Present Situation & Sustainable Energy Scenario of Lochboisdale up to 2014

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Acknowledgement

It is matter of great pleasure for us to have an opportunity of carrying out this highly interesting study " Present Situation and Sustainable Energy Scenario for Lochboisdale up to 2014" as an international class in South Uist, Scotland. We feel that this study has given us an opportunity to materialize our academic and practical knowledge, for which we are very much indebted especially to the Storas Uibhist and Community Energy Scotland (CES), University of Flensburg, Sustainable Energy System and Management (SESAM), German Academic Exchange Service (DAAD).

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SESAM, IC 2009
South Uist Team

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List of Abbreviations & Acronyms

BAU	-	Business As Usual
CES	-	Community Energy Scotland
CF	-	Conversion Factor
CFL	-	Compact Fluorescent Lamp
CO_2	-	Carbon dioxide
CO_{2e}	-	Equivalent of Carbon Dioxide
DEFRA	-	Department for Environment, Food and Rural Affairs
EE	-	Energy Efficiency
EU	-	European Union
GDP	-	Gross Domestic Product
GHGs	-	Green House Gases
HH	-	Household
IC	-	International Class
IPCC	-	Intergovernmental Panel on Climate Change
LEAP	-	Long-range Energy Alternative Planning
LPG	-	Liquefied Petroleum Gas
P	-	Pence
RE	-	Renewable Energy
SBSA	-	Scottish Building Standard Agency
SESAM	-	Sustainable Energy Systems and Management
UNFCCC	-	U.N. Framework Convention on Climate Change
UK	-	United Kingdom
VAT	-	Value Added Tax

List of Units

Tons/y	-	Tons per year
kWh	-	Kilo -Watt Hour
MW	-	Mega Watt
MWh	-	Megawatt hour
MWh/y	-	Megawatt per year
m^2	-	Square Meter
kg	-	Kilogram
£	-	UK Pound

Conversions

1 inch	-	2.54 Centi Meter
1 kWh	-	Kilo-Watt Hour
1 Ton	-	1000 kg
1 MW	-	1000 kW
1 MWh	-	1000 kWh

Executive Summary

In February 2009, the Storas Uibhist has hosted a study visit with the International Class 2009 from the University of Flensburg, Germany. Both the Storas Uibhist and the Community Energy Scotland (CES) requested Sustainable Energy System and Management (SESAM), University of Flensburg, Germany to conduct energy related study in Lochboisdale, Outer Hebrides, Scotland. The seven member students from Nepal, Indonesia and South Korea were assigned the task to assess the current energy consumption and CO_2 emission of Lochboisdale, and to build the sustainable energy scenario up to 2014.

The aim of this study is to provide a coherent picture of the current energy situation, future energy demand, and CO_2 emission of Lochboisdale with alternative solutions to the Storas Uibhist, CES and other stakeholders. This report contains the following three main parts:

- The current energy consumption and CO_2 emission in Lochboisdale.
- Estimation of future energy consumption and CO_2 emission based on Business as Usual (BAU) scenario up to 2014.
- The alternative scenario including the combination of improvement of energy efficiency and expansion of renewable energy like wind, micro hydro, solar and tidal energy.

As a starting point for the energy scenario the various secondary information like a feasibility study for a wind and tidal projects were reviewed in Germany. In Lochboisdale, the primary data was collected through questionnaires, personal interviews and on-site measurement. The questionnaires were distributed to total of 137 households and 18 non-households like commercial and Industry sectors. The response rate of households and non-households (e.g. commercial, industry, public transport etc.) were around 51%, and 100% respectively.

Based on the result of the survey, the current total energy consumption of Lochboisdale is 10,561 MWh/y. The household sector accounts for 51.8% and the non-household sector 48.2 % of total energy consumption. In terms of CO_2 emission, Lochboisdale emits 3,173.26 tons/yr. Out of this; the household sector is contributing 54.8% of CO_2 emission, while non-household sector 45.2 % of total CO_2 emission.

The future energy demand up to 2014 is calculated in two scenarios: Business as Usual (BAU) and alternative scenario. In the BAU, the team calculated the future energy demand based on the household growth, energy efficiency policies of the UK/Scottish Government, building standards, best practice of energy efficiency, tourism growth, harbor extension plan

etc. The CO_2 is calculated based on share of renewable energy, renewable energy policies, share of different fuels etc. In this scenario, the total energy demand in 2009 will be 10,489.28 MWh/y in 2009, while it will be 15,350.3 MWh in 2014 because of harbor extension plan. The energy will increase by 46.34% from 2009 - 2014. In BAU scenario, the total CO_2 emissions in 2009 will 3,059.64 tons in 2009, while it will be 4,130 in 2014. This increase (35%) of CO_2 emission is mainly due to harbor extension. Without harbor extension, CO_2 emission would decrease every year from 2008 due to increasing share of renewable energy and improvement of energy efficiency.

In the alternative energy scenario, the team calculated the energy demand based on the improvement of energy efficiency in existing and new buildings (both household and non-households) with best practice. In this scenario the total energy demand will increase from 9,960.18 MWh/y in 2009 to 13,569.14 MWh/y in 2014, which is 36.23%. This increase in energy demand is due to mainly harbor extension plan. The CO_2 emission is calculated based on energy demand, share of renewable energy in energy mix and expansion of renewable energy in Lochboisdale. In this scenario, the total emission in 2009 will be 2,926.43 tons/y, but it will be 3,554.48 tons/y in 2014, which is increased of 21.46%.

The team has proposed the three main recommendations for reduction of energy consumption and CO_2 emission in the Lochboisdale. These are energy efficiency improvement, expansion of renewable energy and promotional campaign. The team suggests for improvement of house insulation and use of public transportation. Regarding insulation improvement, households at least need to follow standard guidance of envelope insulation installment from Scottish Building Standards Agency (SBSA). It will contribute to the substantial reduction of heating demand (42%). It is also recommended that more people use public transportation to reduce CO_2 emission.

Regarding the second recommendations, the team suggests to focus development and utilizations of renewable energy in Lochboisdale. Lochboisdale has high renewable energy potential like wind, hydro and tidal to meet energy demand locally and reduce CO_2 emission. Additionally, there are many other renewable energy sources like biomass (e.g. sea weeds, household waste etc.), solar, tidal and hydrogen driven systems which can be coupled with wind energy to get a consistent source of energy. Regarding awareness and promotional campaign, the survey results have shown that around 33% of respondents have neither knowledge nor interest on GHGs and carbon neutral village issues. Raising public awareness will definitely encourage them to support and even participate themselves in making Lochboisdale a carbon neutral village.

1 Introduction

1.1 Background of the Study

The project was carried out in Lochboisdale, which is the largest population town on the South Uist, Outer Hebrides, Scotland (See figure 1). There are 137 households and approximately 332 inhabitants in the Lochboisdale area. However, not all of the households are fully occupied during the year.[1] There are also about 18 non-household properties such as police station, hotels, dental clinic, fuel station, ferry terminal etc.

As a part of the Lochboisdale regeneration plan, the Storas Uibhist and CES are currently developing the Lochboisdale harbor extension project. In addition, there are several renewable energy projects discussed such as wind and micro-hydro power for both the community development and income generation purposes. The Storas Uibhist is interested in finding out the impact of the harbor extension project and renewable energy projects on the future energy demand and CO_2 emission in the Lochboisdale area.

Figure 1: Project Boundary

Source: Storas Uibhist

Therefore, both the Storas Uibhist and CES have invited seven students from Indonesia, Nepal and South Korea who are currently taking the postgraduate program, SESAM at the University of Flensburg, Germany. The team conducted the study in Lochboisdale from February 15th to March 20th, 2009. The team also conducted a literature review and prepared the research instruments during a 4 months preparatory period in Germany. The detailed scope and methodology of the study are described in Chapter 3.

[1] Rona Mackay, Development Officer in Community Energy Scotland, email response, mailed January 2009.

1.2 Lochboisdale Harbour Extension Project

In October 2008, the Storas Uibhist prepared a special report, which is called “Lochboisdale Harbour Evaluation of Existing Provision and Future Opportunities”. According to the report, the existing harbour provision doesn’t meet the demands of current users, especially:

- Onshore ferry service
- Fisheries
- Leisure sailors
- Local community
- Pedestrians
- Business opportunities

As part of a Lochboisdale harbour extension plan, the Storas Uibhist and the local city council have decided to upgrade the existing harbor facilities by end of 2011. It will enable Lochboisdale to meet the demands of all users and to improve the productivity and economic growth.

1.3 Aim and Scope of Research

The aim of this research is to provide to the Storas Uibhist, CES, Local Council and other stakeholders a coherent picture of the current energy situation, future energy demand and supply, and CO_2 emission of Lochboisdale with alternative solutions for sustainable development. Based on the discussions with the commissioning agency, this report provides the following information and suggestions:[2]

1) The current energy consumption and CO_2 emission in Lochboisdale
2) Estimation of future energy demand and CO_2 emission based on Business as Usual (“BAU”) scenario up to 2014.
3) The alternative scenario including the combination of improvement of energy efficiency and expansion of renewable energy sources like wind and micro hydro energy.

[2] Kirsty Campbell, “Flensburg University Study Visit”, Letter of Storas Uibhist, February 2009.

2 Methodology of the Study

To carry out this study a multiple approach was used for collecting, verifying and analyzing both primary and secondary information. The aim was to collect sufficient and reliable information to assess the current energy consumption and CO_2 emission, to estimate the future energy demand and CO_2 emission, and to meet its future demand eco-friendly based on improvement of energy efficiency and expansion of renewable energy sources in alternative scenario.

2.1 Data Collection

To carry out the study, all necessary data were obtained from both primary and secondary sources as follows:

i) Primary Data

Firstly, the quantitative data were collected through a survey using questionnaires. Secondly, the qualitative data were mostly collected through personal interview. Finally, some technical data were collected from the site visit and on-site measurement.

Survey

All statistical data to calculate the current energy consumption and CO2 emission were collected through questionnaires (see sample copy in annex 1 & 2). Different questionnaires were developed for the two sectors studied: household and non-household sectors (e.g. commercial, public and Industry).

For the household sector, the questionnaires were distributed to all 137 households via post. 70 of them responded and were collected with a response rate of 51%. However, 3 households were found to be empty during the whole year. In addition, it was found that 10 houses were holiday's house. For the non-household sector, the questionnaires were distributed to all 18 commercial, public and industrial properties such as the police station, dental clinic and hotel etc. It has shown an overall response rate of 100% (See table 1). More detailed breakdowns of the questionnaire collection are described in chapter 5.

Table 1: Survey Response rate

	Total household	Responded	Not Occupied	Holiday houses	No response	Response rate (%)
Household	137	***70***	3	10	54	***51***
Non-Household	18	***18***	-	-	-	***100***

Source: SESAM, IC 2009

Personal interview

During the data collection, face-to-face interviews were conducted with tenants and landlords of households. Additionally, the team had the chance to meet with fishermen and staff of city council. The aim of the interviews was to collect more qualitative information from the community stakeholders.

On-site visit & measurement

The team also had the chance to visit the hydro project site. The purpose of the visit was to get knowhow on proposed hydro project and to collect some additional data from the site.

ii) Secondary Data

In addition, secondary data has been obtained from the various sources as mentioned below:

Literature review

During the preparatory period in Germany, various reports on harbor extension, wind, hydropower etc were reviewed which were provided by Storas Uibhist. The team also studied different other reports, articles and books related to wind, hydropower, solar, tidal energy and CO_2 reduction, and downloaded relevant data from the internet (see bibliography for full list of sources).

Analysis of technical data

The team analyzed both wind, solar and tidal resource data, which was measured near Lochboisdale area.

2.2 Calculation Methods

To convert the energy consumptions from different energy mixes into CO_2 emissions, the conversion factor adapted by Department of Environment Food and Rural Affairs (DEFRA), UK were used. DEFRA initially identified the GHGs conversion factors in 2005 to assist commercial and public sectors to convert their energy consumption data into CO2 equivalent data.[3] The conversion factors are annually updated by DEFRA.

Once the current energy consumption and CO_2 emission were calculated, both BAU and alternative scenarios were built by using Long-range Alternative Planning System (LEAP). LEAP is developed at the Stockholm Environment Institute and is globally well-known software for energy planning and climate change mitigation assessment.[4] According to the United Nations, "more than 85 countries have used LEAP for the reporting purpose to the U.N. Framework Convention on Climate Change (UNFCCC)."[5]

2.3 Major Assumptions

Various assumptions were used to build both BAU and alternative scenarios. This study has also certain limitations that need to be taken into consideration. However, some of these limitations as described below can be seen as a fruitful avenue for the future project development of Lochboisdale. Table 2 shows the assumptions and targets the team used to build both BAU and alternative scenarios.

[3] Defra, "Environmental Reporting", http://www.defra.gov.uk/environment/business/envrp/conversion-factors.htm, accessed March 2009.
[4] Charles Heaps, Ph.D, "An Introduction to LEAP", Stockholm Environment Institute, page 5, February 2008.
[5] Ibid.

Table 2 Assumptions & targets for BAU and Alternative Scenario

	Business As Usual	***Alternative Target***
Household[6]	• + 0.53% per year (+ 40 additional Houses) (additional facilities in the non-household sector) – (see table 3)	• + 0.53% per year (+ 40 additional Houses) (additional facilities in the non-household sector) –(see table 3)
Tourism Growth[7]	• + 2.15 % per year (only for Lochboisdale hotel)	• + 2.15 % per year (only for Lochboisdale hotel)
Energy efficiency[8]	• + 1.1 % per year • 25% energy efficiency for 40 new households and 6 shops	• +1.1 % per year Improve house insulation for existing households. (25% of total household will consume 50% less energy than their current consumptions
Renewable energy contribution	• Current : 15% of electricity from renewable energy • Expanding renewable energy contribution by 37.3% by 2014 (31% of electricity by 2011 and 50% by 2020)	• 2 renewable energy projects (wind, hydro) • District heating system for only 40 additional houses • Expanding renewable energy contribution by 37.3% by 2014 (31% of electricity by 2011 and 50% by 2020)
	• Bio-fuel contribution for transport: 7% by 2014	• Rise bio-fuel contribution by 10% by 2011

For both BAU and alternative scenarios, the team applied a household growth rate of 0.53 % per year. In addition, as a part of the harbour extension project, 40 additional houses will be constructed until beginning of 2012. Similarly, tourism growth rate was used as a key driving factor only for Lochboisdale hotel, assuming that the future energy demands of the rest of the non-household sector would not be affected by the growth of tourism. Due to the harbour

[6] Storas Uibhist, "Lochboisdale Harbour Evaluation of Existing Provision and Future Opportunities", October 2008
[7] Estimated based on Snedden Economic, "Outer Hebrides Tourism Facts and Figures Update", Review of 2007 season, page 5, June 2007
[8] Defra, "UK Energy Efficiency Action Plan 2007", page 12, 2007.

extension project, several business and industrial facilities will be added. The full list of newly added facilities is described in table 3.

Table 3 New facilities as a part of Harbour Extension Project

Sector	*Harbor Extension Project*
Household	• 40 additional Houses: 2010- 20 houses 2011: 20 houses • Impact from the beginning of 2012
Non-household	• Impact from the beginning of 2012 • Fish Processing Plant: same size as Barra • 6 additional Shops: gift shop-we can use the current data • Waiting room for ferry passengers • 20 additional fishing boats • Excluding a Ferry from our project on both energy consumptions & CO2 emissions

Source: Adapted from Storas Uibhist

For the alternative scenario, the team has set two main targets: improvement of building insulation and expansion of renewable energy contribution on the future energy demand.

2.4 Limitations

First of all, in this study all greenhouse gases (GHG) emissions are expressed in 'equivalent carbon dioxide' CO_{2e}, The five other GHG, methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF_6) which are identified by the Intergovernmental Panel on Climate Change (IPCC) are all converted into CO_{2e} in this study.

This report excludes the amount of CO_2 that can be absorbed by nature. The team only calculated the amount of CO_2 reduction and offset through improvement of energy efficiency and expansion of renewable energy.

This report does not include detailed technical and financial analysis of the proposed renewable energy project as the scope of the project is more focused on identifying locally available renewable energy resources in order to reduce CO_2 emission in Lochboisdale area.

Finally, the team does not provide any political suggestion. Since the research was conducted for small community level, the team was supposed to carry out the study within the existing political boundary.

2.5 Defining the Boundary

In defining the boundary for CO_2 emission is one of the most important tasks to decide what should be included and excluded and also to avoid double counting. Double counting is one of the most common mistakes in calculating either CO_2 emission or carbon footprint. According to the SESAM, IC 2008 report, "Double counting means counting the environmental impact of single activity, product or service more than once." [9]

There are two most commonly used strategies to define the boundary:

> **Geographical (administrative) boundary:** In this case, the researcher counts all emissions which occurred within the geographical boundary of project.[10]
>
> **Responsibility boundary:** Regardless of where the emissions occurred, the researcher counts all emissions which are caused by the activities of local residents.[11]

Each strategy has its own pros and cons. For instance, in case of tourists, if the researcher uses the responsibility boundary, it would be very hard to track all emissions which are caused by tourists from all around the world. On the other hand, the geographical boundary also has some problems. For example, if there is no conventional power plant within the geographical boundary, all emissions which are emitted from the energy consumptions of local residents would not be counted. Thus, often the researcher modifies one of these strategies depending on the specific goal of the study or current condition of the site, but the method should be always consistent.

In this study, two different boundary options are used. For the household sector, the team used the responsibility boundary. Thus, all emissions which are emitted by local residents are counted although there is no conventional power plant in Lochboisdale. For non-household especially commercial and industry sectors, we also used the modified responsibility boundary. All emissions which are caused by their income generating activities are counted. It means although the emissions are caused by tourists from outside of the geographical boundary indeed, they are a part of income generating activities of business owners in Lochboisdale. Thus, it is counted as their responsibilities.

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[9] SESAM, IC 2008 Report, "Ecological Footprint of Sleat", P. 8

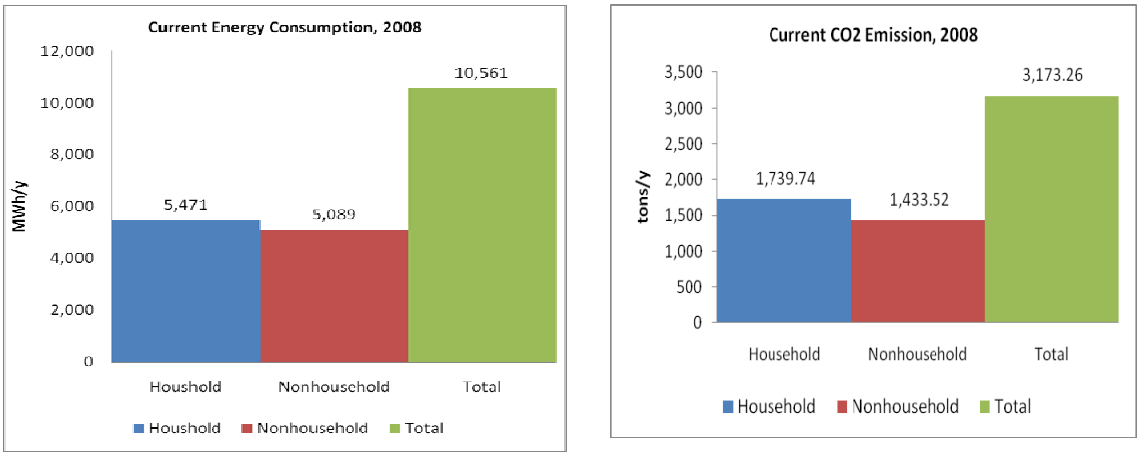
[10] Ibid.

[11] Ibid.

3 Current Energy Situation and CO2 Emission

In this chapter, key findings from the survey are described. As figure 2 shows, the current total energy consumption of Lochboisdale is 10,561 MWh/y. The household sector accounts for 51.8 %, and the non-household sector contributes 48.2 % of total consumption.

Figure 2: Current Energy Consumption & CO_2 Emission



Source: SESAM IC 2009

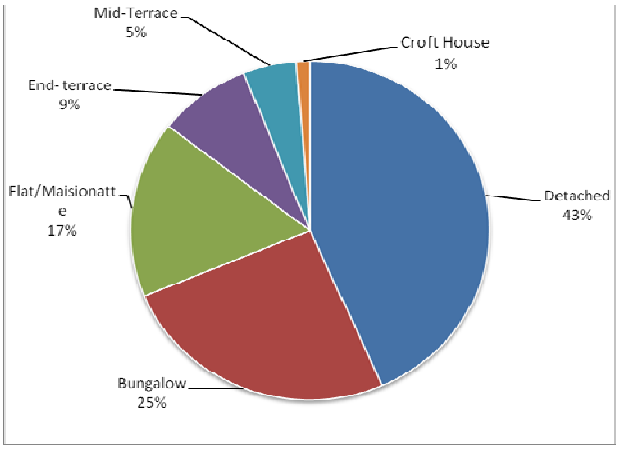
In terms of CO_2 emission, Lochboisdale emits 3,173.26 tons/yr. Over 54.8 % of emission is caused from the household sector, and the non-household sector accounts for 45.2 % of total CO_2 emission. More detailed results of each sector are described in the following sections.

3.1 Household Sector

Based on the result of survey, there are seven different housing types in Lochboisdale as shown in figure 3 below. Among them, majority (36%) are detached houses followed by bungalow (21%). The average size of buildings is 105 m^2, and most households are occupied by 2 to 3 people. According to the representative of the local council, the average household income in Lochboisdale is around 23,000 £/y[12]. Based on the analysis of the survey result, it is found that, the average expenditure per household is around 19% of total income on the energy bills.

[12] Roderick Macdonald, personal interview, 13.03.March 2009.

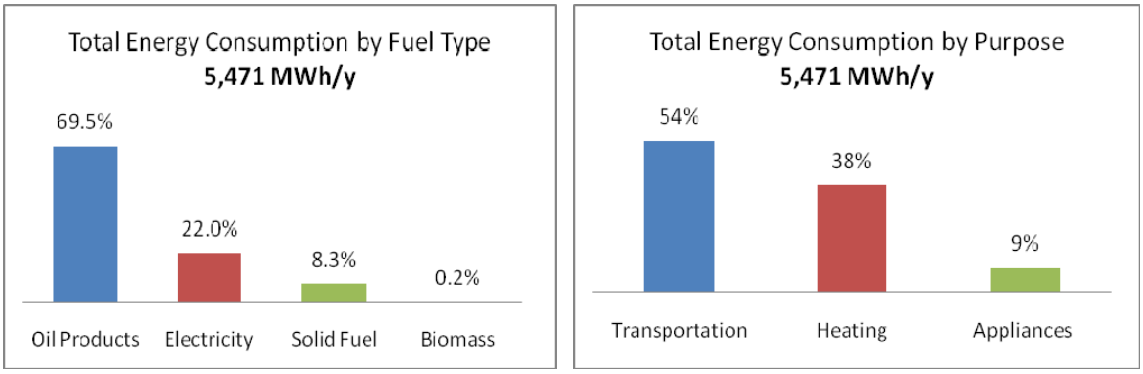
Figure 3: Type of House in Lochboisdale



Source: SESAM, IC 2009

The total energy consumption of the household sector is 5,471 MWh/y. Figure 4 shows that in terms of energy carriers, oil products such as gasoline, diesel, kerosene and LPG contribute the largest share (69.5%) to the total household energy consumption. Electricity is the second largest (22%) energy carriers in the household sector. Wood biomass and Solid fuels like coal and peat all together only account for 8.5%. Based on the energy consumption by purpose, transportation is the highest consumer (54%), heating consume 38% and electrical appliances only account for 9% of total household energy consumption.

Figure 4: Current Households Energy Consumption by Fuel Type & Purpose

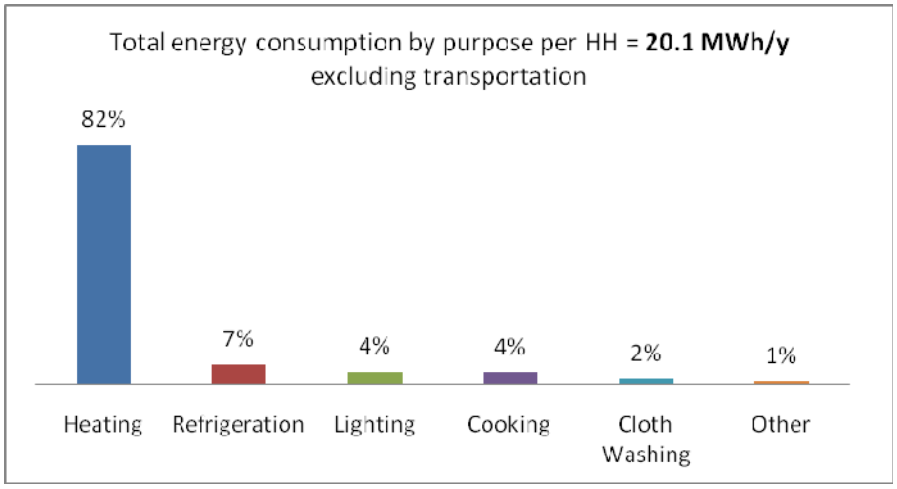


Source: SESAM, IC 2009

Energy index is an indication of amount of energy consumed per unit area or per household. Based on the survey result, it is found that average energy consumption per household (excluding transportation) in Lochboisdale is around 20.1 MWh/y. As shown in figure 5, almost 82% of the total energy is used for heating per household. The average heating index

in Lochboisdale is found to be 157 kWh/m^2. But benchmark heating index in Scotland is 91 kWh/m^2 which consists of 58 kWh/m^2 for space heating and 33 kWh/m^2 for water heating[13]. This shows that the average heating index of Lochboisdale is 42% higher than that of Scotland. So there is high potential for energy saving in heating in Lochboisdale.

Figure 5: Current Household Energy Consumption by Purpose



Source: SESAM, IC 2009

From the survey result, it shows that almost half of the total energy consumption (excluding transportation) per household comes from electricity. In average, one household in Lochboisdale consumes 9,517 kWh of electricity per year, which is 15% higher than that of Western Isles (8,283 kWh/y/hh)[14]. This shows that there is high potential for reducing the electricity consumption in Lochboisdale.

3.1.1 Household Transportation

From the survey result, it is found that household transportation consumes about 2,926 MWh/y, which is 53% of the total household energy consumption. This figure shows that household transportation is consuming more energy than the average Scottish energy consumption (30 %) by private transportation[15]. For transportation, diesel consumption accounts for 53% while gasoline accounts for 47%. The average number of car per person in Lochboisdale is 0.39 while the average Scottish figure is 0.42 per person[16]. Even though the average car per person figure in Lochboisdale is lower than the Scottish average, the high energy consumption in transport shows that the average distance traveled per person is

[13] BRE, 2007, p. 9

[14] Department of Energy and Climate Change, 2008

[15] Calculation based on Scottish Energy Study, 2008, P.9 and P.12

[16] ibid, P.11

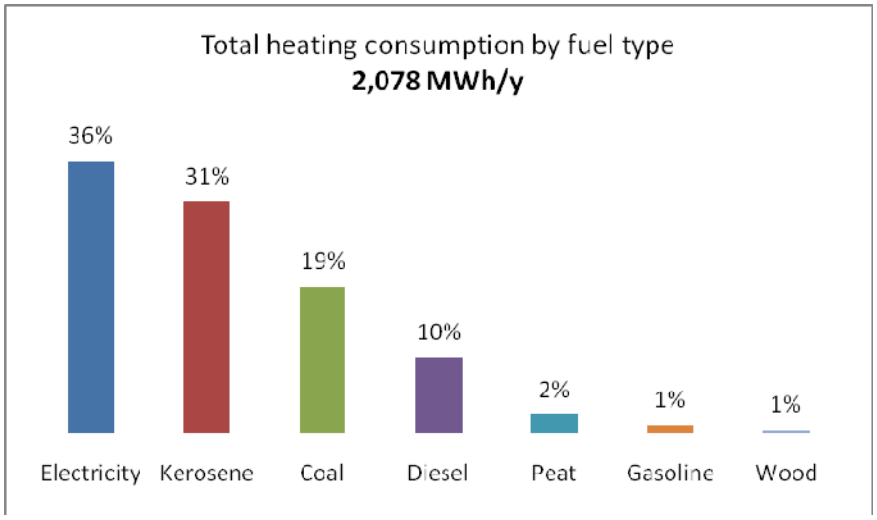
higher than Scottish average. The respondents use cars for their daily activities mainly for work, shopping and also for leisure purposes.

The survey result shows that, only 37% of respondents are willing to use the public transport. Around 54% of respondents are not willing to use public transport. There are some barriers to use the public transport such as infrequent bus schedules, far distance between the drop off points and not convenient for the disable people etc. Public buses are currently operated by private companies under the periodic contract with Local Council.

3.1.2 Household Heating

Household heating consumes about 2,078 MWh/y, which is 38% of the total household energy consumption (including transportation) or 82% (excluding transportation). There are different fuels used for space and water heating such as electricity, kerosene, coal, diesel, peat, gasoline and wood as shown in figure 6. Electricity and kerosene are found to be used for both space (36%) and water heating (31%).

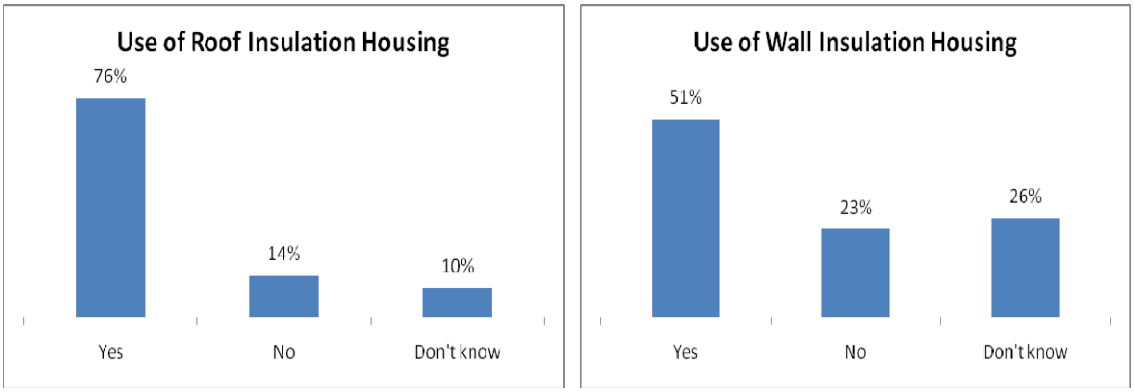
Figure 6: Current Household Heating Consumption by Fuel Types



Source: SESAM, IC 2009

Based on the survey results (figure 7), 76% of respondents' houses have roof insulation and 51% of them have wall insulation. The average thicknesses are 5.6 and 3.7 inches for roof and wall insulations respectively. There is still high percentage of households without insulation as shown in figure 7.

Figure 7: Use of Housing Insulation



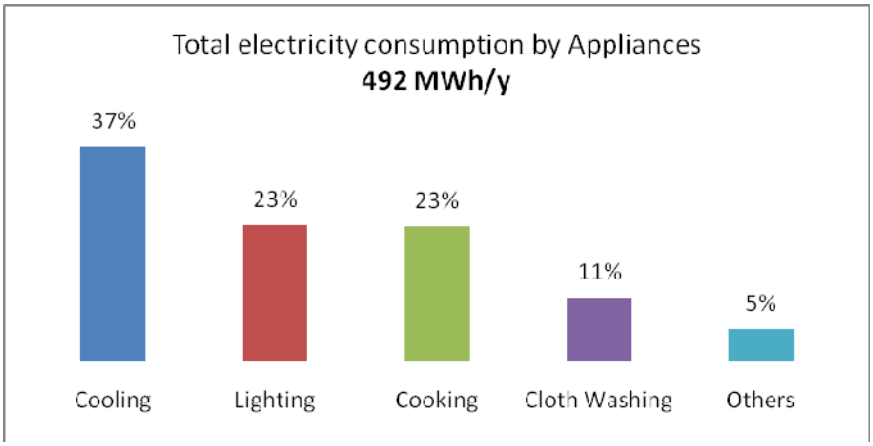
Source: SESAM, IC 2009

According to the opinions for respondents, there are several energy saving options like using double glazing windows and doors, heating timer, and better insulation material. 7 respondents answered that after installing insulations on their houses, they saved around 33% of their expenditures on energy.

3.1.3 Household Appliances

Household electrical appliances are found to consume about 492 MWh/y, which accounts for 9% of the total household electricity consumption. The Scottish average energy consumption by electrical appliances was 18% in 2002.[17] As figure 8 shows, cooling, lighting and cooking are main areas of electricity consumption on the household electrical appliances.

Figure 8: Current Household Electricity Consumption by Appliances



Source: SESAM, IC 2009

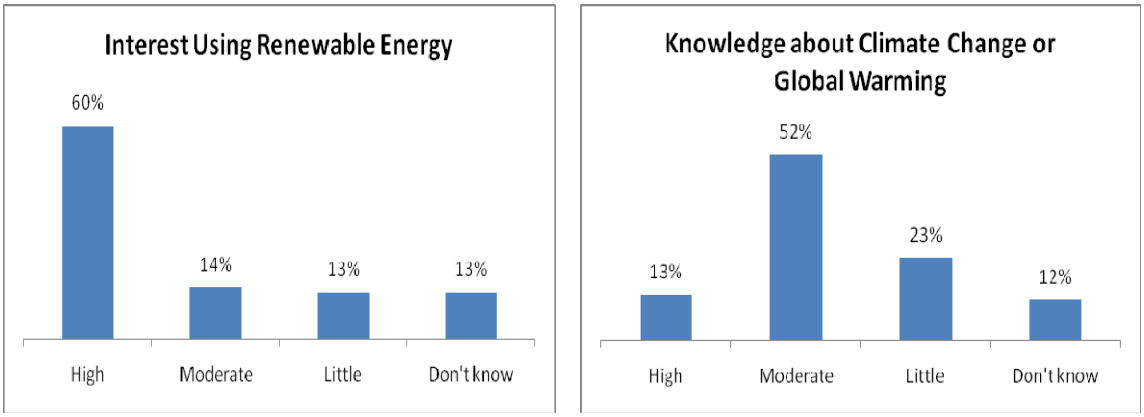
[17] Department for Environment, Food and Rural Affairs (DEFRA), "Economic Instruments to Improve Household Energy Efficiency", 2002 (http://www.hm-treasury.gov.uk/d/household_energy.pdf), P.14

Based on the survey results, around 70% of the respondents are already using energy efficient lamps to reduce their energy expenditures.

3.1.4 People's Opinions on Renewable Energy & Climate Change

During the household survey, several questions were asked to assess the knowledge and interest of respondents on renewable energy, climate change and carbon neutral village. The survey results are as shown in figure 9. The figure shows that the majority (more than 70%) of respondents are interested in using renewable energy sources. Also the marority of them (65%) have some knowledge on climate change. This indicates that people are intereseted in developing Lochboisdale as a carbon neutral village. However, there is further need of creating awareness to the people as some (around 12%) don't know about RE and climate change.

Figure 9: Interest on Renewable Energy & Climate Change

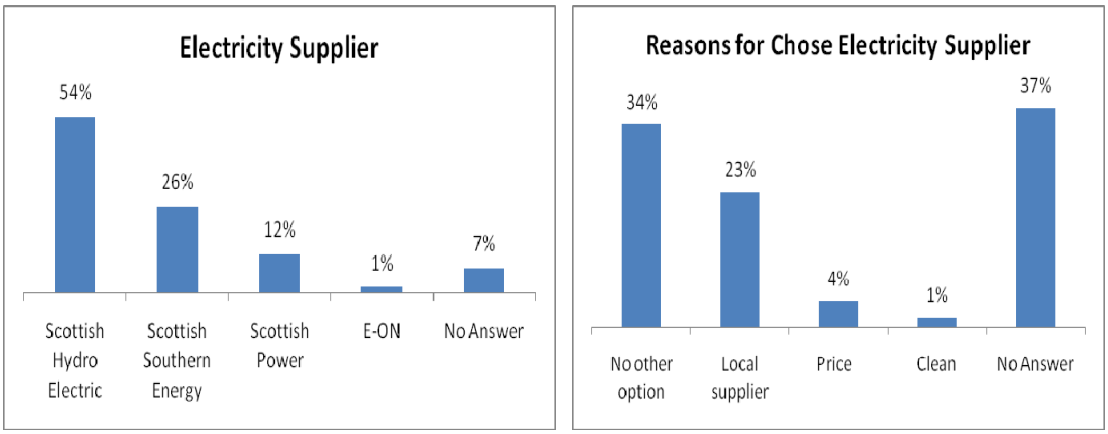


Source: SESAM, IC 2009

3.1.5 Energy Supplier & Price

Since there is no power plant in Lochboisdale, all electricity is supplied from the national grid in mainland. There are four electricity suppliers in Lochboisdale namely Scottish Hydro Electric (54%), Southern Energy (26%), Scottish Power (12%) and E-On (1%). Based on the survey result, more than half of the respondents are using Scottish Hydro Electric as their electricity supplier. As shown in figure 10, about one third (34%) said that they have chosen the current electricity supplier, they said that because there is no other option besides Scottish Hydro Electric. This shows that they are not aware of availability of other suppliers in their areas. Some respondents (4%) said that they have chosen the supplier based on price.

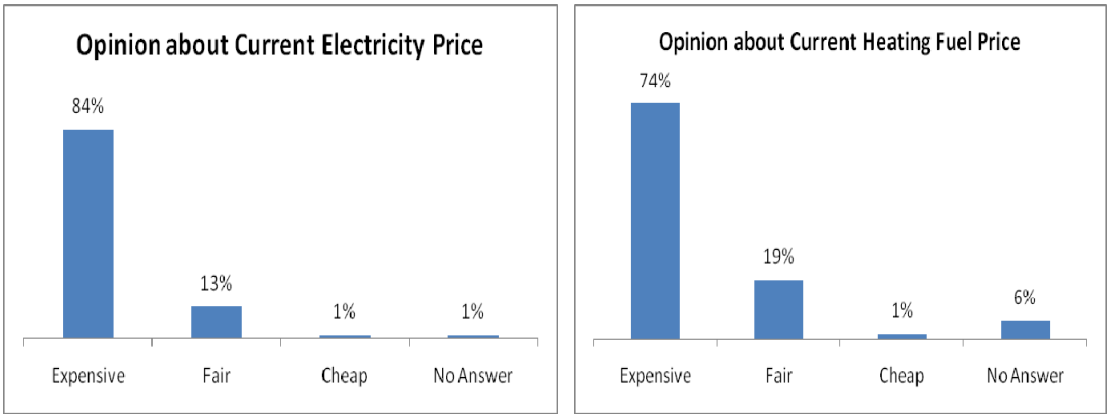
Figure 10: Energy Supplier & Reasons for selection



Source: SESAM, IC 2009

In terms of electricity price, as shown in figure 11 below, most of respondents (84%) are of the opinion that the current electricity prices are expensive. 74% of them stated that the current heating fuel prices are also expensive. Only very few (1%) said that the current price is cheap. This also indicates the high percentage of expenditure on household energy.

Figure 11: Opinion on energy prices



Source: SESAM, IC 2009

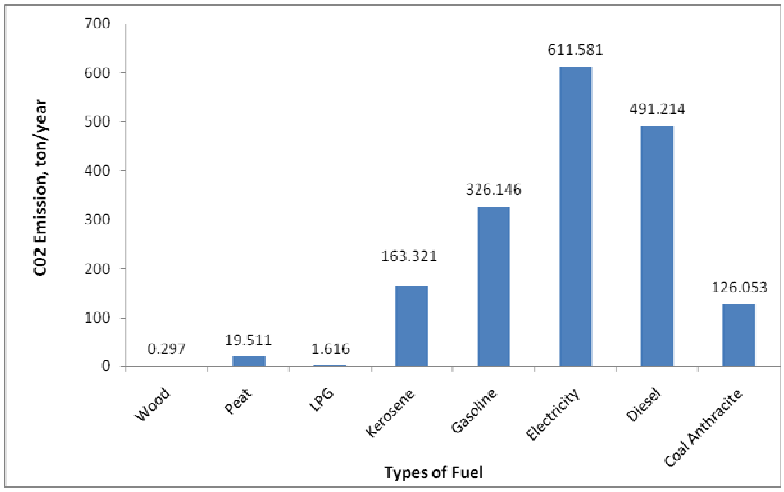
As all other fuels are also imported from mainland, except locally available peat, the additional delivery cost is making the fuel prices in Lochboisdale higher than on the mainland. Detailed electricity unit prices and fuel prices are described in the Annex 3.

3.1.6 CO2 Emission

The calculation of CO_2 emission in the project boundary is based on the primary data from the household questionnaires. According to the households' energy consumption, the team calculated the total CO_2 emission from the household sector in Lochboisdale area (figure 12).

To convert the energy consumptions into CO_2 emission DEFRA's GHGs conversion factors were used except peat, for which the IPCC conversion factor was used. From the calculation, the total CO_2 emission from the household sector is found to be 1,739.74 tons/y.

Figure 12: CO_2 Emission in the household sector by fuel type, 2008



Source: SESAM, IC 2009

The above figure 12 shows that electricity contributes the largest amount to the CO_2 emission in Lochboisdale, which accounts for 35.15% of the total household CO_2 emission. This is mainly due to the high amount of electricity consumed for heating purposes. Diesel is the second largest CO_2 emitter in the household sector accounting for 28.23%. Diesel is being used for both heating and transport purposes. Gasoline, Kerosene and coal are contributing 18.75%, 9.39% and 7.25% respectively to the total household CO_2 emission. Gasoline is also being used for heating and as a transport fuel. The lowest CO_2 emission is from wood (0.02%) and LPG (0.09%), which are being used for heating. All the fossil fuels except LPG have been used for heating contributing the highest emission of CO_2.

The calculated average CO_2 emission per household is around 12.98 tons/y, which is almost same as the Scottish average CO_2 emission (12.90 tons/y).[18] The average CO_2 emission per person per year is 5.24 tons, which is lower than the UK average of 9.2 tons.[19] . This UK figure might have included all emissions. For direct emission, UK figure should be lower than

[18] Energy Saving Trust of the Scottish Government, "Highest Carbon Emitters Revealed", http://www.energysavingtrust.org.uk/scotland/Scotland/Scottish-small-businesses-and-community-groups/Scottish-Business-News/Scottish-news-archive/News-archive-Week-ending-23rd-November-2007, November 2007, accessed March 2009.

[19] Time for Change, "CO2 emissions by country", http://timeforchange.org/CO2-emissions-by-country, accessed 01 March 2009.

this. But the survey result is based on direct emission. The world average CO_2 emission per person per year is 4 tons.[20] This shows that in terms of CO_2 emission per person per year, Lochboisdale emits lower emission than the average inhabitant of the UK, but almost same as world's average.

Electricity contributes the largest amount to the CO_2 emission, which accounts for 35.15% of the total household CO_2 emission. It is mainly due to large amount of electricity consumed for heating purposes. Diesel is the second largest CO_2 emitter in the household sector accounting for 28.23%. Diesel is mainly used for both heating and transport purposes. The lowest CO_2 emissions are from wood (0.02%), which are used for heating and fully imported from mainland.

a) Transportation

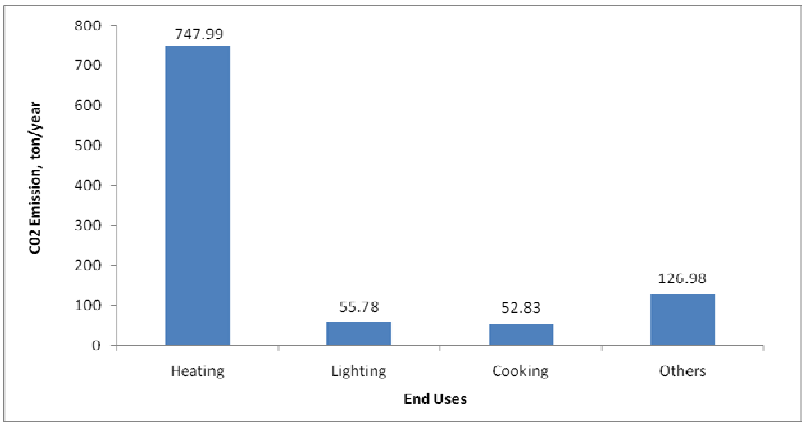
Based on the primary data, 43% of the respondents own gasoline (petrol) vehicles and 52% have diesel vehicles in Lochboisdale. The total CO_2 emission from the transport fuels is found to be 756.15 tons/y. This accounts for 43.46% of the total household emission. Among the transport fuel, diesel is contributing around 58% and gasoline around 42% to the total CO_2 emission of household transport fuels. From the household transportation, the average CO_2 emission per person is 2 tons/y. The average CO_2 emission per household is 5.6 tons/y. The high amount of CO_2 emission from household transport is mainly due to inconvenient service of public transport and the high usage of private vehicles even for short distances.

b) Heating and Other Purposes

Based on the primary data, the total CO_2 emission by heating and other purposes in the household sector is found to be 983.59 tons/y, which is 56.54 % of total household CO_2 emission. The figure 13 below shows the CO_2 emissions by household end uses like heating, cooking, lighting and other appliances. Heating contributes the largest share of emission accounting for 76%, followed by other appliances (13%). Lighting and cooking are contributing almost same amount of emissions, 5.67% and 5.37% respectively. This illustrates that there is a high potential for reducing the CO_2 emission in the heating sector.

[20] Jane Smith, "Appendix B: Example EcoTeams Report: Household Report", Global Action Plan, http://www.globalactionplan.org.uk/upload/resource/Appendix%20B-Example%20EcoTeams%20feedback%20report.pdf, page4, accessed March 2009.

Figure 13: CO_2 Emission by End Use, 2008



Source: SESAM, IC 2009

3.2 Non-Household Sector

As Lochboisdale has quite a low population and is remote from the mainland, the non-household sector like commerce and industry operates on a small scale. Lochboisdale has the fishing business, a bank, an automobile maintenance shop, a hotel, a fuel station etc. Within the boundary, there is also a church and a police station. Currently, there is no fish processing plant in Lochboisdale, so the fishermen are mostly taking their catch to Barra for processing. A large amount of fish is also exported directly to abroad like Spain. As a part of the harbour extension project, a new fish processing plant is planned to be established in the Lochboisdale harbour.

As table 4 shows, the team divided the non-household sector into the four sub-sectors based on types of businesses:

Table 4: Examples of Boundary Issues

Sub-sector	***Inclusion***
Industry	Fishing industry
Commercial	Banks, Workshop, Car Rental company, Hotel, Fuel station
Public	Police station, Dental Clinic, Church, Post office, community (Internet room), Street Lamps
Transport	Public Transport Bus, Ferry office, School Bus

Source: SESAM, IC 2009

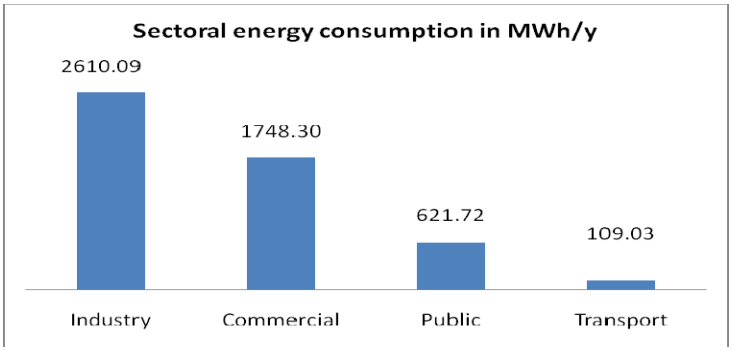
3.1.7 Energy consumption

Based on the survey result, the total energy consumption of the non-household sectors is found to be 5,089.14 MWh/y. The energy consumption by sector and fuel is described in detail below.

a) Energy Consumption by Sector

As shown in figure 14, the energy consumption in non-household sector is dominated by fishing industry (51.29 %) followed by commercial (34.35 %) and the public sector (12.22 %). Transportation contributes the lowest (about 2.14%) share to the total energy consumption. As it is assumed that most of the Lochboisdale people are not significantly contributing CO_2 emission from ferry, it is not counted in the CO_2 emission of Lochboisdale.

Figure 14: Energy Consumptions by sub-sector for non-household sector

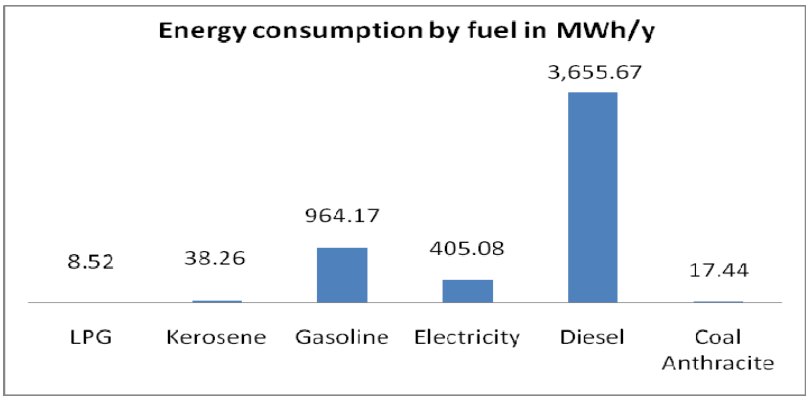


Source: SESAM, IC 2009

b) Energy Consumption by Fuel Type

The energy consumption pattern of the non-household sector by fuel type is described in figure 15.

Figure 15: Energy Consumptions by Fuel Type in non-household sector



Source: SESAM, IC 2009

For the non-household sector, diesel is the main energy consumer which accounts for 71.83 % of the total non-household energy consumption followed by gasoline (18.95%) and electricity (7.96%). Kerosene (0.75%), coal (0.34%) and LPG (0.17%) all together account only a small part of the total non-household energy consumption. Diesel consumption is very large due to the fishing boats, public and school transports. Some enterprises are also using diesel for space heating. Thus, diesel has a significant effect on the net energy consumption in the non-household sectors.

Like in the household sector, all electricity is supplied from the mainland, because there are no power plants in the Lochboisdale area. In addition, non household sectors in Lochboisdale consume no fuel-wood due to the lack of resource in the area.

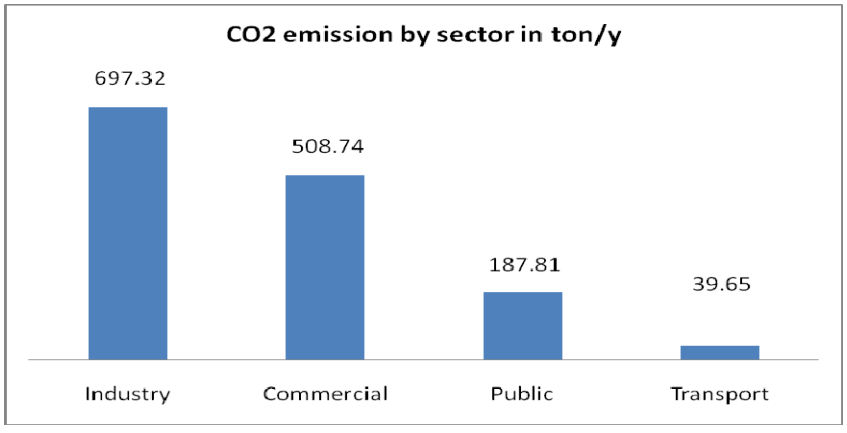
3.1.8 CO2 Emission

CO_2 emission from the electricity consumption was calculated based on the energy mix of suppliers. There are three electricity suppliers, E.ON, Scottish Hydro and Scottish Southern, for the non-household sectors in Lochboisdale area. Each supplier has different emission factors based on mix of fuels used to generate the electricity. Based on this the conversion factors are taken for calculation. DEFRA's conversion factors are used to convert the fuel consumption for vehicles into the CO_2 emission like household sector.

a) CO_2 Emission by sector

The total CO_2 emission of the non-household sector is 1,433.52 tons/y. A more detailed breakdown of CO_2 emissions by sector is shown in figure 16 below:

Figure 16: CO_2 Emission by sector in non-household sector



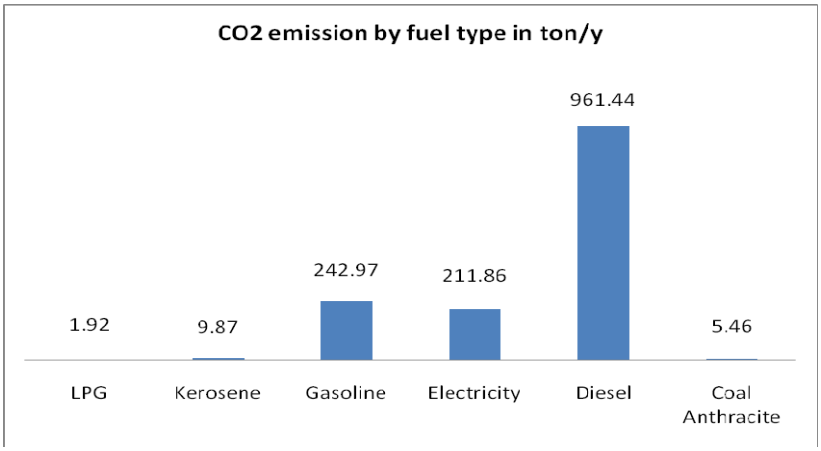
Source: SESAM, IC 2009

It was found that the industry sector contributes 48.64% of total emission from the non-household sector followed by commercial (35.49%), public (13.10%) and transport sectors (2.77%). As shown in figure 16, CO_2 emission of industry sector is relatively higher than other sectors mainly due to the high diesel consumption by fishing industry. In the public and commercial sector, main contributors are also diesel and electricity as well.

b) CO_2 emission by Fuel Type

The CO_2 emission of non-household sector by fuel type is shown in figure 17 below:

Figure 17: CO_2 Emission by fuel types in non-household sector



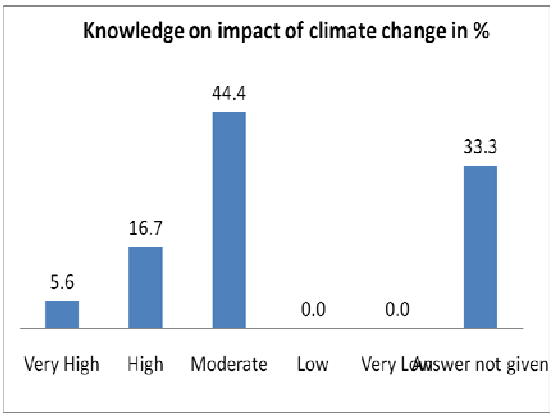
Source: SESAM IC 2009

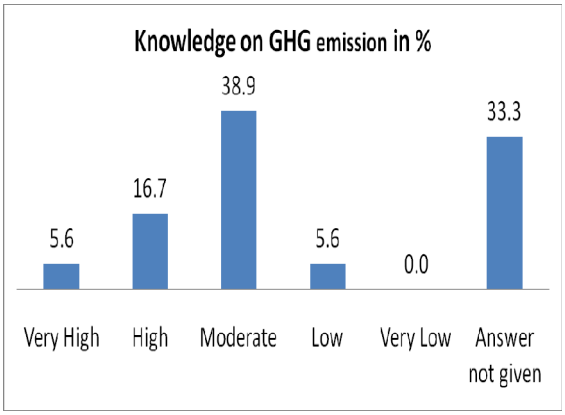
As shown in figure 17, diesel is the main contributor of CO_2 emission in the non-household sector due to its high use in fishing boats, heavy vehicles etc. It accounts for 67.07 % of the total CO_2 emission from non-household sector. With a share of 16.95% gasoline is slightly above electricity (14.78 %), kerosene (0.71%), coal (0.69 %) and LPG (0.13%).

3.1.9 People's Opinions on GHG Emission and Global Warming

To analyze the awareness and willingness of local people within the non-household sector regarding the GHG emissions and global warming issues, the survey was conducted through questionnaire and face-to-face interview. All the 18 respondents of the non household sector responded on the questionnaires. The findings about the knowledge of these people on the impact of climate change and GHG emission are given in figure 18 below.

Figure 18: Survey Result on Knowledge on Impact of Climate Change and GHG emission



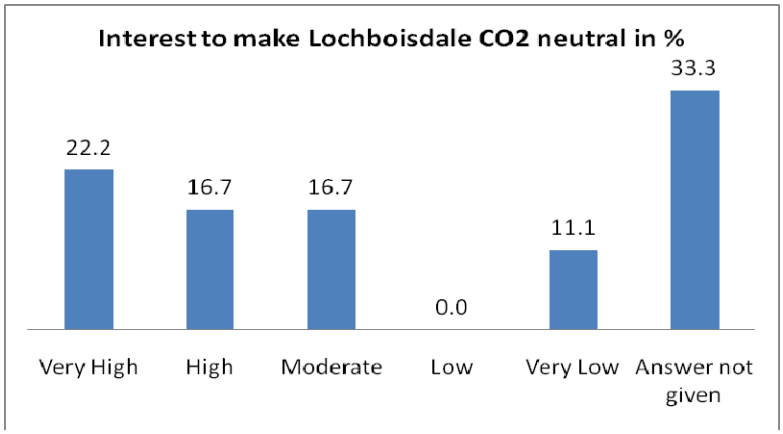


Source: SESAM, IC 2009

More than 66% of respondents have moderate or higher level of knowledge on impact of climate change. Similarly, more than 60% have moderate, high or very high knowledge on GHG emission. However, still 5.6% of respondents have no or little knowledge on it. About one third of respondents (33.3%) did not answer the questions. This group might have also some or high knowledge on GHG emission and global warming. However, it also shows the importance of raising public awareness for 33% of the non-household sector.

As shown in figure 19, almost 40% of the respondents answered that they are very much interested to make Lochboisdale as a CO_2 neutral village. 16.7% of respondents have a moderate level of interest. The team assumes that it is due to the lack of sufficient knowledge on GHG emission and global warming. 11.1% of respondents expressed very low interest. 33% did not give any answer about this question in the questionnaire.

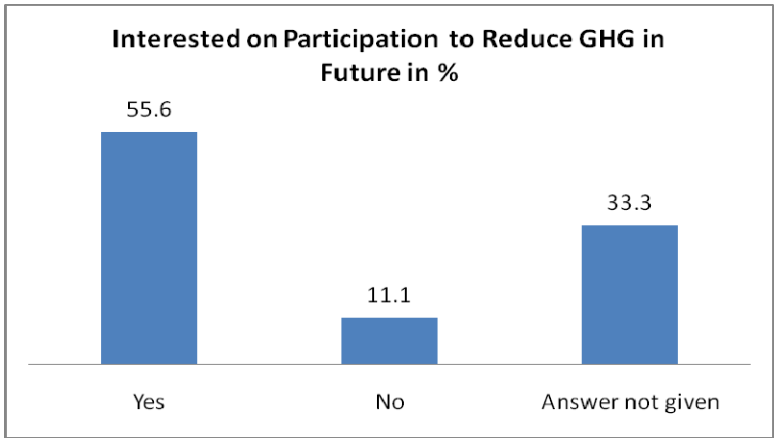
Figure 19: Interest of people to make Lochboisdale as CO_2 neutral village



Source: SESAM, IC 2009

It is a fact that more than half (55.6%) of the respondents said that they are moderately, highly or even very highly interested in participating in the GHG emission reduction in the future (Figure 20), which shows quite some potential for the future plans of Lochboisdale. However, around 11% of respondents clearly expressed that they have no interest for participation to reduce GHG. So there is need of creating awareness to them. Besides this, there are a quite a number of people (33.3%) who did not respond towards this question (Figure 20).

Figure 20: Survey Result of interest of People in Participation to reduce GHG



Source: SESAM, IC 2009

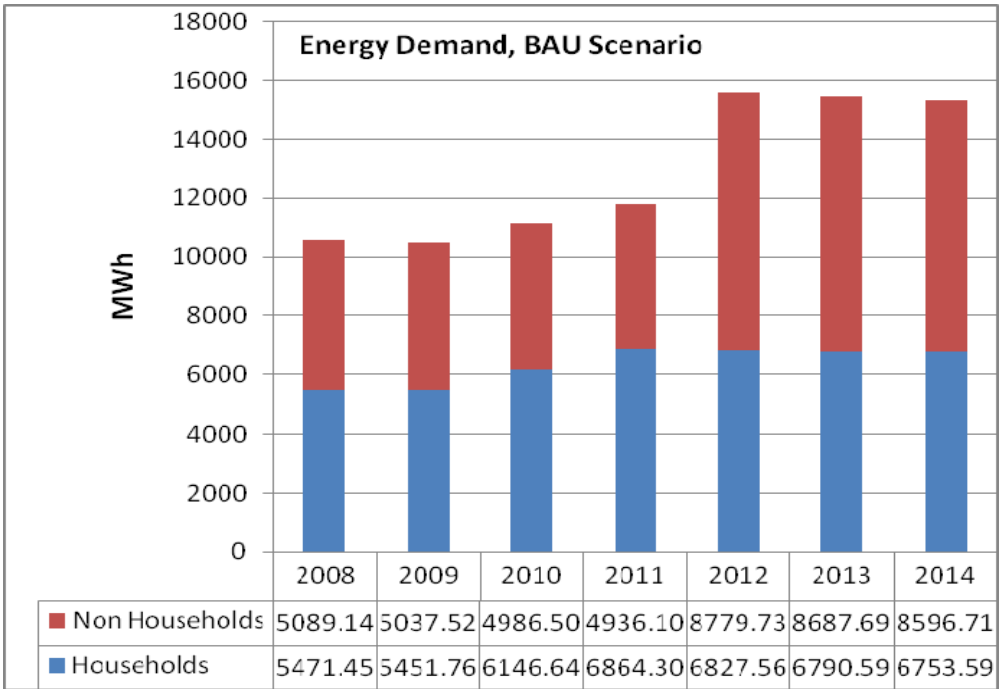
Based on the result of the survey, the team assumes that providing managers and/or staffs of the non-household sector with some awareness programs will encourage them to participate in eco-friendly activities like the carbon neutral initiative.

4 Business as Usual Scenario (BAU)

In this study, a BAU scenario is made up to the year 2014 using Long-range Alternative Energy Planning (LEAP) software. The main purpose is to analyze how the energy situations of Lochboisdale will look like, if current trend of supply and demand of energy will continue. Similarly, BAU scenario also considers current energy policies/targets which have already been enforced or likely to be enforced within the planning period.

Figure 21 shows the future energy demand up to 2014 in the BAU Scenario. The total energy demand will decline slightly by 0.68% in 2009 compared to 2008 due to the impact of the improvement of energy efficiency measures. The average energy demand will rise by 6.07% from 2010 to 2011 and by 32% in 2012 due to the impact of the harbour extension project. However, from 2012 to 2014, the demand drops steadily due to energy efficiency improvement. Overall, from 2008 to 2014, the energy demand rises from 10,560.6 MWh/y in 2008 to 15,350.3 MWh/y in 2014 which is a growth rate of 45%.

Figure 21: Energy demand in BAU Scenario

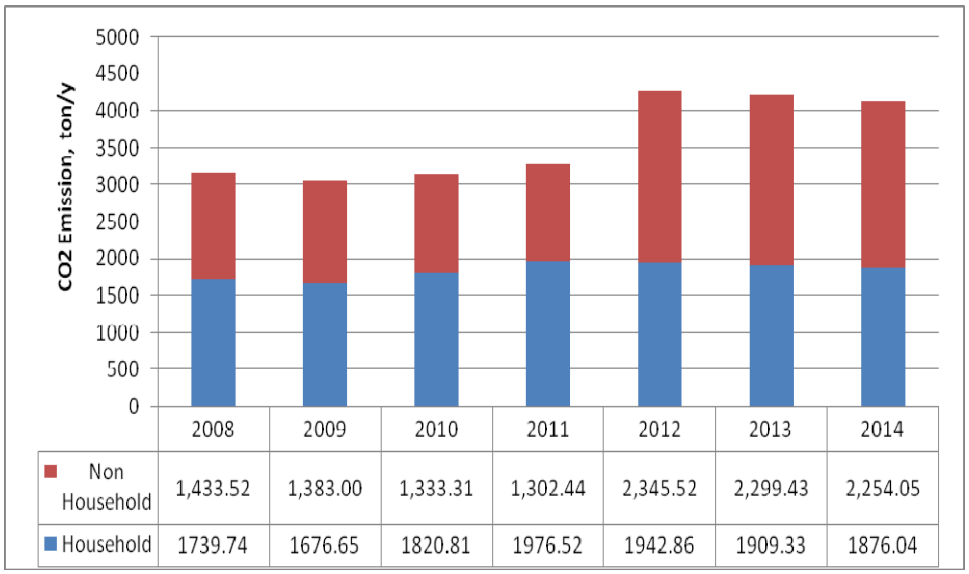


	2008	2009	2010	2011	2012	2013	2014
Non Households	5089.14	5037.52	4986.50	4936.10	8779.73	8687.69	8596.71
Households	5471.45	5451.76	6146.64	6864.30	6827.56	6790.59	6753.59

Source: SESAM, IC 2009

In terms of CO_2 emission (Figure 22), the total predicted emission will decline slightly by 4.52% in 2009 compared to the base year 2008. From 2010 to 2011, the total emission will rise by 3.62% on average mainly due to the 40 additional houses as a part of the harbour extension project. The amount of CO_2 emission in 2012 will rise significantly by around 29.9%. However, from 2012 to 2014, the emission will decrease again steadily due to the combination of significant efficiency improvement and increased share of renewable energy in the overall energy mix. Overall, from 2008 to 2014 the total CO_2 emission will rise from 3,173 tons/y in 2008 to 4,072 tons/y in 2014 by 28%. More detailed assumptions and results by sector are described in the following sub-chapters.

Figure 22 : CO2 Emission in BAU Scenario



	2008	2009	2010	2011	2012	2013	2014
Non Household	1,433.52	1,383.00	1,333.31	1,302.44	2,345.52	2,299.43	2,254.05
Household	1739.74	1676.65	1820.81	1976.52	1942.86	1909.33	1876.04

Source: SESAM, IC 2009

4.1 Household Sector

The BAU scenario of energy consumption in the household sector in Lochboisdale is based on three main assumptions: annual household growth by 0.53%[21], annual energy efficiency improvement by 1.1% (based on energy efficiency target of 9% from 2008 to 2016)[22], and reduction of energy consumption by 25% for a new building compared to the existing one[23]. The base year for the BAU is 2008. The household growth rate of Lochboisdale is taken from the growth rate of Western Isles. According to Storas Uibhist, household numbers will

[21] Storas Uibhist, "Lochboisdale Harbour Evaluation of Existing Provision and Future Opportunities", page 25, October 2008
[22] Department for Environment, Food and Rural Affairs (DEFRA), "UK Energy Efficiency Action Plan 2007", 2007 (http://ec.europa.eu/energy/demand/legislation/doc/neeap/uk_en.pdf) , page 27, accessed March 2009
[23] Ibid, page 15.

increase by 14% from 2006 to 2031 in Western Isles. Energy consumption of a new building which is 25% lower than existing building refers to the Scottish building standards regulations which came in force on March 4th, 2002. [24]

The decline of energy consumption is mainly due to energy efficiency impacts in the household sector which consist of improving technical energy efficiency and changing behavior for energy saving. [25] Firstly, improving the technical energy efficiency in Lochboisdale means that many households will try to use more energy efficient products such as Compact Fluorescent Lamp (CFL) for lighting, double glazing windows, and high efficient and smaller capacity of appliances or vehicles. Secondly, changing behavior in energy consumption indicates that the household members will make energy efficiency efforts such as not using unnecessary lights, avoiding stand by mode for appliances, and using public transportation if applicable.

As a part of the harbor extension project, 40 additional houses will be built by the end of 2011 in two phases with 20 buildings in 2010 and 20 additional houses in 2011. With annual growth rate of household by 0.53% and 40 additional houses, the total number of households in 2014 is predicted to reach 179 with 169 fully occupied and 10 holiday households. More detailed prediction of the number of household during the project period is shown in table 5 below.

Table 5 Prediction of Household Numbers, 2008- 2014

Year	Household			
	Fully Occupied (HH)	Holiday (HH)	Total (HH)	Growth
2008	124	10	134	-
2009	125	10	135	0.53%
2010	145	10	155	15.38%
2011	166	10	176	13.40%
2012	167	10	177	0.53%
2013	168	10	178	0.53%
2014	169	10	179	0.53%

Source: SESAM, IC 2009

4.1.1 Energy Demand

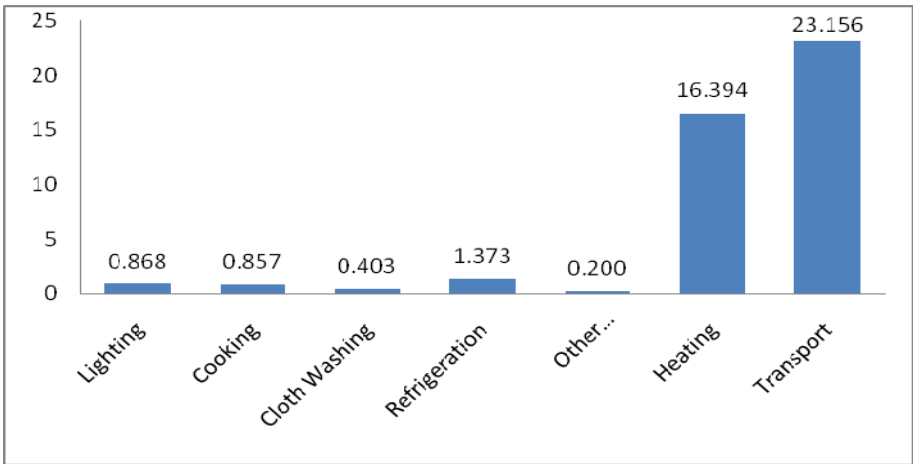
Total energy demand in the future is calculated based on energy consumption per household in 2008 (Figure 23). The energy consumption is divided into several consumption areas such as transportation, heating, refrigeration, cooking, lighting, cloth washing and other

[24] Department for Environment, Food and Rural Affairs (DEFRA), "Economic Instruments to Improve Household Energy Efficiency", 2002 (http://www.hm-treasury.gov.uk/d/household_energy.pdf), page 15, accessed 17-March-2009.

[25] Ibid, page 10.

appliances. The two largest shares of energy consumption per household are transportation and heating which account for 54% and 38% respectively. In Lochboisdale, the average energy consumption per fully occupied household is 43.25 MWh/yr.

Figure 23: Energy consumption of each fully Occupied Household in 2008



Source: SESAM, IC 2009

There are visible patterns of the future energy demand of Lochboisdale shown in table 6. In 2009, the energy demand will decrease by 0.36% (5,452 MWh) compared to the current energy consumption in 2008. It is mainly due to the improvement of energy efficiency although the total number of household will rise slightly. From 2010 to 2011, the energy demand will increase substantially due to 40 additional houses: 6,147 MWh in 2010 and 6,864 MWh in 2011. From 2012 to 2014, the energy demand will steadily drop down by 0.54% per year. The energy demand of holiday households will decline by 0.6 % on average, because the harbour extension project will not lead to the increase of the number of holiday households.

Table 6 shows the breakdown of household energy demand by fuel types which consists of wood biomass, solid fuels, oil products and electricity. According to the BAU scenario, solid fuels and electricity will still dominate the fuel demand of the community in the next 5 years. Solid fuels will account for 70%, and the electricity will contribute 21% on average from 2008 until 2014. Solid fuels especially gasoline and diesel will still be used for transportation, while electricity and kerosene will be used mainly for the heating purpose in the household sector. A small amount of coal anthracite, peat, and wood will be used as fuels for heating as well as LPG for cooking. The rest of electricity will remain the same for electrical appliances including lighting, cooking, refrigeration, and cloth washing.

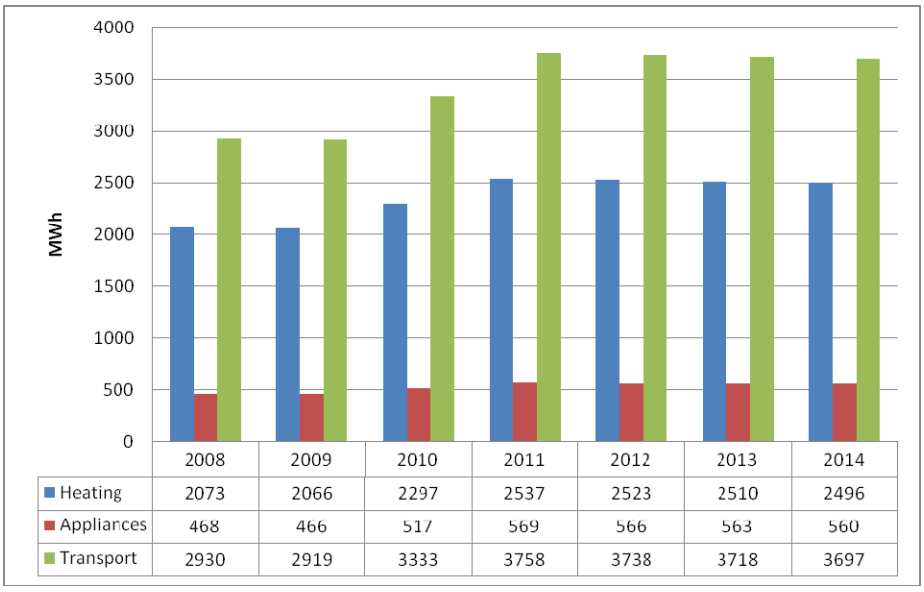
Table 6: Energy Demand by Fuel between 2008 and 2014 (MWh)

Fuel	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*
Wood	11	11	13	14	14	14	14
Peat	51	51	57	62	62	62	61
LPG	7	7	8	9	9	9	9
Kerosene	633	631	699	770	766	762	758
Gasoline	1294	1290	1475	1665	1656	1647	1638
Electricity	1204	1200	1329	1464	1457	1449	1441
Diesel	1868	1861	2122	2390	2378	2365	2352
Coal Anthracite	403	401	445	490	487	485	482
Total	**5471**	**5452**	**6147**	**6864**	**6828**	**6791**	**6754**

Source: SESAM, IC 2009

Energy demand by purpose is divided into three sub-sectors: heating, appliances, and transportation. As figure 24 shows, from 2009 until 2014 composition of energy consumption in heating, appliances and transportation sectors will remain same. The heating sectors will consume 37%, appliances 8% and transportation 55% of total energy in the household sector. From all sub-sectors, the energy demand will decline in 2009 and will rise again from 2010 and 2011. Then, it will gradually decline until 2014. This pattern is the same like total energy demand pattern due to the combination of household growth, the improvement of energy efficiency, and the harbor extension plan.

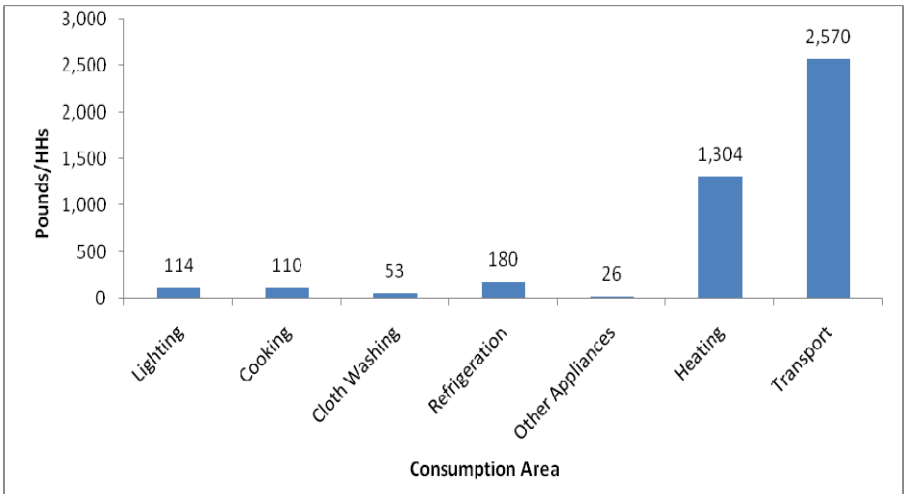
Figure 24: Energy Demand by Purposes, 2008 - 2014



Source: SESAM, IC 2009

Demand cost is the amount of money needed to fulfill the energy demand for each household. This cost covers only fuel or operational cost. Based on our survey (Figure 26) demand cost for one fully occupied household in Lochboisdale is 4,357 £/y. One household is spending 59% of its total energy expenditure for transport and 30% for the heating purpose. The remaining 11% expenditure is for lighting, cooking etc.

Figure 25: Demand Cost of each fully occupied Household in 2008



Source: SESAM, IC 2009

The trend of the total demand cost for all households in Lochboisdale is as shown in table 7. The total demand cost is based on the fully occupied and holiday household categories. Before the completion of the harbour extension project, total cost saving will be 0.36% in 2009 compared to 2008. Then, it will rise to 0.54 % per year after the completion of harbour extension project.

Table 7: Demand Cost for all Households (in thousand UK Pounds), 2008 - 2014

	2008	***2009***	***2010***	***2011***	***2012***	***2013***	***2014***
Fully Occupied Household	540	538	609	683	679	675	672
Holiday Household	11	11	11	11	11	11	11
Total	551	549	620	693	690	686	682

Source: SESAM, IC 2009

4.1.2 Energy Supply

At present, all energy for household in Lochboisdale is being imported from the mainland except peat. In the BAU scenario, this situation might be continued. Energy supply of peat

from Lochboisdale was 0.05 thousand MWh in 2008, and it will increase slightly up to 0.06 thousand MWh in 2014. More detailed energy supply and demand data of 2008 are presented in the following table 8.

Table 8 Energy Supply and Demand for Households, 2008 (in thousand MWh)

	Electricity	***Gasoline***	***Kerosene***	***Diesel***	***LPG***	***Coal Anthracite***	***Peat***	***Wood***	***Total***
SUPPLY									
Production	0	0	0	0	0	0	0.05	0	0.051
Imports	1.204	1.294	0.633	1.868	0.01	0.403	0	0.011	5.471
Total Primary Supply	***1.204***	***1.294***	***0.633***	***1.868***	***0.01***	***0.403***	***0.05***	***0.011***	***5.471***
DEMAND									
Fully Occupied Household	1.180	1.269	0.621	1.831	0.01	0.395	0.05	0.011	5.363
Holiday Household	0.024	0.026	0.013	0.037	0	0.008	0	0	0.108
Total Household Demand	***1.204***	***1.294***	***0.633***	***1.868***	***0.01***	***0.403***	***0.05***	***0.011***	***5.471***

Source: SESAM, IC 2009

4.1.3 CO2 Emission

In the BAU scenario, the following assumptions are made to calculate the future CO_2 emission:

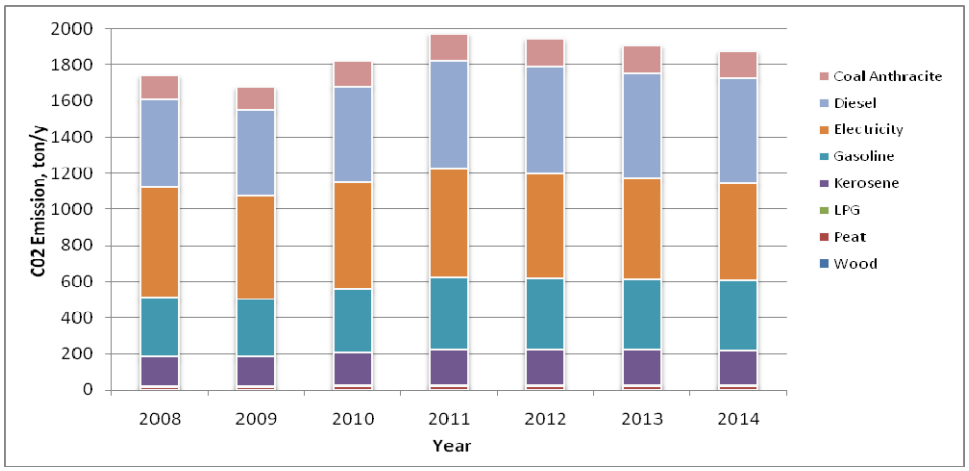
- New buildings will consume 25% less energy than the existing buildings[26]
- 40 additional household buildings[27]
- Scottish government's energy efficiency target: 1.1% increase per year[28]
- UK Renewable Transport Fuel Obligation (5% of the total fuels demand, bio-fuels by 2010, and as per EU new agreed target for 10% bio-fuels by 2020).[29] Thus, it is estimated that by 2014 bio-fuels will contribute around 7% of the transport fuel.[30]

[26] Defra, "Environmental Reporting", http://www.defra.gov.uk/environment/business/envrp/conversion-factors.htm, page 15, accessed March 2009.
[27] Storas Uibhist, "Lochboisdale Harbour Evaluation of Existing Provision and Future Opportunities", page 25, October 2008
[28] Ibid.
[29] Defra, "UK Energy Efficiency Action Plan 2007", page 12, 2007

[30] UK, (2007). UK Road Transport Bio fuels Market. Available at http://www.berr.gov.uk/files/file43824.pdf, accessed March 2009

All assumptions mentioned above will affect the future CO_2 emission in Lochboisdale. Based on the total energy demand from 2008 to 2014 with above targets, the CO_2 emission scenario is as shown in figure 26 below.

Figure 26: CO_2 Emission by Fuel Types, BAU Scenario



Source: SESAM, IC 2009

The above figure 26 shows that the CO_2 emission will decline from 2008 to 2009 due to increasing share of renewable energy and bio-fuels and improvement of efficiency in household buildings. In 2008, the total emission from the household sector was 1,739 tons/y, and it is estimated to be 1,676 tons/y in 2009. Due to the additional 40 households, the CO_2 emission will increase from 2010 to 2011. Then, it will decline again from 2011 because of expansion of renewable energy mainly on the electricity supply, improvement of energy efficiency and increasing share of bio-fuels.

As shown in the above figure, the largest CO_2 contributor is electricity from 2008 (35.2%) to 2011 (30.6%). Then, diesel will dominate due to increasing use in transportation as fuel and heating in household buildings including the additional 40 households. Wood and peat will be expected as the lowest CO_2 emission contributors in future as well.

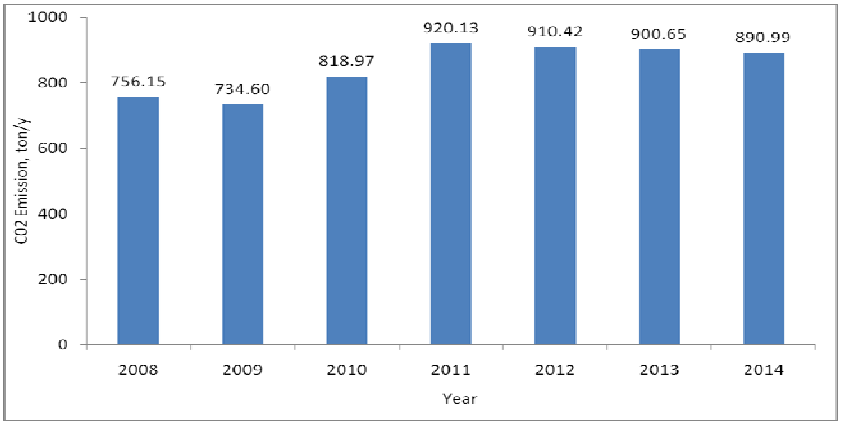
a) Transportation

In the BAU scenario, CO_2 emission from household transport will slightly decrease from 2008 to 2009 (Figure 27). However, from 2010 to 2011, it will increase again because of increasing number of vehicles in the new 40 households.

Bio-fuels like bio-ethanol and bio-diesel are CO_2 neutral energy sources. Thus, it is projected that increasing trend of using bio-fuels and obligation of UK to use them as transport fuels will reduce the CO_2 emission in the transport sector. For instance, transport fuels emitted 756.15

tons of CO_2 in 2008, and the figure will increase to 920.13 tons/y in 2011. Due to the impact of bio-fuels contribution, after 2011 emission will steadily decrease every year.

Figure 27: CO_2 Emission from Household Transport, BAU Scenario

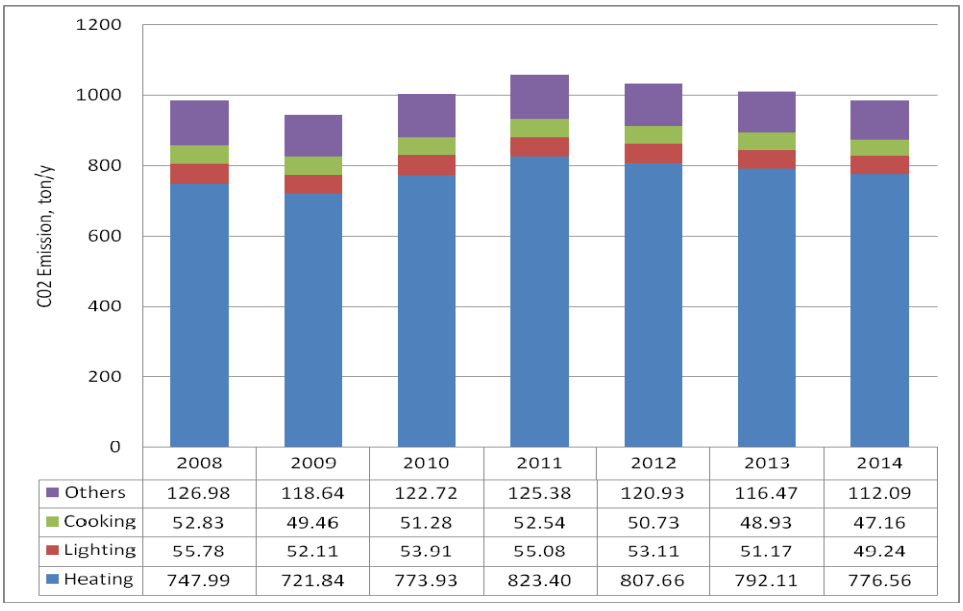


Source: SESAM, IC 2009

b) Heating and Other Purposes

In the BAU scenario, the CO_2 emissions from heating, lighting, cooking and appliances will decrease from 983.59 tons in 2008 to 942 tons in 2009. However, it will increase again from 2009 to 2011 due to the 40 additional houses. As shown in figure 28 below, the CO_2 emission is projected to decrease from 1,056.39 tons in 2011 to 985 tons in 2014. This is due to mainly increasing contribution of renewable energy for electricity and improvement of energy efficiency for both appliances and building insulation.

Figure 28: CO_2 Emission by End Uses, BAU Scenario



	2008	2009	2010	2011	2012	2013	2014
Others	126.98	118.64	122.72	125.38	120.93	116.47	112.09
Cooking	52.83	49.46	51.28	52.54	50.73	48.93	47.16
Lighting	55.78	52.11	53.91	55.08	53.11	51.17	49.24
Heating	747.99	721.84	773.93	823.40	807.66	792.11	776.56

Source: SESAM, IC 2009

The figure above shows that heating contributes the largest share in CO_2 emission in every year followed by appliances mainly refrigerators and cloth washing machine. Heating alone contributed around 75% in 2008 and will contribute around 71% in 2014.

4.2 Non-Household Sector

The main assumptions used for the BAU scenario in the non-household sector are as follows:

i) Due to the lack of future projection data on energy consumption in the non-household sector of Lochboisdale, tourism growth rate of Outer Hebrides was used to estimate the future energy demand.

ii) The number of tourists in Outer Hebrides increased by 8.9% between 2002 and 2006. [31]

iii) It is assumed that the tourism growth in Lochboisdale will affect on energy consumption of Lochboisdale Hotel only. The energy consumption of the rest of non-household sector will remain same.

iv) The size of a fish processing plant is assumed to be the same size as the fish processing plant in Barra which consumes 591.47 MWh per year.[32] For other additional entities, the size and energy consumptions are assumed as the current energy consumption of same type of existing entities in Lochboisdale.

v) Both fuel consumption and CO_2 emission of the ferry is excluded.

4.1.4 Energy Demand

The BAU scenario (Figure 29) shows that the total energy demand will be 8,596.71 MWh/y in 2014. By the end of 2011, the total energy demand will decline by 3% due to improvement of energy efficiency. However, the total energy demand will increase by 77.87% due to the growth in energy demand from the proposed harbor extension plan from 2012 to 2014. With the assumption of the continuity of current energy efficiency policy till 2014, the total energy demand will decrease by around 2.08% from 2012 to 2014.

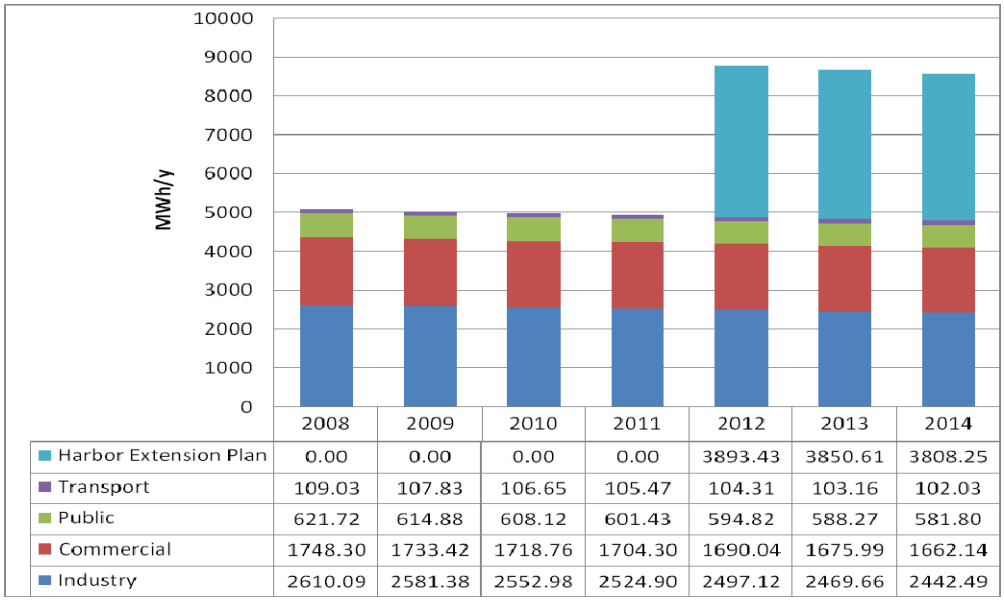
a) Energy Demand by Sector

The industrial sector dominates the future energy demand in the non-household sector up to 2011 (Figure 29). As a part of the harbor extension project, some commercial and industrial facilities especially the fish processing plant will start operating by the beginning of 2012. Thus, after the completion of the harbor extension, the new fish processing plant will be the

[31] Outer Hebrides Tourism Facts and Figures, 2007
[32] Barra team in SESAM IC 2009, "Electricity Supply from Wind to Fish Factory", page 6, March 2009

single largest energy consumer which will consume around 591.47 MWh per year. [33] Similarly, 20 additional fishing boats will be the second largest energy consumer which will contribute to the growth of total energy demand after 2012. A more detailed breakdown of energy demand by sub-sectors up to 2014 in the BAU scenario is shown in figure 29 below.

Figure 29: Energy Demand by Sector in BAU Scenario up to 2014



	2008	2009	2010	2011	2012	2013	2014
Harbor Extension Plan	0.00	0.00	0.00	0.00	3893.43	3850.61	3808.25
Transport	109.03	107.83	106.65	105.47	104.31	103.16	102.03
Public	621.72	614.88	608.12	601.43	594.82	588.27	581.80
Commercial	1748.30	1733.42	1718.76	1704.30	1690.04	1675.99	1662.14
Industry	2610.09	2581.38	2552.98	2524.90	2497.12	2469.66	2442.49

Source: SESAM, IC 2009

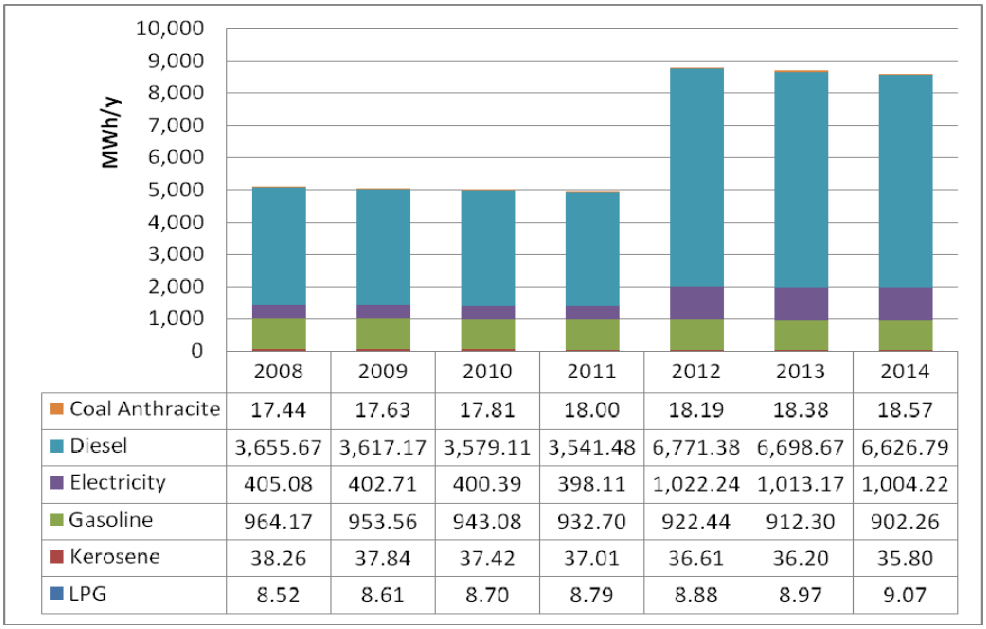
b) Energy Demand by Fuel

According to the BAU scenario, diesel will dominate the fuel mix of the non-household sector in Lochboisdale until 2014 (Figure 30). By the end of the year 2011, the diesel demand will reach 3,541.48 MWh which is 71.75% of the total energy demand. Gasoline and electricity will also remain as important energy carriers. However, the energy demand will rise after implementation of the harbor extension project from the beginning of 2012. From the BAU scenario, the total demand in 2012 will be 8,779.73 MWh with contribution by diesel (77.13%), gasoline (10.51%), electricity (11.64%) and to a smaller amount by other sources like LPG, kerosene and coal. Electricity demand will be more than the gasoline after 2012 due to the new fish processing plant. From 2012, the demand will decline because of improvement of energy efficiency. By the end of 2014, the total demand will be 8,596.71 MWh, which will be met mainly by diesel (77.09%), electricity (11.68 %) and gasoline (10.5%).

[33] Ibid.

The energy demand by fuel type in BAU scenario up to 2014 is shown in the figure 30 below:

Figure 30: Energy Demand up to 2014 by Fuel Type in BAU Scenario



	2008	2009	2010	2011	2012	2013	2014
Coal Anthracite	17.44	17.63	17.81	18.00	18.19	18.38	18.57
Diesel	3,655.67	3,617.17	3,579.11	3,541.48	6,771.38	6,698.67	6,626.79
Electricity	405.08	402.71	400.39	398.11	1,022.24	1,013.17	1,004.22
Gasoline	964.17	953.56	943.08	932.70	922.44	912.30	902.26
Kerosene	38.26	37.84	37.42	37.01	36.61	36.20	35.80
LPG	8.52	8.61	8.70	8.79	8.88	8.97	9.07

Source: SESAM, IC 2009

4.1.5 Energy supply

In BAU scenario, all energy demand will be met by importing the energy from mainland except peat. However, the fuel mix of the electricity suppliers will be changed based on the Scottish government's renewable energy target as shown below:

Table 9: Renewable Energy Share on Electricity

Unit : kg/kWh	2008	2009	2010	2011	2012	2013	2014
Share of Renewable Energy on Electricity	15.0%	20.3%	25.6%	31.0%	33.1%	35.2%	37.3%

Source: Energy Saving, UK[34]

4.1.6 CO2 Emission

The CO_2 emission under the BAU scenario is affected mainly by two factors as follows;

a) Decrease of electricity demand due to improvement of energy efficiency.

[34] http://energy.savills.co.uk/news/planning-reforms-can-help-government-achieve-its-target.asp, accessed in 11th March 2009

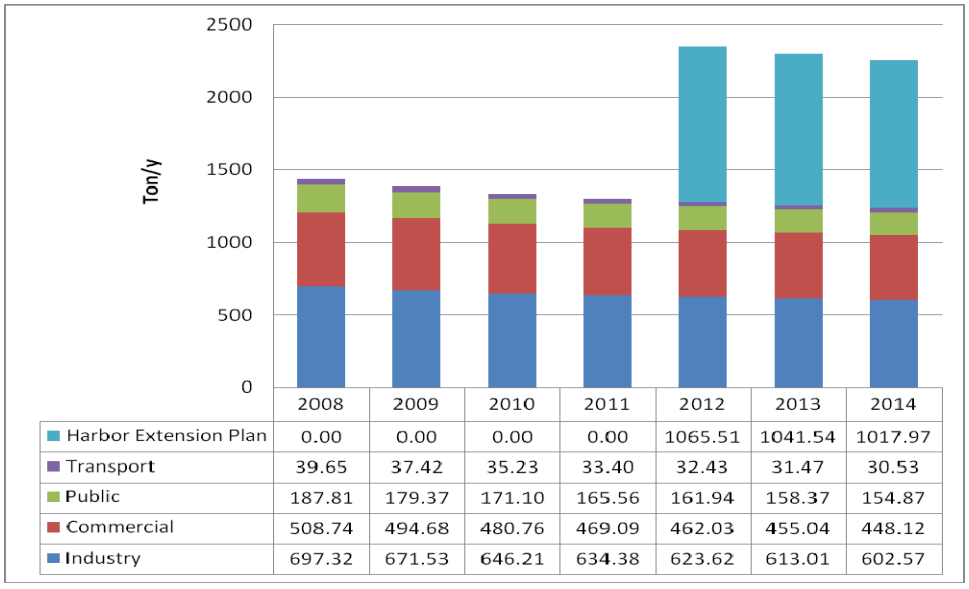
b) Scottish government had set a target that 50% of Scottish electricity demand should be met from renewable by 2020 with a milestone of achieving 31% by 2011. This makes compliance for electricity suppliers to increase the share of renewables in their fuel mixes which will lead to the reduction of CO_2 emission.

According to the BAU scenario (Figure 31), the CO_2 emission will decrease by 9.14% by the end of 2011 compared to the reference year 2008. However, from the beginning of 2012 the CO_2 emission will increase again by 80.08%. This is mainly due to additional electricity and diesel demand by the fish processing plant and fishing boats.

a) CO_2 Emission by sector

In the non-household sector of Lochboisdale area, up to 2011 the industrial sector is the largest CO_2 emitter followed by the commercial, public and transport sectors. From the beginning of 2012, the CO_2 emission will increase significantly due to the impact of the harbor extension project. For instance, the industrial sector will emit 634.48 tons of CO_2 which accounts for 48.71% of the total non-household emission in 2011. CO_2 emission will be increased by 1,043.09 (80.08 %) tons after the implementation of harbor extension in 2012, and the total emission in the non-household sector will reach 2,254.05 tons in 2014. The CO_2 emission by sector for the non-household in BAU scenario is shown the figure 31 below:

Figure 31: CO_2 Emission by sector for non-household in BAU Scenario



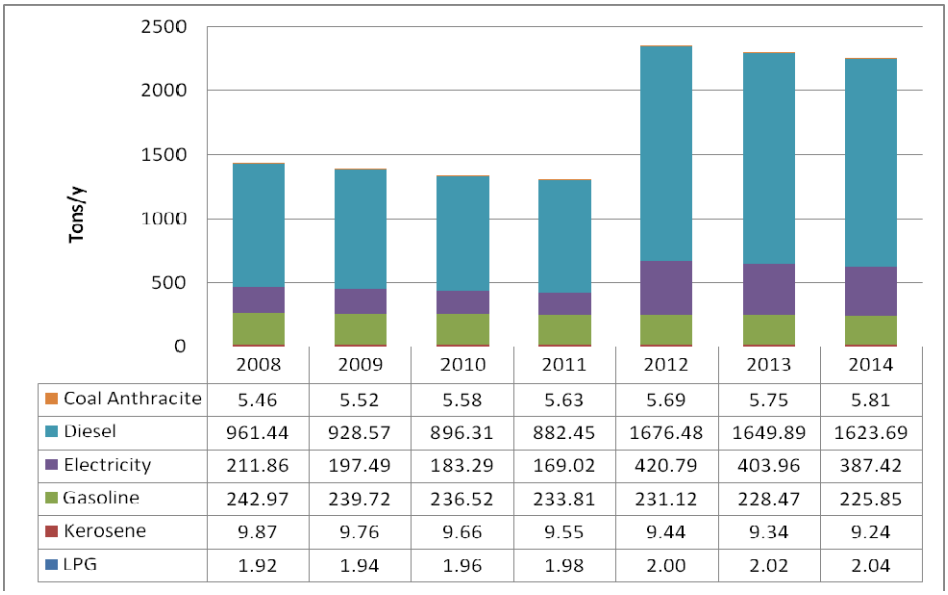
	2008	2009	2010	2011	2012	2013	2014
Harbor Extension Plan	0.00	0.00	0.00	0.00	1065.51	1041.54	1017.97
Transport	39.65	37.42	35.23	33.40	32.43	31.47	30.53
Public	187.81	179.37	171.10	165.56	161.94	158.37	154.87
Commercial	508.74	494.68	480.76	469.09	462.03	455.04	448.12
Industry	697.32	671.53	646.21	634.38	623.62	613.01	602.57

Source: SESAM, IC 2009

b) CO_2 Emission by Fuel Types

According to the BAU scenario (Figure 32), it can be seen that diesel will be the main emitter in the whole period in the non-household sector (Figure 32). The second largest emitter will be gasoline up to 2011 followed by the electricity. The trend of CO_2 reduction up to 2011 will decline due to the expansion of renewable energy in energy mix of the Scottish electricity suppliers. After 2012, electricity will be the second largest emitter mainly due to the new fish processing plant. By 2014, diesel will contribute 1,623.69 tons (72.03 %) of CO_2 emission. The CO_2 emission pattern by fuel types in the non-household sector is shown the figure 32 below:

Figure 32: CO_2 Emission by fuel types in the non-household sector



	2008	2009	2010	2011	2012	2013	2014
Coal Anthracite	5.46	5.52	5.58	5.63	5.69	5.75	5.81
Diesel	961.44	928.57	896.31	882.45	1676.48	1649.89	1623.69
Electricity	211.86	197.49	183.29	169.02	420.79	403.96	387.42
Gasoline	242.97	239.72	236.52	233.81	231.12	228.47	225.85
Kerosene	9.87	9.76	9.66	9.55	9.44	9.34	9.24
LPG	1.92	1.94	1.96	1.98	2.00	2.02	2.04

Source: SESAM, IC 2009

5 Alternative Scenario

In this chapter, alternative scenarios are described. Compared to the BAU Scenario, the alternative scenario is additionally affected by the implementation of renewable energy systems (wind and micro hydro) and district heating, increasing share of bio-fuels and public transportation usage. As a result of the alternative scenario, in 2014 the total energy demand will be 13,569 MWh/y, which is 11.60 % lower than BAU scenario. In terms of CO_2 emission, the total emission in 2014 will be 3,544 tons/y where as under the alterative scenario it will be 13.94% lower than the BAU scenario.

5.1 Energy Demand

The energy demand for both household and non-household sectors is described in detail in following sub-chapters.

5.1.1 Household Sector

An alternative scenario for the household sector was developed based on the reduction of the heating consumption, expansion of the renewable energy and the increasing usage of the public transportations. Firstly, 25% of 124 existing fully occupied households are expected to reduce their heating consumption by 50% through improving their house insulations. This energy saving target of 50% is set based on the best practice in UK[35], which is little bit higher than the Scottish Building Standard[36]. Secondly, a growing use of public transportation will be one of the quickest ways that people can reduce CO_2 emission. Based on the survey result, 37% of existing households are willing to use public transportation. However, it will be difficult to offer more public transportation services within a short period of time. So, it is expected that at least 50% of them will use public transport. Similarly, 50% of additional 40 households are expected to use public transportation.

In the alternative scenario, the energy demand of Lochboisdale will be 5,857 MWh, in 2011 (see table 11), which is higher than the BAU scenario (6,864 MWh) in the same year. As shown in table 11 below, demand trend of existing fully occupied and holiday households will decrease over the years from 2008 until 2014. For additional fully occupied households, the demand will appear at the first time in 2010, increase in 2011 and then decrease a little bit until 2014.

[35] DEFRA, UK Energy Efficiency Action Plan 2007, P.24

Table 10: Total Energy Demand based on Alternative Scenario (in MWh)

	2008	***2009***	***2010***	***2011***	***2012***	***2013***	***2014***
Fully Occupied Household	5363	4815	4721	4705	4680	4654	4622
Additional Fully Occupied Household	0	0	527	1046	1040	1035	1029
Holiday Household	108	108	107	106	105	105	104
Total	***5471***	***4923***	***5355***	***5857***	***5825***	***5794***	***5756***

Source: SESAM, IC 2009

The table 12 shows that the largest share of the future energy demand will be by diesel followed by gasoline and electricity. From 2009, the electricity share will be higher than gasoline share but still lower than diesel share. Compared to the BAU scenario, each fuel contributes more equally to the share of the total energy demand. This is mainly due to the target of using more public transportation in the alternative scenario.

Table 11: Energy Demand by Fuel in Alternative Scenario from 2008 to 2014

	2008	***2009***	***2010***	***2011***	***2012***	***2013***	***2014***
Wood	11	11	12	14	14	14	13
Peat	51	51	56	61	61	61	60
LPG	7	7	8	9	9	9	9
Kerosene	633	631	686	759	755	750	744
Gasoline	1294	1060	1149	1244	1237	1230	1224
Electricity	1204	1200	1314	1451	1443	1435	1425
Diesel	1868	1561	1693	1837	1827	1818	1807
Coal Anthracite	403	401	436	483	480	477	473
Total	***5471***	***4923***	***5355***	***5857***	***5825***	***5794***	***5756***

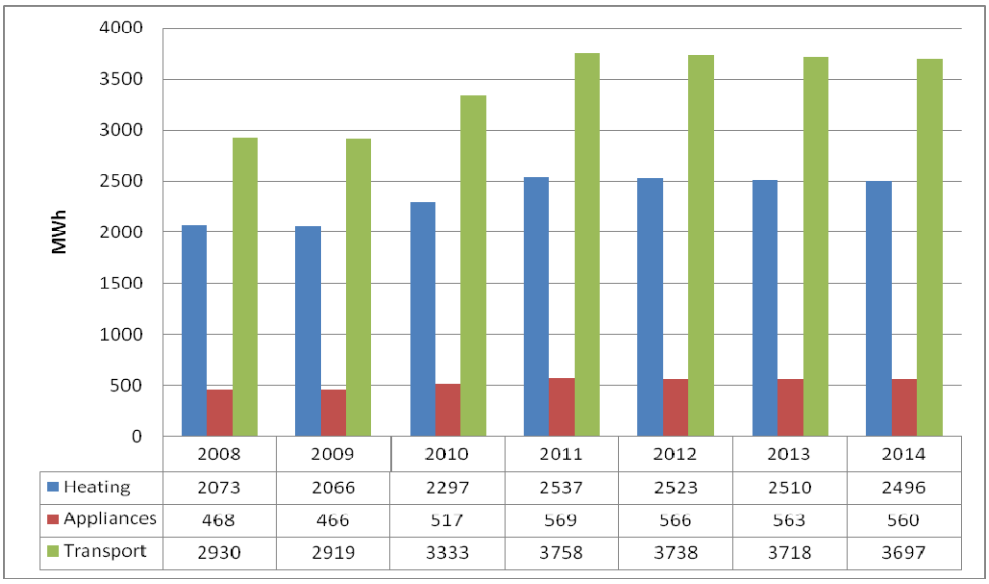
Source: SESAM, IC 2009

The figure 33 shows the alternative scenario of households' energy demand in appliances, heating and transport from 2008-2014. The energy demand in heating will slightly decrease in 2009 as well as after the harbour extension project in 2012-2014 because of energy efficiency efforts including home insulation improvement. The magnitude of heating

[36] Scottish Building Standards Agency (SBSA), "Domestic Handbook 2009", 2009 (http://www.sbsa.gov.uk/tech_handbooks/th_pdf_2009/Domestic_2009.pdf) , accessed 16-March-2009.

consumption in alternative scenario is much lower than in BAU scenario although the growth is almost similar. In transportation, the energy demand in 2009 will decrease significantly (17%) compare to 2008. This is related to the assumed switching from private cars to public transportation of 23 existing households in 2009. The demand of public transportation is expected to increase especially as a result of demand from new additional households in 2010-2011 before a little decrease in the following years afterwards.

Figure 33: Energy Demand by Purpose in Alternative Scenario from 2008 to 2014



	2008	2009	2010	2011	2012	2013	2014
Heating	2073	2066	2297	2537	2523	2510	2496
Appliances	468	466	517	569	566	563	560
Transport	2930	2919	3333	3758	3738	3718	3697

Source: SESAM, IC 2009

In terms of the demand cost (Table 13), it covers only fuel and operational costs. Investment and maintenance costs are not covered in this case. Demand cost which consists of heating, appliances and transport costs show a similar pattern with energy demand. In 2009, this cost will decline slightly and then rise again substantially from 2010 to 2011. From 2013, it will drop down gradually until 2014. Total demand cost in 2014 is expected to reach around 573 thousand Pounds, which is lower than in 2011 (583 Thousand Pounds) after the completion of the harbor extension. Prior to the harbor extension project at the end of 2009, the demand cost will be 490 thousand Pounds, which is lower than 551 thousand Pounds in 2008.

Table 12: Demand Cost of Alternative Scenario (Thousand UK Pounds)

	2008	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*
Heating	168	163	178	197	195	194	193
Appliances	61	61	67	74	73	73	72
Transport	322	266	289	313	311	309	308
Total	**551**	**490**	**534**	**583**	**580**	**577**	**573**

Source: SESAM, IC 2009

5.1.2 Non-Household Sector

In the alternative scenario, 10% of transport fuel demand will be expected to be met by bio-fuel which is already proven in other countries like Germany and Brazil[37]. Based on this, blending of 10% bio-fuel in fuel station of Lochboisdale is expected to be supplied by 2012. It is also projected that all public buildings will use the latest and the most efficient technologies for heating and lighting purposes like best house insulation or CFL. As a result, the overall building efficiency will increase by around 50%, and it will certainly lead to the substantial reduction of the energy demand. Based on the energy efficiency target, the future energy demand in alternative scenario is as shown in figure 34 below.

Figure 34: Energy Demand based on Alternative Scenario by Sector

	2008	2009	2010	2011	2012	2013	2014
Harbor Extension Plan	0.00	0.00	0.00	0.00	3671.98	3629.39	3587.27
Transport	109.03	107.83	106.65	105.47	104.31	103.16	102.03
Public	621.72	614.88	567.15	561.33	555.57	549.87	544.23
Commercial	1748.30	1733.42	1718.76	1704.30	1574.41	1560.36	1546.51
Industry	2610.09	2581.38	2552.98	2524.90	2497.12	2469.66	2442.49

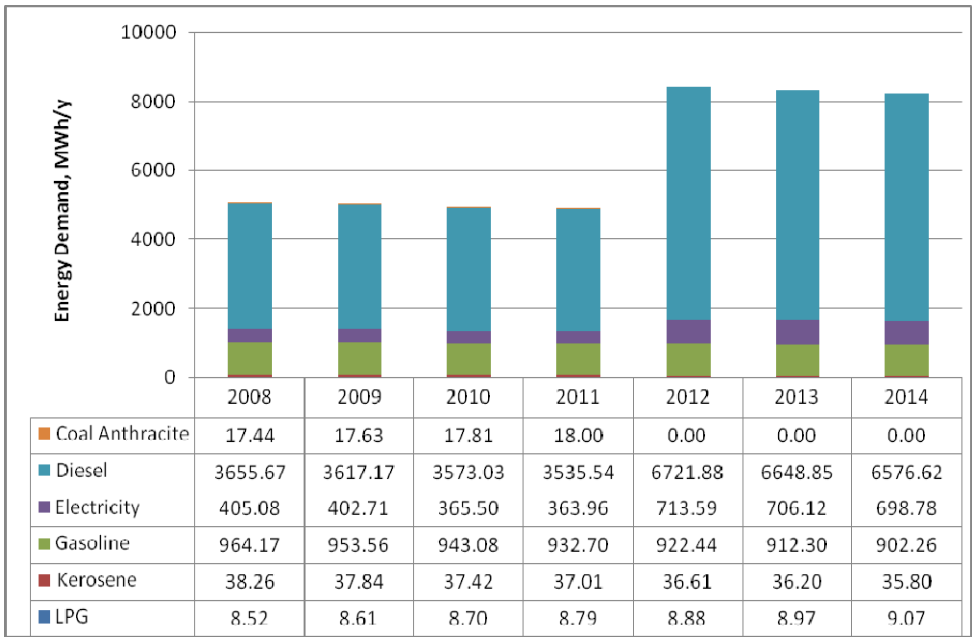
Source: SESAM, IC 2009

[37] UK, "UK Road Transport Bio fuels Market.", http://www.berr.gov.uk/files/file43824.pdf, accessed March 2009

The energy demand will decline from 5089.14 MWh in 2008 to 4896 MWh in 2011, but it will rise again in 2012 due to the harbour extension (Figure 35). After 2012, as the impact of improvement of energy efficiency, the energy demand will slightly decrease. The energy demand will decline in transport in every year due to the increasing share of bio-fuel in the public transport, while energy demand in public sector will decline due to an assumption of 50% energy efficiency. In the commercial sector, due to tourism growth by 2.15% annually the energy demand is not expected to decrease compared to other sectors.

The energy demand by fuel type is as shown in figure 35 below. It shows that diesel will dominate the energy demand due to fishing boats, public transports and heating. The extension of the harbour will lead to significant growth of diesel demand. The electricity demand will also rise significantly after the harbour extension in 2012. However, the gasoline demand remains almost constant in all years.

Figure 35: Energy Demand based on Alternative Scenario by Fuel Type



	2008	2009	2010	2011	2012	2013	2014
Coal Anthracite	17.44	17.63	17.81	18.00	0.00	0.00	0.00
Diesel	3655.67	3617.17	3573.03	3535.54	6721.88	6648.85	6576.62
Electricity	405.08	402.71	365.50	363.96	713.59	706.12	698.78
Gasoline	964.17	953.56	943.08	932.70	922.44	912.30	902.26
Kerosene	38.26	37.84	37.42	37.01	36.61	36.20	35.80
LPG	8.52	8.61	8.70	8.79	8.88	8.97	9.07

Source: SESAM, IC 2009

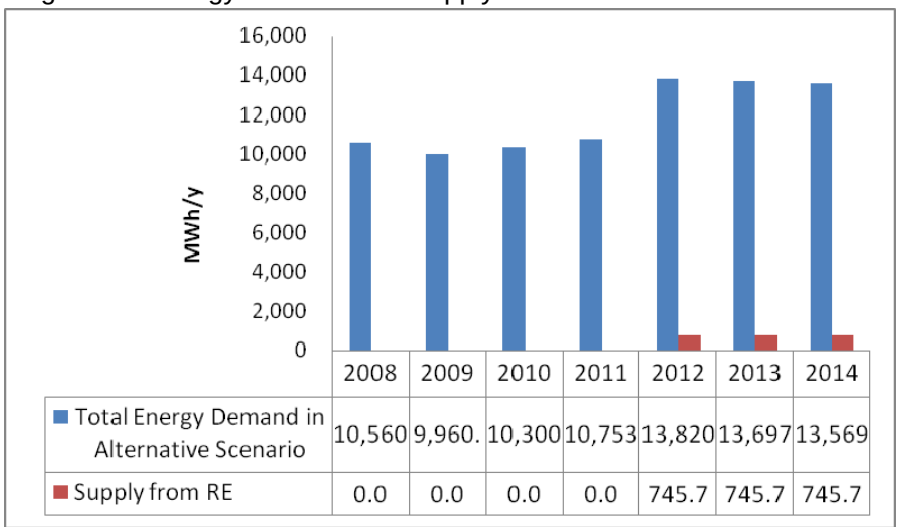
After 2011, energy demand will increase significantly in both scenarios but decrease slightly in the alternative scenario mainly due to substantial efficiency improvements for heating and appliances etc.

5.2 Energy Supply

In the alternative scenario, the total energy demand will be 9,960 MWh in 2009 to 13,569 MWh in 2014 (Figure 36). These figures are after the application of energy efficiency in

alternative energy scenario. The total energy supply from renewable energy (wind and hydro power) in Lochboisdale will be 745.7 MWh from 2012 to 2014 with an average share of 5.4 % in total energy demand.

Figure 36: Energy Demand and Supply from RE in alternative scenario



	2008	2009	2010	2011	2012	2013	2014
Total Energy Demand in Alternative Scenario	10,560	9,960.	10,300	10,753	13,820	13,697	13,569
Supply from RE	0.0	0.0	0.0	0.0	745.7	745.7	745.7

Source: SESAM, IC 2009

The potential of renewable energy and promising supply options up to 2014 in Lochboisdale is described in the following section. The alternative solutions are based on the potential of renewable energy in Lochboisdale.

5.1.3 Renewable Energy potential in Lochboisdale

There are several types of renewable energy resources available in Lochboisdale. One of the highest potential is wind energy which is available throughout the year. Other potentials are from micro hydro power and tidal energy. There is potential of solar energy but it is still an expensive technology, especially under the renewable energy law of the UK. There is a small potential of biomass like sea weed and household organic waste. An overview of the potential in Lochboisdale of the three major renewable energy sources wind, hydro and tidal are as follows.

a) Wind Energy

There are over 1,400 wind turbines generating over 1,300 MW of electricity in the UK in 2006. The average investment cost is around £ 750,000/MW and could produce electricity at 3p/kWh. South Uist area has excellent wind energy potential with an identified capacity from 850 kW to 14,000 kW. The mean wind speed in South Uist is estimated around 8 to 12 m/s at 75 meters height[38]. The utilization of wind energy for power generation has several

[38] Wind power feasibility study done by West Coast Energy Ltd. in 2006

requirements like the sufficient annual mean wind speed and easy accesses to the project site. For the installation of small scale wind turbines below 50 kW, an average wind speed up to 7 m/s will be sufficient. From the above mentioned feasibility report, it is concluded that in general almost everywhere in South Uist area there is sufficient wind potential to develop both technically and economically feasible projects.

b) Hydro Power

Based on the pre-feasibility study done by Fabel Mauncell in 2008, there is one potential site for micro hydro power in Lochboisdale. The total capacity of this power plant is 44 kW, and it could generate around 200 MWh energy annually (with an efficiency of 51%). The proposed site has a gross head of 33 m with a mean flow 0.18 m^3/s[39].

c) Tidal Energy

Based on the study done by West Coast Energy Ltd. in 2006, the west coast of Lochboisdale has potential of a tidal power plant with a capacity of 2.8 MW. This site has a spring tidal range up to 3.6 m. This report has also mentioned the design of a mean basin area of 1.92 km^2, dam length below 130 m and above low water 450 m. This site will be producing electricity with an annual output around 6,000 MWh with total investment cost up to 3.1 million pounds.

d) Solar Energy

The annual mean solar insolation in South Uist is around 950 kWh/m^2.[40] The application of solar thermal or solar photovoltaic will generate the maximum output only in this area during the summer season. The utilization of this energy resources could be only optimized for small scale application like solar photovoltaic for street lighting or solar roof-top system for households.

5.1.4 Renewable Energy and Electricity System in Scotland

The UK government currently uses the Renewable Portfolio Standard ("RPS") to promote renewable energy development; capital subsidies, grants, or rebate; sales taxes, energy tax, excise tax, or VAT reduction, and tradable renewable energy certificates (ren21, 2007). Presently in Scotland, 15 % of total electricity demands are supplied from renewable energy sources. Scotland has set a target of supply of 50% electricity from renewable energy sources by 2020. Both financial framework and a national renewable energy target will offer

[39] Faber Maunsell, May 2008

[40] AEA, 2007

the investment security and stable market to the potential investor. Thus, it will encourage them to make more investment in renewable energy development, Scotland.

There is a big issue regarding the electricity interconnection or feed in to grid in the Western Isles. The grid capacity of the 123 kV circuit from Skye – Fort Augustus is already fully booked or contracted to some electricity suppliers. It means that Scottish and Southern Energy, the largest grid operator in Scotland, will not consent any more generation in South Uist and Barra which would feed over to Skye before the transmission line is upgraded. The term of fully booked does not refer to the technical limitation but it is merely based on the already full contract papers. The contract is usually dominated by large power plant capacity[41]. It could be a major barrier for the renewable energy development in Lochboisdale.

5.1.5 Alternative Solution up to 2014

Based on the potential of the renewable energy resources as described above and due to the short planning period (up to 2014), the team has assumed the following most possible alternative solutions to reduce CO_2 emission.

a) Wind to heat System for New Additional Houses and shops

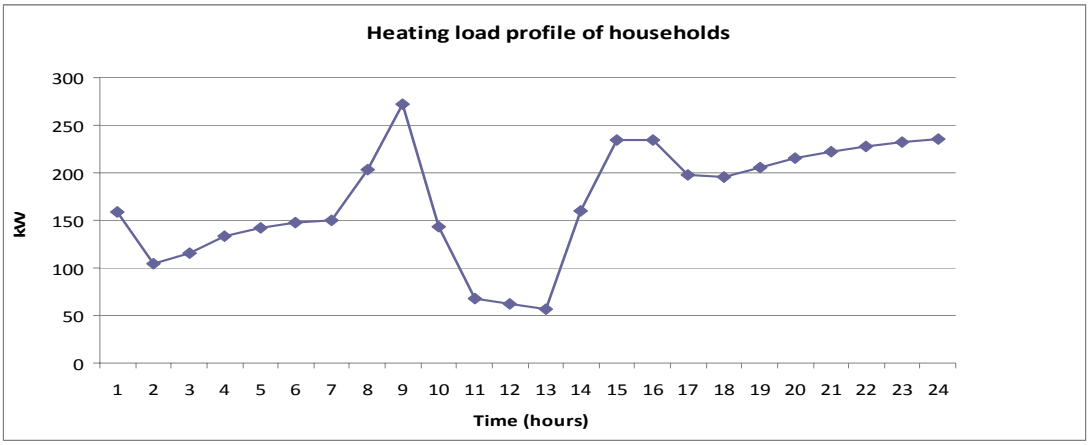
From the survey, the team found that heating accounts for more than one third (38%) of the total energy consumption in the household sector of the Lochboisdale. The sources of energy for heating system were found to be entirely based on fossils fuels and electricity from grid resulting in 56.54% (983 tons/year) of the total household CO_2 emissions. In this regards, due to availability of the highly promising wind resources, wind energy seemed to be a highly exciting alternative for providing energy to meeting heating demand in Lochboisdale.

For the heating demand, a wind to heat system (dry electric heaters) is proposed for the additional 40 houses and 6 new shops of the harbour extension plan. In this system, the electricity generated from wind is directly converted into heat for space heating and hot water requirements. From the BAU scenario, total heating demand for the 40 new houses and 6 additional shops was found to be 513.53 MWh/y for the year 2012. A 150 kW wind turbine was chosen to meet the necessary heat demand (See table 14 below). The monthly average wind speed of Benbecula is used for the calculation of annual energy yield from the wind turbines.

The daily approximate heating load profile for the households is given below.

[41] "SOUTH UIST, ERISKAY AND BENBECULA WIND ENERGY FEASIBILITY STUDY" report,2006, P 69

Figure 37: Approximate Daily heating load profile of households



Source: Trigo, 2007[42]

Based on the above heating load profile (Figure 37), the approximate energy absorbed in the system by the heating load is estimated by using a software named "Homer". The summary of the findings of BAU and alternative scenario is shown in table 14 below:

Table 13: BAU and alternative scenario for heating system

	2012	2013	2014
BAU Scenario			
Heating demand for 6 additional shops +40 HH (MWh)	506.38	503.71	500.61
Alternative Scenario			
Energy generated from wind (MWh)	578.16	578.16	578.16
Energy Absorbed by heating load[43] (MWh)	430.07	430.07	430.07
From Grid (MWh)	76.31	73.65	70.54
% from renewable energy coverage	**84.93**	**85.38**	**85.91**

The table above shows that the wind turbine will be able to meet around 85 % of the heating demand of 40 households and 6 additional shops. The unmet demand will be taken from the grid. Excess energy during low demand can be supplied to the grid.

b) Fish Processing Plant

A fish processing plant will be established as a part of the harbour extension plan, and the processing capacity will be a bout the same as the existing processing plant in Barra. The total demand of this plant is estimated as 591.47 MWh in 2012. According to the BAU

[42] Trend adapted from Trigo (2007)," The impact of energy efficiency solutions & Renewable Electricity Generation in three Rural Communities in Scotland" P 65

[43] Based on simulation result of Homer

scenario, the demand will decline by 1.1 % per year due to the energy efficiency target set by the Scottish government.

In the alternative scenario, it is assumed that the implementation of the micro-hydro plant (estimated capacity of 44kW) will be completed by the end of 2011 and it will start producing electricity from 2012. From this micro-hydro, the annual energy yield will be 200 MWh/y throughout its life span[44]. All energy generated from the micro-hydro plant will be supplied to the fish processing plant, and the remaining energy demand will be fulfilled from the grid.

Table below 15 shows results of the alternative and BAU scenario. It can be seen that the proposed micro-hydro plant can cover around one third of the total energy demand of the fish processing plant.

Table 14: BAU and alternative scenario of fish processing plant from 2012 to 2014

Year	2012	2013	2014
BAU Scenario			
Energy Consumption (MWh/y)	591.47	584.96	578.53
Alternative Scenario			
Energy from micro-hydro (MWh/y)	200	200	200
Energy from grid (MWh/y)	391.47	384.96	378.53
% of Renewable energy coverage	**33.81**	**34.19**	**34.57**

Source: SESAM, IC 2009

c) Energy Supply for Lochboisdale Hotel

From the survey result it is found that Lochboisdale hotel is one of the major energy consumers in Lochboisdale. It is using coal, diesel and electricity for heating. In the alternative scenario, a 40 kW wind turbine will be installed to supply the energy to the hotel mainly for heating. The wind turbine will generate around 169.6 MWh/y of energy. Due to the dynamic nature of both supply and demand, the whole energy generated from wind will not be practically possible to be tapped unless some sort of energy storage systems will be introduced. Thus, it is assumed based on the simulation result of wind to heat systems that around 70% of the energy demand will be fulfilled by energy from the wind turbine (Table 16). The rest will be supplied from the grid during deficit period. The excess energy from wind during low demand can be supplied to the grid.

[44] Western Isles hydropower feasibility study, 2008, P. 39

Table 15: BAU and Alternative scenario of Lochboisdale Hotel from 2012 to 2014

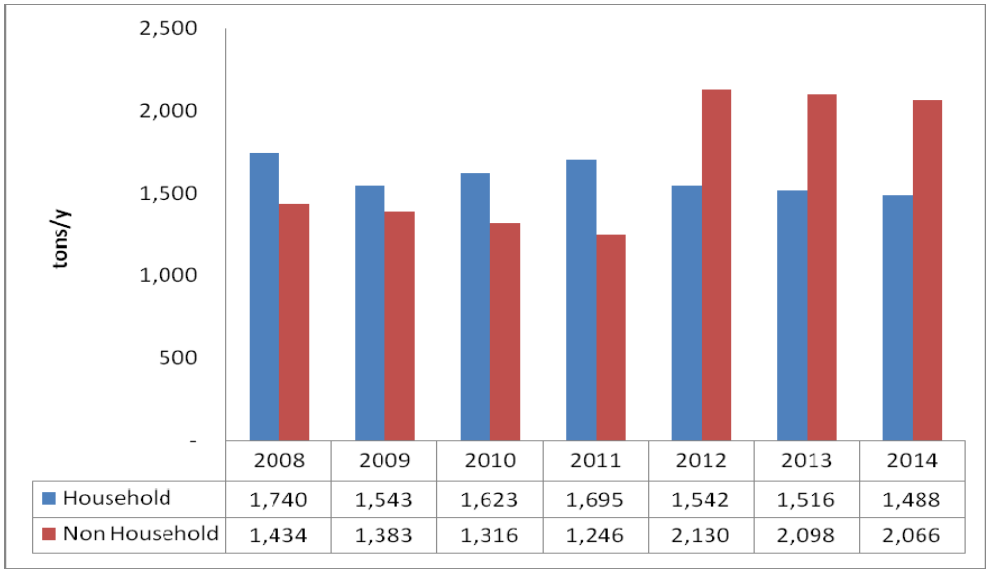
	2012	***2013***	***2014***
BAU Scenario			
Total Heating & Electricity Demand (MWh/y)	162.99	164.70	166.43
Alternative Scenario			
Energy generated from Wind (MWh)	169.6	169.6	169.6
Capacity Factor[45]	0.44	0.44	0.44
Energy absorbed by load (MWh/y)[46]	115.63	115.63	115.63
Energy to be supplied from Grid(MWh/y)	47.35	49.07	50.80
% coverage from wind energy	**70.95**	**70.21**	**69.48**

Source: SESAM, IC 2009

5.3 CO2 Emission

In the alternative scenario, the total CO_2 emission from household and non-household sector is 2,926.43 tons/year in 2009 and 3,554.48 tons/year in 2014, which is increased by 31.74% mainly due to harbour extension plan (Figure 38). As shown in figure 38 below the CO_2 emission from household is higher than non household up to 2011. But after 2012, the CO_2 emission from non household is higher than from household due to the harbour extension plan.

Figure 38: Total CO_2 Emission in Household & Non Household Sectors, Alternative Scenario



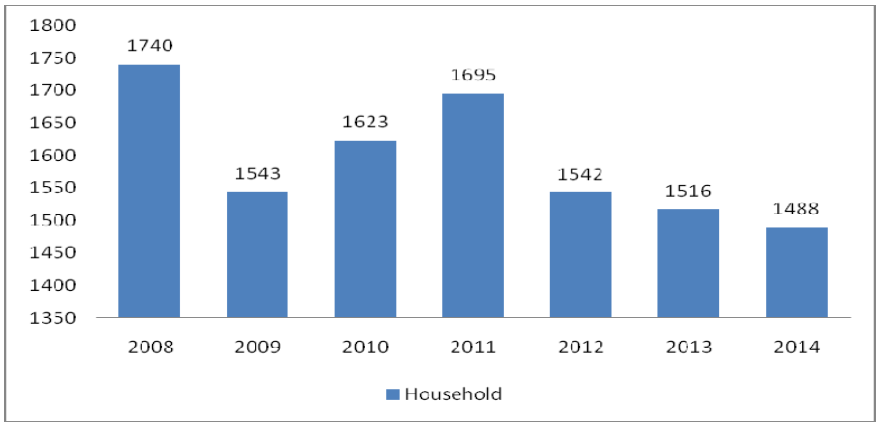
Source: SESAM, IC 2009

[45] Calculated based on "SOUTH UIST, ERISKAY AND BENBECULA WIND ENERGY FEASIBILITY STUDY" report, P 69
[46] Based on estimation from Homer

5.1.6 Household Sector

In the alternative scenario, the total CO_2 emission of the household sector is as shown in Figure 39 below. In 2009, emission will decrease significantly by 11% compared to 2008. Similarly, the emission in 2012 will decrease by 9% compared to 2011. This is mainly due to the increasing use of public transportation in 2009 and the impact of the implementation of renewable energy and the district heating system in 2012. The total CO_2 emission will decline substantially by 2014 (14.5%) compared to 2008.

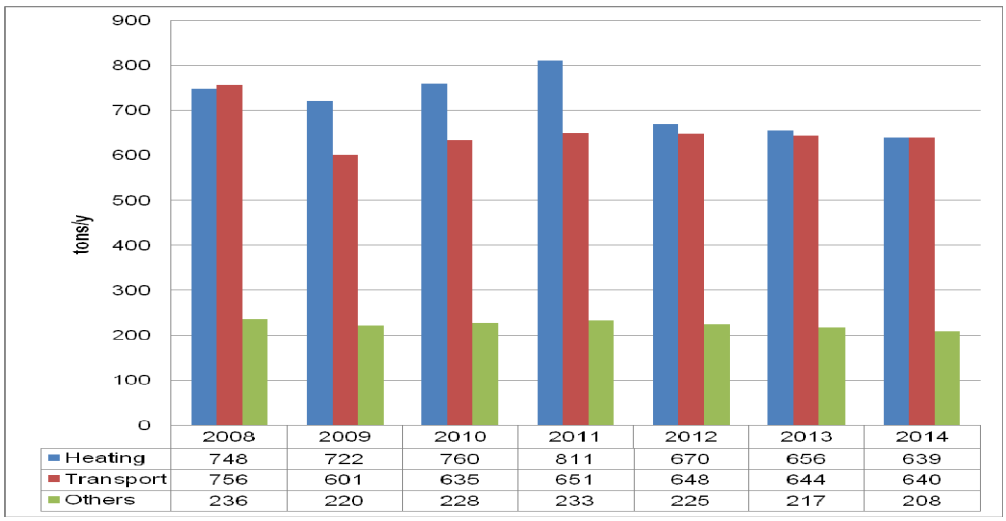
Figure 39: Total CO_2 Emission of Alternatives Scenario (including renewable energy)



Source: SESAM, IC 2009

As figure 40 shows, heating will see the highest CO_2 emission in 2011 (811 tons), then it will fall to 670 ton in 2012 because of the wind power plant application for district heating of the new households. For the transport, there will be a big drop (20%) in 2009 as 18.5% of existing households will use public transportation.

Figure 40: Total CO_2 Emission by Purposes, Alternatives Scenario



	2008	2009	2010	2011	2012	2013	2014
Heating	748	722	760	811	670	656	639
Transport	756	601	635	651	648	644	640
Others	236	220	228	233	225	217	208

Source: SESAM, IC 2009

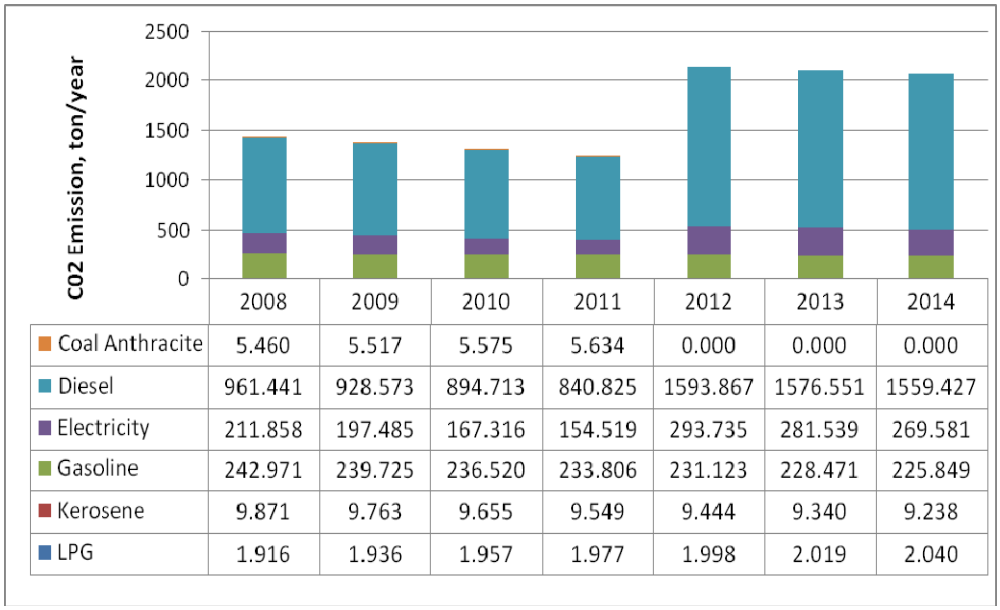
CO_2 emission from others areas such as lighting, cooking, and refrigeration will change due

to the low impact of the harbor extension plan. These areas are mainly affected by energy efficiency effort as happened in BAU scenario.

5.1.7 Non-Household Sector

In the alternative scenario, renewable energy (wind and micro hydro systems) will be implemented to reduce the CO_2 emission. Overall, renewable energy will contribute around 55% of the total energy demand of the Lochboisdale Hotel, 85% of heating demand of the six new shops under the harbor extension and 34% of energy demand of the fish processing factory. This will reduce about 131 tons of CO_2 emission every year from 2012. The CO_2 emission in alternative scenario is as shown in figure 41 below. CO_2 emission will decline from 1,433.52 ton in 2009 to 1,246.31 tons in 2011 due to the expansion of renewable energy and efficiency improvement in buildings mainly heating. However, the CO_2 emission will be the highest in 2012 (2,130.17 tons) and decline slightly after that. Among the fuels, diesel is contributing the highest CO_2 emission (71.6% on average) even after the harbor extension in 2012.

Figure 41: CO_2 Emission in Non-household Sector by Fuel, Alternative Scenario



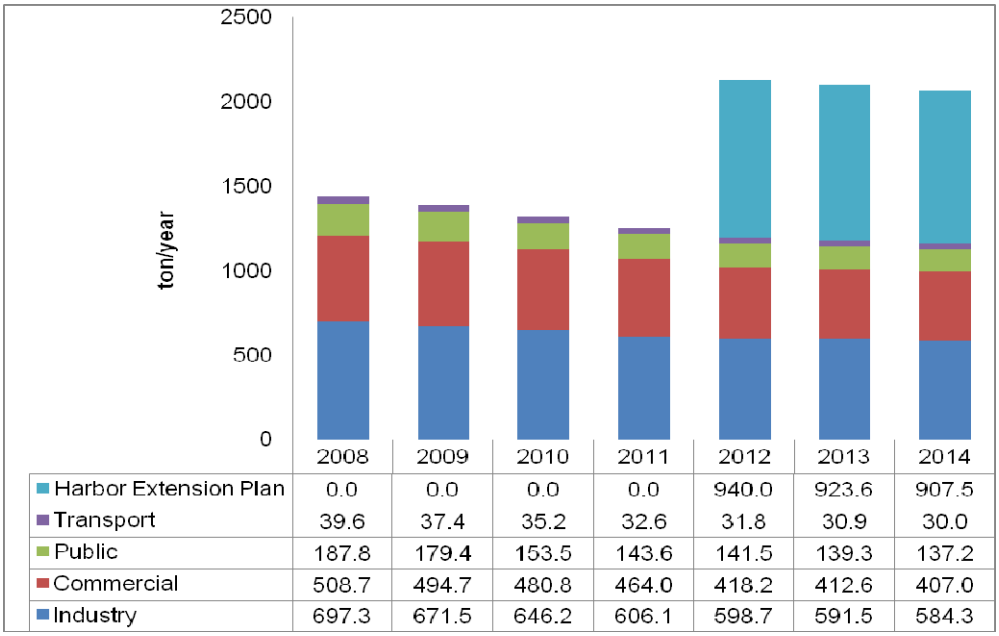
	2008	2009	2010	2011	2012	2013	2014
Coal Anthracite	5.460	5.517	5.575	5.634	0.000	0.000	0.000
Diesel	961.441	928.573	894.713	840.825	1593.867	1576.551	1559.427
Electricity	211.858	197.485	167.316	154.519	293.735	281.539	269.581
Gasoline	242.971	239.725	236.520	233.806	231.123	228.471	225.849
Kerosene	9.871	9.763	9.655	9.549	9.444	9.340	9.238
LPG	1.916	1.936	1.957	1.977	1.998	2.019	2.040

Source: SESAM, IC 2009

As figure 41 shows, gasoline is the second largest CO_2 contributor even up to 2011, and then due to the harbor extension, electricity will move up as the second largest CO_2 contributor. Since Lochboisdale hotel installs two wind turbines in 2012, no emission will be emitted from coal, which is being used currently by the Hotel for heating.

The CO_2 emission by sector is shown in figure 41 below. Currently, the industry sector is responsible for the largest amount of CO_2 (697.32 tons in 2008), but after 2012 the harbor extension will dominate the emission of CO_2 (44.13%). Fishing boats consume a lot of diesel releasing high amount of CO_2. In the harbor extension, individual fisheries will contribute 36.30% of total emission in 2012 and 36.61% (756.4 tons) in 2014.

Figure 42: CO_2 Emission in Non-household Sector by Sectors, Alternative Scenario



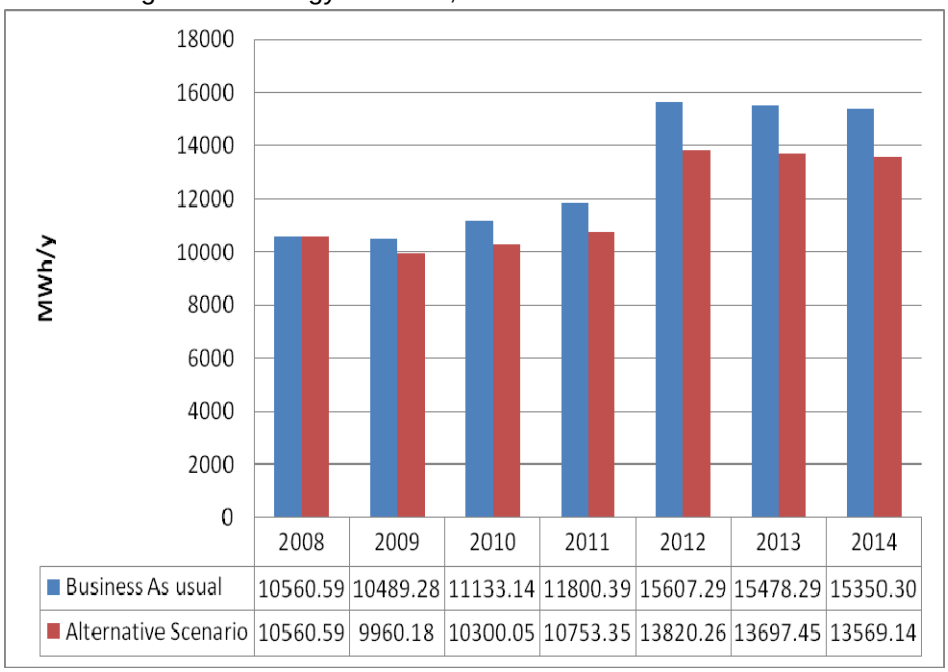
	2008	2009	2010	2011	2012	2013	2014
Harbor Extension Plan	0.0	0.0	0.0	0.0	940.0	923.6	907.5
Transport	39.6	37.4	35.2	32.6	31.8	30.9	30.0
Public	187.8	179.4	153.5	143.6	141.5	139.3	137.2
Commercial	508.7	494.7	480.8	464.0	418.2	412.6	407.0
Industry	697.3	671.5	646.2	606.1	598.7	591.5	584.3

Source: SESAM, IC 2009

5.4 Comparison between BAU and Alternative Scenario

The total energy demand of both household and non-household in BAU scenario will be 10,489.28 MWh while in the alternative scenario it will be 9,960.18 MWh in 2009, which is a reduction of 5% (Figure 43). In 2014, the total energy demand in BAU will be 15,350.3 MWh, while in the alternative scenario, it will be 13,569.14 MWh. The energy demand will reduce by 11.6% as shown in figure 43. The higher reduction of energy demand in 2014 is mainly due to higher share of renewable energy and improvement of energy efficiency. The higher energy consumption in 2014 as compared to 2009 is mainly due to harbour extension.

Figure 43: Energy Demand, BAU and Alternative Scenario



	2008	2009	2010	2011	2012	2013	2014
Business As usual	10560.59	10489.28	11133.14	11800.39	15607.29	15478.29	15350.30
Alternative Scenario	10560.59	9960.18	10300.05	10753.35	13820.26	13697.45	13569.14

Source: SESAM, IC 2009

In case of CO_2 emission, the total emission in 2009 in the BAU scenario will be 3,059.65 tons, while in alternative scenario, it will be 2,926.43 tons (Figure 44). The total reduction of CO_2 will be 133.21 tons which is a reduction of 4.35%. In 2014, the total CO_2 emission in BAU scenario will be 4130.09 tons but in the alternative scenario it will be 3,554.48 tons which is a reduction of 14%. This shows that there will be significant reduction of CO_2 in 2014 in the alternative scenario.

Figure 44: CO_2 Emission, BAU and Alternative Scenario

	2008	2009	2010	2011	2012	2013	2014
Business As usual	3173.26	3059.65	3154.11	3278.95	4288.38	4208.76	4130.09
Alternative Scenario	3173.26	2926.43	2938.29	2941.49	3672.57	3614.21	3554.48

Source: SESAM, IC 2009

6 Findings and Recommendations

Based on the survey results, energy efficiency and possible renewable energy options in Lochboisdale, the following are the main findings and recommendations of the study.

6.1 Findings

6.1.1 Current Situation

- The current total energy consumption of Lochboisdale is 10,560 MWh/y. The household sector contributes 51.8 % and the Non-household sector 48.2 % of the total energy consumption.
- In terms of CO_2 emission, Lochboisdale emits 3,173 tons/y. The household sector contributes 54.8 % and the non-household sector 45.2% of CO_2 emission.
- The average heating index of households in Lochboisdale is found to be 157 kWh/m^2 which is quite higher than the benchmark heating index in Scotland (91 kWh/m^2).
- In average, one household in Lochboisdale consumes 9,517 kWh of electricity per year, which is 15% higher than that of the Western Isles (8283 kWh/y/HH).
- The average CO_2 emission per household is 12.98 tons/y and 5.24 tons/year per person in Lochboisdale.

6.1.2 Business as Usual Scenario

- The BAU scenario is affected by improvement of energy efficiency, household growth rate, tourism growth rate, expansion of bio-fuel supply, and renewable energy target of the Scottish government.
- Based on the BAU scenario, the energy demand rises from 10,560 MWh/y in 2008 to 15,350 MWh/y in 2014 which is a total growth rate of 45%.
- During the same period, the total CO_2 emission rises from 3,173 tons/y in 2008 to 4,130 tons/y in 2014 which is a growth of 30%.

6.1.3 Alternative Scenario

- Based on the alternative scenario, in 2014 the total energy demand will be 13,569 MWh/y, which is 11.60 % lower than in the BAU scenario.
- The total CO_2 emission in 2014 (3,544 tons/y) under the alterative scenario will be 14.18% lower than BAU scenario.

- Compared to the BAU Scenario, the alternative scenario is additionally affected by the implementation of renewable energy systems (wind and micro hydro), increasing share of bio-fuels and the use of public transportation.

6.2 Recommendations

6.2.1 Energy Efficiency

There are some saving options which can also reduce the CO_2 emission significantly. The two simplest ways that the households can follow are mentioned below:

- ***Using more energy efficient products/technologies***
    - Compact Fluorescent Lamp ("CFL") for lighting
    - High efficient and smaller capacity of appliances or vehicles
    - Double glazing windows and improving house insulation.
- ***Changing Behaviors***
    - Not using unnecessary lights, avoiding standby mode for appliances, not using car so much, car share, turning the heating down slightly, and using public transportation as far possible.

The recommendations for energy efficiency improvement in the household sector focus on two areas: improvement of house insulation and use of public transportation as the main means of transportation.

a) House Insulation

Regarding insulation improvement, households at least need to follow standard guidance of envelope insulation instalment from the Scottish Building Standards Agency (SBSA)[47]. It will lead to substantial reduction of heating demand (42%)[48].

Improving house insulation requires a high investment, as much as 3,500 – 5,500 Pounds per household[49]. The saving of cost is around 547 pounds per year per household due to insulation improvement, thus the payback period of the investment is around 6-10 years.

It is recommended to create a community fund to provide a subsidy to the households with

[47] Scottish Building Standards Agency (SBSA), "Domestic Handbook 2009", Section 6.2 (http://www.sbsa.gov.uk/tech_handbooks/th_pdf_2009/Domestic_2009.pdf), accessed 16th-March-2009.
[48] Building Research Establishment (BRE), "International Comparison of Energy Standards in Building Regulations: Denmark, Finland, Norway, Scotland and Sweden", 2007 (http://www.sbsa.gov.uk/pdfs/BRE_Final_Report.pdf, accessed 16th-March-2009.
[49] The Scottish Government, "Central Heating Programme", Leaflet, 2008

high fuel poverty[50]. The community fund could come from local community based companies such as Storas Uibhist.

b) Public Transportation

It is recommended that more people use public transportation to reduce CO_2 emission. Generally, the inhabitants in Lochboisdale do not use public transportation often, because it operates infrequently. In order to respond that request, the public transportation service provider and local government need to consider offering additional routes, more frequent services or free bus service as introduced in Samsoe island, Denmark [51]

6.2.2 Renewable Energy

The following are main recommendations for development and utilisations of renewable energy in Lochboisdale.

a) Expansion of Renewable Energy

Renewable energy offers enough potential to reduce CO_2 emission. It also helps to reduce the energy bill. As mentioned above in sub-chapter 5.2.1, Lochboisdale has high renewable energy potential like wind, hydro and tidal to reduce CO_2 emission. Therefore, it is highly recommended to promote small scale renewable technologies and utilizes them to meet the local demands. This option can also help to overcome the current constraint of grid capacity.

In this study, a suggestion of using wind energy for heating system is shown. However, there are many other renewable energy sources like biomass (e.g. sea weeds, household waste etc.), solar, tidal hydrogen driven systems which can be coupled with wind energy to get a consistent source of energy. So, it is recommended to conduct a feasibility study of utilizing wind energy coupled with other renewable energy sources. In addition, tidal energy potential of 2.89 MW has been identified near to Lochboisdale. It is highly recommended to carry out a detailed study of the proposed tidal power plant. This project is expected to reduce a substantial amount of CO_2 emission.

b) Off-grid System

As mentioned in Chapter 5, limited capacity of the Skye grid will be the major barrier for the renewable energy development that will be connected to the grid.

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[50]Fuel poverty is defined as a condition when a household spends more than 10% of total income (Scottish Executive Environment Group, 2005, P.60

[51] PlanEnergi, “Samsoe a Renewable Energy Island: 10 Years of Development and Evaluation”, 2007, accessed

There is no need of permission if electricity generated is entirely for site use provided that the standard safety and qualification requirement are met. A small scale power development plan up to 11 kW that will connect to the grid does not require a connection agreement with the Utility like Scottish Southern Energy. However, a simple notification will still be needed after the installation.

6.2.3 General Recommendations

As mentioned in chapter 3, around 33% of respondents have either no knowledge or interest on GHGs and carbon neutral village issues. Raising public awareness will definitely encourage them to support the future developments of Storas Uibhist and even participate themselves in making Lochboisdale a carbon neutral village. For instance, Samsø Island in Denmark, the first renewable energy community around the globe, has achieved the target to be powered entirely from locally available renewable energy sources. The Samsø Island project was initially planned in 1997 and invested by the Danish Federal Government, but after that the majority of projects were funded by local inhabitants. Therefore, in 2007 they have achieved the target to be powered 100% from locally available renewable energy sources.

It is anticipated that this example can be replicated to make Lochboisdale as a carbon neutral village in the near future. Furthermore, there is strong need to raise awareness among the community members and encourage them to get involved carbon neutral initiative.

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Annexes

Annex 1. Household Questionnaires

A. GENERAL INFORMATION

Name of family (Optional):
……..

1. What type of property do you live in:

- Flat/Maisonette
- Bungalow
- Detached
- Semi-detached
- End-terrace
- Mid-terrace
- Other *(please specify)* ……

2. What is the total area/size of your house? …….. (Sq.ft) or ……..(Sq. m)

3. How many bedrooms do you have? ……

4. How many people live there? …….. (Person/people)

B. ENERGY INFORMATION

5. Please provide the annual energy consumption in your house.
(Please use your bills; otherwise give us your estimation, EXCLUDING FUEL FOR TRANSPORTATION).

Energy Source	**Quantity**	**Unit**	**Cost (£)**
Electricity		kWh/y	
Heating		kWh/y	
Gasoline		Litres/y	
Diesel		Litres/y	
LPG (Gas)		kg/y	
Kerosene		Litres/y	
Wood		Tonnes/y	
Peat		Kg/y	
Others (please specify including **Renewable Energy in blank rows below**)			
		……../y	
		……../y	

6. Please provide information about lighting in your house.

Type of Lamps	Quantity	Rated Power (Watt)	Daily operating hours
Incandescent Lamps			
Fluorescent Lamps			
Compact Fluorescent Lamps (CFLs)			
Other Specify …			

7. Please provide information about your electrical appliances.

Type of Appliances	Quantity	Rated Power	Daily operating hours
Stoves			
Washing Machine			
Refrigerator			
Other Specify,			

8. Please provide information about insulation

8.1 Does your house have roof insulation?

☐ Yes ☐ No ☐ Don't Know

If yes, what is the thickness of the roof insulation?

……. inch ☐ Don't know

8.2 Does the building have wall insulation?

☐ Yes ☐ No ☐ Don't Know

If yes, what is the thickness of the wall insulation?

……. inch ☐ Don't know

8.3 How much energy (or energy expense) has been saved annually since you Installed the Insulation?_____ %

9. If possible, where do you think you can reduce the energy consumption in your house? (Please describe briefly on how to do it)

☐ **Heating** ……..

☐ **Electricity** ……

☐ **Transportation** ……..

☐ **Other** ……

C. TRANSPORTATION INFORMATION

10. Please fill out the types of vehicles (e.g. car, boat, lorry, motorcycle etc) fuel used and their mileage in the past year in the table below

Types of Vehicle		**No. vehicles**	**Purposes** (work, business, leisure, etc)	**Fuel consumption (Lt/year)**	**Mileage (miles/year)**
Petrol	Small (up to 1.4 lt)				
	Medium (1.4-2.0 lt)				
	Large				
Diesel	Small (up to 1.7 lt)				
	Medium (1.7-2.0 lt)				
	Large				
Others	LPG or CNG				

11. Are you willing to use public transport rather than your own vehicle for daily activity? (Please give brief reasons)

☐ **Yes**
……..

☐ **No**
……

D. OTHER INFORMATION

12. What percentage (%) of your total income do you spend for the energy bill?

…… (% of total income).

13. What do you think about the current electricity price?

☐ Expensive ☐ Fair ☐ Cheap

14. What do you think about the current heating price?

☐ Expensive ☐ Fair ☐ Cheap

15. Who is your electricity supplier? ……

16 What are the main reasons to select the electricity supplier? ……

17. My knowledge about the impact of climate change or global warming is

☐ High ☐ Moderate ☐ Little ☐ I don't know

18. My interest in developing Lochboisdale as carbon Neutral Village (Eco-Village) is

☐ High ☐ Moderate ☐ Little ☐ I don't know

19. My interest in using renewable energy (e.g. Wind or wave) as my energy source is

☐ High ☐ Moderate ☐ Little ☐ I don't know

Annex 2. Non- Household Questionnaire

I. General Information

1) Name of Organisation:……..

II. Current Situation

1) Which types of energy carriers do you use in your organisation? (Please fill out all applicable options)

Energy Carriers	Amount
Coal	…… tonnes/y
Manufacturing	…… tonnes/y
Heating	…… tonnes/y
Cooking	…… tonnes/y
Others (……)	…… tonnes/y
Natural Gas	……..m^3/y
Manufacturing	……..m^3/y
Heating	……..m^3/y
Cooking	……..m^3/y
Others (……)	……..m^3/y
Electricity	…….. kWh/y
Manufacturing	…….. kWh/y
Lighting	…….. kWh/y
Heating	…….. kWh/y
Cooking	…….. kWh/y
Office equipment/Entertainment	…….. kWh/y
Others (……..)	…….. kWh/y
Fuel wood	…… kg/y
Manufacturing	…….. kg/y
Lighting	…….. kg/y
Heating	…….. kg/y
Cooking	…….. kg/y
Others (……)	…….. kg/y
Diesel	…….. litter/y
Manufacturing	…….. litter/y
Lighting	…….. litter/y
Heating	…….. litter/y
Cooking	…….. litter/y
Others (……)	…….. litter/y
Gasoline	…….. litter/y
Manufacturing	…….. litter/y
Lighting	…….. litter/y
Heating	…….. litter/y
Cooking	…….. litter/y
Others (……..)	…….. litter/y
Kerosene	…….. litter/y
Manufacturing	…….. litter/y
Lighting	…….. litter/y
Heating	…….. litter/y
Cooking	…….. litter/y
Others (……..)	…….. litter/y

Renewable Wind power (kW) Solar Power (kW) Solar Thermal (㎡) Bio-diesel/Bio-ethanol Biomass Waste Others (……)	 …….. kWh/y …….. kWh/y …….. kcal/y …….. litter/y …….. kg/y …….. kg/y …….. /y

2) Please provide information about energy used for lighting:

Type of Lamps	Number	Rated Power (W)	Daily Operating Hours
Incandescent Lamps			
Fluorescent Lamps			
Compact fluorescent Lamps(CFLs)			
Halogen lamps			
Other Specify, ……			

3) Please provide information about energy use for transportation purpose in your organisation:

Types of Vehicle	Type of fuel	No. vehicles	**Purposes** (work, business, leisure, etc)	Fuel consumption (Lt/year)	Mileage (Miles/year)
Bus					
Van					
Taxi					
Truck					
Ferry					
Others					

III. Alternatives

1) Where do you think you can reduce the energy consumption in your organisation? Please describe briefly.

☐ Manufacturing/Processing
……..……..

☐ Heating
……
……

☐ Lighting ……..……
……

☐ Electricity
…..……
……..

☐ Transportation
……
……

☐ Others
……
……

2) What percentage (%) of your total income do you spend for your energy bill?
…… (% from total income).

3) Who is your electricity supplier? ……

4) What are the main reasons to select the electricity supplier? ……

5) My knowledge on impact of Climate change is

☐ Very high ☐ High ☐ Moderate ☐ Low ☐ Very low

6) My knowledge on Green House Gas (GHG) emission is

☐ Very high ☐ High ☐ Moderate ☐ Low ☐ Very low

7) My interest in developing Lochboisdale as carbon Neutral Village (Eco-Village) is:

☐ Very high ☐ High ☐ Moderate ☐ Low ☐ Very low

8) If you can reduce GHG emission with small change, are you interested in participating?

☐ Yes ☐ No

Annex 3. Current Energy Price & Conversion Factor

Electricity Supplier	***Selling Price (£/kWh)***
Scottish Hydro Electric	0.15
Scottish Southern Energy	0.12
Scottish power	0.14
E-On	0.14
Fuel type	***Selling Price***
Gasoline	0.76
Kerosene	0.477 £/liter
Diesel	0.810 £/liter
LPG	0.621 £/liter
coal	347.5 £/ton

Fuel Type	***Energy Conversion factor***	***unit***
Electricity	1	kWh/kWh
Diesel	10.47	kWh/liter
Gasoline	9.21	kWh/liter
Kerosene	10.07	kWh/liter
LPG	7.10	kWh/liter
Peat	2,645.84	kWh/ton
Coal	8,722.22	kWh/ton
Wood	4,305.57	kWh/ton

Fuel Type	***CO_2 Conversion factor***	***unit***
Diesel	0.263	kg/kWh
Gasoline	0.252	kg/kWh
Kerosene	0.258	kg/kWh
LPG	0.225	kg/kWh
Peat	0.381	kg/kWh
Coal	0.313	kg/kWh
Wood	0.026	kg/kWh
Electricity for HH	0.508	kg/kWh
Electricity for Non HH	0.527	kg/kWh

Annex 4. Spread Sheet Calculation

Annex 4.1. Energy Balance Sheet on 2008 (KWh)

	Electricity	Oil Products	Solid Fuels	Biomass	Total
Production	0	0	51,209	0	51,209
Imports	1,604,548	8,468,791	420,171	11,438	10,504,948
Exports	0	0	0	0	0
From Stock Change	0	0	0	0	0
Total Primary Supply	1,604,548	8,468,791	471,380	11,438	10,556,157
Total Transformation	0	0	0	0	0
Statistical Differences	0	0	0	0	0
Household	1,203,900	3,802,174	453,936	11,438	5,471,448
Non Household	400,648	4,666,617	17,444	0	5,084,709
Total Demand	1,604,548	8,468,791	471,380	11,438	10,556,157
Unmet Requirements	0	0	0	0	0

Annex 4.2. Total Energy Demand on the BAU Scenario

Units: Kilowatt-Hours								
BAU		2008	2009	2010	2011	2012	2013	2014
Households	Fully Occupied Household	5,363,316.80	5,344,060.10	5,287,284.80	5,263,781.50	5,235,458.80	5,207,122.40	5,178,775.60
	Holiday Household	108,131.20	107,701.30	106,558.90	106,041.60	105,470.80	104,900.20	104,329.00
	Additional Fully Occupied Household	0	0	752794.1	1494472.4	1486628.3	1478571.3	1470481.8
	HH Sub Total	5,471,448.00	5,451,761.40	6,146,637.80	6,864,295.50	6,827,557.90	6,790,593.90	6,753,586.40
Non HH	Industry	2,610,087.40	2,581,376.40	2,552,981.30	2,524,898.50	2,497,124.60	2,469,656.10	2,442,489.90
	Commercial	1,748,300.50	1,733,423.80	1,718,756.30	1,704,296.10	1,690,041.60	1,675,991.60	1,662,143.50
	Public	621,723.24	614,884.34	608,120.66	601,431.14	594,815.58	588,272.55	581,801.61
	Transport	109,031.00	107,831.70	106,645.60	105,472.50	104,312.30	103,164.90	102,030.10
	Harbor Extension Plan	-	-	-	-	3,893,434	3,850,606	3,808,250
	Non Sub Total	5,089,142.14	5,037,516.24	4,986,503.86	4,936,098.24	8,779,728.18	8,687,691.45	8,596,714.71
Total		10,560,590.14	10,489,277.64	11,133,141.66	11,800,393.74	15,607,286.08	15,478,285.35	15,350,301.11

Annex 4.3. Energy Demand by Fuel of HH on the BAU Scenario

Annex 4.4. Breakdown Energy Demand of HH on the BAU Scenario

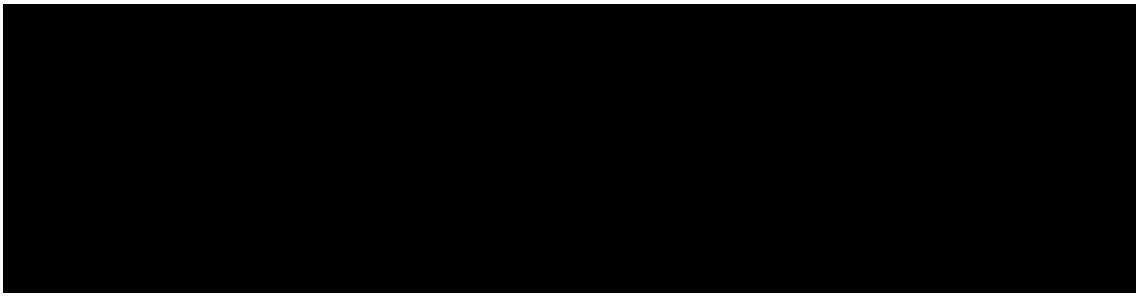
Annex 4.5. Energy Demand by Fuel of Non HH on the BAU Scenario

Annex 4.6. Energy Demand by Sector of Non HH on the BAU Scenario

Annex 4.7. Breakdown Energy Demand of Non HH on the BAU Scenario

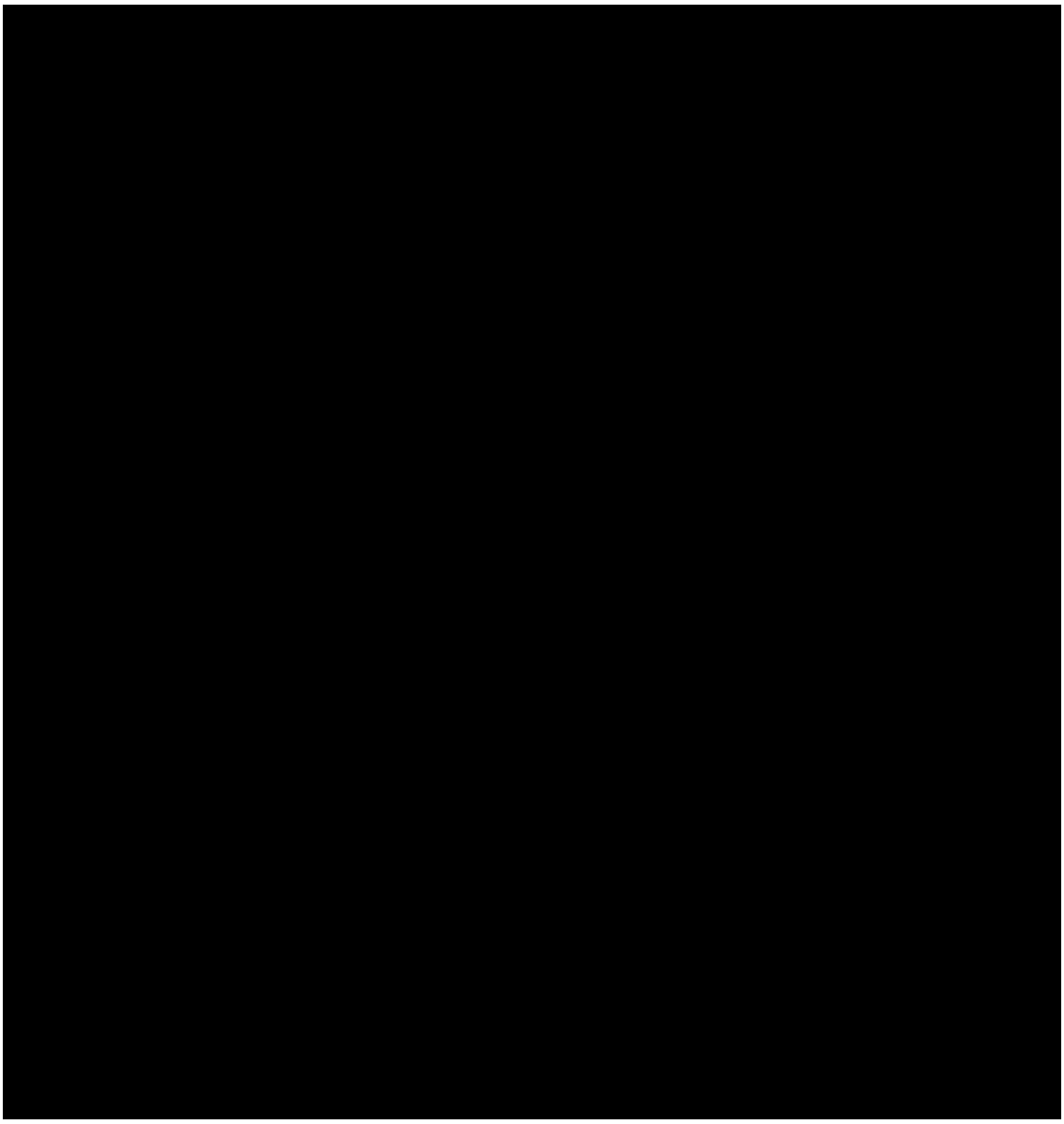
Units: Kilowatt-Hours										
BAU				2008	2009	2010	2011	2012	2013	2014
Industry	Marine Harvest	Electricity	Lighting	2,228.50	2,204.00	2,179.80	2,155.80	2,132.10	2,108.60	2,085.40
			Heating	43,140.00	42,665.50	42,196.10	41,732.00	41,272.90	40,818.90	40,369.90
			Appliances	328.5	324.9	321.3	317.8	314.3	310.8	307.4
		Gasoline	Transport	92,088.90	91,075.90	90,074.10	89,083.30	88,103.30	87,134.20	86,175.70
		Diesel	Transport	838,760.50	829,534.10	820,409.20	811,384.70	802,459.50	793,632.40	784,902.50
	Individual Fisheries	Diesel	Industry\Transport	1,633,541.00	1,615,572.00	1,597,800.80	1,580,224.90	1,562,842.50	1,545,651.20	1,528,649.00
	Sub Total			2,610,087.40	2,581,376.40	2,552,981.30	2,524,898.50	2,497,124.60	2,469,656.10	2,442,489.90
Commercial	Lochboisdale Hotel	Electricity	Elctricity	96,987.50	98,005.90	99,034.90	100,074.80	101,125.60	102,187.40	103,260.40
		Diesel	Heating	41,885.70	42,325.50	42,769.90	43,219.00	43,672.80	44,131.30	44,594.70
			Transport	37,697.10	38,092.90	38,492.90	38,897.10	39,305.50	39,718.20	40,135.20
		LPG	Cooking	8,515.80	8,605.20	8,695.60	8,786.90	8,879.10	8,972.40	9,066.60
		Coal	Heating	17,444.40	17,627.60	17,812.70	17,999.70	18,188.70	18,379.70	18,572.70
	Failte	Electricity	Lighting	2,563.60	2,535.40	2,507.50	2,479.90	2,452.60	2,425.70	2,399.00
			Heating	4,420.00	4,371.40	4,323.30	4,275.70	4,228.70	4,182.20	4,136.20
	Lawrences	Electricity	Electricity	49,875.30	49,326.70	48,784.10	48,247.50	47,716.70	47,191.90	46,672.70
	Kathleen	Electricity	Lighting	760	751.7	743.4	735.2	727.1	719.1	711.2
			Heating	3,744.00	3,702.80	3,662.10	3,621.80	3,582.00	3,542.60	3,503.60
	Laing Motors	Electricity	Electricity	16,934.00	16,747.70	16,563.50	16,381.30	16,201.10	16,022.90	15,846.60
		Gasoline	Others	46,044.40	45,538.00	45,037.00	44,541.60	44,051.70	43,567.10	43,087.90
		Diesel	Transport	9,193.50	9,092.40	8,992.40	8,893.50	8,795.60	8,698.90	8,603.20
			Others	104,714.20	103,562.30	102,423.10	101,296.50	100,182.20	99,080.20	97,990.30
		Kerosene	Heating	20,137.50	19,916.00	19,696.90	19,480.20	19,266.00	19,054.00	18,844.40
	Macaulay Askernish LTD	Electricity	Electricity	11,044.00	10,922.50	10,802.40	10,683.50	10,566.00	10,449.80	10,334.80
		Gasoline	Manufacturing	718,293.30	710,392.10	702,577.80	694,849.40	687,206.10	679,646.80	672,170.70
			Others	107,744.00	106,558.80	105,386.70	104,227.40	103,080.90	101,947.00	100,825.60
		Diesel	Transport	340,321.00	336,577.50	332,875.20	329,213.50	325,592.20	322,010.70	318,468.60
		Kerosene	Heating	18,123.80	17,924.40	17,727.20	17,532.20	17,339.40	17,148.60	16,960.00
	Royal Bank of Scotland	Electricity	Lighting	3,137.00	3,102.50	3,068.40	3,034.60	3,001.20	2,968.20	2,935.60
			Heating	8,320.00	8,228.50	8,138.00	8,048.40	7,959.90	7,872.40	7,785.80
			Appliances	10,170.00	10,058.10	9,947.50	9,838.10	9,729.80	9,622.80	9,517.00
		Diesel	Transport	54,451.40	53,852.40	53,260.00	52,674.20	52,094.70	51,521.70	50,955.00
	Toban An Dualchais	Electricity	Lighting	60.3	59.7	59	58.4	57.7	57.1	56.4
			Heating	12,192.00	12,057.90	11,925.30	11,794.10	11,664.30	11,536.00	11,409.10
			Appliances	3,526.70	3,487.90	3,449.50	3,411.60	3,374.00	3,336.90	3,300.20
	Sub Total			1,748,300.50	1,733,423.80	1,718,756.30	1,704,296.10	1,690,041.60	1,675,991.60	1,662,143.50
Public	NHS Dental Clinic	Electricity	Lighting	584.7	578.3	571.9	565.6	559.4	553.2	547.1
			Heating	52,954.20	52,371.70	51,795.60	51,225.90	50,662.40	50,105.10	49,553.90
			Appliances	4,836.90	4,783.70	4,731.00	4,679.00	4,627.50	4,576.60	4,526.30
	Post Office	Electricity	Electricity	4,000.00	3,956.00	3,912.50	3,869.40	3,826.90	3,784.80	3,743.20
		Diesel	Transport	431,945.90	427,194.50	422,495.40	417,847.90	413,251.60	408,705.80	404,210.10
	Lochboisdale Amenity Trust	Electricity	Electricity	3,556.00	3,516.90	3,478.20	3,439.90	3,402.10	3,364.70	3,327.70
	Church	Electricity	Electricity	1,500.00	1,483.50	1,467.20	1,451.00	1,435.10	1,419.30	1,403.70
		Diesel	Heating	12,565.70	12,427.50	12,290.80	12,155.60	12,021.90	11,889.60	11,758.80
	Police Station	Electricity	Electricity	5,299.90	5,241.60	5,184.00	5,126.90	5,070.50	5,014.80	4,959.60
		Diesel	Transport	83,771.30	82,849.80	81,938.50	81,037.20	80,145.80	79,264.20	78,392.30
	Street Lamps	Electricity	Lighting	20,708.64	20,480.84	20,255.56	20,032.74	19,812.38	19,594.45	19,378.91
	Sub Total			621,723.24	614,884.34	608,120.66	601,431.14	594,815.58	588,272.55	581,801.61
Transport	Cal Mac Ferries	Electricity	Lighting	12,874.30	12,732.70	12,592.60	12,454.10	12,317.10	12,181.60	12,047.60
			Heating	26,880.00	26,584.30	26,291.90	26,002.70	25,716.70	25,433.80	25,154.00
			Appliances	2,455.20	2,428.20	2,401.50	2,375.10	2,349.00	2,323.10	2,297.60
	Local Public Buses	Diesel	Transport	56,629.40	56,006.50	55,390.40	54,781.10	54,178.50	53,582.60	52,993.20
	School Bus	Diesel	Transport	10,192.10	10,080.00	9,969.20	9,859.50	9,751.00	9,643.80	9,537.70
	Sub Total			109,031.00	107,831.70	106,645.60	105,472.50	104,312.30	103,164.90	102,030.10
Harbor Extension Plan	Fish Factory	Electricity	Electricity	0	0	0	0	591,470.00	584,963.80	578,529.20
	Individual Fisheries	Diesel	Transport	0	0	0	0	3,267,082.00	3,231,144.10	3,195,601.50
	Six Small shops	Electricity	Electricity	0	0	0	0	25,847.20	25,562.90	25,281.70
	Waiting Room	Electricity	Electricity	0	0	0	0	9,034.90	8,935.50	8,837.20
	Sub Total			-	-	-	-	3,893,434	3,850,606	3,808,250
Total				5,089,142.14	5,037,516.24	4,986,503.86	4,936,098.24	8,779,728.18	8,687,691.45	8,596,714.71

Annex 4.8. Total Energy Demand on the Alternative EE Scenario



Annex 4.9. Energy Demand by Fuel of HH on the Alternative EE Scenario

Annex 4.10. Breakdown Energy Demand of HH on the Alternative EE Scenario



Annex 4.11. Energy Demand by Fuel types of Non HH on the Alternative EE Scenario

Annex 4.12. Breakdown Energy Demand of Non HH on the Alternative EE Scenario

Units: Kilowatt-Hours										
Alternative				2008	2009	2010	2011	2012	2013	2014
Industry	Marine Harvest	Electricity	Lighting	2,228.52	2,204.01	2,179.76	2,155.78	2,132.07	2,108.62	2,085.42
			Heating	43,140.00	42,665.46	42,196.14	41,731.98	41,272.93	40,818.93	40,369.92
			Appliances	328.50	324.89	321.31	317.78	314.28	310.83	307.41
		Gasoline	Transport	92,088.89	91,075.91	90,074.08	89,083.26	88,103.35	87,134.21	86,175.73
		Diesel	Transport	838,760.47	829,534.11	820,409.23	811,384.73	802,459.50	793,632.45	784,902.49
	Individual Fisheries	Diesel	Industry\Transport	1,633,541.00	1,615,572.05	1,597,800.76	1,580,224.95	1,562,842.47	1,545,651.21	1,528,649.04
	Sub Total			2,610,087.38	2,581,376.43	2,552,981.28	2,524,898.48	2,497,124.60	2,469,656.25	2,442,490.01
Commercial	Lochboisdale Hotel	Electricity	Elctricity	96,987.51	98,005.88	99,034.94	100,074.81	101,125.59	102,187.41	103,260.38
		Diesel	Heating	41,885.67	42,325.47	42,769.88	43,218.97	43,672.77	44,131.33	44,594.71
			Transport	37,697.10	38,092.92	38,492.90	38,897.07	39,305.49	39,718.20	40,135.24
		LPG	Cooking	8,515.80	8,605.22	8,695.57	8,786.87	8,879.14	8,972.37	9,066.58
		Coal	Heating	17,444.44	17,627.61	17,812.70	17,999.73	18,188.73	18,379.71	18,572.70
	Failte	Electricity	Lighting	2,563.60	2,535.40	2,507.51	2,479.93	2,452.65	2,425.67	2,398.99
			Heating	4,420.00	4,371.38	4,323.29	4,275.74	4,228.71	4,182.19	4,136.19
	Lawrences	Electricity	Electricity	49,875.31	49,326.68	48,784.09	48,247.46	47,716.74	47,191.86	46,672.75
	Kathleen	Electricity	Lighting	760.03	751.67	743.40	735.23	727.14	719.14	711.23
			Heating	3,744.00	3,702.82	3,662.09	3,621.80	3,581.96	3,542.56	3,503.59
	Laing Motors	Electricity	Electricity	16,934.00	16,747.73	16,563.50	16,381.30	16,201.11	16,022.90	15,846.64
		Gasoline	Others	46,044.44	45,537.96	45,037.04	44,541.63	44,051.67	43,567.10	43,087.87
		Diesel	Transport	9,193.52	9,092.39	8,992.37	8,893.46	8,795.63	8,698.88	8,603.19
			Others	104,714.17	103,562.31	102,423.13	101,296.47	100,182.21	99,080.21	97,990.32
		Kerosene	Heating	20,137.50	19,915.99	19,696.91	19,480.25	19,265.97	19,054.04	18,844.45
	Macaulay Askernish LTD	Electricity	Electricity	11,044.00	10,922.52	10,802.37	10,683.54	10,566.02	10,449.80	10,334.85
		Gasoline	Manufacturing	718,293.33	710,392.11	702,577.79	694,849.44	687,206.09	679,646.83	672,170.71
			Others	107,744.00	106,558.82	105,386.67	104,227.42	103,080.91	101,947.02	100,825.61
		Diesel	Transport	340,321.04	336,577.51	332,875.16	329,213.53	325,592.18	322,010.67	318,468.55
		Kerosene	Heating	18,123.75	17,924.39	17,727.22	17,532.22	17,339.37	17,148.64	16,960.00
	Royal Bank of Scotland	Electricity	Lighting	3,137.00	3,102.49	3,068.37	3,034.61	3,001.23	2,968.22	2,935.57
			Heating	8,320.00	8,228.48	8,137.97	8,048.45	7,959.92	7,872.36	7,785.76
			Appliances	10,170.00	10,058.13	9,947.49	9,838.07	9,729.85	9,622.82	9,516.97
		Diesel	Transport	54,451.37	53,852.40	53,260.03	52,674.16	52,094.75	51,521.71	50,954.97
	Toban An Dualchais	Electricity	Lighting	60.32	59.66	59.00	58.35	57.71	57.07	56.45
			Heating	12,192.00	12,057.89	11,925.25	11,794.07	11,664.34	11,536.03	11,409.13
			Appliances	3,526.68	3,487.89	3,449.52	3,411.58	3,374.05	3,336.93	3,300.23
	Sub Total			1,748,300.58	1,733,423.72	1,718,756.16	1,704,296.16	1,690,041.93	1,675,991.67	1,662,143.63
Public	NHS Dental Clinic	Electricity	Lighting	584.69	578.26	571.90	565.61	559.39	553.23	547.15
			Heating	52,954.20	52,371.70	26,185.85	26,157.05	26,128.27	26,099.53	26,070.82
			Appliances	4,836.86	4,783.65	2,391.83	2,389.20	2,386.57	2,383.94	2,381.32
	Post Office	Electricity	Electricity	4,000.00	3,956.00	1,978.00	1,975.82	1,973.65	1,971.48	1,969.31
		Diesel	Transport	431,945.94	427,194.53	422,495.39	417,847.94	413,251.62	408,705.85	404,210.08
	Lochboisdale Amenity Trust	Electricity	Electricity	3,556.00	3,516.88	1,758.44	1,756.51	1,754.58	1,752.65	1,750.72
	Church	Electricity	Electricity	1,500.00	1,483.50	741.75	740.93	740.12	739.30	738.49
		Diesel	Heating	12,565.70	12,427.48	6,213.74	6,206.90	6,200.08	6,193.26	6,186.44
	Police Station	Electricity	Electricity	5,299.92	5,241.62	2,620.81	2,617.93	2,615.05	2,612.17	2,609.30
		Diesel	Transport	83,771.33	82,849.85	81,938.50	81,037.18	80,145.77	79,264.16	78,392.26
	Street Lamps	Electricity	Lighting	20,708.64	20,480.84	20,255.56	20,032.74	19,812.38	19,594.45	19,378.91
	Sub Total			621,723.28	614,884.31	567,151.77	561,327.81	555,567.48	549,870.02	544,234.80
Transport	Cal Mac Ferries	Electricity	Lighting	12,874.28	12,732.66	12,592.60	12,454.08	12,317.09	12,181.60	12,047.60
			Heating	26,880.00	26,584.32	26,291.89	26,002.68	25,716.65	25,433.77	25,154.00
			Appliances	2,455.23	2,428.23	2,401.52	2,375.10	2,348.97	2,323.13	2,297.58
	Local Public Buses	Diesel	Transport	56,629.42	56,006.50	55,390.43	54,781.13	54,178.54	53,582.58	52,993.17
	School Bus	Diesel	Transport	10,192.14	10,080.03	9,969.15	9,859.49	9,751.04	9,643.77	9,537.69
	Sub Total			109,031.07	107,831.74	106,645.59	105,472.48	104,312.29	103,164.85	102,030.04
Harbor Extension Plan	Fish Factory	Electricity	Electricity	0.00	0.00	0.00	0.00	591,470.00	584,963.83	578,529.23
	Individual Fisheries	Diesel	Transport	0.00	0.00	0.00	0.00	3,267,082.00	3,231,144.10	3,195,601.51
	Six Small shops	Electricity	Electricity	0.00	0.00	0.00	0.00	25,847.17	25,562.86	25,281.66
	Waiting Room	Electricity	Electricity	0.00	0.00	0.00	0.00	9,034.88	8,935.50	8,837.21
	Sub Total			0.00	0.00	0.00	0.00	3,893,434.05	3,850,606.29	3,808,249.61
Total				5,089,142.31	5,037,516.20	4,945,534.80	4,895,994.93	8,740,480.35	8,649,289.08	8,559,148.09

Annex 4.13. Conversion factor for CO_2 emission (based on DEFRA)

Diesel	0.263	kg/kWh
Gasoline	0.252	kg/kWh
Kerosene	0.258	kg/kWh
LPG	0.225	kg/kWh
Peat*	0.381	kg/kWh
Coal	0.313	kg/kWh
Wood	0.026	kg/kWh
Electricity for HH	0.508	kg/kWh**
Electricity for Non HH	0.527	kg/kWh**

*Note: * Peat conversion based on IPCC Guidelines and LEAP conversion*

*** Fuel mix conversion factor for the 2008*

Annex 4.14. CO2 Conversion factor for electricity from 2008 – 2014

Annex 4.15. CO_2 Conversion factor for transports

Unit : kg/kWh	2008	2009	2010	2011	2012	2013	2014
Biofuel Share	0.0%	2.5%	5.0%	5.5%	6.0%	6.5%	7.0%
Diesel	0.263	0.256	0.250	0.249	0.247	0.246	0.245
Gasoline	0.252	0.246	0.239	0.238	0.237	0.236	0.234

Annex 4.16. CO_2 Conversion factor for transports in alternative scenario

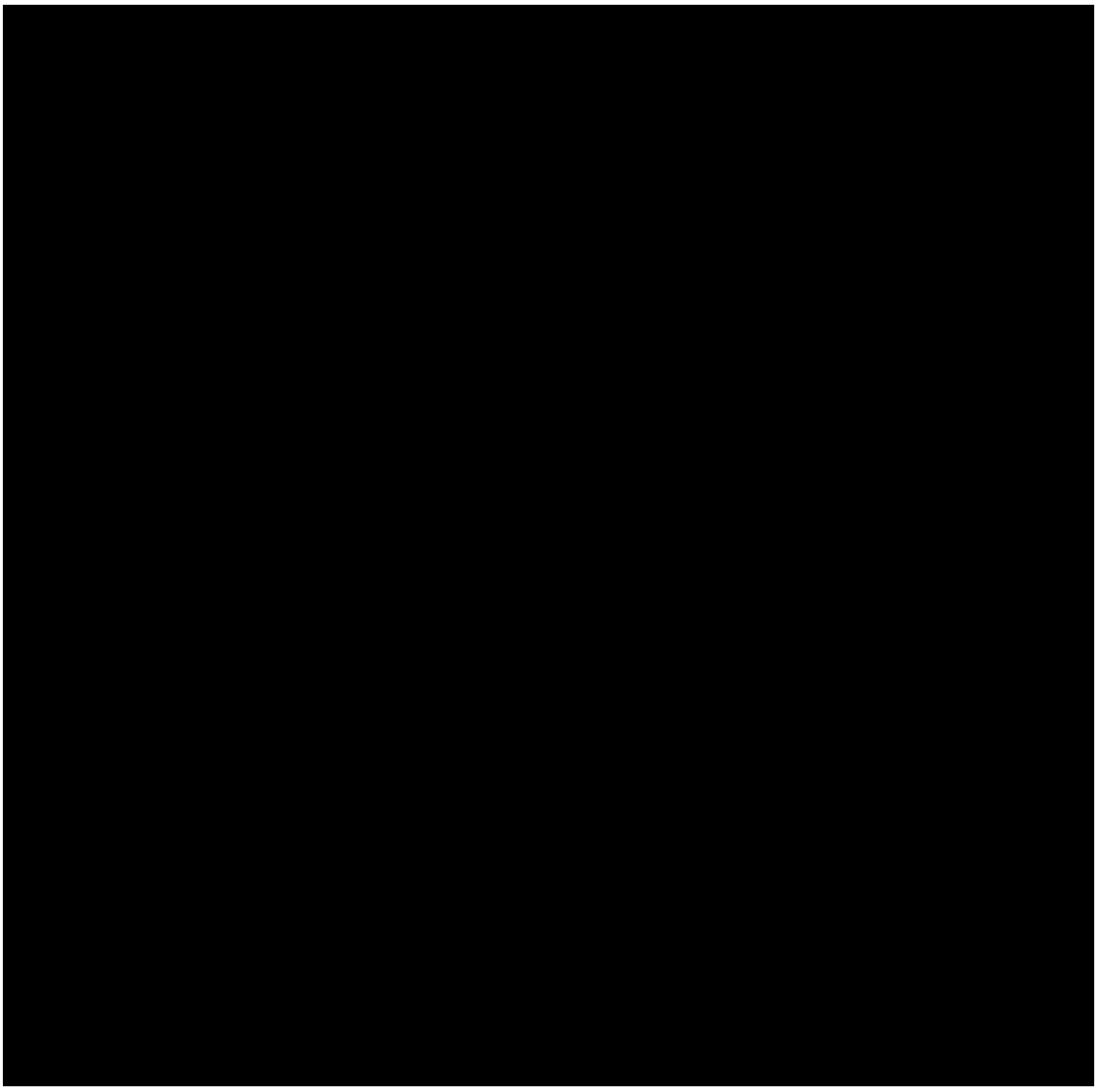
Unit : kg/kWh	2008	2009	2010	2011	2012	2013	2014
Biofuel Share	0.0%	2.5%	5.0%	10.0%	10.0%	10.0%	10.0%
Diesel	0.263	0.256	0.250	0.237	0.237	0.237	0.237
Gasoline	0.252	0.246	0.239	0.227	0.227	0.227	0.227

Annex 4.17. Total emission on the BAU scenario

Annex 4.18. Emission of Household on the BAU

CO_2 Emission (Units: kg CO_2)							
Household by type							
	2008	2009	2010	2011	2012	2013	2014
Fully Occupied HH	1,705,357.94	1,643,525.22	1,570,946.55	1,522,947.28	1,496,677.15	1,470,598.72	1,444,713.05
Holiday Household	34,382.17	33,122.74	31,660.52	30,680.56	30,151.27	29,625.99	29,104.45
Additional Fully Occ.	-	-	218,198.93	422,891.05	416,031.85	409,101.28	402,226.27
Total	1,739,740.11	1,676,647.96	1,820,806.00	1,976,518.89	1,942,860.26	1,909,325.99	1,876,043.77
Household by fuel							
	2008	2009	2010	2011	2012	2013	2014
Wood	297.38	296.31	328.89	363.60	357.93	356.74	355.55
Peat	19,510.55	19,440.33	21,546.39	23,711.15	23,593.46	23,475.24	23,356.52
LPG	1,615.86	1,610.06	1,784.07	1,969.63	1,963.26	1,956.92	1,950.55
Kerosene	163,321.07	162,733.42	180,333.82	198,685.41	197,622.53	196,554.49	195,481.41
Gasoline	326,146.21	317,001.95	353,370.10	396,893.93	392,684.56	388,490.17	384,394.02
Electricity	611,581.45	571,384.21	591,035.69	603,845.42	582,359.95	560,976.74	539,856.44
Diesel	491,214.09	478,581.63	533,219.26	597,701.13	591,757.17	585,825.44	579,794.28
Coal Anthracite	126,053.49	125,599.92	139,187.78	153,348.62	152,521.43	151,690.16	150,854.92
Total	1,739,740.11	1,676,647.83	1,820,806.01	1,976,518.90	1,942,860.30	1,909,325.90	1,876,043.70
Percentage of El.	35.2%	34.1%	32.5%	30.6%	30.0%	29.4%	28.8%
Household by purpose							
	2008	2009	2010	2011	2012	2013	2014
Heating	747,994.63	721,843.32	773,932.39	823,396.01	807,660.04	792,106.86	776,559.95
Transport	756,151.68	734,595.19	818,970.59	920,128.74	910,421.31	900,649.50	890,990.07
Lighting	55,779.42	52,113.21	53,905.34	55,076.88	53,114.63	51,169.06	49,240.18
Cooking	52,832.67	49,460.61	51,282.31	52,536.01	50,734.94	48,933.14	47,162.36
Others	126,981.71	118,635.62	122,715.37	125,381.25	120,929.34	116,467.43	112,091.21
Total	1,739,740.11	1,676,647.96	1,820,806.00	1,976,518.89	1,942,860.26	1,909,325.99	1,876,043.77

Annex 4.19. Breakdown emission of HH on the BAU

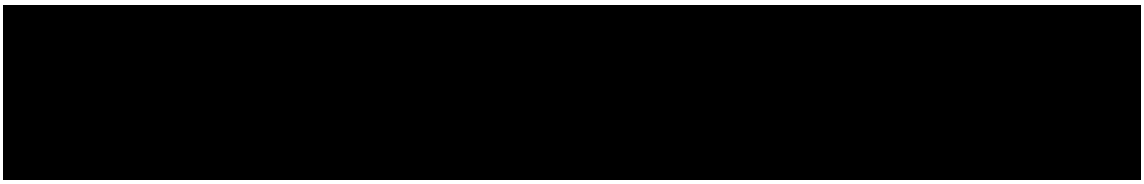


Annex 4.20. Emission of Non-HH on the BAU

Annex 4.21. Breakdown emission of Non-HH on the BAU

CO_2 Emission (Units: kg CO_2)										
				2008	2009	2010	2011	2012	2013	2014
Industry	Marine Harvest	Electricity	Lighting	1,165.51	1,080.82	997.87	915.25	877.64	840.72	804.53
			Heating	22,562.22	20,922.71	19,316.48	17,717.44	16,989.24	16,274.93	15,574.28
			Appliances	171.81	159.33	147.08	134.92	129.38	123.92	118.59
		Gasoline	Transport	23,206.40	22,377.35	21,563.74	21,214.30	20,869.91	20,530.56	20,196.14
		Diesel	Transport	220,594.01	212,713.28	204,979.24	201,657.50	198,384.04	195,158.18	191,979.30
	Individual Fisheries	Diesel	Transport	429,621.28	414,273.05	399,210.53	392,741.20	386,365.92	380,083.36	373,892.26
	Sub Total			697,321.23	671,526.54	646,214.94	634,380.61	623,616.12	613,011.66	602,565.10
Commercial	Lochboisdale Hotel	Electricity	Elctricity	50,724.46	48,061.06	45,336.08	42,487.05	41,626.51	40,743.20	39,836.77
		Diesel	Heating	11,015.94	11,131.61	11,248.48	11,366.60	11,485.95	11,606.53	11,728.41
			Transport	9,914.34	9,767.97	9,617.45	9,667.29	9,717.11	9,766.90	9,816.67
		LPG	Cooking	1,916.06	1,936.17	1,956.51	1,977.05	1,997.80	2,018.79	2,039.99
		Coal	Heating	5,460.10	5,517.44	5,575.38	5,633.91	5,693.06	5,752.85	5,813.26
	Failte	Electricity	Lighting	1,340.76	1,243.33	1,147.88	1,052.85	1,009.57	967.15	925.51
			Heating	2,311.66	2,143.69	1,979.12	1,815.26	1,740.67	1,667.49	1,595.70
	Lawrences	Electricity	Electricity	26,084.78	24,189.29	22,332.33	20,483.62	19,641.71	18,815.91	18,005.83
	Kathleen	Electricity	Lighting	397.48	368.63	340.31	312.13	299.30	286.71	274.37
			Heating	1,958.11	1,815.81	1,676.43	1,537.65	1,474.46	1,412.47	1,351.65
	Laing Motors	Electricity	Electricity	8,856.48	8,212.89	7,582.42	6,954.73	6,668.89	6,388.50	6,113.45
		Gasoline	Others	11,603.19	11,475.58	11,349.32	11,224.48	11,101.03	10,978.91	10,858.15
		Diesel	Transport	2,417.89	2,331.52	2,246.75	2,210.35	2,174.45	2,139.10	2,104.26
			Others	27,539.83	27,236.88	26,937.28	26,640.98	26,347.92	26,058.09	25,771.45
		Kerosene	Heating	5,195.48	5,138.33	5,081.80	5,025.89	4,970.63	4,915.93	4,861.86
	Macaulay Askernish LTD	Electricity	Electricity	5,776.01	5,356.28	4,945.11	4,535.71	4,349.30	4,166.45	3,987.06
		Gasoline	Manufacturing	181,009.91	179,018.81	177,049.61	175,102.05	173,175.94	171,270.99	169,387.02
			Others	27,151.49	26,852.82	26,557.45	26,265.30	25,976.39	25,690.64	25,408.05
		Diesel	Transport	89,504.42	86,306.89	83,168.87	81,821.08	80,492.90	79,184.04	77,894.23
		Kerosene	Heating	4,675.94	4,624.50	4,573.62	4,523.31	4,473.57	4,424.34	4,375.68
	Royal Bank of Scotland	Electricity	Lighting	1,640.65	1,521.43	1,404.65	1,288.35	1,235.39	1,183.45	1,132.52
			Heating	4,351.36	4,035.17	3,725.40	3,416.97	3,276.55	3,138.81	3,003.68
			Appliances	5,318.91	4,932.39	4,553.75	4,176.79	4,005.09	3,836.71	3,671.56
		Diesel	Transport	14,320.72	13,809.10	13,307.01	13,091.38	12,878.85	12,669.44	12,463.08
	Toban An Dualchais	Electricity	Lighting	31.54	29.28	27.01	24.79	23.75	22.77	21.76
			Heating	6,376.42	5,913.07	5,459.15	5,007.22	4,801.40	4,599.53	4,401.51
			Appliances	1,844.46	1,710.43	1,579.11	1,448.40	1,388.85	1,330.46	1,273.18
	Sub Total			508,738.39	494,680.35	480,758.27	469,091.20	462,027.01	455,036.17	448,116.65
Public	NHS Dental Clinic	Electricity	Lighting	305.80	283.59	261.80	240.13	230.27	220.57	211.07
			Heating	27,695.05	25,682.53	23,710.93	21,748.11	20,854.25	19,977.43	19,117.37
			Appliances	2,529.70	2,345.88	2,165.75	1,986.48	1,904.83	1,824.74	1,746.20
	Post Office	Electricity	Electricity	2,092.00	1,939.98	1,791.06	1,642.77	1,575.27	1,509.04	1,444.09
		Diesel	Transport	113,601.77	109,543.35	105,560.48	103,849.83	102,164.06	100,502.80	98,865.75
	Lochboisdale Amenity Trust	Electricity	Electricity	1,859.79	1,724.65	1,592.25	1,460.42	1,400.41	1,341.54	1,283.79
	Church	Electricity	Electricity	784.50	727.49	671.65	616.03	590.73	565.89	541.53
		Diesel	Heating	3,304.78	3,268.43	3,232.48	3,196.92	3,161.76	3,126.96	3,092.56
	Police Station	Electricity	Electricity	2,771.85	2,570.43	2,373.13	2,176.64	2,087.18	1,999.45	1,913.36
		Diesel	Transport	22,031.85	21,244.76	20,472.33	20,140.58	19,813.64	19,491.46	19,173.97
	Street Lamps	Electricity	Lighting	10,830.62	10,043.59	9,272.57	8,504.96	8,155.40	7,812.51	7,476.18
	Sub Total			187,807.70	179,374.67	171,104.43	165,562.86	161,937.81	158,372.41	154,865.87
Transport	Cal Mac Ferries	Electricity	Lighting	6,733.26	6,243.98	5,764.63	5,287.42	5,070.11	4,856.93	4,647.84
			Heating	14,058.24	13,036.66	12,035.88	11,039.52	10,585.81	10,140.73	9,704.15
			Appliances	1,284.07	1,190.76	1,099.36	1,008.36	966.92	926.24	886.39
	Local Public Buses	Diesel	Transport	14,893.53	14,361.47	13,839.29	13,615.02	13,394.01	13,176.23	12,961.61
	School Bus	Diesel	Transport	2,680.52	2,584.76	2,490.80	2,450.43	2,410.64	2,371.46	2,332.83
	Sub Total			39,649.62	37,417.63	35,229.95	33,400.75	32,427.49	31,471.59	30,532.81
Harbor Extension Plan	Fish Factory	Electricity	Electricity	0.00	0.00	0.00	0.00	243,467.84	233,231.26	223,190.44
	Individual Fisheries	Diesel	Transport	0.00	0.00	0.00	0.00	807,688.01	794,554.49	781,612.17
	Six Small shops	Electricity	Electricity	0.00	0.00	0.00	0.00	10,639.53	10,192.20	9,753.41
	Waiting Room	Electricity	Electricity	0.00	0.00	0.00	0.00	3,719.05	3,562.68	3,409.30
	Sub Total			-	-	-	-	1,065,514	1,041,541	1,017,965
Total				1,433,516.94	1,382,999.19	1,333,307.59	1,302,435.42	2,345,522.87	2,299,432.46	2,254,045.74

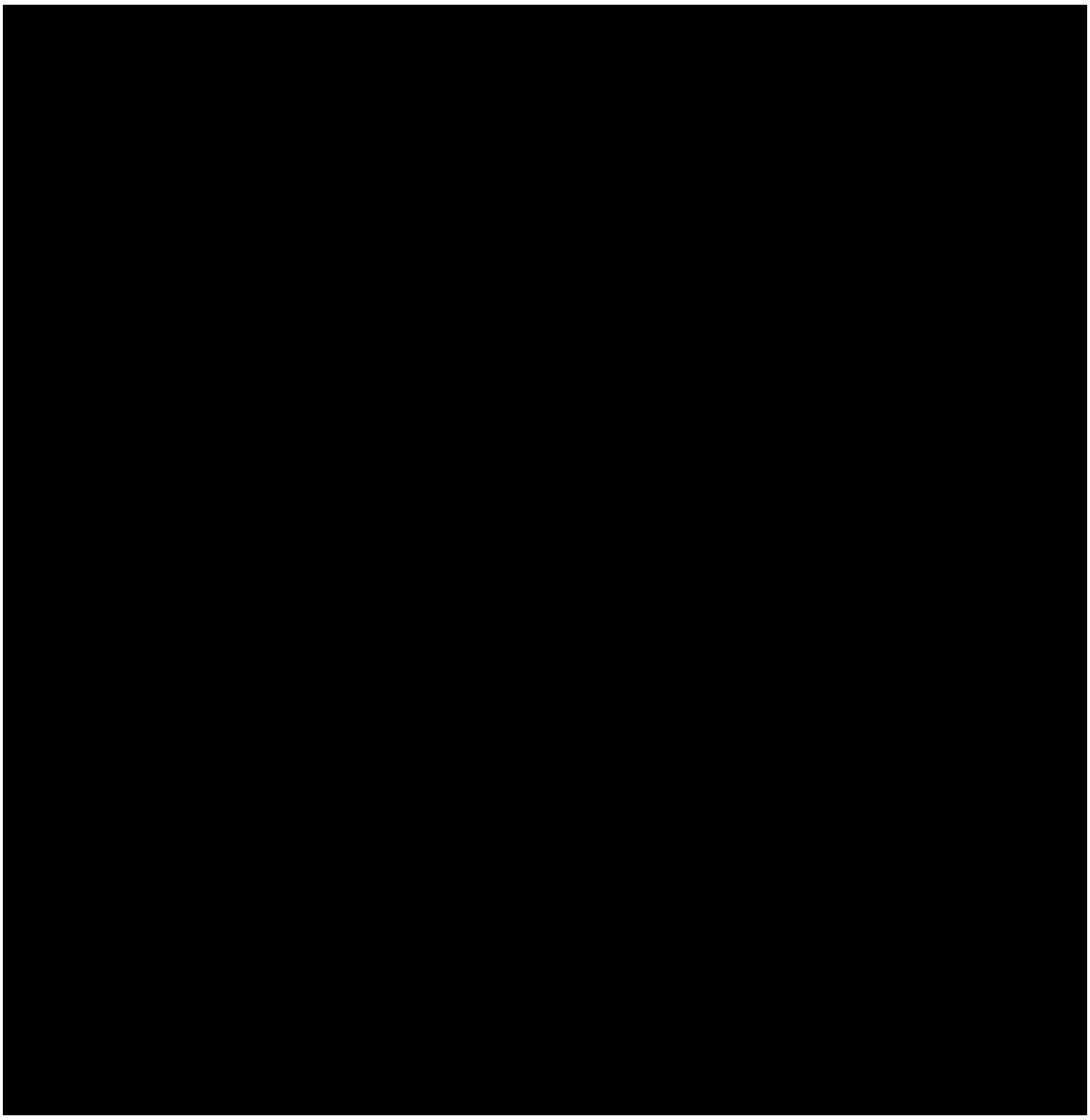
Annex 4.22. Total Emission on the Alternative Scenario



Annex 4.23. Emission of HH on the Alternative Scenario

CO_2 Emission (Units: kg CO_2)							
Household by type							
Alternative	2008	2009	2010	2011	2012	2013	2014
Fully Occupied HH	1,705,357.93	1,510,312.21	1,428,126.19	1,356,870.07	1,335,213.45	1,313,712.09	1,290,413.12
Holiday Household	34,382.21	33,122.70	31,660.52	30,021.06	29,568.27	29,118.54	28,671.91
Additional Fully Occ.	-	-	162,765.26	308,286.44	177,623.57	173,457.50	169,264.22
Total	1,739,740.15	1,543,434.91	1,622,551.97	1,695,177.57	1,542,405.28	1,516,288.13	1,488,349.25
Household by fuel							
Alternative	2008	2009	2010	2011	2012	2013	2014
Wood	297.38	296.32	322.17	357.62	284.32	282.87	280.25
Peat	19,510.55	19,440.72	21,151.74	23,364.15	18,698.44	18,595.99	18,434.49
LPG	1,615.87	1,610.06	1,784.07	1,969.62	1,963.27	1,956.91	1,950.55
Kerosene	163,321.07	162,732.45	176,997.62	195,754.36	156,493.39	155,630.60	154,279.92
Gasoline	326,146.23	260,629.89	275,453.89	282,911.27	279,907.49	278,391.71	276,857.66
Electricity	611,581.45	571,383.97	584,252.23	598,313.70	538,072.13	517,422.63	496,068.39
Diesel	491,214.10	401,739.85	425,993.55	441,434.30	426,216.97	423,902.66	421,419.37
Coal Anthracite	126,053.49	125,601.64	136,596.71	151,072.55	120,769.27	120,104.75	119,058.61
Total	1,739,740.15	1,543,434.91	1,622,551.97	1,695,177.57	1,542,405.28	1,516,288.13	1,488,349.25
Percentage of El.	35.2%	37.0%	36.0%	35.3%	34.9%	34.1%	33.3%
Household by purpose							
Alternative	2008	2009	2010	2011	2012	2013	2014
Heating	747,994.64	721,843.76	759,532.10	811,172.71	670,120.97	655,718.35	639,360.49
Transport	756,151.70	601,381.75	635,116.86	651,010.70	647,505.36	644,000.26	640,495.05
Lighting	55,779.42	52,113.22	53,905.33	55,076.86	53,114.63	51,169.01	49,240.16
Cooking	52,832.69	49,460.56	51,282.31	52,536.02	50,734.96	48,933.10	47,162.39
Others	126,981.71	118,635.62	122,715.37	125,381.28	120,929.36	116,467.41	112,091.17
Total	1,739,740.15	1,543,434.91	1,622,551.97	1,695,177.57	1,542,405.28	1,516,288.13	1,488,349.25

Annex 4.24. Breakdown emission of HH on the Alternative Scenario



Annex 4.25. Emission of Non-HH on the Alternative Scenario

Annex 4.26. Breakdown emission of Non-HH on the Alternative Scenario

CO_2 Emission (Units: kg CO_2)										
Alternative (incl. RES)				2008	2009	2010	2011	2012	2013	2014
Industry	Marine Harvest	Electricity	Lighting	1,165.52	1,080.82	997.85	915.24	877.63	840.73	804.53
			Heating	22,562.22	20,922.69	19,316.50	17,717.43	16,989.25	16,274.94	15,574.29
			Appliances	171.81	159.32	147.09	134.91	129.37	123.93	118.60
		Gasoline	Transport	23,206.40	22,377.35	21,563.73	21,214.29	20,869.92	20,530.56	20,196.14
		Diesel	Transport	220,594.00	212,713.28	204,979.25	192,054.77	189,942.16	187,852.80	185,786.42
	Individual Fisheries	Diesel	Transport	429,621.28	414,273.06	399,210.52	374,039.25	369,924.81	365,855.64	361,831.23
	Sub Total			697,321.23	671,526.53	646,214.94	606,075.89	598,733.14	591,478.60	584,311.21
Commercial	Lochboisdale Hotel	Electricity	Eletricity	50,724.47	48,061.05	45,336.10	42,487.05	19,492.86	19,563.31	19,596.48
		Diesel	Heating	11,015.93	11,131.60	11,248.48	11,366.59	0.00	0.00	0.00
			Transport	9,914.34	9,767.98	9,617.45	9,206.94	9,303.61	9,401.30	9,500.01
		LPG	Cooking	1,916.06	1,936.17	1,956.50	1,977.05	1,997.81	2,018.78	2,039.98
		Coal	Heating	5,460.11	5,517.44	5,575.38	5,633.92	0.00	0.00	0.00
	Failte	Electricity	Lighting	1,340.76	1,243.33	1,147.88	1,052.86	1,009.59	967.14	925.50
			Heating	2,311.66	2,143.68	1,979.11	1,815.28	1,740.67	1,667.48	1,595.70
	Lawrences	Electricity	Electricity	26,084.79	24,189.28	22,332.32	20,483.60	19,641.73	18,815.89	18,005.85
	Kathleen	Electricity	Lighting	397.50	368.61	340.31	312.14	299.31	286.73	274.39
			Heating	1,958.11	1,815.82	1,676.43	1,537.65	1,474.45	1,412.46	1,351.65
	Laing Motors	Electricity	Electricity	8,856.48	8,212.91	7,582.42	6,954.73	6,668.89	6,388.50	6,113.47
		Gasoline	Others	11,603.20	11,475.57	11,349.33	11,224.49	11,101.02	10,978.91	10,858.14
		Diesel	Transport	2,417.90	2,331.52	2,246.74	2,105.08	2,081.93	2,059.02	2,036.38
			Others	27,539.83	27,236.89	26,937.28	26,640.97	26,347.92	26,058.10	25,771.45
		Kerosene	Heating	5,195.48	5,138.33	5,081.80	5,025.90	4,970.62	4,915.94	4,861.87
	Macaulay Askernish LTD	Electricity	Electricity	5,776.01	5,356.29	4,945.10	4,535.73	4,349.31	4,166.45	3,987.08
		Gasoline	Manufacturing	181,009.92	179,018.81	177,049.60	175,102.06	173,175.93	171,271.00	169,387.02
			Others	27,151.49	26,852.82	26,557.44	26,265.31	25,976.39	25,690.65	25,408.05
		Diesel	Transport	89,504.43	86,306.89	83,168.86	77,924.84	77,067.67	76,219.93	75,381.51
		Kerosene	Heating	4,675.93	4,624.49	4,573.62	4,523.31	4,473.56	4,424.35	4,375.68
	Royal Bank of Scotland	Electricity	Lighting	1,640.65	1,521.43	1,404.63	1,288.35	1,235.40	1,183.46	1,132.51
			Heating	4,351.36	4,035.16	3,725.39	3,416.99	3,276.56	3,138.79	3,003.66
			Appliances	5,318.91	4,932.40	4,553.75	4,176.78	4,005.12	3,836.72	3,671.55
		Diesel	Transport	14,320.71	13,809.10	13,307.02	12,467.97	12,330.83	12,195.19	12,061.04
	Toban An Dualchais	Electricity	Lighting	31.55	29.26	27.01	24.77	23.76	22.75	21.78
			Heating	6,376.42	5,913.06	5,459.13	5,007.21	4,801.41	4,599.54	4,401.52
			Appliances	1,844.45	1,710.42	1,579.12	1,448.40	1,388.87	1,330.47	1,273.19
	Sub Total			508,738.43	494,680.31	480,758.22	464,005.98	418,235.20	412,612.86	407,035.46
Public	NHS Dental Clinic	Electricity	Lighting	305.79	283.57	261.80	240.13	230.26	220.58	211.08
			Heating	27,695.05	25,682.53	11,987.33	11,105.05	10,755.23	10,406.16	10,057.85
			Appliances	2,529.68	2,345.85	1,094.93	1,014.34	982.39	950.50	918.69
	Post Office	Electricity	Electricity	2,092.00	1,939.98	905.49	838.84	812.42	786.05	759.74
		Diesel	Transport	113,601.78	109,543.36	105,560.47	98,904.61	97,816.66	96,740.67	95,676.53
	Lochboisdale Amenity Trust	Electricity	Electricity	1,859.79	1,724.64	804.98	745.73	722.24	698.80	675.41
	Church	Electricity	Electricity	784.50	727.49	339.56	314.56	304.66	294.77	284.90
		Diesel	Heating	3,304.78	3,268.43	1,634.21	1,632.41	1,630.62	1,628.83	1,627.03
	Police Station	Electricity	Electricity	2,771.86	2,570.43	1,199.75	1,111.45	1,076.44	1,041.50	1,006.64
		Diesel	Transport	22,031.86	21,244.77	20,472.33	19,181.50	18,970.50	18,761.83	18,555.45
	Street Lamps	Electricity	Lighting	10,830.62	10,043.59	9,272.57	8,504.96	8,155.40	7,812.51	7,476.18
	Sub Total			187,807.70	179,374.64	153,533.42	143,593.59	141,456.82	139,342.20	137,249.50
Transport	Cal Mac Ferries	Electricity	Lighting	6,733.25	6,243.96	5,764.63	5,287.42	5,070.11	4,856.93	4,647.84
			Heating	14,058.24	13,036.67	12,035.87	11,039.51	10,585.79	10,140.71	9,704.15
			Appliances	1,284.09	1,190.78	1,099.37	1,008.36	966.91	926.26	886.38
	Local Public Buses	Diesel	Transport	14,893.54	14,361.47	13,839.30	12,966.69	12,824.06	12,683.00	12,543.48
	School Bus	Diesel	Transport	2,680.53	2,584.77	2,490.79	2,333.74	2,308.07	2,282.68	2,257.57
	Sub Total			39,649.64	37,417.65	35,229.95	32,635.72	31,754.94	30,889.58	30,039.42
Harbor Extension Plan	Fish Factory	Electricity	Electricity	0.00	0.00	0.00	0.00	161,141.49	153,489.16	146,032.57
	Individual Fisheries	Diesel	Transport	0.00	0.00	0.00	0.00	773,318.31	764,811.81	756,398.88
	Six Small shops	Electricity	Electricity	0.00	0.00	0.00	0.00	1,808.71	1,732.66	1,658.07
	Waiting Room	Electricity	Electricity	0.00	0.00	0.00	0.00	3,719.04	3,562.68	3,409.30
	Sub Total			0.00	0.00	0.00	0.00	939,987.55	923,596.30	907,498.81
Total				1,433,517.00	1,382,999.13	1,315,736.53	1,246,311.18	2,130,167.64	2,097,919.55	2,066,134.39