, technical and educational category. Around 15% of the barriers belong to those associated with institutional and social obstacles. Only 5% of PV barriers are legislative.

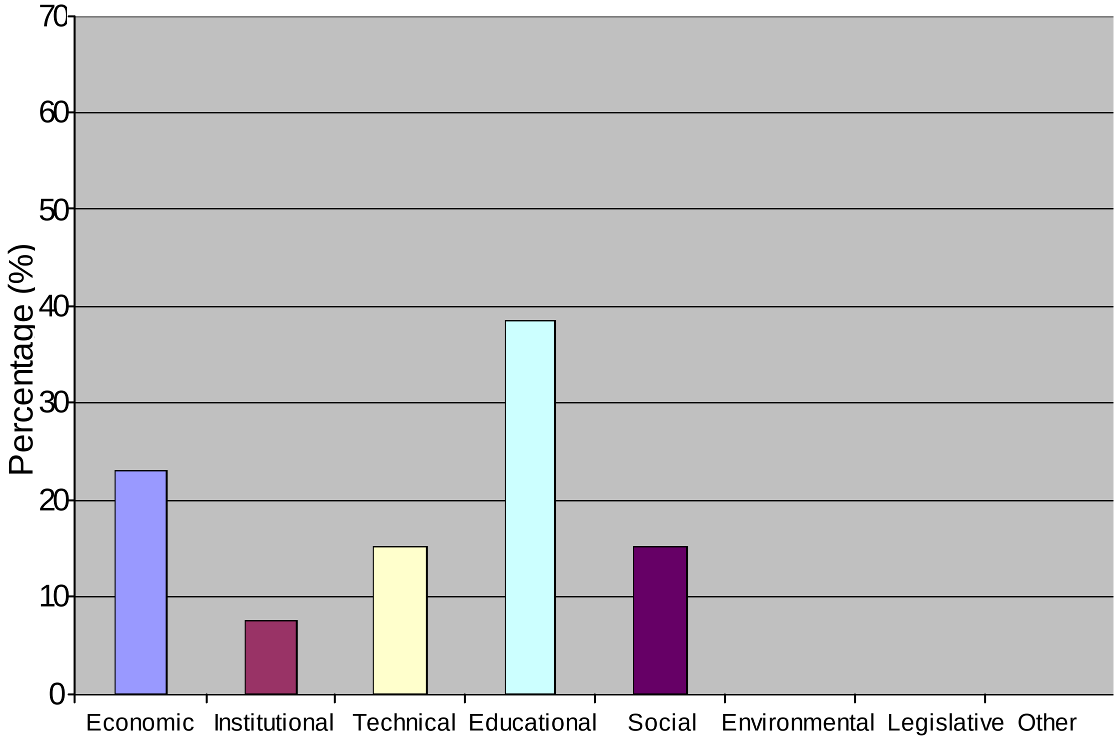

Fig 9.15 Barriers that are specific to Wind

Figure 9.15 represents barriers that are specific to wind power when integrated into buildings. Educational barriers are the most prominent type of barrier for this technology with almost 40% of the total. Economic barriers are the next most prolific with over 20% of the total. At over 15% of the total number of barriers, technical and social barriers both share this figure. Institutional barriers represent about 8% of the total number of barriers for wind power

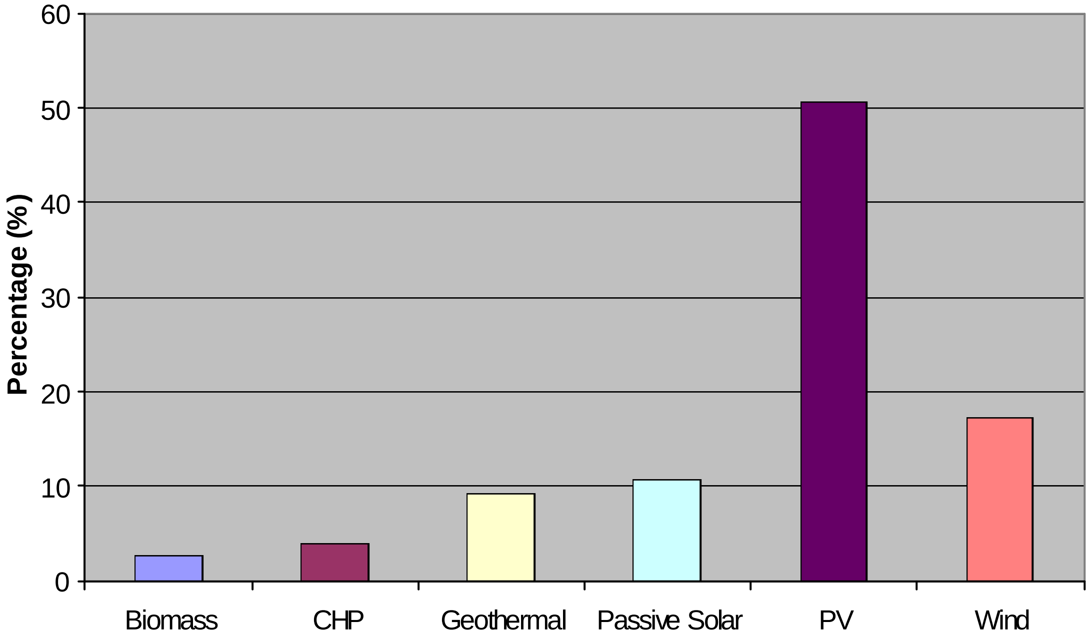

Fig 9.16: Total Barriers per Technology

Figure 9.16 shows how the total number of barriers were distributed between the different technologies. PV accounted for the vast majority (over 50%) of the barriers and this maybe accounts for more detailed information where PV is concerned while also being involved in the greatest number of projects (See figure 9.2). Wind then had the most barriers with almost a fifth of all barriers existing under this BIR technology. Passive solar then had just over 10% of all barriers. Geothermal had just under 10% of all barriers. CHP had around 3% of the total number of barriers. While Hydro, natural ventilation and biomass all had 3% of overall barriers.

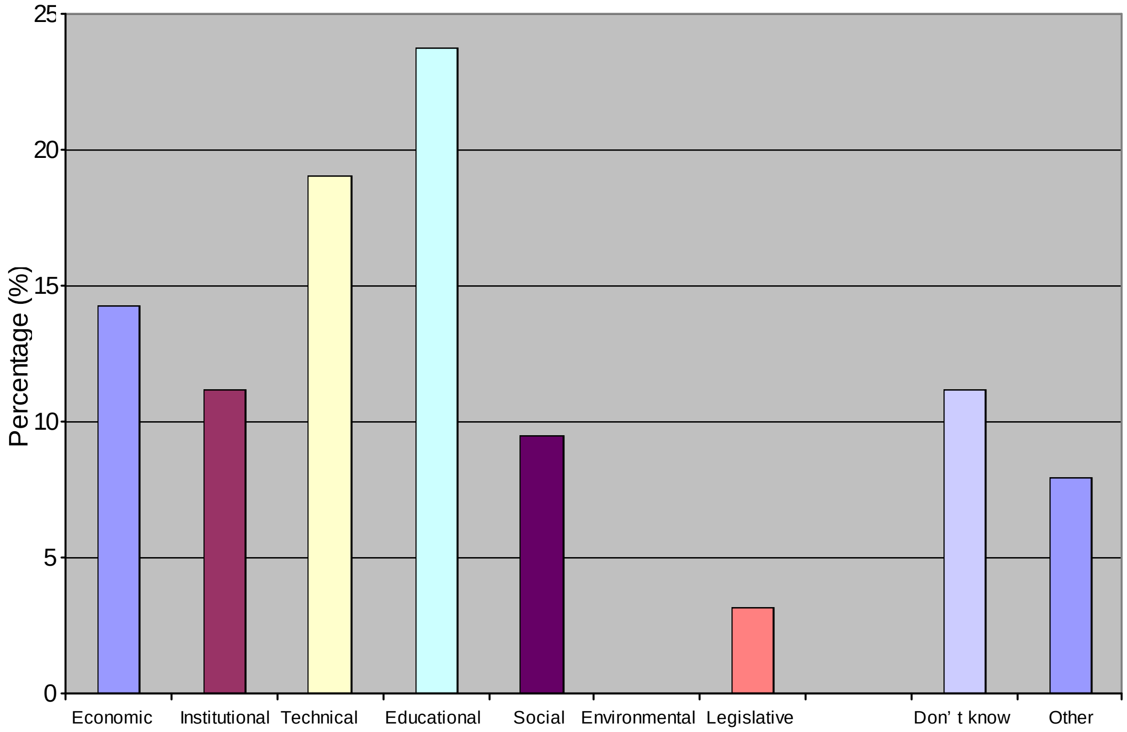

Fig 9.17: Barriers as a percentage of total

Figure 9.17 shows each barrier category as a percentage of the total number of barriers. Educational barriers are the most prolific with almost a quarter of all barriers being an educational one. This is followed closely by technical barriers which accounts for almost 20% of all barriers. Economic barriers then account for around 14% of the total number of barriers. Social barriers represent just under 10% of the total number of barriers for BIRs. Legislative barriers account for the smallest number of barriers with around 3% of the total number of barriers identified. Around 11% of individuals were not aware of what barriers had existed or were going to exist. 8% knew of other barriers which did not come under the classification system suggested or were a combination of several which could not be singled down to one attribute.

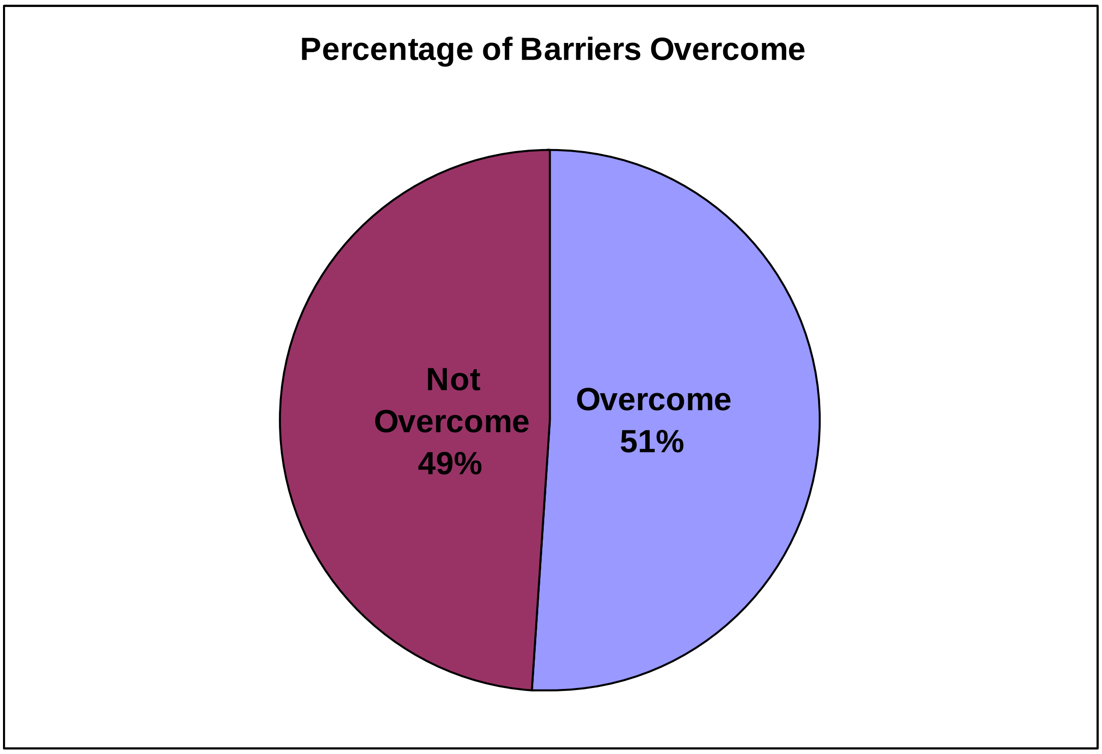

Fig 9.18: Overall Barriers overcome/not overcome

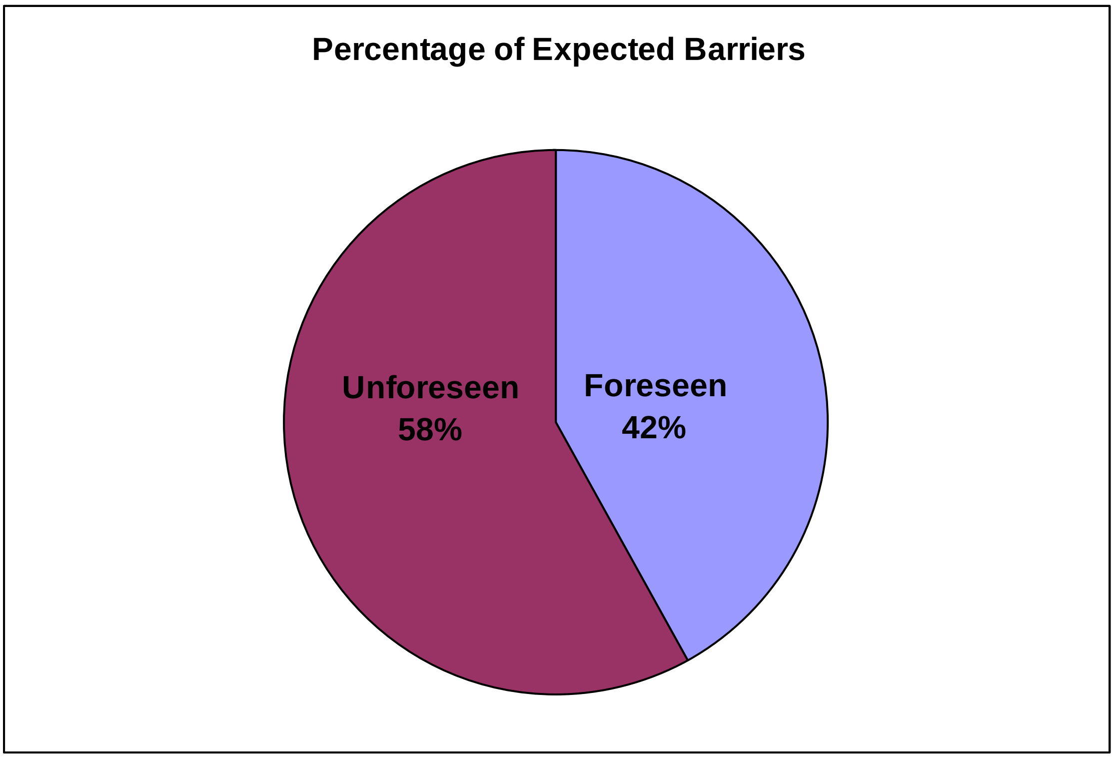

Fig 9.19: Overall Barriers foreseen/not foreseen

9.2 Comments - 'Further Recommendation'

The final question on the questionnaire asked: *"Which of the following measures could be implemented to improve the overall (BIRs) process?"* It was made up of a list of potential improvements that had been mentioned in previous literature with regards to BIRs or renewables in general. Interviewees were allowed to read the list which contained around twenty options and comment on the ones they thought were most relevant to their role. However, they were also given the opportunity to comment on each one if they so chose (and many of them did). This resulted in quite a detailed picture of not just what's negative (e.g. need for greater standardisation) about the process of incorporating BIRs in Scotland but also what's positive about it (e.g. ease of planning).

'*High priority'* refers to those improvements which 60% to 100% of individuals recommended. These are discussed first and represent improvements that would have the greatest positive effect on the development of BIRs in Scotland.

'*Medium priority'* refers to those improvements which 30% to 59% of individuals recommended. These are discussed second and represent improvements that would have a more moderate positive impact on the development of BIRs in Scotland.

'*Low priority*' refers to those improvements which 0% to 29% of individuals recommended. These are discussed last and represent improvements which would have less of a substantial positive impact on the development of BIRs in Scotland

9.2.1 Greater funding (high recommendation)

This was the most highly recommended improvement and displays how given all the funding, there is perhaps a disparity between the amount of funding different technologies receive. This shows how despite the fact that the majority of projects received some form of funding, it was obviously not sufficient to plug the financial gap that still exists.

9.2.2 *Greater standardisation* – (high recommendation)

This is a recommendation that appeared surprisingly high on the list for improvements. One of the problems encountered was with a roof solar collector which was made to a standard size. It was then the roof size that had to be altered to make fit. Another example was where certain components had to be manufactured by a university which raised issues of insurance over the installed system. Also, where components had to be attained individually and from various sources, time was added to the projects development. However, it was noted when the same individual was undertaking a similar project it was easy to know where to get everything.

The general opinion off bespoke or one off systems is that they are more expensive and potentially more problematic. It would be more favourable to see entire systems for sale as a package. This would include perhaps consultation, parts, installation, maintenance contract, and insurance sold as a package, or at least available as an option. A streamlining of the whole process would be the goal in this case.

9.2.3 *Establish best practice* (high recommendation)

Many felt that best practice guidelines were what was missing for BIRs. A number of guides were recommended by those involved in social housing who felt that this was not an issue and good best practice guides did exist:

?? 'Energy Saving Trust' (Case Studies)
?? 'Communities Scotland' (Best Practice Guide)

It is essential though that good practice guides, case studies, tool kits, and worked examples exist but even more so that they are disseminated effectively among everyone to ensure access for everyone.

For more information go to:
www.energysavingstrust.co.uk/housingfunding/casestudies.cfm
www.communitiesscotland.gov.uk or Tel: (01292) 611810

9.2.4 *Public perception* (high recommendation)

Conversely, public perception appears high up on the list of recommended improvements but its barrier category (social barrier) is one of the least encountered barriers out of them all (less than 10% - See figure 9.17). This could be due to the interviewees feeling that while public attitudes are important, they do not pose a specific barrier – as is the case with larger projects in rural areas (i.e. windfarms). Most of the public perception issues were issues related to user-familiarity, user-friendliness, and traditionally ingrained behaviour like opening windows when it was too hot, rather than turning the heating down.

9.2.5 Lower costs (high recommendation)

'Lowering the cost' was expected to be high on the list of recommended improvements as it is widely known that an economic gap still exists for many of the technologies that needs plugged with some form of grant, loan, etc. Many of those interviewed were fairly confident prices would eventually fall but would like see more stimulus for the UK manufacturing market when it comes to BIRs. Again, the best way to achieve this is to increase demand which can be achieved by making more funding options open. Some of the interviewees were only considering PV installations under the Domestic Field Trials because of 100% funding and wouldn't be considering them otherwise. Trials of this sort are required for other technologies, perhaps running successively but with a timetable allowing projects to plan in advance and plan with future integration in mind.

9.2.6 *Better-trained personne*l (high recommendation)

Many felt that having better-trained personnel was an important issue even though a lot of the issues with personnel were related to attitude issues towards the technology and the experimental nature of it. It was felt more choice and perhaps the creation of apprenticeship schemes would have been useful. One method which seemed effective was with one particular company that specialised in one of the technologies. They began as installer but then " retreated" to becoming the provider, training local companies to do the installations themselves. This aided in expanding the knowledge base and is a good model for other companies to follow. The first company's fee would not be compromised, as it would still operate on a consultation basis whilst expanding the technology's application.

9.2.7 Finance options (medium recommendation)

Although information on finance options appeared to be quite available, many felt that more information was needed. More up-to-date information and greater awareness of the options among those not necessarily considering BIR projects is probably the priority. A leaf should be taken out the book of Housing Association managers who seem to have little trouble with options and their understanding. However, this is easier because they have trained individuals with their job focussed on fund raising as well as with support structures in place.

9.2.8 *Comparative information* (medium recommendation)

An unbiased comparative guide to all the available technologies equivalent to a 'WHICH? Guide' was suggested as a way of providing more comparative information on technologies. A need for more developments where different technologies can be trialed under similar conditions then compared was also desired. A selection of criteria that could rate a property on which BIR technologies would be best employed could be a useful and simple way of determining a property's suitability before making any concrete measures.

9.2.9 Grid connection (medium recommendation)

There were a number of concerns made regarding interaction with the electricity companies. For many projects, grid-connection is essential and one of the key reasons for choosing BIRs. It features as one of the main ways of achieving economic feasibility for some projects (via ROCs) but for some has served as an additional stumbling block. A lack of clarity with the local DNO was cited as an issue with some projects as well as a general need for more responsibility towards the energy market. A gap was found in the area for strategic support from the electrical companies. While this was apparently due to " a lack of understanding" on their part, it must be said that more support should be offered from the DNOs. A wide level of understanding with regards to grid-connection can obviously not be achieved immediately and effortlessly from those not directly involved with the electricity industry. A form of assistance could easily be offered by DNOs to new projects wishing for Grid connection as part of an introductory guide. Then, the dissemination of information would be rapidly increased. Perhaps the electricity industry is relying upon meeting their renewables obligation through large-scale generation, without having to be concerned with meeting it via embedded generation.

9.2.10 *Reduce external contractor problems* (medium recommendation)

As with any normal construction project there is inevitably going to be external contractor problems but Bahaj (2001) named this as a serious barrier to a PV cladding project in Southampton. As BIRs projects are a marriage between the renewable energy industry and the construction industry (among many others), there is going to be essentially a "cross-pollination" of problems where each sector will experience difficulties usually associated with one another's trade. Those behind the renewable energy side may have problems with contractors, materials, the rewiring of electrics and structural problems; those behind the construction side may have problems with the new materials, lack of experience, new practices, and precise instrumentation. This highlights the need for multidisciplinary co-operation from the start.

One project that did not experience any contractor problems was a group that negotiated a partner in procurement with the contractor, so they were involved from the start of the design process. This method was described as “wholly non-conflict” and could be a way of minimising the risk of external contractor problems.

9.2.11 More R&D emphasis – (medium recommendation)

This seems to be an improvement that many feel is not a priority but they feel that if it does bring cost down then it is an attractive proposition.

9.2.12 *Easier to identify local partners* (medium recommendation)

This is perhaps an issue with some projects as there is no obvious place to go to find suppliers, tradesman, or other local industrial partners that may be sympathetic to the needs of a new BIR project.
Clients are unable to choose whom they want as supplier or a subcontractor as this choice belongs to the contractor. This is because if a client was able to choose and they failed to meet the contractors’ expectations, then it would be the client that would be liable. The contractor would be able to refrain from further work until any other problems were sorted out and not be held to account for any delays. Housing associations tend to partner with their contractors for periods of 10 years. It is then ensured in the drawing up of the contracts that all expectations are outlined with regards to the emphasis on sustainability.
In one project, a test-bed of 5 houses was created before the main project. This ensured that for the main phase of the project all contacts had been established and had been tried and tested.
However, not all projects will be able to sign extended exclusive contracts with their preferred contractor citing who they want as suppliers or subcontractors, or build test-beds prior to the main project to ensure all contacts are in place. However, these two solutions have to be combined and scaled down to form a solution that could benefit the average project. Some of the interviewees spoke of the assistance of the ‘Solar Association'' and the PV Domestic Field

Trials in providing industrial contacts (whether local or not). Unfortunately, organisations specialising in one of the renewables is do not exist for every technology, while the same is true for large national demonstration programmes. However, the same effect could be achieved on the local scale by creating a consortium of those who have worked in the past on BIR projects within a local council's jurisdiction. Glasgow City Council have used a " Sustainability Briefing Note" that attempts " to formulate sustainable solutions" during the planning stage of certain building projects. Using established contractors who understand these issues and have experience of working with these developments is crucial, as is giving access of their names and companies to new projects that propose BIRs. A sustainability briefing note should be adopted for all building projects in Scotland. This would at least ensure that every proposed development had at least considered BIRs as an option whilst being offered the necessary means of applying them.

9.2.13 *Multidisciplinary co-operation* (medium recommendation)

Increased multidisciplinary co-operation is an improvement that features slightly lower than might be expected. However, a quite clear correlation was seen between those projects that said they had fewer problems with those projects that also boasted a wide degree of multidisciplinary interaction. It seems that a high level of multidisciplinary interaction should be a prerequisite for BIR projects, at least at this stage of their development. Currently, individuals of certain trades are working with members of other occupations, maybe for the first time in their life/career. However, this barrier must be crossed, as it is important for the initial development of BIRs that interaction occurs until such cross-disciplinary skills are learnt to a sufficient standard.

9.2.14 *Improved guidance at local level* (medium recommendation)

This was a relatively popular choice for an improvement. Those that said it was not a problem felt that it was simply " a case of knowing where to get it" . Incidentally, that place was local universities and it would seem that those that did consult a university, tended to not feel that they were in need of local guidance.

9.2.15 *Improved guidance at a national level* (medium recommendation)

Improved guidance at a national and local level were equal on the number of recommendations they each received. However, some felt that guidance at national level was unnecessary if it is provided for at a local level. It was recommended that national level is where best-practice is best disseminated from.

9.2.16 Make planning simpler (low recommendation)

Most planners and councils were happy and some cases "thrilled" with prospect of new BIR projects and are supportive. 'More understanding' was suggested as a requirement and with the case of G77 it is maybe a valid concern. Planning is a necessary requirement and treating BIRs as an exception and loosening the planning restrictions would be more detrimental than beneficial for the industry.

9.2.17 *More time for planning stage* (low recommendation)

Again it was generally felt that the planning process was quite adept and if a commitment is made then time can be made for planning.

9.2.18 *Improved product information* (low recommendation)

Improving product information is a problem that obviously does not affect a lot of projects (0%) and is a good sign. However, one project did find that they were surprised by the cost of the meters; there was also uncertainty over which panels, switch-gear, and inverters over which were the best ones to use. In addition, information monitors intended for residents of social housing with a PV installation proved difficult to understand and they felt simpler monitors would be a benefit. This situation would perhaps improve as time progresses and the technology matures and user-friendliness starts to feature more.

10.0 CONCLUSIONS & DISCUSSION

10.1 Discussion

During the undertaking of the project, it felt remarkably separated into two distinct sections: the impression of the BIR process before the interviews and the impression of the BIR process after. Even though there was a sufficient amount of information of past projects to draw on, many of those experiences seemed quite different from those that were discussed during the completion of the questionnaires. There were of course similarities but perhaps the feelings of frustration were far better communicated in person than on paper. This frustration exists because BIRs can work well in Scotland and this was proved many times over by talking to those involved with what is essentially pioneering work. The technology in many cases is mature and extremely competent but requiring cost reductions. However, there are many aspects of integrating renewables into a building that are not mature, like the installation, the guidance, the standardisation, the comparative information, to name a few.

A stark contrast was also noticed between the situation that exists for BIRs and that for larger-scale renewables (e.g. windfarms). While the latter suffers from issues related to environmental and planning barriers, for BIRs these obstacles are virtually obsolete. However, BIRs require a far greater degree of multidisciplinary co-operation than conventional renewables. Integration is not just required from the renewables but also from those involved in every sphere of interaction.

A questionnaire was a useful tool in the gathering of the information that was required although it would have been preferable to have carried out a wider survey involving more individuals. Due to the relatively small number of BIR projects in Scotland any form of statistical analysis was discounted from the start. To have widened the horizons of the study would have detracted from the reasons for using an interview method in the first place. However, given more time and resources a detailed picture of the BIR process could be assembled for the whole of the UK. This could give useful information on perhaps area specific barriers (e.g. skill shortages), while allowing the expansion of effective measures for removing BIRs barriers in general.

10.2 Conclusions

Using BIRs is a dynamic way of achieving a variety of goals that may be relevant to an individual, a community, a social housing group, a business, a council, or a country. But integrating renewables into buildings has a dynamic set of problems associated with it also. While it is unrealistic to say that it would be possible to remove all the barriers that exist for BIRs, it is possible to identify as many as possible. When an obstacle is foreseen it can be avoided, or at the very least accommodated for.

Out of all the projects that encountered legislative problems, none of them predicted that it would be an issue. The legislative barriers being referred to in each case were all related to Grid connection. This highlights the need for greater awareness about the grid connection process with the intent to claim ROCs. It is currently a complicated process and far more difficult than may be perceived in the available literature. All legislative barriers encountered were as of the date-of-interview currently unsolved, although some of the projects had not yet been completed.
Almost 70% of the technical barriers that are encountered are unforeseen and this number needs to be reduced if BIRs are to develop more effectively. An increased awareness of the technical barriers that are likely to occur is needed if the likelihood of them being overcome is to be increased.
Educational and technical barriers are the first and second most common barriers respectively. Together they represent a greater proportion of the total barriers than any of the other barriers added together.

Those interviewed who had had experience with DNOs relating to grid connection felt that it should be made easier to negotiate with them. The information regarding grid connection should be made more available and the process more transparent as many think that it is a case of simply ‘plugging in’. The current electricity company structure is complex and makes it difficult to negotiate for organisations let alone individuals. This process needs more efficient streamlining if a higher number of projects are to be encouraged by grid connection.

Large domestic field trial similar to that of the one for PV should be planned and scheduled to run successively for other RE technologies. This would allow for building projects to design with the intent of integrating other BIRs in the future. This would encourage a more efficient and widespread use of the technology.

The availability of financing options for BIRs must be more available and should be considered by every proposed development in a document similar to a " Sustainability Briefing Note" as has been developed by Glasgow City Council. A " Sustainability Briefing Note" gives advice to developers about suitable glazing, heating, insulation, and the use of BIRs, etc. to increase the sustainability of a property.
More council's should embrace sustainability briefing notes of this kind while the information on integrating renewables in them should be expanded to contain contacts, suppliers, and a self-assessment tool for deciding if a particular development could benefit from certain BIRs. It should generally offer the maximum possible amount of guidance to make the process as easy as possible.
A 'Sustainability Briefing Note' of this kind should contain an expanded section on BIRs to highlight partners, contacts, consultants, potential pitfalls and generally offers the maximum possible amount of guidance to make the process as easy as possible.

There is a demand for a BIR guide equivalent to a 'WHICH?' publication which offers unbiased, up-to-date information on all the technologies. It should be able to assist experts and non-experts in making informed decisions about the most appropriate products and systems.

Many of the projects being encouraged to embrace BIRs are community projects or social housing groups. Where individuals are expected to interact with any of the instruments (e.g. reading meters, etc), consideration must be given to the user-friendliness of the systems. Industry or designers need to acknowledge this if these types of projects are to be encouraged to use BIRs as more than just a one off.

Integrated RE systems should be sold as all-encompassing packages with the option of having consultation, parts, installation, maintenance and insurance all sold as one. This would help in streamlining the process and allow greater access to the technology.

Regional apprenticeship or retraining schemes need to be established for those involved with the installation of BIRs. This could be effective in solving cross-boundary issues that are created by educational and technical barriers. More specialist companies need to follow the suit of companies like SolarCentury (www.solarcentury.com) who begin as ‘installer’ but then retreat to a role as ‘provider’, training local companies to complete installations.

The percentage of barriers encountered at each stage is roughly the same so it is not immediately clear which one needs the most attention. The first phase (planning, design, etc.) has obviously received the most attention already as funding and grants have been employed to assist this stage. This has been successful in encouraging more projects and ensuring more economic barriers are overcome. After that, it is perhaps the second phase (construction, installation, etc.) that needs the most attention, as this stage will decide how much of a success the third phase (maintenance, repairs) is. A project’s overall success will then be increased further if the project is up and running immediately and a minimum amount of follow up work is required, encouraging those involved to become involved again with BIRs.

10.3 Recommendations for those working with BIRs

Many of those who had worked on projects for the first time felt there was a huge learning curve and that should they partake in a project again it would be much easier for them. A large amount of useful information is therefore in existence but is generally not available except on an anecdotal basis.

It was therefore useful to tap into this wealth of knowledge to ensure that any information that can be of use in removing or dealing with barriers is noted.

For those who intend to work with BIRs there needs to be the more widespread use of good practice guides and case studies, while there should be greater availability of tool kits and worked examples.

Negotiating with contractors at the earliest possible opportunity so that they are involved in the design process. This option is not available to everyone but has been demonstrated as one way of minimising external contractor problems during the project.

Projects should feature as high a level as possible of multidisciplinary and interdisciplinary co-operation as a way of reducing potential barriers. Those projects that demonstrated the highest incidence of multidisciplinary and interdisciplinary co-operation experienced by far the fewest barriers.

Universities are a useful place for those involved with new BIRs projects if seeking guidance at a local level.

Half of all economic barriers are likely to happen in the initial stages of a project while a third of them are likely to occur in the stages after completion of a project. Budgets need take into account this fact and ensure there is sufficient capital in reserve.

10.4 Implications for sustainable development

By encouraging BIRs into the built environment there are many issues of sustainability which are inadvertently being addressed. It helps to expand the role of renewable energy within our energy system which offers cleaner and more efficient power. By harnessing renewables through their integration with buildings, it will contribute to a diminishing reliance upon resources that diminish faster than they can be generated. It can help households that need to spend 10% of their income or more on fuel bills to alleviate the issues related to fuel poverty; increasing their quality of life, improving their health, and ensuring the wider costs do not get imposed on their communities.

BIRs can contribute towards greater energy security and energy diversification which can create secure frameworks for investment, undistorted pricing, stable and transparent relations between consumer and supplier (OECD 2001b).

It will help to separate economic growth from long term environmental degradation which has been a feature of humans energy use for the majority of recent history.

The barriers that exist for BIRs are barriers that exist for sustainable development. These in turn are barriers that may have a negative effect on the economy, the environment, and social welfare. The benefits to be gained from helping to extradite these barriers far outweigh what has to be invested. BIRs are not going to solve every socio-economic problem society poses, however the wider implications for Scotland’s sustainability through encouraging BIRs will have an extremely positive effect on the economy, environment, individual, and the community.

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APPENDICES:

Appendix A - Cover Letter

Tel: [redacted]

e-mail: scott509@hotmail.com

[redacted]

July 2003

Dear _____________

As part of a project linked with Strathclyde University, I am investigating the barriers faced by those involved in the building integrated renewables development process within Scotland. The aim of the project is to obtain the views of those involved at different levels of developing building integrated renewables. This is the first time a study of this type has been conducted and would prove useful to those wishing to integrate renewables into their building projects in the future.

I will contact you by telephone during the month of July in order to arrange a mutually suitable date and time to obtain your views on the building integrated renewables process within Scotland. I look forward to speaking with you.

Yours Sincerely,

Scott Dwyer

Appendix B – Questionnaire Aims

Aims

?? To examine the barriers faced by those involved in the building integrated renewables (BIR) development process

?? To explore the views of BIR developers and how the current process might be improved

?? To find which barriers are specific to those involved at different levels of the BIR development process

Study goals

1. To discover which barriers exist and at what stage they occur to developers of BIR in Scotland and how they were overcome
2. To find which barriers are specific to a certain type of project and which are universal
3. To distinguish between which were foreseen barriers and which were unforeseen barriers
4. To discover the motivation behind the projects e.g. R&D, climate change levy abatement, cheaper electricity/heating, prestige (wont apply to everyone e.g. contractors/architects - money)
5. To ascertain main avenues of funding (likely to be private of confidential)
6. To identify how they would make the BIR development process easier for themselves and/or others in the future

Appendix C - Questionnaire

<u>THIS QUESTIONNAIRE SEEKS TO IDENTIFY "BARRIERS". THESE MAY INCLUDE ANY IMPEDIMENT THAT HAS BEEN ENCOUNTERED. FOR EXAMPLE: PLANNING, FINANCIAL, TECHNICAL OR ANY OTHER PROBLEM</u>.

1. Which technologies did your project encompass?

☐ Biomass ☐ CHP ☐ Heat Pump ☐ Hydro ☐ Natural Ventilation

☐ Passive Solar ☐ Photovoltaic cells ☐ Wind ☐ Other (please specify)_________

2. Was your project grid connected? Yes ☐ No ☐

3. What was your role?

☐ Planning ☐ Building Design ☐ Systems Design ☐ Construction ☐ Commissioning

☐ Installation ☐ Maintenance ☐ Financial ☐ Research Based ☐ Project Management

☐ Other (please specify) _____________

4. Which barriers were encountered during the first phase? (i.e. planning, building design, systems design)

(Tick left box if foreseen) ☐☐ ECONOMIC (e.g. equipment leasing, sponsorship, assessing market value)

☐☐ INSTITUTIONAL (e.g. safety, visual, noise, planning application, NG)

☐☐ TECHNOLOGICAL (e.g. building generated turbulence, short product life)

☐☐ EDUCATIONAL (e.g. lack of trained professionals, no best practice)

☐☐ SOCIAL (e.g. public opposition, NIMBYism, attitudes)

☐☐ ENVIRONMENTAL (e.g. protection of the environment)

☐☐ LEGISLATIVE (e.g. G77, NPPG6)

☐☐ OTHER ☐☐ NONE ☐☐ DON'T KNOW

(Give any additional information here)

5. How were these overcome?
(Please give details)

6. Which barriers were encountered during the second phase? (i.e. construction, commissioning, installation)

(Tick left box if foreseen)

- ☐☐ ECONOMIC (e.g. equipment leasing, sponsorship, assessing market value)
- ☐☐ INSTITUTIONAL (e.g. safety, visual, noise, planning application, NG)
- ☐☐ TECHNOLOGICAL (e.g. building generated turbulence, short product life)
- ☐☐ EDUCATIONAL (e.g. lack of trained professionals, no best practice)
- ☐☐ SOCIAL (e.g. public opposition, NIMBYism, attitudes)
- ☐☐ ENVIRONMENTAL (e.g. protection of the environment)
- ☐☐ LEGISLATIVE (e.g. G77, NPPG6)
- ☐☐ OTHER ________________ ☐ NONE ☐ DON' T KNOW

(Give any additional information here)

7. How were these overcome?

8. Which barriers were encountered during the third phase? (i.e. maintenance, upgrading, repairs)

Tick right box if foreseen

- ☐☐ ECONOMIC (e.g. equipment leasing, sponsorship, assessing market value)
- ☐☐ INSTITUTIONAL (e.g. safety, visual, noise, planning application, NG)
- ☐☐ TECHNOLOGICAL (e.g. building generated turbulence, short product life)
- ☐☐ EDUCATIONAL (e.g. lack of trained professionals, no best practice)
- ☐☐ SOCIAL (e.g. public opposition, NIMBYism, attitudes)
- ☐☐ ENVIRONMENTAL (e.g. protection of the environment)
- ☐☐ LEGISLATIVE (e.g. G77, NPPG6)
- ☐☐ OTHER ☐☐ NONE ☐☐ DON' T KNOW

(Give any additional information here)

9. How were these overcome?

10. Please tick which of the following could be implemented to improve the overall process?

✍✍*Simplify planning process*
✍✍*More information on finance options*
✍✍*More comparative information on the technologies*
✍✍*Establish best practice guidelines*
✍✍*Better-trained personnel*
✍✍*Improve public perception of building integrated renewables*
✍✍*Reduce external contractor problems*
✍✍*Improved product information*
✍✍*More time for the planning stage*
✍✍*Improved guidance at a local level*
✍✍*Improved guidance at a national level*
✍✍*More emphasis on R&D*
✍✍*Greater availability of funding*
✍✍*Greater standardisation*
✍✍*Make it easier to identify local industrial partners*
✍✍*Lower costs of technology*
✍✍*Greater multidisciplinary co-operation*
✍✍*Don't know*
✍✍*Nothing*
✍✍*Other (please specify)*_________________