Shetland Energy Source Analysis

ACKNOWLEDGEMENT

This report has been realised with the support and input of many experts. We thank all those who have provided input and contributions and helped to shape the document.

GLOSSARY

LPG	Liquefied Petroleum Gas
MPG	Miles per Gallon
CO2	Carbon Dioxide Gas
ppl	pence per litre
NAEI	National Atmospheric Emissions Inventory
kWh	kilowatt hours of energy
MWh	Megawatt hours of energy (1MWh = 1000kWh)
GWh	Gigawatt hours of energy (1GWh = 1000MWh)
T	Metric Tonne = 1000 kilograms
kT	Thousand Metric Tonne (1kT = 1000 Metric Tonne or 1000T)
EfW	Energy from Waste, is the district heating scheme waste incinerator in Lerwick, Shetland Islands.

EXECUTIVE SUMMARY

This report has been carried out as part of a pan European project called **Cradle 2 Cradle Islands (C2Ci)**, awarded by the Interreg IVB North Sea Region Programme. The report examines the energy sources, environmental CO2 impacts, and the associated energy costs to the local economy.

To date, limited work has been done to fully understand and quantify the different type of energy sources used within the Shetland Isles. Although Shetland hosts one of the largest oil and liquefied gas terminals in Europe, and has the most productive wind turbine in the world, there is no known study that has been conducted to define the energy sources financial impact and associated CO2 emissions.

This energy analysis aims to increase understanding of the current and future interactions of the energy sources used in Shetland. It presents the Shetland community with key information to allow the development of new and effective energy policies as energy costs peak at a very unpredictable time. This analysis provides policy makers information to plan the right resources and technologies and determine the environmental impacts surrounding any future energy source infrastructure.

KEY FINDINGS

- Between **1990 and 2008 Shetland energy use has increased by 58%** from 1'000GWh to 1'550 GWh.
- **Energy cost to the Shetland economy was almost £84m in 2008. This is a £17m increase from 2007, when the energy cost was £67m.**
- CO2 Emissions have increased from 323kT in 1990 to just under 507kT in 2008, a rise of 57%.
- Shetlands' energy use and associated carbon emissions are very high per head of population.
- The two largest Shetland energy sources are 'grid' electricity and GasOil.
- There has been a strong decline in the use of coal, peat and LPG as people change to oil based heating or district heating.
- In rural parts of Shetland many have changed to electrical heating from solid fuel.
- Shetlands use of road fuels has declined through the use of more efficient vehicles and a shift from petrol to road diesel.
- Shetland is highly vulnerable to minor fluctuations in whole sale energy costs.
- Shetland is almost completely dependent on external energy sources and associated supply chains.
- The Shetland population during the analysis period has been relatively constant at around 22,000.
- Cost of energy is continually increasing.
- CO2 emissions can be reduce

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INTRODUCTION

There are multiple barriers to the development of effective energy policies, many of which could be supported by key information. Historically, energy policy development has focused on effective implementation of an energy infrastructure and to secure a strong supply chain at a country and regional level, with limited effort focused on local CO2 emissions. Nowadays, energy, finance and emissions are intrinsically linked, therefore policy makers require more accurate information in order to make informed decisions.

The role of local authorities in supporting energy policy has now reached a critical stage. They have authority and the decision making powers over land-use planning, transport, building, and other areas that have energy community impact. This is true for the Shetland local authority, which has a strong involvement in energy, owning many transport links in and around the Islands and also owning buildings and infrastructure.

This report aims to provide and disseminate an initial overview of the current Shetland energy sources. The objective is to develop a better understanding of the energy issues facing Shetland in the near future. By looking at past energy sources, policy makers will be able to identify the energy trends for Shetland and develop effective policies. Through the findings of this report, policy makers and local authority representatives should also be able to disseminate effectively key energy facts about Shetland. The historic energy source data has been collected from a variety of sources however it is important to note that the information presented within this document does not include the impact of Sullom Voe Oil Terminal. These figures were considered commercially confidential and are therefore not included within this report

This report is therefore divided into six sections. The first section of the report provides the aims and objectives of the study. The second section describes what an energy balance and an energy analysis are. The third section presents the different types of energy sources used in Shetland, provides insight into the quantity of energy used in Shetland from 1990 to 2008, summarises the energy consumption comparison for each of the major energy sources and shows the proportion of energy imported and the energy produced locally. The fourth section defines the total CO_2 emissions produced in Shetland in addition to those from each of the different energy sources. The fifth section investigates the cost of the energy sources to the Shetland community. The sixth and final section gives an indication of Shetland's CO_2 position compared to the rest of the world.

AIMS & OBJECTIVES

The sections below present the aims and objectives of this document.

AIMS

This report aims to increase the understanding of Shetland's energy position (as of 2008). It also aims to summarise the financial and environmental impacts of energy. It provides a single point of information summarising energy sources in and within the Shetland context - information that can be used by decision makers to develop Shetland's future energy policies.

No work was undertaken to define the role of Shetland's energy policy, the energy market, required future skills, resources and technologies, and the need for investment in new infrastructure.

OBJECTIVES

After reading this report, the reader should be able to:

1. Understand what an energy source analysis is
2. Have a clearer understanding of the different types of energy sources used in Shetland
3. Recognise how much energy is being used in Shetland
4. Identify where the energy comes from
5. Understand how much energy is imported to Shetland
6. Comprehend Shetland's CO_2 footprint
7. Compare Shetland's CO2 emissions to other countries
8. Understand the approximate cost of energy to Shetlanders
9. Have an idea of the CO2 emissions from the cars within Shetland
10. Recognise the requirements within a Shetland energy policy based on key information

WHAT IS AN ENERGY SOURCE ANALYSIS?

The aim of an energy source analysis is to provide an assessment of the different sources of energy available for use. An energy source analysis can usually be utilised to support decision makers to define future energy policies.

WHY AN ENERGY ANALYSIS?

It is important to understand where the energy comes from and where the energy is being used to develop an effective energy policy for Shetland.

In real terms, if one knows where the energy comes from, one can understand the financial and technical risks and impacts associated with a particular energy source.

When it is clear where the energy is being used it is possible to:

- Target the use of resources
- Define future financial commitments
- Put in place appropriate policies and strategies
- Make informed decisions
- Utilise the correct type of technology in the right place to address a particular energy requirement

ENERGY SOURCES

This section summarises the different sources of energy within Shetland.

WHAT ARE THE DIFFERENT TYPES OF ENERGY SOURCES USED IN SHETLAND?

The vast majority of energy consumed/produced within the Shetland Islands is derived from hydrocarbon based products. The energy sources used in Shetland comprise the following:

- Diesel
- Gas Oil (sometimes referred to as red diesel)
- LPG
- Petrol (Gasoline)
- Kerosene
- Aviation Fuel (JET A1)
- Peat
- Coal
- Energy from Waste (EfW)
- Renewable energy sources
- 'Grid electricity'[1]

HOW MUCH ENERGY IS SUPPLIED TO IN SHETLAND?

[1] It is recognised that grid electricity is not an energy source, however, the energy is distributed and consumed in the form of electricity and is therefore metered in this form. Shetland grid electricity comes from heavy fuel oil at the primary power station.

The figure below, Figure 1, summarises Shetland's supply since 1990. It shows that the Energy supplied to Shetland has continually increased since the 1990 base line level. It also illustrates the steady decline since an energy peak in 2001, shown by a green circle in Figure 1. The 2001 energy peak has been attributed to a mini boom in the fishing industry. The decline is due to increased efficiency efforts in and around the Shetland Isles and a decline in industrial activities.

The trend line, in red on Figure 1, shows the percentage increase in energy use since 1990. From this trend line, one can see that the energy usage since 1990 levels have dramatically increased by 58% to 2008.

It is important to note that almost 1'000GWh of energy was used in 1990. This has now reached a 1'550 GWh in 2008.

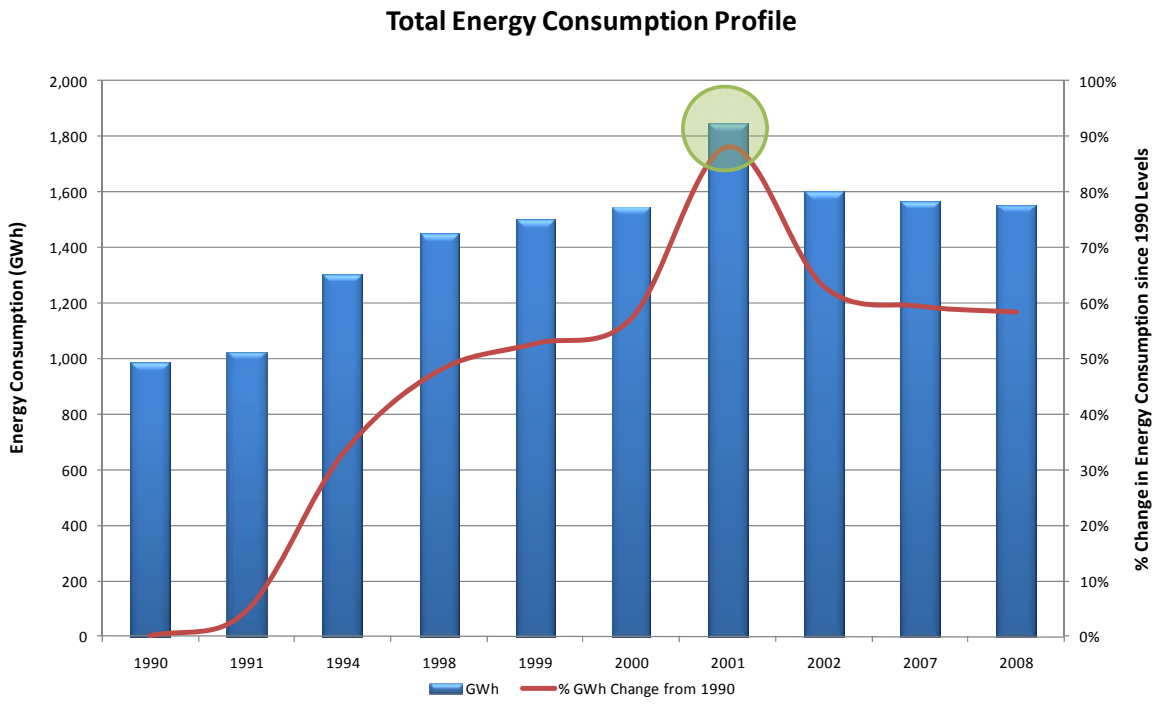

Figure 1 Energy consumption by Shetland and its percentage trend since 1990

ENERGY COMPARISON BETWEEN YEARS 1990 AND 2008

The figure below, Figure 2, illustrates an energy consumption comparison between the year 1990 and year 2008 for each of the major energy sources. The blue coloured bars on the chart represent the year 1990 and the red coloured sections on the chart the year 2008.

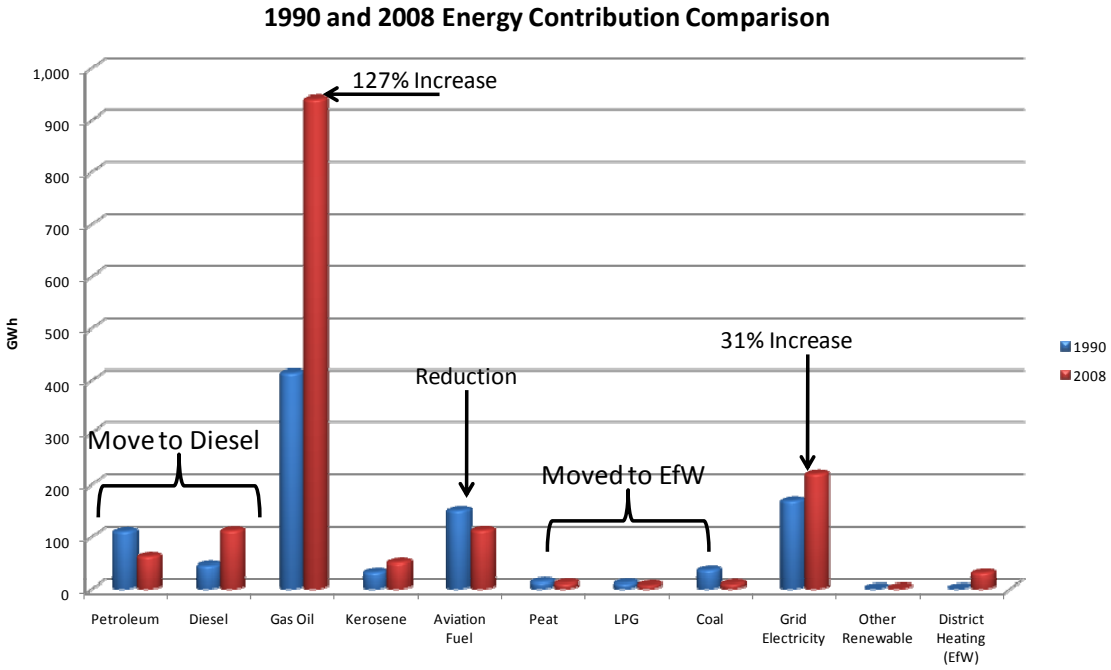

Figure 2 Energy comparison between 1990 and 2008

Figure 2 shows that there has been a significant increase in gas oil use (127% increase) and a 31% increase in "Grid" derived energy sources usage. It also shows that the use of peat, LPG and coal has reduced as consumers have transferred to heating oil (Gas Oil & Kerosene) and electric and district heating (Lerwick district heating scheme). In addition, locally sourced Aviation Fuel consumption has reduced. This is due to a number of factors including the fact that aircraft have become more efficient, airplane fuel sourced locally has declined with the use of UK mainland sources, a reduction of Shetland's North sea oil based related activity and the closure of Unst Airport that supplied offshore platforms.

In contrast one can see that petroleum consumption has reduced, whilst road diesel has increased. Nevertheless, in the overall scheme of things, road fuel quantity has decreased since 1998. This is due to three main factors; (a) diesel contains more energy than petrol per litre; (b) significant shift from petrol vehicles usage in Shetland; and (c) diesel engines are more efficient than petrol fuelled cars. For example, a standard petroleum vehicle achieves a 30MPG and a shift to a diesel vehicle allows a 70MPG).

Figure 2 shows that Shetland's diverse energy source is narrowing, potentially putting Shetland at higher financial and dependence risks. If Shetlands' trend towards narrowing its energy source base continues, it will become more dependent on global energy price fluctuations.

Figure 3 below illustrates how strong the Shetland Islands dependence is on two main sources of energy - Gas oil (in blue) and 'Grid' (in red).

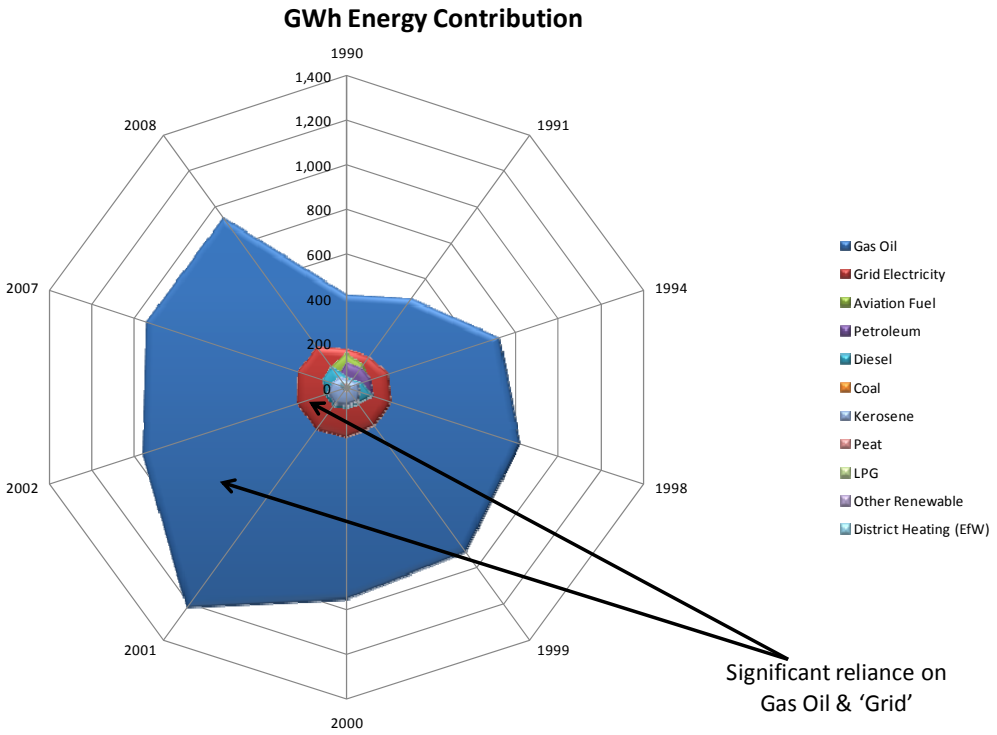

Figure 3 Shetland Energy dependence on gas oil and 'grid'

The figure below, Figure 4, is used to further illustrate the strong Shetland dependence upon electrical grid energy and gas oil. It also shows the Energy Contribution of each energy source through each year that data was available and gives a real indication of trend.

As mentioned, the overall petroleum and diesel consumption for the transport sector has declined over the years. As diesel vehicles have become more efficient, the overall consumption for road vehicles has decreased.

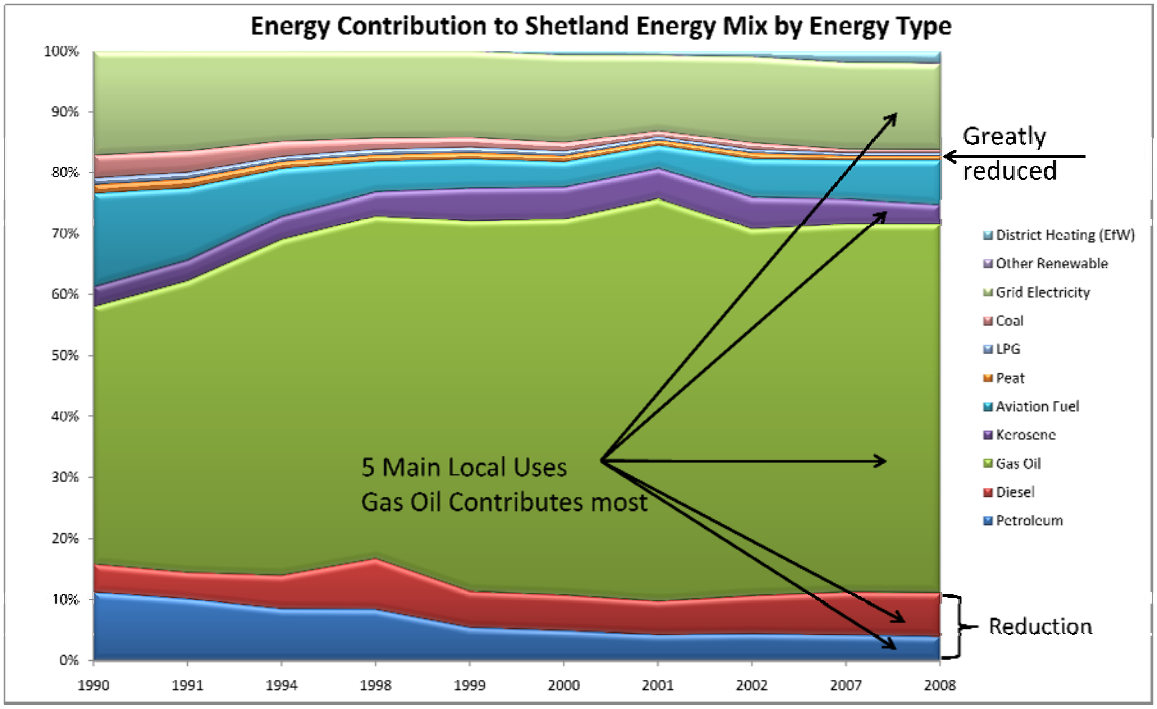

Figure 4 Trend and contribution of Gas Oil to Shetlands energy consumption

HOW MUCH ENERGY IS SOURCED LOCALLY AND HOW MUCH IS IMPORTED?

The figure below, Figure 5, illustrates the proportion of energy imported and the energy produced locally. In 1990 the only local sources of energy were peat and some small renewable projects (namely Foula and Fair isle energy schemes). This resulted in only 1% of the overall Shetland energy mix being produced locally, with the other 99% imported.

By 2008, Burradale wind farm, many small renewable projects, and some peat usage, combined with the district heating scheme have increased local energy source contribution to 4% of the energy mix.

Figure 5 clearly shows that a significant effort will be required to reduce Shetlands reliance on externally imported energy sources.

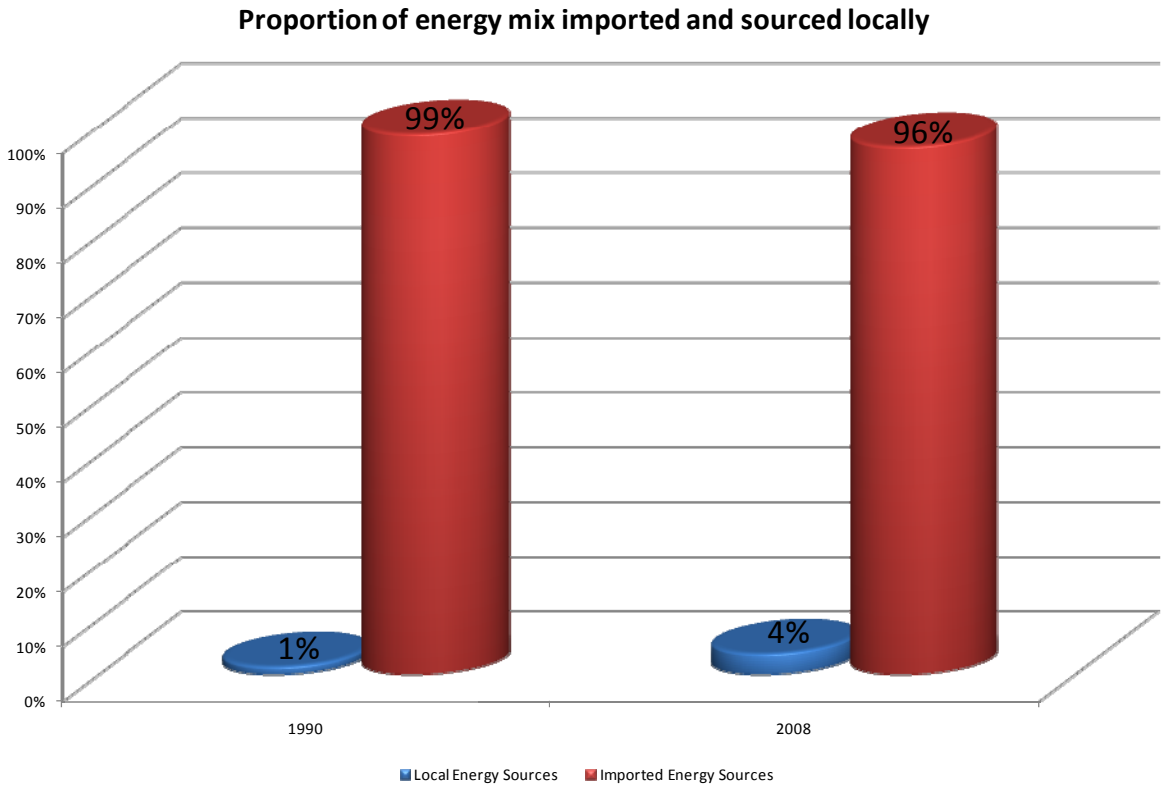

Figure 5 Percentage comparison between imported and locally produced energy sources

CO2 EMISSIONS

This section aims to define the total CO_2 emissions produced in Shetland from the different energy sources.

COMPARISON OF CO2 EMISSIONS BETWEEN 1990 AND 2008

The figures below, Figures 6 and 7, illustrate the 1990 and 2008 energy sources and their respective CO_2 contributions.

In 1990 there were not many green energy projects operating and no district heating system in Shetland. The "Grid" had almost no renewable energy in the generation mix. As a result the "Grid" contributed the most carbon dioxide emissions per unit of energy as can be seen on figure 6.

In addition, there were many more petrol fuelled cars on the roads compared to the inefficient and somehow unreliable diesel fuelled vehicles of the time.

Gas Oil (used for heating and industrial usage – fishing, agriculture and construction) accounted for the largest percentage energy source. It was, however, the second largest source of CO_2 emissions at the time.

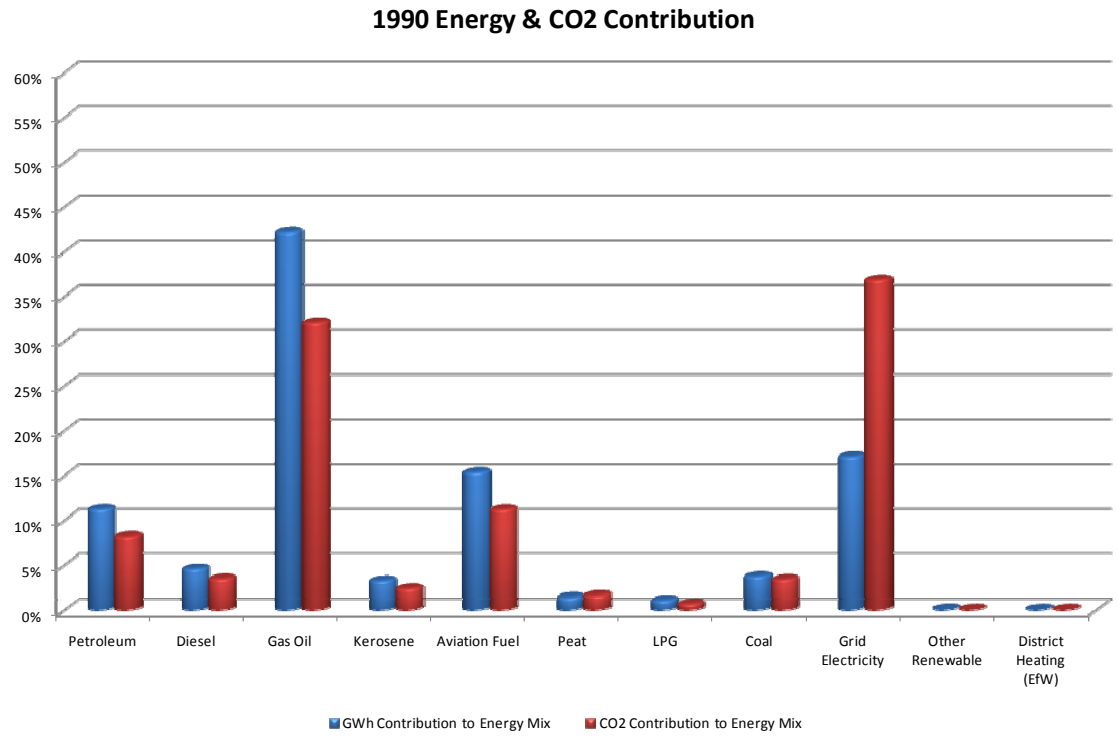

Figure 6 1990 emissions and energy contribution by energy source

In 2008, road fuel consumption reduced. This was not due to a reduction in cars on the roads, but due to a significant increase in fuel economy and a transition to modern high efficiency diesel fuelled vehicles. The significant increase in fuel economy in modern high efficiency diesel engines have contributed in an overall reduction in CO2 emissions.

Peat, Coal and LPG consumption have decreased dramatically as users have transferred to gasoil, electric and district heating as sources for heating energy.

CO2 Emissions from the Grid, Gas Oil and Kerosene have increased from the 1990s figures while the district heating plant started (Energy from Waste (EfW)), all contributing to Shetland's CO2 emissions.

Due to the large increase in gas oil consumption, the relative contribution from 'grid' derived energy has reduced (although the actual energy consumed from the 'grid' is higher than in 1990).

It is important to note that the energy mix on the 'Grid' includes the surplus from the Sullom Voe oil terminal power station that, according to SEPA sources, is highly inefficient, and results in an increase in overall Grid energy mix CO_2.

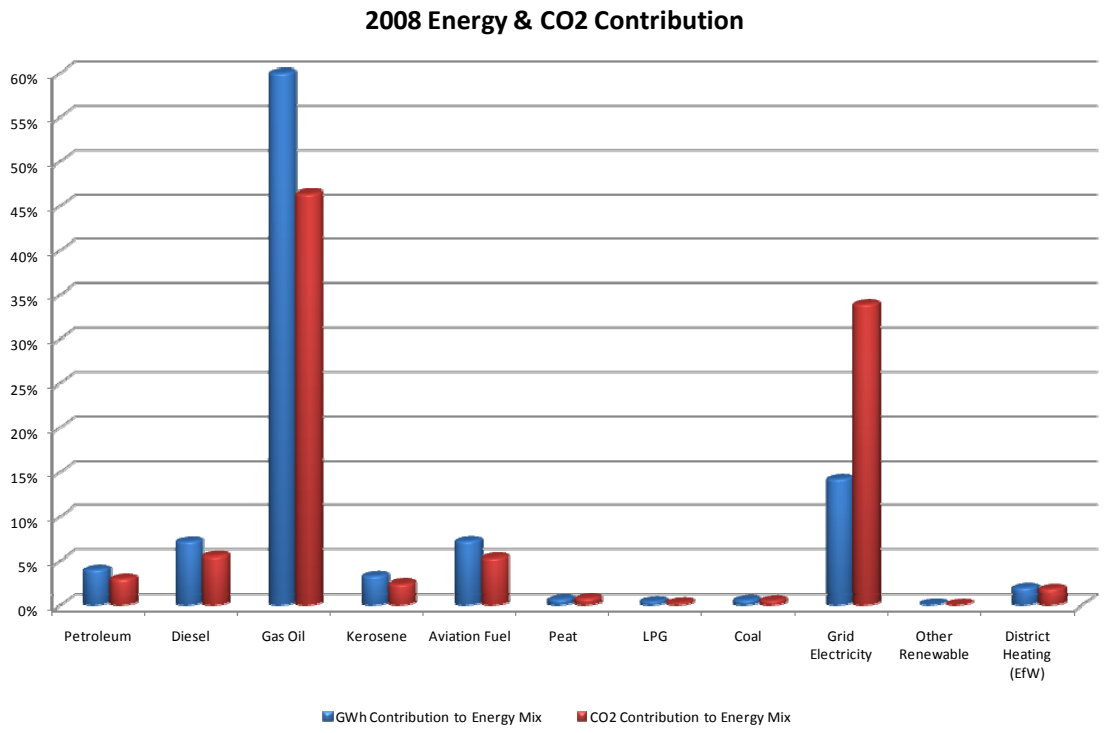

Figure 7 2008 emissions and energy contribution by energy source

Figure 8 illustrates the changes in CO2 emissions between the year 1990 and year 2008. All in all, there has been a significant increase in gas oil and "Grid" derived carbon emissions. In 1990, it was the Grid that had the highest CO2 emissions while in 2008 this has shifted to Gasoil mostly due to the increase in industrial activities (predominantly fishing and aquaculture). Peat,

LPG and coal emissions have reduced as consumers transferred to heating oil (Gas Oil & Kerosene), electric and district heating.

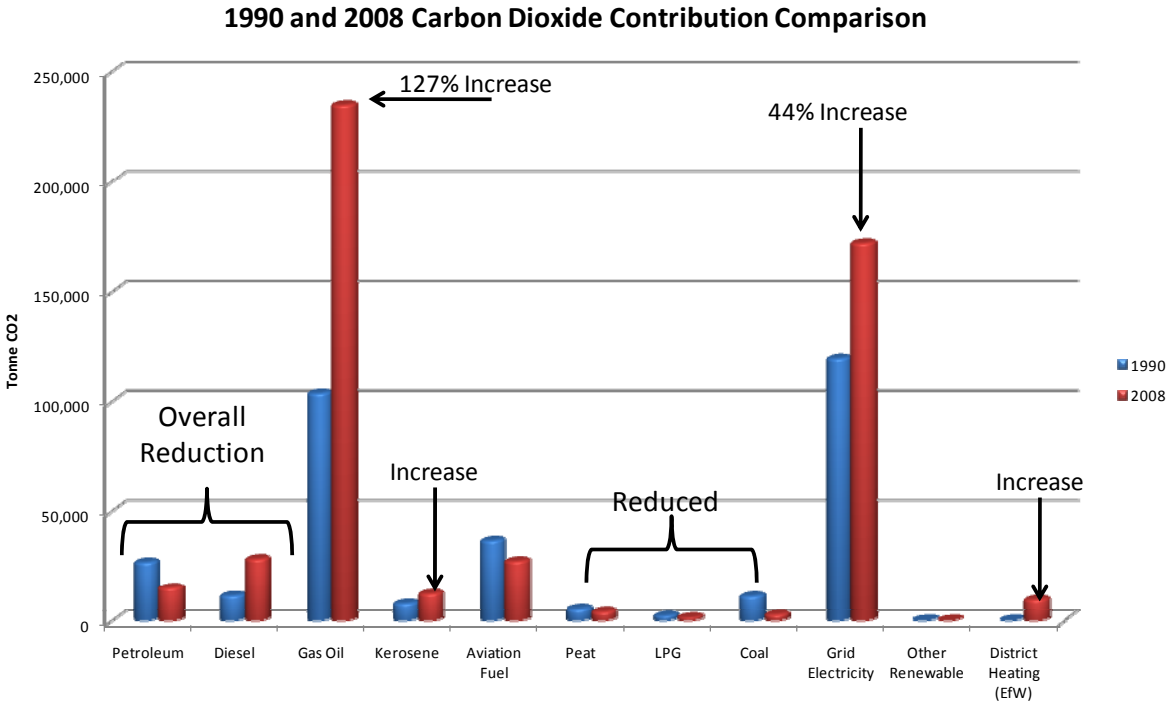

Figure 7 2008 Emissions and energy contribution by energy source highlighting changes from 1990

HOW MUCH CO_2 IS BEING PRODUCED IN SHETLAND?

The figure below, Figure 8, shows that Carbon emissions have continually increased since the 1990 base line level. The trend line (in red) shows a 57% percent increase in carbon emissions between 1990 and 2008, with a peak in 2001. In 1990, the CO_2 emissions from Shetland were just above 300,000 tonnes per year. By 2008 this has increased to just over 500,000 tonnes and peaked at 600,000 tonnes of CO_2 in 2001.

Since the 2001 peak (attributed to a mini boom in the fishing industry), there has been a steady decline in emissions, through increased efficiencies, installations of renewables and as a result of the district heating scheme displacing fossil based heating systems in the main town of Lerwick.

Burradale wind farm has contributed to a reduction of CO2 emissions from grid based electricity in year 2000 onwards. However it was not the main contributing factor to the overall reduction of CO_2 emissions between 2001 and 2002. A reduction in the fishing fleet and associated industries are believed to be the main factor in the significant CO_2 reduction between 2001 and to 2002. In addition, many micro renewable projects and some energy efficiency measures have also contributed to a certain extent in the reduction of carbon emissions throughout the years. It is also important to note that historic figures suggest that emissions will continually increase unless action is taken. However, it should be noted that, the rate of increase may reduce with time.

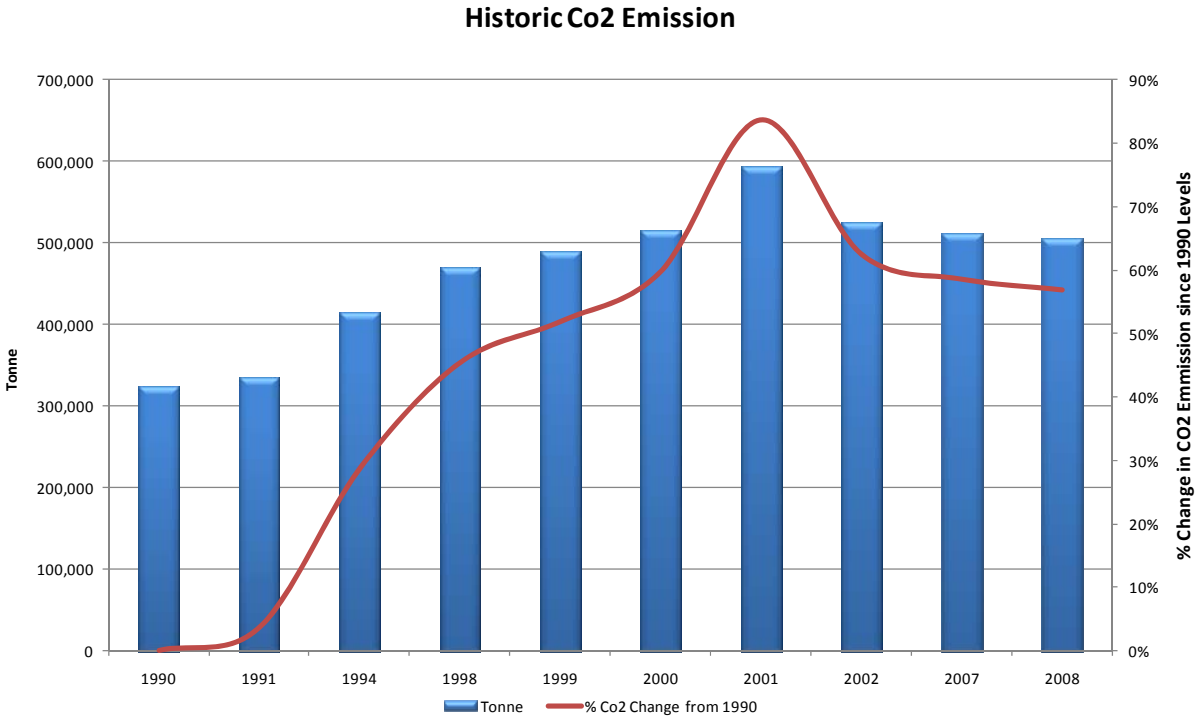

Figure 8 Trend in CO2 emissions between 1990 and 2008

The figure below, Figure 9, is used to illustrate Shetland's emissions from different energy sources

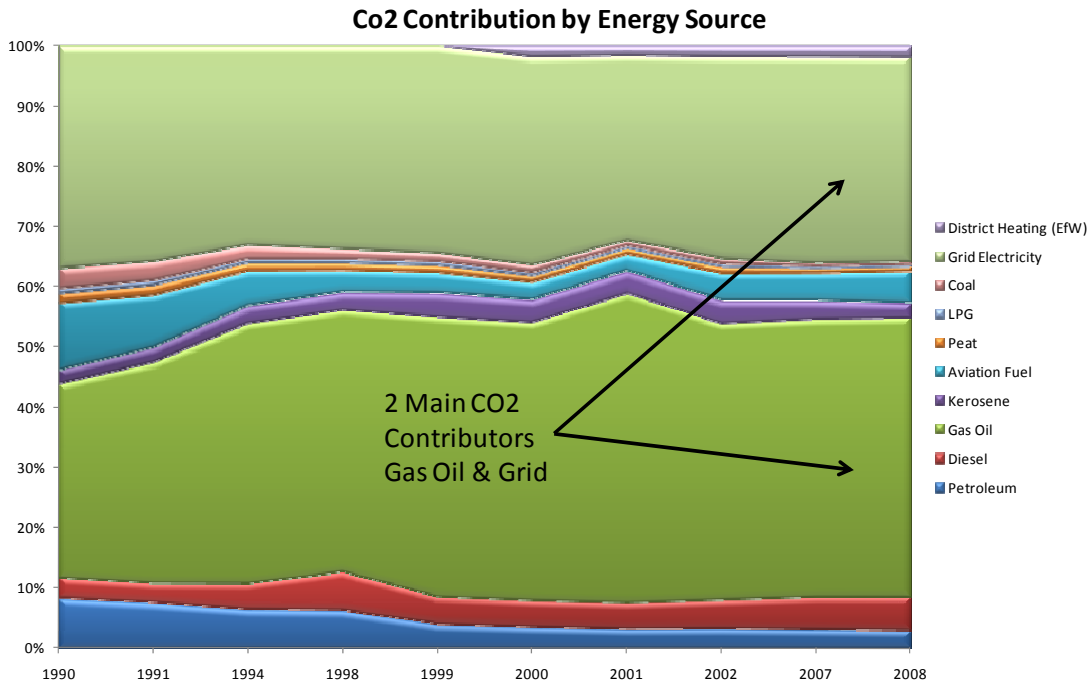

Figure 9 CO_2 emissions contribution from each energy source

The figure shows the two main sources of carbon dioxide emissions, which are electrical grid energy and gas oil. Note that CO_2 Emissions have increased from 323kT in 1990 to just under 507kT in 2008.

WHAT IS THE ENERGY COST TO SHETLANDERS?

This section looks into the costs of energy sources to the Shetland community.

COMPARISON OF TOP 5 ENERGY SOURCE CONTRIBUTIONS

The figure below, Figure 10, compares the top 5 energy sources that consumers use in Shetland. It compares the energy source contribution against cost and their associated emissions for the 2008 year.

Figure 10 shows that Grid' energy is the second highest cost per unit energy after diesel (note that the green chart is almost twice the height of the blue chart for the grid electricity). It also shows that the energy delivered to consumers

via the electrical network is producing the highest emissions per unit energy.

GasOil offers the lowest cost per unit energy. Because the Gasoil cost per unit is the lowest in Shetland, it is the predominant energy source used by almost all inhabitants. Therefore it forms the highest overall cost to Shetlanders, contributing to over 40% of the Shetland cost.

The very high costs of road fuel can be attributed to the compound tax (duty and VAT). The remoteness of the Islands also contributes to the increase in fuel costs largely due to the increased cost of delivering the fuel.

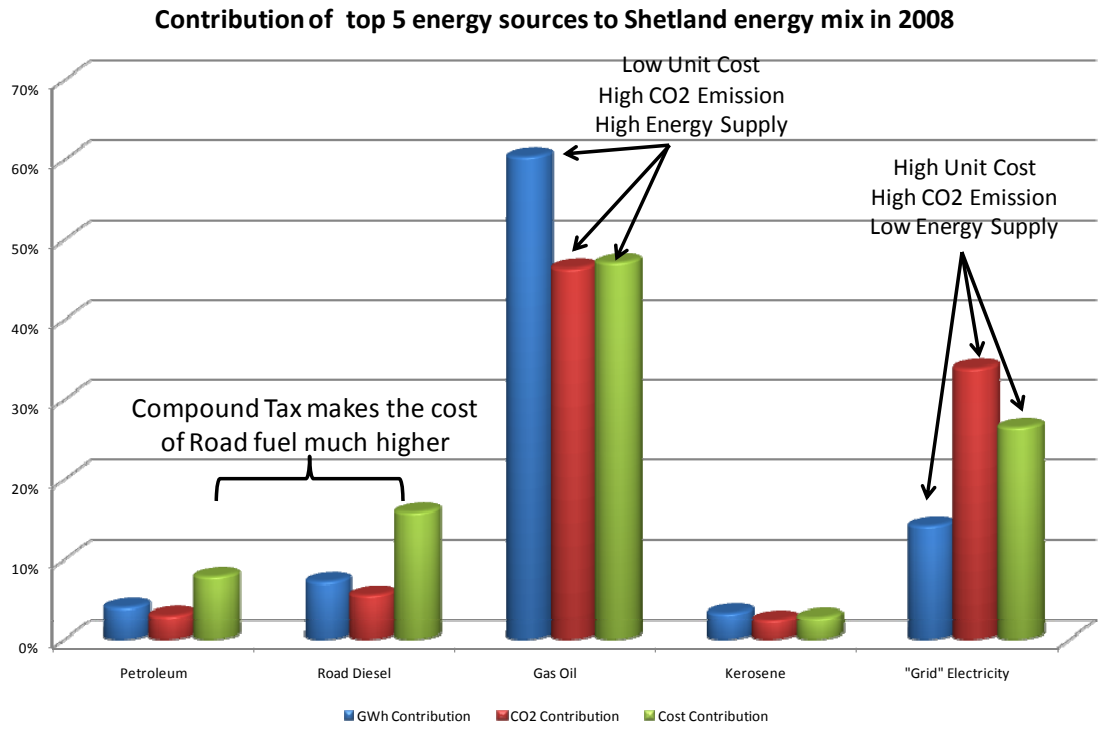

Figure 10 Top 5 energy contributions in GWh, their CO2 emissions and associated cost

WHAT IS THE COST OF ENERGY TO SHETLANDERS

Figure 11 illustrates the cost of energy to Shetlanders for year 2007 and 2008 for each of the 5 main contributing energy sources to Shetland. When looking at the impact of energy costs, it is important to note that average unit energy costs have been considered for 2007-08.

It shows that between 2007 and 2008 there was a significant increase in energy costs due to whole sale prices (raw resource) increasing significantly. The largest increase in Shetlands expenditure can be seen in the gas oil segment (in green on figure 11), where raw whole sale price fluctuations are passed directly to customers.

The energy crisis between 2007 and 2008 saw an annual increase in Shetland expenditure on energy of almost £17m. In that one year, the unit cost of fuel oil (gas oil) increased from 30ppl to 45ppl.

As Shetland relies on 96% of its energy from external sources, figure 11 highlights the vulnerability of Shetland's economy to external energy cost factors. It is a fact that the increase in energy costs has to be absorbed by individuals, industry and public sector agencies.

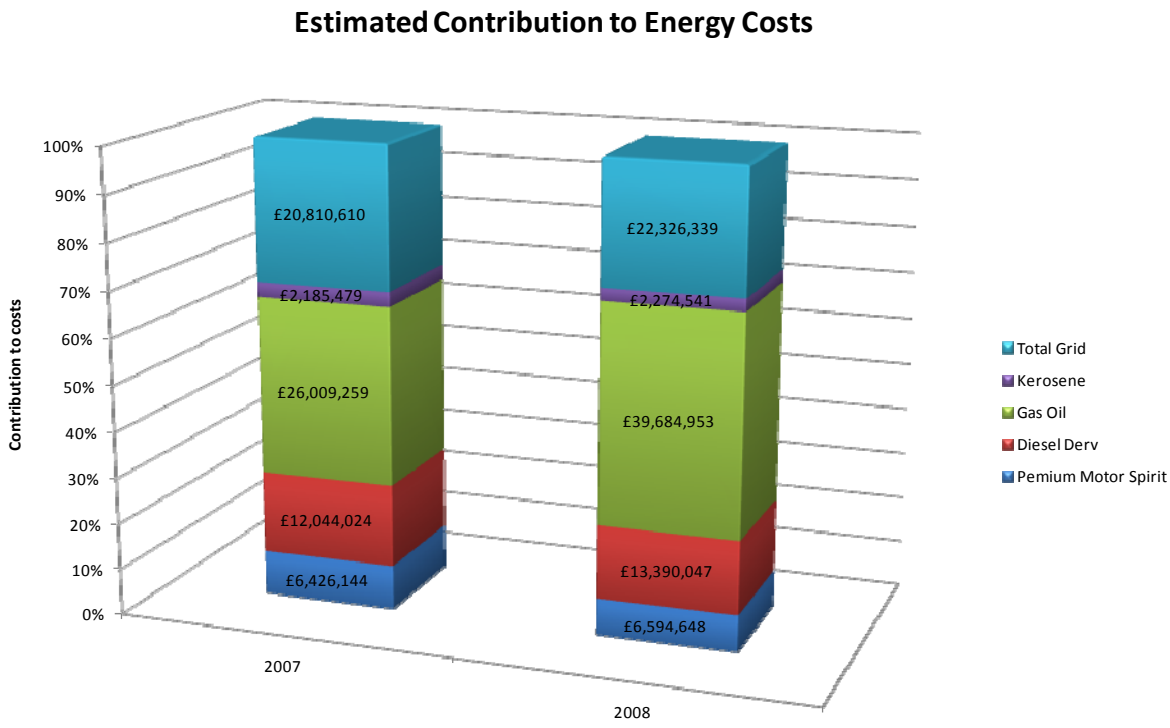

Figure 11 Costs of energy to Shetlanders

AUTOMOTIVE SECTOR

This section looks into some of the changes that have occurred within the automotive sector. Figure 12 shows the increase in private vehicles (cars and small vans) between 1991 and 2008 (in light blue colour). Although not visible on figure 12, it is important to note that there has been a decline in public transport vehicles in the same time period. In 1991, there were 129 public transport vehicles, while in 2007 there were 94, a drop of 27%.

In addition, overall numbers of vehicles in 1991 was 10,618 (all types), while in 2008 there were 14,981 (all types), an overall increase of 41%. It is important to note that vehicles licensed in Shetland have doubled in number in 32 years.

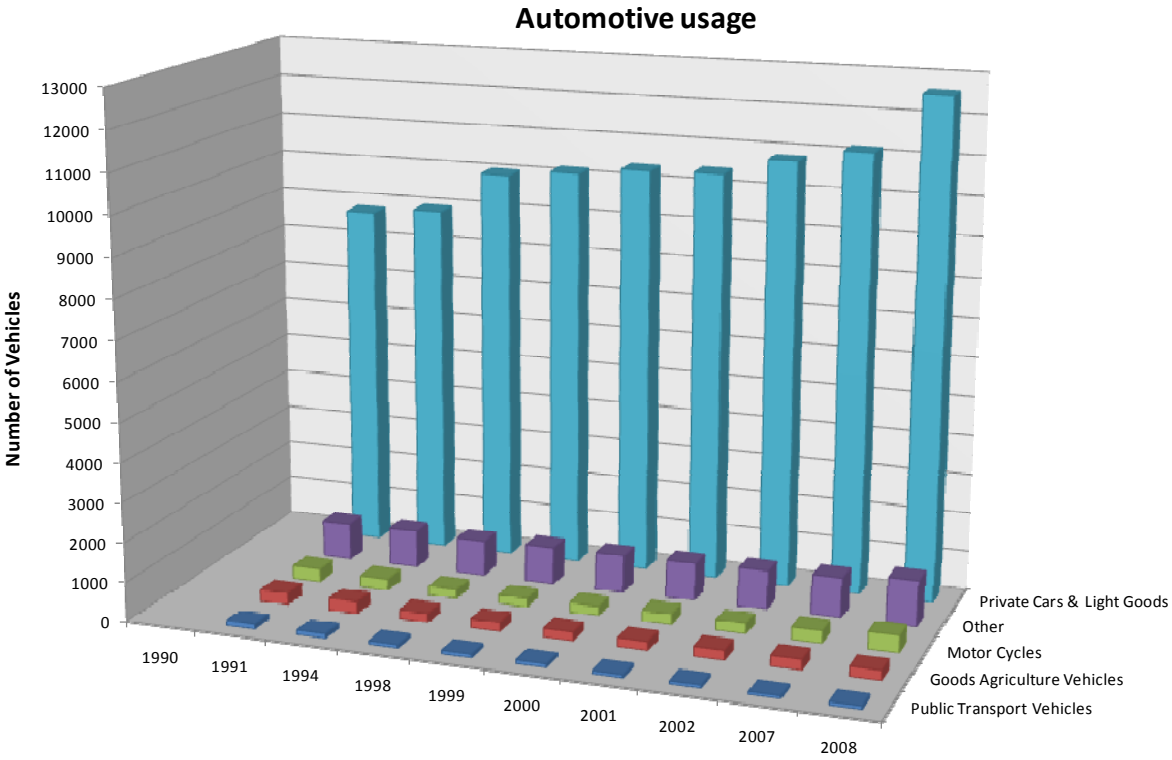

Figure 12 Number of vehicles in Shetland

The figure below, Figure 13, shows the percentage transition from petrol to diesel road fuel in Shetland. Whilst there are more vehicles on the Shetland roads in 2008 compared to 1991 (see figure 12), the most popular type of vehicle is now more commonly fuelled by diesel rather than petrol. This provides a much greater fuel economy and is the reason behind overall road fuel consumption decline between 1998 and 2008 (see figure 4).

The CO2 emissions for the 11,659 vehicles on the road in Shetland in 1998 was 59,460 tonnes and for the 14,981 vehicles in 2008 was 42,874 tonnes. The increase in vehicle numbers in

Shetland has not increased CO2 emissions, it has in fact reduced it by 17,000 tonnes (due to the higher efficiency of new vehicles).

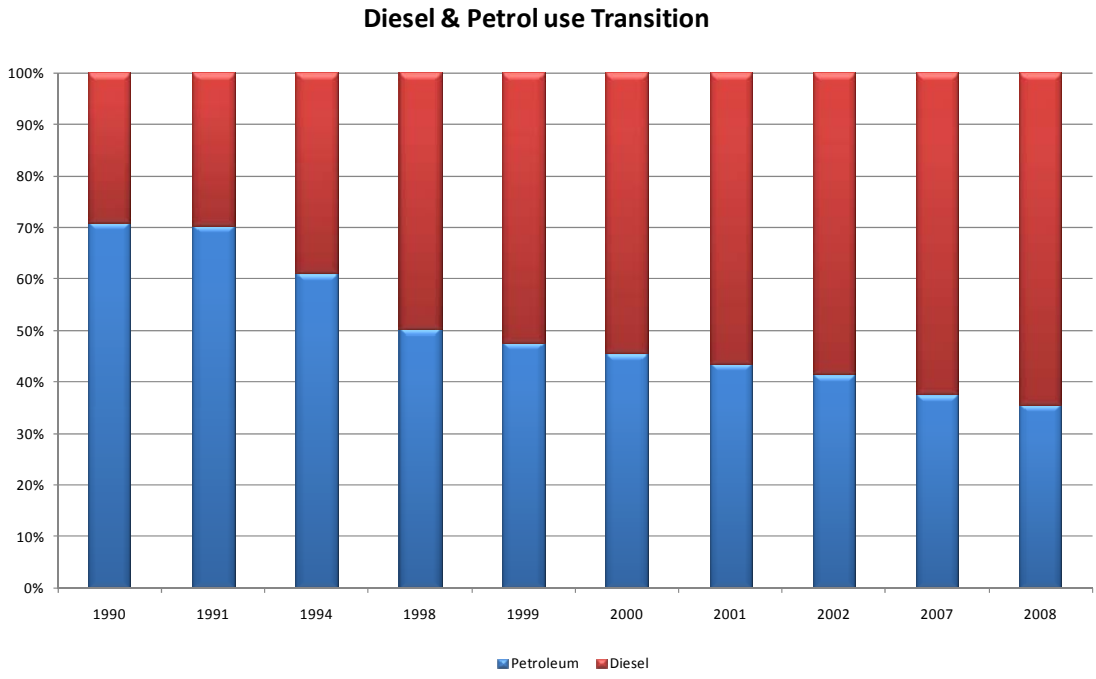

Figure 13 Shetland's transition from petrol to diesel fuelled vehicles

COMPARISON OF SHETLAND'S EMISSIONS TO THE REST OF THE WORLD

This section provides an indication of Shetland's CO_2 position when compared to the rest of the world. It compares the present energy supply analysis of Shetland per capita (per person per year) with the National Airborne Emissions Inventory (NAEI) statistics and other areas in the world against what is considered to be the sustainable target of atmospheric CO_2 emissions per person per year.

The NAEI statistics consider distributed emissions per person per year – that is the outputs from Shetlands industrial activities are not all attributed to Shetland but to other regions too. The NAEI data are statistically distributed around the UK population. Within the NAEI method for calculating emissions, marine going vessels are only considered up to 12km from the coast, and flight emissions are only considered up to the first kilometre of flight height.

Figure 14 below shows the carbon dioxide emissions per capita for Shetland based on the findings of this energy source analysis. It shows that based on energy source analysis, Shetlands' CO_2 emission per capita appears much greater than the NAEI reported statistics (in blue in figure 14). The NAEI statistics reported 9 tonnes of CO_2 emissions per capita, whilst the energy source analysis indicates that Shetland has nearly 22 tonnes of CO_2 emissions per capita. The difference in figures between the two analysis methods can be attributed to the relatively high level of energy intensive industrial activity that is present in Shetland. In fact, figure 14, shows that Shetland has much higher CO_2 emissions per capita than the most polluting nations including the USA. It should however be noted that the Shetland population is around 20,000 compared to over 300 million inhabitants in the USA.

Figure 14 also considers three possible scenarios for reducing CO_2 emissions in Shetland. The first scenario is represented with a red bar. This red bar shows the impact of 'greening' the Shetland electrical grid by replacing conventional generation with advanced energy storage and renewable energy technologies. This also shows that if Shetland embarked on such a development, then its CO_2 emissions per capita would be lower than the USA.

The second scenario is represented by the green bar. This scenario shows the potential impact of looking at ways to reduce gas oil consumption by 50% (more efficient use of fuel and opportunities to change gas oil heating to more sustainable alternatives). It does not take greening the grid into consideration. Again in this scenario, Shetland's CO_2 emission per capita is lower than the USA. Also applying this potential scenario instead of the first scenario would lead to a much lower CO_2 emission per capita.

The third scenario is represented by the purple bar. This scenario provides an insight into the impact of combining both the red and green bars, or greening the grid and reducing the use of gas oil by 50%. In this scenario, Shetland would be in line with the published the NAEI CO2 emission per capita, with potential savings of more than 13 tonnes of CO_2 per capita.

It is important to note that the high carbon footprint for Shetland is due to the industrial nature of the energy usage within Shetland and its remoteness. It is this industry that supports jobs and employment and sustains the population in the islands.

In summary:

- Increasing the portion of renewable energy on the electrical network, introducing intelligent load management & energy storage (through smart metering for

example) has potential to significantly reduce emissions.

- The introduction of intelligent electrical load management in conjunction with renewable energy and appropriate tariffs also has potential to reduce demand for gas oil for heating and save end users money.
- 'Greening' the grid and reducing the demand for gas oil by 50% has the potential to significantly reduce the carbon foot print of the Shetland population. This also has the potential to bring Shetland more inline with the NAEI 2008 published figure.

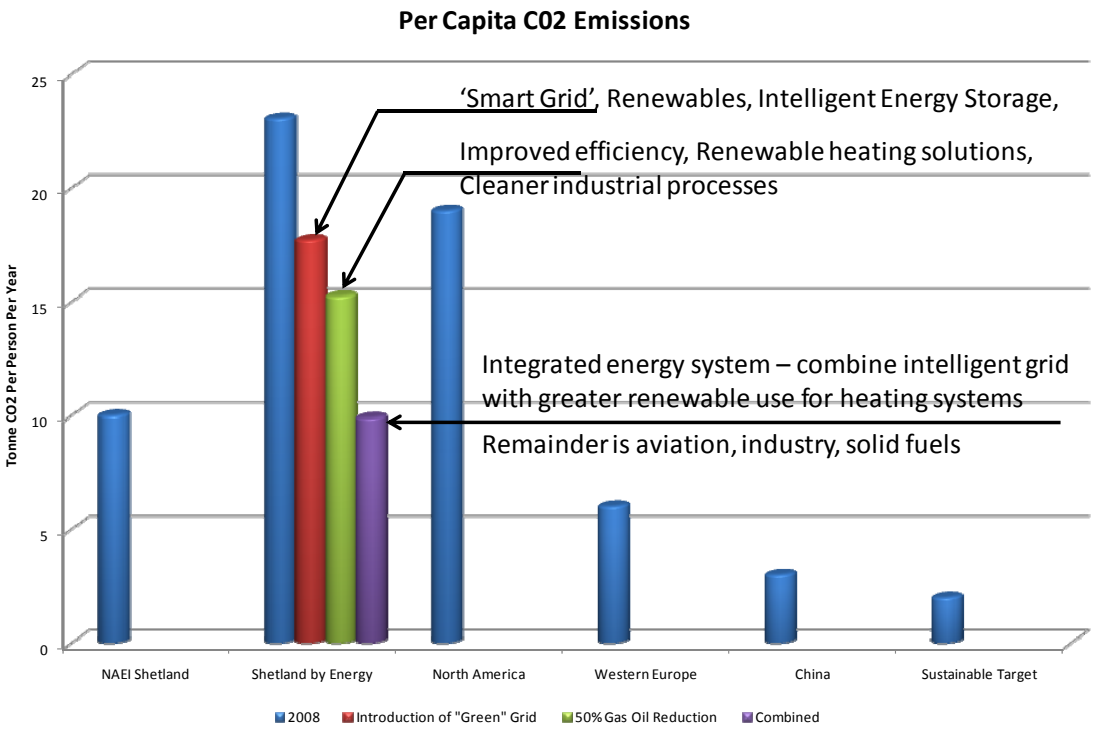

Figure 14 Shetland CO_2 emissions in comparison to the rest of the world[2]

[2] It should be noted that the CO2 reduction scenarios shown are used in order to highlight the potential that different approaches may achieve.

DISCLAIMER

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