Department of Mechanical & Aerospace Engineering

IMPACTS AND MITIGATION OF LATEST CLIMATE CHANGE LEGISLATION ON PARTICIPANT ORGANISATIONS

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Copyright Declaration

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In the loving memory of my grandparents – Mr. & Mrs. Omar Khan

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ABSTRACT

In order to reduce the energy consumption from large non-energy-intensive businesses in UK, government has introduced the mandatory CRC Energy Efficiency Scheme. After several revisions, CRC Energy Efficiency Scheme is now pushing its participants to reduce their carbon emissions. Due to complex design and several revisions, participant organisations have struggled to identify and meet the requirements of the scheme.

Research has been carried out by a number of researchers to analyse the impacts of CRC and their mitigation. However, the available information is only at a higher level, and there is lack of detailed information on practical measures that an organisation should take to comply with the scheme and reliably reduce / mitigate its impact. The need for research was identified to find and implement the measures, and develop a best practice approach to reduce the impacts of the scheme.

This research was conducted at a CRC participant organisation which operates in a number of sectors, mainly Aggregates and Construction. The project identified the emerging challenges to the organisation due to CRC, and their possible solutions. It was identified that CRC has introduced serious implications to the participant businesses. Participant companies are now required to improve their systems and procedures to meet these challenges. In addition to that, it is now vital for participant companies to reduce their energy use and carbon emissions due to the financial implications of CRC. However, while implementing the carbon reduction opportunities, organisations have struggled to achieve the anticipated level of carbon emission reductions when using new and innovative technologies due to the under-performance of products. In addition to the dangers associated with new and innovative technologies, there are issues with comparatively longer existing opportunities, as their financial impacts change with time due to changes in the incentivising schemes.

The project identified the requirements for the participating organisation’s data & information to ensure compliance with the scheme. Opportunities were identified to mitigate the impacts of the scheme through new & improved systems, procedures, carbon reduction measures and renewable energy systems. Latest techniques were used for comparing the carbon reduction opportunities, and for informed decision making and as a result of the analysis a new tool, CALoRIC (Carbon Abatement Low Risk Investment Curve), was developed. Viable opportunities were implemented, and their performance monitored and verified. A best practice approach was then identified to reduce the risks associated with innovative and existing technologies.

It was also identified that, in addition to the proposed and implemented projects, absolute carbon emissions in a company may reduce due to a number of factors, such as reduced business activity, an increase in energy awareness or indirect impact from other activities such as maintenance *etc*, and Energy Benchmarking was found necessary to find the actual reductions from various factors. Decision makers in an organisation require this information to decide their further carbon reduction strategy. It was concluded that that the company must implement the 10 suggested carbon reduction opportunities, in addition to increasing its emission reduction from other factors, in order to achieve its carbon reduction target.

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List of Abbreviations

AC units	Air Conditioning Units
AGL (or agl)	above ground level
AMR	Automatic Meter Reading
BRE	Building Research Establishment
CALoRIC	Carbon Abatement Low Risk Investment Curve
CCA	Climate Change Agreements
CCL	Climate Change Levy
CEO	Chief Executive Officer
CERT	Carbon Emission Reduction Target
CFO	Chief Financial Officer
CO_2e	CO_2 Equivalent Emissions
CPF	Coating plant fuel
CRC	Carbon Reduction Commitment (Energy Efficiency Scheme)
CRCIS	CRC Information System
CRO	Carbon Reduction Opportunity
CTS	Carbon Trust Standard
DEC	Display Energy Certificate
DECC	Department of Energy & Climate Change
DEFRA	Department for Environment, Food and Rural Affairs
DTI	Department of Trade & Industry
EA	Environment Agency
EAM	Early Action Metric
ECA	Enhanced Capital Allowance
EPC	Energy Performance Certificate
ERIC	Emissions Reduction Investment Curve
ESRU	Energy Systems Research Unit
EU	European Union
EU ETS	European Union Emissions Trading Scheme
FIT	Feed In Tariff
FM	Facilities Management
FOI	Freedom of Information
FOIS	Freedom of Information (Scotland)
GDP	Gross Domestic Product
GHG	Greenhouse Gases
HH	Half Hourly
HHM	Half hourly meter
IRR	Internal Rate of Return
IS	Information System
IT	Information Technology
kVA	kilo Volt-Ampere
kWh	kWh (Unit of energy)
kWp	Kilowatt Peak (Solar panels)
LED	Light Emitting Diode
LFO	Light Fuel Oil
LPG	Liquefied Petroleum Gas
M&V	Monitoring & Verification
MACC	Marginal Abatement Cost Curve

MD	Managing Director
$MtCO_2$	Million metric tonnes of Carbon dioxide
MWh	MWh (Unit of energy)
NHH	Non Half Hourly
NHS	National Health Service, UK
NPV	Net Present Value
PFI	Private Finance Initiative
PLT	Performance League Table in CRC
RHI	Renewable Heat Incentive
RML	Residual Measurement List
ROC	Renewable Obligation Certificate
SEC	Specific Energy Consumption
SGU	Significant Group Undertaking
Solar PV	Solar Photovoltaic Panels
SON	Sodium Vapour Lamp
UK ETS	United Kingdom Emissions Trading Scheme
UMS	Un-metered Supply
WFD	Water Framework Directive
YTD	Year-to-date

1 INTRODUCTION

1.1 Emissions reduction in UK businesses

The Kyoto protocol entered into force in the UK in 2005. As a result, the country is now bound to reduce its greenhouse gas emissions by 12.5% below their 1990 level by 2008-2012, and 80% below the 1990 level by 2050. Scotland has set an ambitious target of reducing GHG emissions by at least 42% by 2020 and by at least 80% by 2050. The UK government has set its policies to achieve its targets through a mix of energy conservation and energy supply measures. In the 2007 White Paper on energy (DTI, 2007), the government proposed its strategy to achieve these targets through specified practical measures.

Energy supply

To increase the share of renewable energy systems within the electricity grid, different schemes have been introduced such as Renewable Obligation Certificates (ROC) in 2002, Feed in Tariffs (FIT) in 2010 and the Renewable Heat Incentive (RHI) in 2011.

Energy conservation

To reduce energy consumption within UK businesses, the government has introduced a number of initiatives such as:

- EPC and DEC for public sector organisations;
- Smart metering for business premises;
- CRC Energy Efficiency Scheme.

To reduce their energy consumption and carbon emissions, large emitters and energy intensive businesses have now become liable to emissions trading, carbon levies & taxation, *etc*. Initiatives such as EU-ETS, UK-ETS, CCA/CCL are pushing businesses to reduce their carbon emissions. However, the non-energy-intensive businesses in the UK have remained free from these liabilities until the introduction of the CRC Energy Efficiency Scheme.

The UK Government has used both methods of carbon taxation (e.g. CCL) and emission trading schemes (e.g. EU-ETS, UK-ETS) to reduce carbon emissions from businesses. Both have advantages and disadvantages. Lee et al (2007) concluded that carbon taxation has a modest impact on emissions and adversely affects GDP, referring to the example of Norway, where relatively high carbon taxes since 1991 have delivered only a 2% reduction in carbon emissions. However, the highest polluter pays most in a carbon taxation scheme. Emission trading schemes provide a sense of carbon abatement costs against the market price of carbon but, as identified in the work of Lee et al (2007) and claimed by the opponents of emission trading schemes, such schemes can actually provide a license to pollute.

These previously implemented carbon taxation and emission trading schemes have mainly targeted the energy-intensive emitters. In the 2007 White Paper on energy, the CRC Energy Efficiency Scheme was first proposed to target large non-energy-intensive businesses and public sector organisations. In the scheme, an organisation that has consumed more than 6,000 MWh of electricity during the CRC Qualification Period (which was year 2008 for the first phase of CRC), and has at least one half-hourly meter settled in the half-hourly electricity market, was required to register as a full participant. On the other hand an organisation performing below this the 6,000 MWh threshold was required to make an energy information disclosure. CRC, which is a mandatory scheme, now has just under 3,000 businesses and public sector organisations in the UK as full participants. These organisations are responsible for over 10% of UK emissions, which is around 55 $MtCO_2e$. It is estimated that the scheme will reduce carbon emissions by 1.2 million tonnes per year by 2020.

1.2 CRC – The scheme and its rules

The CRC Energy Efficiency Scheme, commonly known as CRC, was introduced as a revenue recycling scheme. The scheme required participants to purchase carbon allowances on the basis of their carbon emissions, with the money generated from the sale of allowances going into a money recycling pot. An annual performance league table was to be published according to participant organisations' energy performance. This performance was based on an organisation's reduction in absolute carbon emissions, revenue-related carbon emissions and early actions to monitor and control its energy and carbon emissions. Best performers in the league table were to receive more money than the amount they had paid into the money recycling pot, while poor performers were to receive less money in return.

In the October 2010 spending review, major changes to CRC were announced, and the revenue recycling part was removed from the scheme. While participant organisations have to purchase carbon allowances as proposed before, now the amount spent on the purchase of allowances is not recycled back. In this way, CRC has become a carbon tax. The performance league table was still part of the scheme, but only as a reputational driver. The requirement for 'information disclosure' from the organisations below the 6,000 MWh threshold has also been removed.

A brief description of each of the main CRC rules is given below. This information is the prerequisite of an understanding of the impacts of CRC on a participant organisation (as discussed in chapter 2) and the identification of the systems & procedures required by a CRC participant company.

Qualification criteria

CRC is a mandatory scheme to target the non-energy-intensive businesses in the UK, which are not already covered by EU ETS, or which have less than 25% of their emissions covered by CCA. If any such organisation has consumed more than 6,000

MWh of electricity through their half-hourly metering in calendar year 2008, it must register as a participant.

According to the rules set for CRC (Environment Agency, 2008), the public sector will participate on their individual listings, or the listing of their organisation type in FOI Acts, and if they meet the qualification criteria through their electricity supply. But, for government departments, CRC participation is mandatory.

Organisational structure

In CRC, the organisational structure is important to identify liabilities. The organisational structure could be in the form of ‘undertakings’ and ‘group undertakings’ for private sector participants.

CRC phases and Timeline

A participant must understand the phases and timeline of CRC to prepare for compliance. There are three phases of the scheme. Phase 1 lasts for four years, and the remaining two phases last for six years each. Before each phase there is a ‘qualification year’ in which participants assess whether they qualify for that phase of the scheme. The qualification year for the first phase was calendar year 2008. Except the qualification year in 2008, a CRC year runs from April to March, as can be seen in figure 1. The year after the qualification year is the busiest for participants, as they have to register with the online CRC registry, and submit a Footprint and Annual Report by the last working day of July. From the second year in each phase to the last year in the phase, participants need to submit Annual Reports and surrender the allowances on the basis of their carbon emissions. After the October 2010 spending review, this requirement of purchasing and surrendering allowances was lifted only for the first reporting year of phase 1.

Responsibility

According to CRC rules, the participant company must nominate the following at the time of registration.

- **CRC Senior Officer**
  The Senior Officer must be a person in the participant company with top level management responsibility, who would be required to review and sign the internal audits of the company. In CRC, the Senior Officer is also held responsible in case of non-compliance.
- **CRC Primary Contact**
  The Primary Contact is a point of contact at the company for CRC registry and for the CRC team at the Environment Agency.
- **CRC Secondary Contact**
  The Secondary Contact is a second point of contact at the company in case the Primary Contact is unavailable.
- **CRC Account Representative/s**

Later during the scheme (not at the time of registration, but before the first sale of CRC allowances), the participant company must nominate a CRC Account Representative (at least one, maximum three), who will take responsibility for purchasing and surrendering allowances.

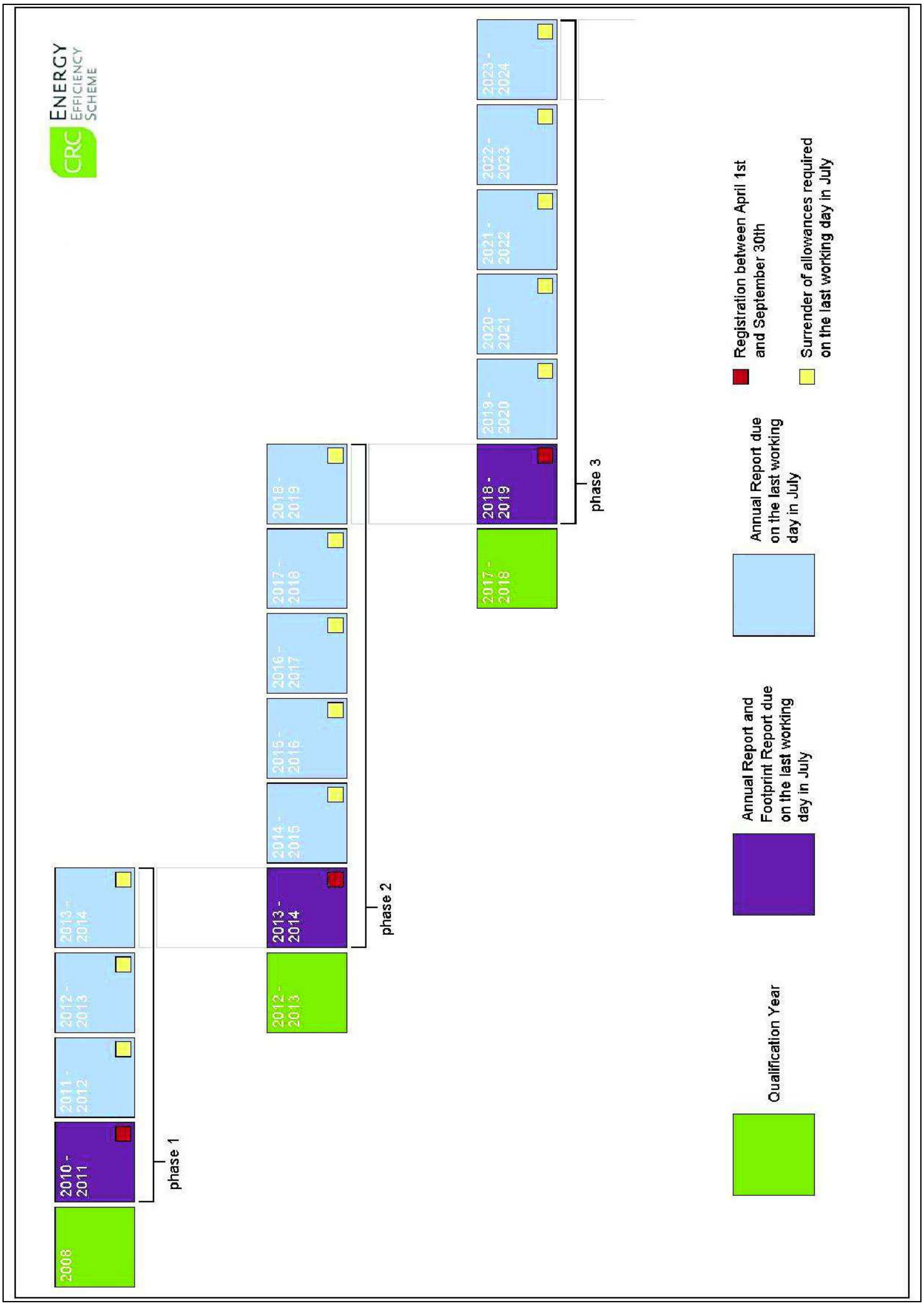

Figure 1: CRC Timeline (Environment Agency, 2012)

Performance League Table – Early Action Metric, Absolute Carbon Reduction Metric and Growth Metric

At the beginning of the scheme, a Performance League Table (PLT) was introduced to provide financial and reputational incentives to those who can demonstrate annual reduction in their carbon emissions. The PLT was based on three metrics – Early Action Metric, Absolute Carbon Reduction Metric and Growth Metric. To score well in the Early Action Metric, a participant must demonstrate that they have taken responsible actions in the early stage of the scheme to reduce their carbon footprint by installing voluntary Automatic Meter Reading (AMR) meters and getting accredited with the Carbon Trust (or equivalent) Standard. To score well in the Absolute Carbon Reduction Metric, the participant must demonstrate year-on-year reductions in their absolute carbon emissions. To score well in the Growth Metric, the participant must demonstrate year-on-year reductions in their normalised emissions (i.e. emissions normalised to annual turnover). After the removal of financial incentive (revenue recycling) from the scheme in the spending review of October 2010, the CRC performance league table now only provides reputational incentive.

- Absolute Carbon Reduction Metric
This metric is based on the percentage change of a participant's absolute carbon emissions in the last 5 years, or the last available years of the scheme if less than 5.

- Growth Metric
This metric is based on the percentage change of a participant's carbon emissions per unit turnover in the last 5 years, or the last available years of the scheme if less than 5.

- Early Action Metric
This metric is divided into two equal parts with a 50% weighting for getting accreditation from the Carbon Trust (or equivalent) Standard and a 50% weighting based on the percentage of the organisation's electricity and gas supplies which are measured through voluntarily installed AMR meters and dynamic unmetered supply (UMS) during a reporting year.

In the first reporting year of Phase 1, the position of a participant in the PRT will depend solely on the 'Early Action Metric' since the other metrics have no weighting in this year as can be seen in figure 2. After Phase 1, the 'Early Action Metric' will not affect a participant's position in the PRT.

	Year 1 2011	Year 2 2012	Year 3 2013	Year 4 and all other years
Early Action Metric	100%	40%	20%	0%
Absolute Metric	0%	45%	60%	75%
Growth Metric	0%	15%	20%	25%

Figure 2: League table in CRC Phase 1 (Environment Agency, 2012)

Carbon Trust Standard

This standard, previously known as the Energy Efficiency Accreditation Scheme, is a quality standard that recognises an organisation's processes and achievements in energy efficiency. Following the name change, the standard focuses on carbon reduction rather than energy efficiency.

In order to achieve the Carbon Trust Standard an organisation must measure the following energy uses.

'Level 1' emissions: This includes energy use from direct emission sources such as gas, oil (liquid fuels including transport fuels) *etc*. and indirect emission sources such as electricity and heat/steam supplies. The organisation must record this information to achieve the standard

'Level 2' emissions: This includes energy use from direct emission sources such as process emissions, fugitive emissions and indirect emission sources such as business travel by air, sea, rail, bus, taxi, hired car *etc*. This information is optional for the first certification, but for recertification it must be provided except where the energy expenditure of the company is less than £50,000.

Carbon allowances

According to the initial CRC plan, participants were required to buy carbon allowances (one allowance for each tonne of CO_2e emitted) on the basis of their CO_2e emissions forecast for the forthcoming CRC year. However, in the 2010 spending review, it was decided that in the first phase of the scheme, allowances will be bought retrospectively as a 'buy-to-comply' approach instead of a 'forecast-and-buy' approach. Revenue recycling has been removed, and the money generated from the sale of allowances retained by government for public finances. The first retrospective sale of allowances for CRC emissions started in June 2012 for the 2011-12 emissions, at a fixed price of £12 per allowance.

There is an unlimited number of allowances available to be purchased in the first phase. A cap on available allowances was initially proposed to be introduced from the second phase, which would drive the price of the allowance. In the CRC 2012 consultation (DECC, 2012), it has been proposed to remove the cap and sell allowances at a fixed price. It has also been proposed that, from the second phase, there should be 2 sales in each year, a low price sale and a comparatively higher price sale later. This is intended to incentivise participants with good energy management as they can figure out their total emissions quicker and buy allowances at a lower price.

Allowance trading mechanism

Each participant organisation is required to appoint at least one Account Representatives (maximum three), who will be permitted to buy, sell and surrender allowances on behalf of a participant organisation. The Account Representative, after being nominated by the primary contact of the organisation (usually MD/CEO), must obtain a digital certificate, at a certain cost, from a digital certificate provider nominated by the Environment Agency.

Energy supplies in CRC

Based on CRC rules (Environment Agency, 2012), five checks must be performed before the supply is included in CRC reporting.

- Check 1: Identify the responsibility of supply

Energy supplies could be the responsibility of either the occupier or owner of the property and it is important to identify who is responsible for the supplies to a site or building. The Environment Agency has published detailed guidance on this issue in 2010: *http://www.environment-agency.gov.uk/static/documents/Business/CRC_-_supply_rules_clarification.pdf.*

In most cases, according to this guidance, the party that is responsible for the supplies is also responsible for payments within CRC.

- Check 2: Identify the types / profiles of supply

The profile type of an electricity supply indicates whether the supply is residual or core. This is actually a 2 digit number which can be found on the meter and on the electricity bill. The number circled in figure 3 shows the profile type '00', which means a core non-domestic supply. More non-domestic meters may have profile types 05, 06, 07 or 08, which are also core supplies. For gas, a supply can be classified as core supply if the supply has a meter that measures on a daily or hourly basis, or if it is a large gas point meter (gas supplies through this meter during a footprint year being greater than 73,200 kWh).
Profile types 01, 02, 03 and 04 are residual electricity supplies. Gas supplies which do not meet the above metering criteria are also residual gas supplies.

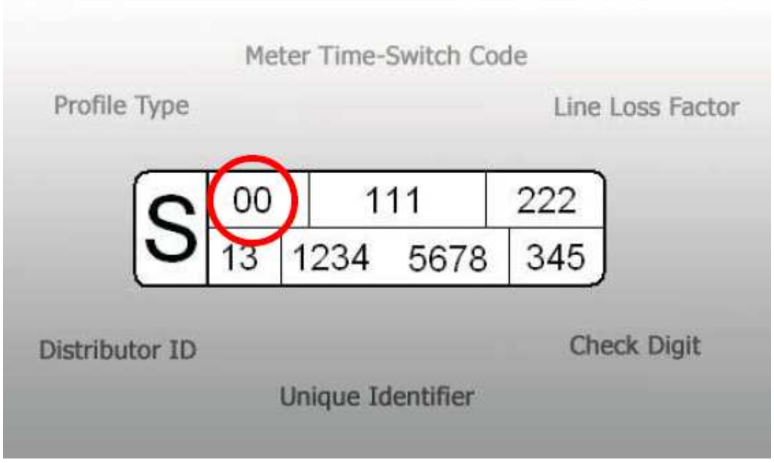

Figure 3: Meter / Supply Information

- Check 3: Identify the type of metering on supplies

Once the profile type has been identified, the type of metering must be confirmed to identify the supply as 'core' or 'residual'. This check is necessary to calculate the CRC participant's score in for the Early Action Metric. There are different types of meters identified in CRC. The first type is Settled HHM (Half Hourly Meters), which are used by the electricity suppliers to calculate bills; these meters are installed on core supplies. The second type is Remotely Read AMR Meters. These are non-settled HH meters. They may be installed both on electricity and gas, and the consumption data must be made available to the customer. They may be read by a third party organisation, which would then make the data available to the customer. If an AMR meter is installed on a residual supply and it meets the conditions mentioned, the supply will be considered as 'core' instead of 'residual'.

- Check 4: Identify the supply as actual / estimated

In CRC, a supply that has been reported based on 'estimated readings' covering a minimum 6 months period during the footprint year will be treated as an estimated supply and will be subjected to a 10% uplift in CRC annual reporting.

- Check 5: Identify if the regulated emissions now meet the residual percentage; if not, include the residual supplies

Regulated emissions include core CRC emissions, emissions reported in EU ETS (if any) and emissions covered by CCA (if any). If the regulated emissions are less than 90% (i.e. as the so-called residual percentage) of the participant organisation's total CRC eligible emissions, then residual emissions must also be included, up to the point where the reported emissions cover at least 90% of the total emissions. Any supplies above that point can also be voluntarily reported. Any core emissions must not be excluded if the regulated emissions make more than 90% of the total emissions.

Use of fuels as mentioned in table 1 must be monitored and reported if the residual percentage is not met by the regulated emissions, up to the point where the residual percentage is achieved. The supplies excluded from the scheme are as follows.

- Supplies for transport, domestic accommodation, and for activities whose emissions are already covered by CCA / EUETS.
- Supplies after meeting the 90% rule, though these may be voluntarily included.
- Supplies to the subsidiaries with over 25% of the emissions covered under CCA, and any emissions that are covered by EUETS.

CRC source list tool

The Environment Agency has developed a spreadsheet tool to assist participants with energy data management for CRC. While this tool is helpful in that it ensures that the 5 checks on energy supplies, as mentioned above, are carried out, it is a protected product which cannot be modified by users.

Fuel type	Measurement unit
Aviation spirit	Tonnes
Aviation turbine fuel	Tonnes
Basic oxygen steel (BOS) gas	kWh
Blast furnace gas	kWh
Burning oil/kerosene/paraffin	Litres
Cement industry coal	Tonnes
Coke oven gas	kWh
Commercial/public sector coal	Tonnes
Coking coal	Tonnes
Colliery methane	kWh
Diesel	Litres
Electricity	kWh
Fuel oil	Tonnes
Gas oil	Litres
Industrial coal	Tonnes
Lignite	Tonnes
Liquid petroleum gas (LPG)	Litres
Peat	Tonnes
Naphtha	Tonnes
Natural gas	kWh
Other petroleum gas	kWh
Petrol	Litres
Petroleum coke	Tonnes
Scrap tyres	Tonnes
Solid smokeless fuel	Tonnes
Sour gas	kWh
Waste	Tonnes
Waste oils	Tonnes
Waste solvents	Tonnes

Table 1: List of Residual Fuels

Reporting and Evidence Pack

At the end of each CRC year, a participant must submit certain reports using the online CRC registry. As shown in figure 1, in the first year of a phase, a participant must register if the organisation meets the qualification criteria. A footprint report is also submitted in the first year of each phase. An annual report, as the name suggests, must be submitted annually in each phase. Two annual reports are required to be submitted in the last year of each phase. However, in the 2012 CRC consultation (DECC, 2012), it has been proposed to remove the requirement of a second annual report in the last year of each phase.

An Evidence Pack must be kept and maintained by each participant. This contains the evidence of information submitted in the registration and in CRC reports. It must also contain information on internal audits signed by top management, records of any installation/removal of meters, records of change of supplier, bills/statements, proof of score in EAM (such as a Carbon Trust Standard certificate or installation records of AMR meters), records of communication with suppliers or scheme administrators (i.e. the Environment Agency), and any information that is required to prove the legitimacy of figures submitted to the CRC registry.

Internal Audits

In CRC, participants are required to carry out regular internal audits to ensure that records are complete, correct and adequate. These audits may include checks on organisational changes, liability assessments, errors in data *etc*. These audits must be signed off by top management, usually the person identified as the primary contact at the time of registration in the scheme.

External Audit

The Environment Agency, who is also the administrator of the CRC scheme, aims to audit 20% of participants each year. It is claimed that participants will be audited on a risk-assessed basis, which means that organisations with more complex data or supplies are more likely to be audited. There will be one of three possible outcomes of an external audit: Pass, Pass with improvement action, or Fail. If the audit shows that the emissions as reported were more than 5% incorrect, then a fine of £40 per tonne of unreported CO_2e will accrue. In the case of severe non-compliance, the senior responsible officer can face prosecution and imprisonment. The results of external audits are published annually so that there is also a risk of reputational damage for an organisation if it fails to meet the compliance requirements. Therefore, it is important to ensure that regular internal audits are conducted, as this helps to prepare an organisation for external audit.

Existing research work on CRC impacts and mitigation

CRC is a complex scheme and there is no generic compliance strategy. CRC does not target particular sectors, so the coverage includes participants from various sectors. The relative impact on organisations is therefore unclear, especially where they differ in relation to their fuel type use, organisational structure, participation in other schemes, *etc*. A few researchers have examined the impacts of CRC on participants in general, or in certain sectors such as health care, water, commercial properties *etc*.

Rabinowitz (2009), for example, discussed the high level implications of CRC on sectors such as commercial properties, local authorities, franchise businesses and construction. These implications included the complexity of identifying who is liable for CRC in commercial properties, lack of control on energy usage by local authorities and franchise businesses, and the new forms of agreement required to handle CRC targets and costs. He also suggested that CRC emissions from the construction sector would vary widely depending on the number of projects undertaken each year. Further, due to the usage of a number of different fuels, residual fuels may also need to be recorded and reported. Finally, he predicted that the price of the carbon allowance would become a factor in an organisation's long term budget.

Sarwar (2008) analysed the impacts of a carbon emissions trading scheme on the UK water industry. She suggested that the key challenges would include data collection and collation, lack of understanding of the scheme's complexity, and the need for a centralised strategy. At a general level, she proposed 10 steps to reduce the impact of CRC as follows:

1. Involve others early.
2. Appoint a Carbon Manager.
3. Understand your greenhouse gas emissions.
4. Cost of carbon reduction.
5. Be energy efficient.
6. Water efficiency.
7. Renewable energy potentials.
8. Source controls.
9. Carbon trading.
10. Supply chain.

Craig (2009) researched the impacts of CRC on the National Health Service and discussed both the negative impacts and underlying opportunities. He suggested that impacts are 'likely to be significant' and identified that high capital projects could be financially beneficial in the longer term.

Bright (2010) discussed the impact of CRC on the tenanted commercial sector. He identified issues such as the variety of ways by which energy may be supplied to a tenanted property, the complexity of the CRC scheme, and the split incentive of commercial leases as principal issues. He also identified that the traditional adversarial relationship between landlord and tenant as a major obstacle to implementing abatement measures. A similar issue was identified in this research for construction companies, which temporarily acquire a property for construction work, are responsible for emissions during the acquired period, but have limited ability to improve metering or the energy efficiency of the site.

Rabinowitz (2009) and Craig (2009) both suggested that marginal abatement cost curves (MACC) should be produced to model carbon reduction strategy against abatement price.

It was observed in the existing research work that only high level information was available about CRC impacts and their mitigation. Use of MACC was suggested as a tool, but no information about the practical use of this tool for CRC participants was found in the literature.

Marginal Abatement Cost Curve (MACC)

MACC is a method to present and compare a number of available carbon abatement opportunities in a graphical manner. The curve provides the carbon abatement potential of each opportunity (tonnes of CO_2e on the x-axis) versus the cost of abatement (£/tonne of CO_2e on the y-axis).

Kesicki (2010) has researched the use of a marginal abatement cost curve with country-level policymakers. The concept was still in use in 1991 as a means to illustrate the cost associated with carbon abatement (Jackson, 1991). Similar curves were used in the 1970s and 1980s to identify crude oil consumption abatement, and later for the saving of electricity consumption (Meier, 1982).

In figure 4, A to J represent various opportunities that are available to reduce carbon emissions. The width of each opportunity on the x-axis represents its carbon abatement potential in tonnes of CO_2e, while the y-axis represents the cost of abatement of that opportunity. Such a tool can be helpful to decision makers, as the cost of abatement can be readily compared to the CRC allowance price. If the allowance price is lower than the cost of abatement for that opportunity, it becomes financially unattractive to take that action. Also, if a carbon reduction opportunity in an organisation offers an attractive (i.e. low) marginal abatement cost, but its potential to reduce carbon emissions (i.e. shown by its width on y-axis) is very low, then the organisation may chose not to spend their resources on this opportunity as it would produce little overall impact.

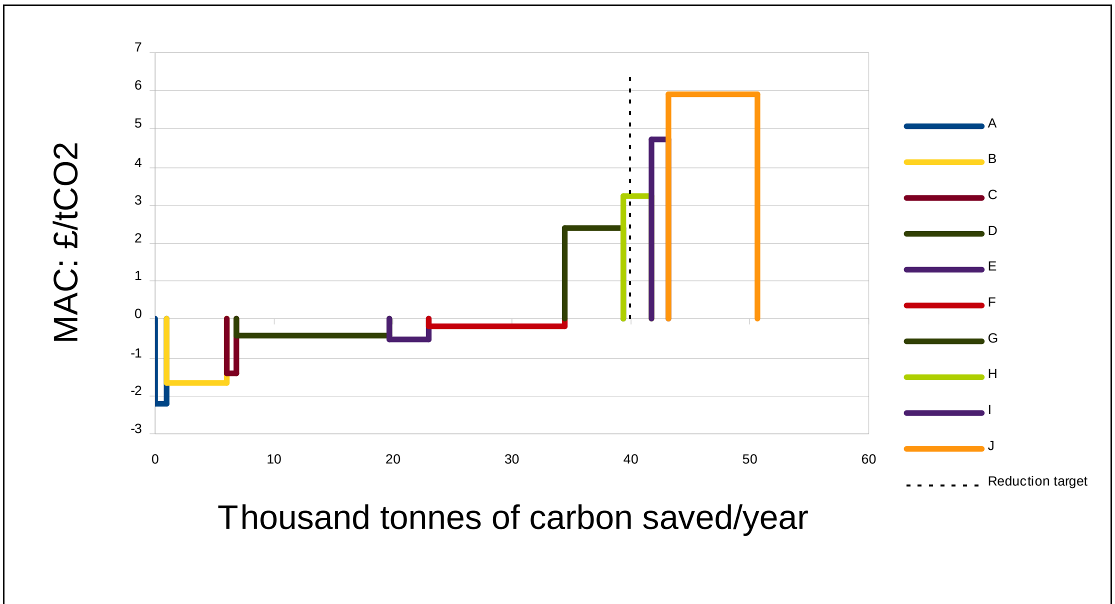

Figure 4: Marginal Abatement Cost Curve (Somar, 2010)

To develop a MACC, a spreadsheet tool was developed by Somar (2010), which was inspired by a similar tool developed by the Carbon Trust (2010). The latter tool is limited to 7 projects at any time, whereas Somar's tool can be used for up to 10 projects although more projects can be added as required.

As shown in figure 5, Somar's tool requires the following information for each project.

- Name of project.
- Capital cost.
- Annual benefit/cost.

- Annual average CO_2e savings.
- Project life.
- Company's accepted discount rate on financial investments.

Project Data

Marginal Abatement Cost (MAC) Curve Calculator

Discount rate		10%
Reduction target (thousand tonnes)		40

Project name		A	B	C	D	E	F	G	H	I	J	
Capital cost	(£)		9,000	20,000	5,000	100,000	75,000	15,000	500,000	200,000	120,000	750,000
Annual benefit/cost	(£)		5,090	17,000	2,570	25,000	15,000	6,000	62,500	20,000	8,000	50,000
Annual average CO_2 savings for project	(tonnes/year)		1,000	5,096	750	12,806	3,297	11,500	4,875	2,390	1,500	7,500
Project life	(years)		10	10	10	11	10	10	10	10	10	10
NPV	(£)		-22,276	-84,458	-10,792	-62,377	-17,169	-21,867	115,965	77,109	70,843	442,772
MAC (carbon not discounted)	(£/tonne)	0	-2.2	-1.7	-1.4	-0.4	-0.5	-0.2	2.4	3.2	4.7	5.9
Discounted life savings of carbon	(tonnes)	0	6,145	31,313	4,608	83,173	20,259	70,663	29,955	14,686	9,217	46,084
MAC (carbon discounted)	(£/tonne)	0	-3.6	-2.7	-2.3	-0.7	-0.8	-0.3	3.9	5.3	7.7	9.6
Cumulative savings for all projects	(thousand tonnes/year)	0	1.0	6.1	6.8	19.7	22.9	34.4	39.3	41.7	43.2	50.7

Figure 5: Information to develop a MACC (Somar, 2010)

This information is normally available within the business case for each project. The annual benefit/cost can be calculated by annual cash flow in terms of a project's operation, maintenance costs and cost benefits. An example is given in table 2.

Project X		
Capital cost	A	£1,000
Annual operating cost	B	£500
Annual maintenance cost	C	£700
Annual energy saving cost	D	£750
Annual incentive	E	£750
Annual benefit/cost	D + E – B – C	£300

Table 2: Information to develop MACC

An important factor in the development of a MACC is the user's accepted discount rate on financial investments. Due to the financial value of the carbon in schemes such as CRC and EU ETS, a project's lifetime carbon saving can also be discounted.

The spreadsheet tool calculates the net present value (NPV) for each opportunity, and divides this value by the average annual CO_2e savings and the project life time. This yields the marginal abatement cost in £/tonne of CO_2e.

Emission Reduction Investment Curves (ERIC)

Lavery (2011) proposed an alternative method claiming as an improved alternative to MACC. This new method is known as an Emission Reduction Investment Curve (ERIC). Though there is little information available about this method, it has been used by Booz & Company (Fayad et al, 2011) to model a carbon reduction strategy. Figure 6 shows an example ERIC curve by Lavery (2011), who argues that MACC curves are unhelpful since they do not display IRR, which is generally a more reliable metric for CEO and CFO level officers within a company.

Internal Rate of Return (IRR)

M. A. Mian (Mian, 2011) defines the internal rate of return, or simply IRR, as: *The internal rate of return (IRR) or economic rate of return (ERR) is a rate of return used in capital budgeting to measure and compare the profitability of investments. It is also called the discounted cash flow rate of return (DCFROR) or the rate of return (ROR).* In more general terms, the internal rate of return on an investment or project is the "annualized effective compounded return rate" or "rate of return" that makes the net present value (NPV as NET*1/(1+IRR)^year) of all cash flows (both positive and negative) from a particular investment equal to zero (Wikipedia, 2013). In the context for this research, in an organisation with investing stakeholders, if the internal rate of return for a carbon reduction opportunity is greater than their acceptable rate of return, the investment would then be considered as acceptable.

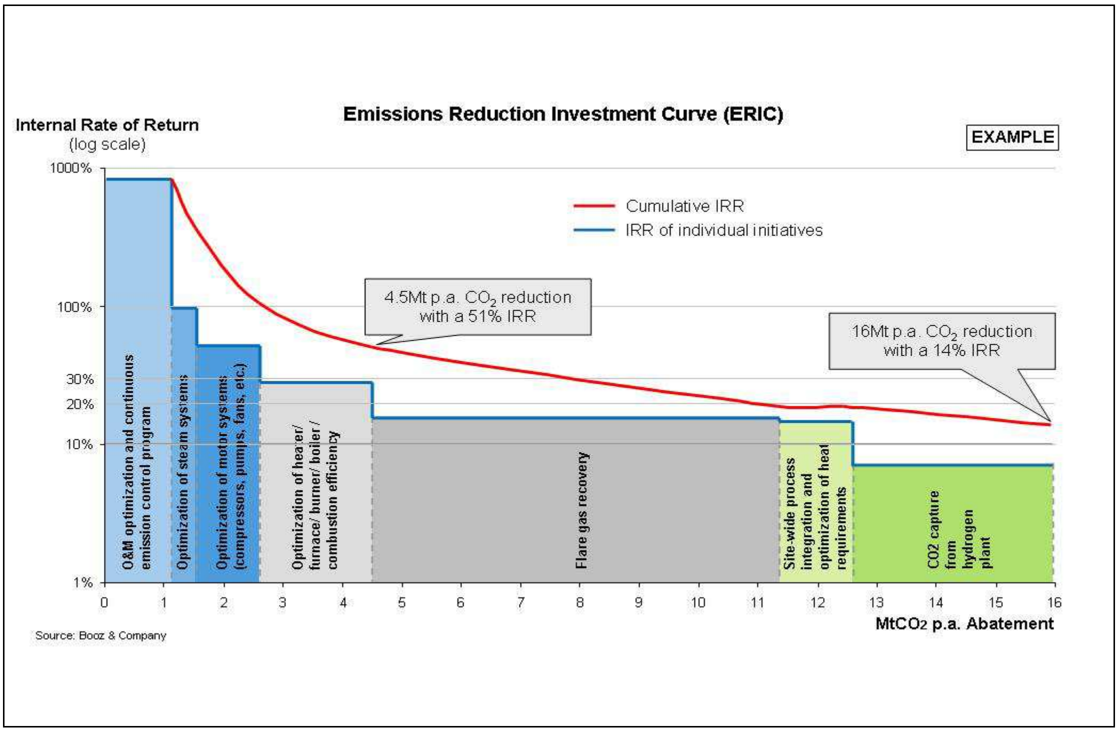

Figure 6: Emissions Reduction Investment Curve (Lavery, 2011)

With MACC, the more negative an opportunity appears on the x-axis, the more attractive it is; this is counter-intuitive. On the other hand if the opportunities were not expressed as both negative and positive in terms of their carbon abatement cost then the method would not allow users to compare opportunities in terms of the abatement cost set against the carbon allowance price.

In ERIC, as with MACC, the x-axis displays the carbon reduction potential of the opportunities. The y-axis, in this case, is a logarithmic scale showing the IRR of each opportunity. The emphasis here is on IRR rather than the money spent per tonne of emissions reduction - ERIC can show the IRR of individual projects as well as the cumulative IRR of multiple projects. Since there is no assumption of discount rate, decision-makers can chose their preferred risk level by examining the IRR.

1.3 Impacts of CRC on a participant

As presented in section 1.2, few researchers have carried out research since the introduction of CRC aimed at understanding the impact on participant companies operating in various sectors. That said, a number of impacts have been identified. Organisations are required to firstly assess if they are liable to participate in CRC, which is itself a daunting and challenging task. The profile and metering types associated with electricity and natural gas supplies are not usually known to facility managers or the finance team, who generally deal with an organisation's energy bills. Therefore, it is a non-trivial task to assess if they are consuming half-hourly metered electricity above the CRC threshold during the qualification period. For organisations, which are already part of EU ETS or hold CCA, the assessment is further complicated. In addition to the above issues, there are issues such as landlord/tenant arrangements, inappropriate metering, and inaccessibility to energy data *etc*. all of which make it difficult to assess the extent of liabilities. Once an organisation has been assessed and identified as a participant, metering of energy usage for all fuel types becomes even more important, which is a challenging task for those organisations that consume a significant amount of fuels other than natural gas and electricity. It is also a challenge to maintain the records of events such as commencement/termination of supply.

CRC, especially after the removal of revenue recycling in the 2010 spending review, has introduced additional costs on participant organisations. And the financial risk may become even greater if a cap on allowance is imposed from the second phase, which would then drive the price of the carbon allowance. There are also risks of punitive fines (and even imprisonment) for non-compliance. Due to these impacts, energy issues are now routinely discussed in the board room, where senior managers consider impact mitigation strategies such as renewable energy systems deployment and energy efficiency measures. Another major risk for private sector firms is reputational damage due to the publication of the league table.

Another major cost burden is associated with the additional systems and procedures required to ensure data capture for compliance. Only through such systems and procedures can a participant with a complex organisational structure meet its obligations within the scheme.

Mitigation of Impacts of CRC

Due to factors that distinguish one participant from another, there is no universal strategy to mitigate the impacts of CRC. Tools such as MACC and ERIC can be a good starting point to find the best opportunities to devise a compliance strategy. Also, there is a strong need to realise the opportunities that CRC has introduced. Reducing emissions potentially means reducing costs. CRC provides the drive for innovative technological solutions (such as tamper proof timers as discussed in section 5.1). CRC and other schemes such as Display Energy Certificate (DEC) have also provided a means to link property value with energy performance. Organisations that hire a specialist Energy Manager or CRC Manager also get the opportunity to identify low/no cost options to reduce energy consumption and thereby save money. Achievements such as a good position in the CRC league table, certification with Carbon Trust Standard or equivalent, and the implementation of renewable energy systems or energy efficient products can also provide organisations with opportunities to increase turnovers through marketing of their achievements.

It is hypothesised that through specifically designed systems and procedures in hand with a carbon reduction strategy, the impacts of the scheme can be mitigated. It is also hypothesised that techniques such as MACC and ERIC are useful adjuncts to devising a carbon reduction strategy.

Risks with new and innovative technologies

With the evolution of sustainable business needs, the market has grown for new and innovative technologies. According to Blok et al (2008), the total investment required for energy efficient technologies is estimated at €60 billion (approximately £50 billion) per annum. In wind, solar PV and bio-fuels alone the market size is estimated to reach £246.9 billion by 2012. Due to this potential, there is a risk of unscrupulous companies selling ‘green’ products that do not deliver the claimed energy savings or carbon reductions. Due to a lack of knowledge about new and innovative technologies, a buyer finds it hard to assess the validity of claims by product/service providers. Examples abound of scams which trick into buying energy saving device that do not work (Which, 2011). There is also an example of a geothermal pump that was Energy Star rated despite the fact that its efficiency claims exceeded any comparable product (Priesnitz, 2010).

As this has brought additional risks with implementing energy efficiency measures and renewable energy systems, there is an ever greater need to verify the carbon reductions from implemented projects. A carbon reduction strategy may be weak and unable to deliver results as expected if these risks are not considered. It is hypothesised here that appropriate monitoring & verification can reduce these risks and ensure the delivery of carbon reduction targets.

1.4 Research Requirements and Knowledge

While researchers have considered the different impacts of CRC and possible mitigation approaches within various sectors, there are still missing elements in the literature.

The existing analysis of impacts is at a high level, and does not identify the systems and procedures that should be in place to meet the requirements of CRC. No research has been found which quantified the cost implications of CRC on a participant organisation at a level of detail that may be acted upon. While the existing research gives recommendations to mitigate the impacts of CRC, there is a lack of information on specific implementations and the beneficial outcomes from such implementations. Tools such as MACC and ERIC have been suggested as an apt means to establish a compliance strategy; no such approach has yet been applied within a CRC participant organisation to determine effectiveness. It has also been identified that, while CRC is acting as a driver to reduce carbon emissions, there is a danger that organisations trying to implement innovation risk being duped. Including such innovative technologies in MACC and ERIC could be high risk unless there is a reliable way to include such opportunities in the compliance strategy.

This research was undertaken to address these missing elements in the previously available research work. Barr Holdings, which is a CRC participant organisation operating in Aggregates, Environmental and Construction sectors was chosen to conduct this research. These sectors contribute 5.6% of the UK’s total energy consumption (DECC, 2010). This company, presenting a complex structure in terms of the number of different fuels used, provided a good opportunity for this research.

This research will not only help the CRC participant Barr Holdings, but also provide an approach that can be applied by any organisation that is liable to a similar scheme, or an organisation that is aiming to develop its carbon reduction strategy. The key contributions that have been made in this research work can be given as follows.

- As identified in sections 1.2 and 1.3, the pre-existing research work did not present a quantification of the impacts of CRC. It was the first systematic research work in which the impacts of CRC were quantified in financial terms, as presented in Chapter 2 section 2.6.
- This was the first research project to identify, implement and improve the required systems & management procedures for a CRC participant, in order to stay compliant and to mitigate the impacts of this complex scheme. Development of tool such as ‘CRC Footprint Tool’, set up of ‘CRC Team’, and implementation of ‘CRC Procedure’ (which have been presented in section 3.1) were necessary for Barr to stay compliant, mitigate the impacts and reduce the risks of non-compliance.
- The research work has presented and trialled different management approaches in terms of decision making for carbon reduction projects, using various decision support tools such as MACC and ERIC for the first time in Construction and Aggregates sectors. A blended CALoRIC tool was also developed as part of this research, as presented in section 4.3, which may be used by other organisations / sectors.
- A new approach, not evident from any available research work, was used in this research work to quantify real carbon emission reductions for an organisation. As presented in section 5.11, it was identified that a company must implement energy benchmarking methods, supported by monitoring & verification of implemented carbon reduction opportunities, to quantify the real carbon reductions that have been achieved in a given time period. It is also important to realise the carbon reduction potential of various carbon reduction opportunities, as it reduces risk, and help in devising further carbon reduction strategy.

Overall, the approach used in this research project is unique itself, and can be used by researchers / energy managers in similar or different sectors, to

- Identify & quantify the impacts of a given scheme (whether legal or optional)
- Identify and compare carbon reduction opportunities using latest decision support tools
- Monitor & verify actual carbon reductions, and implement relevant energy benchmarking methods to quantify actual organisational carbon reductions

1.5 Changes in CRC Scheme

This research work was conducted at Barr Holdings from February 2010 to October 2012. During this period, the first major revision of the scheme was announced by the UK government in October 2010 spending review. The major changes were as follows.

- Revenue recycling was removed from the scheme and it was confirmed that money generated from sale of allowances will be retained by the government for public finances.
- The sale of allowances was postponed by one year, to start from April 2012 instead of April 2011.

- Postponement of the opportunity to have two sales of allowances, i.e. forecast-based and retrospective, allowing for only retrospective purchase of carbon allowances.

These changes were considered and were part of this research. However, the participants continued complaining about the complexity of the scheme and financial burden of the scheme. In order to address these issues, government initiated a consultation in March 2012 on further changes to the scheme. The response to this consultant was published in December 2012, notifying participants of a number of significant changes. Since these changes are being implemented after the research work had been completed at Barr, therefore, this work does not take these into consideration. To understand these changes in the light of this research, the major changes have been summarised as follows.

- The CRC Performance League table was abolished from 2012-13. However, the Environment Agency has proposed to publish the aggregated participants' energy use and emissions data. It means that the participants don't need to consider emissions / energy use coverage by AMR meters and Carbon Trust Standard (or equivalent).
- The number of fuels covered by the scheme was reduced from 29 to 2, leaving Electricity and Natural Gas only under the coverage of CRC Scheme (where the use of Natural Gas for heating purposes only is covered by the scheme). In CRC year 2011-12, Barr had only 33% of its CRC emissions rising from these remaining 2 sources of energy. Therefore, Barr can expect its CRC bill to reduce by approximately one third.
- 90% residual percentage rule was also removed. A 2% de-minimis rule has been introduced for Natural Gas use. So, if the Natural Gas use of an organisation is less than 2% of its Electricity use, then the Natural Gas use can be excluded from CRC reporting for the whole remaining phase. In CRC year 2011-12, Barr's Natural gas use was 4.6% of its electricity use.
- The deadline to surrender purchased CRC allowances was extended by 3 months to last working day in October.

In terms of impact of these changes to this research work, the approaches and tools identified in this research will still remain valid and useful for organisations impacted by CRC or other similar schemes / taxes. Reduction of number of energy sources will provide a reduction in financial burden to CRC participants such as Barr whose only 33% emissions were coming from Electricity and Natural Gas, but on the other side, removal of residual percentage rule may put additional burden on participants to spend resources in collecting data for areas with negligible Electricity and Natural gas use. The abolition of performance league table does not affect a company much, as it was already a less effective reputational driver. The change in terms of Carbon Trust Standard (or equivalent) and voluntary AMR requirements will reduce their cost impact at one end but, on the other end, the organisation will not be able to benefit from the opportunities arising from these. After these changes, it is anticipated that, for Barr, the financial burden of CRC scheme will be reduced by around a third of its current impact, so it will be outweighed by the financial savings from implemented carbon reduction opportunities during this research. In terms of energy sources not covered under CRC Scheme, even after these changes, this remains a valid argument that reduction in costs and carbon emissions from the carbon reduction opportunities in these can help in outweighing the costs of CRC. So, an organisation that is aiming to reduce energy costs and carbon emissions should consider looking into potential energy reduction opportunities in energy sources not covered by a scheme like CRC.

Objectives of the project

The key objectives of the present project were as follows.

- To identify the impacts of CRC on a participating organisation.
- To identify and implement opportunities to mitigate the impacts of CRC.
- To identify a best practice approach to identifying cost-effective carbon reduction opportunities.

Research method

This study was conducted using empirical data derived from field based research. The research includes both qualitative and quantitative methods.

- Empirical Research

Empirical research is defined as research based on observed and measured phenomena. It reports research based on actual observations or experiments using quantitative research methods and will typically generate numerical data involving two or more variables (NSU, 2010). In this research, field based research was conducted within a CRC participant company over an extended period of time (3 years).

- Quantitative Research

Quantitative research refers to the systematic empirical investigation of social phenomena via statistical, mathematical or computational techniques (Given, 2008). This research project involved analysing data during various stages of the CRC process.

- Qualitative research

Qualitative researchers study things in their natural settings, attempting to make sense of, or to interpret, phenomena in terms of the meanings people bring to them (Denzin and Lincoln, 1994). This research involved information acquisition from the employees of a CRC participant company.

- Semi-structured interviews

Semi-structured interviews, also known as in-depth interviews are used in research to provide flexible boundaries to the interviewer in order to get maximum information from the interviewee. In-depth interviews, also involve the capturing of respondents' perceptions in their own words, a very desirable strategy in qualitative research (Saunders et al 2007). In this research, semi-structured interviews addressing various topics were used to obtain both qualitative and quantitative information related to the CRC participant company.

- Focus Group

Henderson (2009) defines a focus group as a form of qualitative research in which a group of people are asked about their perceptions, opinions, beliefs and attitudes towards a product, service, concept, advertisement, idea or packaging. In this research, a focus group was established in the CRC participant company to obtain the views, and approval where required, of a targeted group of employees about the carbon reduction strategy and available opportunities.

Project Approach

The flowchart of figure 7 displays the project approach used within this research project. A brief description of each stage follows.

- Stage 1: Review of CRC & Existing Research

The first stage involved the review of the CRC scheme, its rules, revisions over time and available research. At the end of this stage, the project objectives, research method and project approach were identified.

- Stage 2: CRC Impacts

In the second stage of the project, research focused on a complex CRC participant company. The company's CRC qualification and liabilities were identified by understanding its operations. This stage also included examining the company's existing systems & procedures, and identifying new systems & procedures required to meet the requirements of CRC. At the end of this stage, the financial impacts of CRC on the company were quantified, including a sensitivity analysis.

- Stage 3: Mitigation of CRC Impacts

In the third stage of the project, the required systems & procedures were defined and implemented within the company as required to meet the needs of CRC. Corrective actions were also implemented, where required, based on the outcome of suggested implementations to improve the systems & procedures. In this stage, the carbon reduction opportunities were identified, and MACC/ERIC curves were plotted to compare options. A new CALoRIC curve (Carbon Abatement Low Risk Abatement Curve) was developed to address the issues identified in using MACC/ERIC curves. Relevant carbon reduction opportunities were then implemented on the basis of the CALoRIC outcomes and other company-specific factors. The performance of implemented opportunities was then monitored & verified, and corrective action taken where appropriate. MACC, ERIC and CALoRIC curves were also re-plotted on the basis of learning outcomes from the monitoring & verification work.

- Stage 4: Conclusions

This was the last stage, where learning from the whole project were summarised and concluded. In this stage, some possible future work was also suggested.

1.6 Chapter Summary

To meet its commitment on carbon reduction targets, UK government has introduced several initiatives to business and domestic consumers of energy. These initiatives include both energy efficiency and renewable energy opportunities. The mandatory CRC Energy Efficiency Scheme was one of the initiatives introduced by the government to target energy reduction from non-energy-intensive businesses operating in the UK. Since its introduction, the scheme has been revised several times. Existing research has identified the high level impacts of the scheme and possible solutions to mitigate these impacts. However, it was still difficult for organisations participating in CRC to estimate exactly how much CRC would affect their business, especially after the revenue recycling part was removed from the scheme. No evidence was found about actual implementations of the impact mitigation techniques as suggested. Therefore, a research project was proposed to be conducted within a complex CRC participant organisation. The main objectives of the project were to identify the impacts of CRC and their mitigation opportunities in detail and, by implementation in practice, to determine the best strategy to manage impact mitigation in practice.

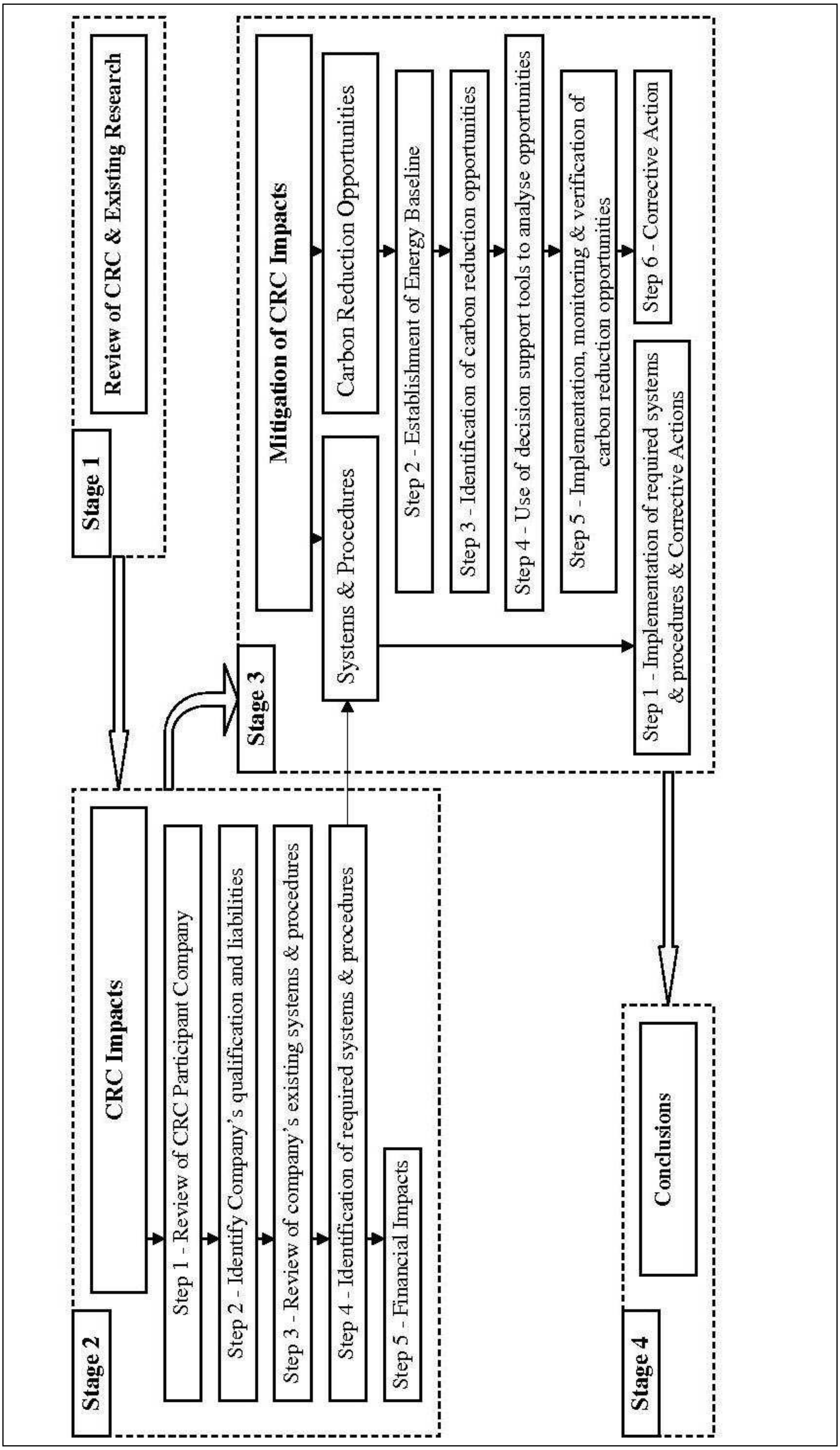

Figure 7: Project Approach

2 MITIGATION OF IMPACTS OF CRC

In chapter 1, the need was identified to analyse the impacts of CRC on participant organisations in depth. To carry out this analysis, a CRC participant company with a diverse range of operations was chosen. This chapter provides information about the company, its operations and its energy use. The chapter also includes the information obtained from the company through observation and structured interviews, which was then used to identify company's liabilities in the CRC. The chapter also includes information about the company's existing systems & procedures that relate to energy use and the collection of the information required to comply with the CRC scheme. At the end of this chapter, an analysis is carried out to estimate the financial impacts of CRC on the company.

2.1 The Company

Barr Holdings was chosen as the CRC participant company for this research. The company operates in a diverse range of business sectors including aggregates, construction, landfill sites, waste recycling, steel fabrication and agricultural precast. According to the Engineering Manager at Barr (Interview 1; AG, 2010), the company has 3 head offices in different parts of Scotland, 17 permanent operational sites and 17 temporary construction sites. The operations of the Construction Division are spread across the UK.

- Barr Industrial

The industrial division mainly operates in the Aggregates sector, which includes quarrying, asphalt production, ready-mix concrete production and road surfacing & civil engineering works.

- Barr Construction

The construction division has a large portfolio comprising the construction management for projects such as hospitals, schools, retail stores, stadia, wind farms, leisure centres, residential and industrial buildings, *etc*.

- Barr Environmental

The environmental division includes landfill, waste recycling/transfers and skip hire.

- Barr Manufacturing

The manufacturing division includes precast concrete production and a steel fabrication business.

Due to the diversity of operations, the company provided an opportunity to analyse a complex CRC participant. With approximately 28,000 tonnes of carbon emissions per annum (Interview 1; AG, 2010), stemming from a range of emissions sources within the business, Barr provided a good platform to look into the CRC scheme's impacts, and an opportunity to test carbon reduction opportunities within some of the company's energy intensive operations.

2.2 Energy use at the company

The company currently uses the following fuels/sources of energy.

- Electricity
- Natural Gas
- Gas oil
- Kerosene
- Light Fuel Oil (LFO) / Burning Oil
- Derv (Diesel)
- Petrol

The research was carried out within the company's premises located at its main depot known as Killoch Depot. Fuel use, as observed at the company, is summarised in table 3.

Energy Source	**Uses**
Electricity	Lighting, Space heating, Motors / Drives in the Quarries, IT equipment
Natural Gas	Negligible use in office stoves
Gas Oil	Mobile plant and machinery on construction sites and quarries, standby / temporary electricity generators on construction sites, Heating in asphalt / coated aggregates production plants
Kerosene	Space heating, Heating in asphalt / coated aggregates production plants
Light Fuel Oil / Burning Oil	Heating in asphalt / coated aggregates production plants
Derv (Diesel)	Company's road-going vehicles (cars, vans, lorries, road going tippers & mixers), external hauliers' vehicles
Petrol	Negligible use in cars

Table 3: Energy use at Barr

Table 4 shows the energy consumption and carbon footprint information for the company in 2008.

2008				
Energy			**Carbon emissions**	
Energy Source	**Unit**	**Unit**	**CO_2 conversion factor**	**tonne-CO_2**
Gas Oil	**Litres**	4,558,680	2.762	12,591
Derv	**Litres**	2,783,444	2.639	7,346
Kerosene / LFO	**Litres**	1,048,206	2.532	2,654
Electricity	**kWh**	10,640,139	0.541	5,756
Gas	**kWh**	533,769	0.1836	98
Petrol	**Litres**	14,421	2.3035	33
Other				59
			Total Emissions	**28,537**

Table 4: 2008 Energy consumption and carbon footprint

Also, energy costs have been derived from the given information, as shown in table 5.

2008					
Energy			**Energy costs**		
Energy Source	**Unit**	**Unit**	**pence/unit**	**Total cost**	**%age**
Gas Oil	**Litres**	4,558,680	47.42*	£2,161,726	34.03%
Derv	**Litres**	2,783,444	103.72*	£2,886,988	45.45%
Kerosene / LFO	**Litres**	1,048,206	39.96*	£418,863	6.59%
Electricity	**kWh**	10,640,139	7.97**	£848,019	13.35%
Gas	**kWh**	533,769	2.09***	£11,156	0.18%
Petrol	**Litres**	14,421	95.02*	£13,703	0.22%
Other				£11,136	0.18%
			Total Cost	**£6,351,591**	

*Gas Oil, Kerosene, Derv and Petrol prices have been taken from DECC statistics (average taken of Jan 2008 and Jan 2009 price), available online at http://www.decc.gov.uk/assets/decc/statistics/source/prices/qep413.xls
**Electricity price has been taken from DECC statistics, available online at http://www.decc.gov.uk/assets/decc/statistics/source/prices/qep531.xls
***Gas price has been taken from DECC statistics, available online at http://www.decc.gov.uk/assets/decc/statistics/source/prices/qep571.xls

Table 5: 2008 Energy costs

2.3 Company's Qualification & Liabilities

CRC Qualification

During the CRC qualification year 2008, the company recorded a consumption of 7,765 MWh of half-hourly electricity, which is above the 6,000 MWh qualification threshold in CRC. The company was not participating in either EU-ETS or Climate Change Agreements and had no generation of renewable energy. Therefore no such supplies can be discounted, and the company must participate in CRC as a full participant.

CRC Liabilities

Based on the review of CRC rules in section 1.2, and comparing with the organisational information available for Barr Holdings, the following liabilities have been identified for the company in CRC.

- Registration in CRC

Since the company meets the qualification criteria of the scheme, it had to register in the scheme by the registration deadline for the 1st phase of the scheme (i.e. July 2010).

- Responsibility

The company is required to nominate the following personnel, where the first three must be nominated before the company applies for registration in the scheme.

- CRC Senior Officer
- CRC Primary Contact
- CRC Secondary Contact
- CRC Account Representative/s

- Energy Use

As the CRC year runs from April to March, Barr must record its energy use for this period. At Barr, the latest available energy use and carbon footprint information was for the calendar year 2010.

As can be seen in figure 8, which was developed on the basis of the company's 2008 carbon footprint breakdown, the total electricity and natural gas supplies will not comprise 90% of total CRC emissions, and therefore the company must record and report its residual supplies.

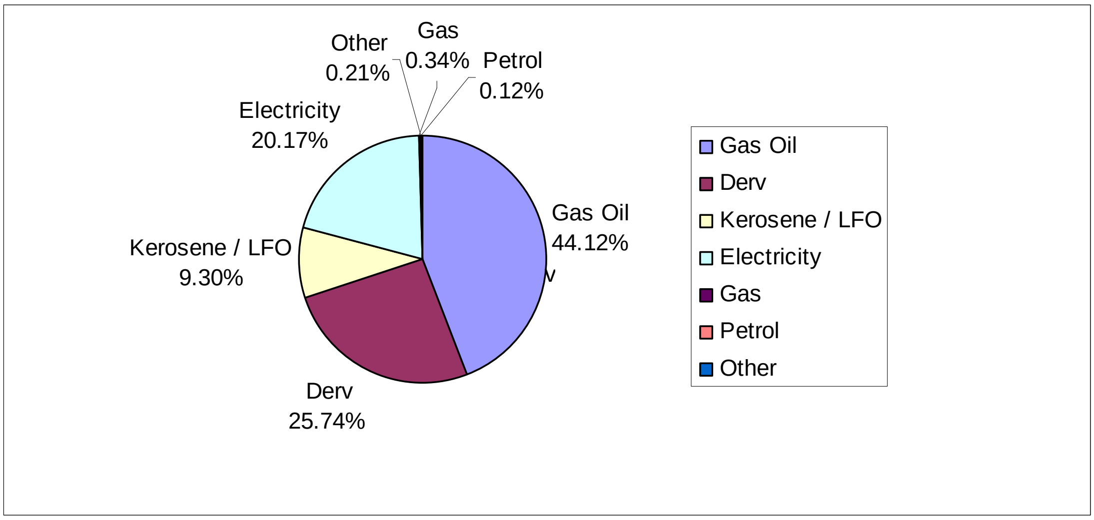

Figure 8: Pie chart: 2008 carbon footprint

Based on the checks required on energy supplies in CRC, as elaborated in section 1.2, the following information was required to be recorded at Barr. This information was separately identified for each energy source at the company to comply with the requirements of CRC.

Electricity

Information required: site name, supply profile, consumption (kWh), actual/estimated consumption, AMR/non-AMR.

For the next phase of CRC, the information requirement for electricity will remain the same. However, if the amendment proposals are implemented then the following additional information will be required to be recorded.

- Electricity used for the purpose of transporting, supplying or shipping of gas.
- Electricity used for the purpose of generating, transmission or distribution of electricity.

Natural Gas

Information required: site name, meter type (daily read, non-daily read), consumption profile (<+73,200 kWh, >73,200 kWh), consumption (kWh), actual/estimated consumption, AMR / non-AMR.

For the next phase of CRC, the information requirement for natural gas will remain the same. However, if amendment proposals are implemented then the following additional information will be required.

- Natural gas used for the purpose of transporting, supplying or shipping of gas.
- Natural gas used for the purpose of generating, transmission or distribution of electricity.

Liquid fuels - Gas Oil

Information required: site name, consumption/delivery, actual/estimated, consumption (litres).

If the amendment proposals are implemented then from phase 2, gas oil will only need to be reported where it has been used for heating purposes. As observed in the quarries and asphalt production plant at Barr, the company currently uses gas oil for both heating and power requirements. This means that there will be an additional requirement to record the end use of gas oil.

Liquid fuels - Kerosene / Burning Oil

Information required: site name, consumption/delivery, actual/estimated, consumption (litres).

If the amendment proposals are implemented then from phase 2 Kerosene will only need to be reported where it has been used for heating purposes. As observed in the asphalt production plants and site workshops at Barr, the company currently uses Kerosene mainly for heating.

Liquid fuels - Diesel (Derv)

Diesel is only required to be recorded if it is not being used for transport. If the amendment proposals are implemented then from phase 2 it will not be required to record and report any diesel use.

Petrol and other fuels

Petrol is not recorded for CRC reporting as minimal quantities are used at Barr for transportation only. No significant quantity of any of the other fuels is used at Barr. If the amendment proposals are implemented then from phase 2 it will not be required to record and report Petrol and other fuels (except electricity, natural gas, gas oil and Kerosene).

- Carbon Trust Standard (or equivalent)

Though achieving a Carbon Trust Standard accreditation (or equivalent) is not mandatory for a CRC participant, it was important for Barr in order to avoid being adversely listed in the CRC Performance League Table.

- AMR metering

Similar to achieving Carbon Trust Standard accreditation (or equivalent), it was not mandatory for a CRC participant to install AMR metering on its non-half-hourly supplies. It was important for Barr to avoid an adverse position in the CRC Performance League Table.

- Turnover

Reporting annual turnover in CRC is also not mandatory. However, if the turnover is not reported then the Growth Metric Score is counted as 0%, which would affect the company’s position in the Performance League Table. Therefore, it was advised that the company must record and report its annual turnover to achieve a score in the Growth Metric. As mentioned in CRC rules, the turnover figures can be used from either the calendar year (January to December) or CRC year (April to March); whichever suits best the participant company.

- Temporary sites

As the company operates 17 temporary sites, their energy usage is required to be recorded to prepare the Residual Measurement List. According to CRC rules, all core supplies to temporary sites must be reported. For the new temporary sites starting in later years when no new residual measurement list is required, the company does not need to report their residual supplies. For this reason, the company must maintain a record of start/end date of supplies to the new temporary sites.

- Evidence Pack

The company must maintain an evidence pack to ensure that complete records are available for the information reported in the CRC registry. Based on the qualification and CRC liabilities identified for Barr in this chapter, the company must maintain evidence of the information it uses to assess its qualification and to comply with the scheme.

- Internal Audits

The company must conduct regular internal audits, signed by the respective Managing Directors of the divisions. Due to the location of head offices for each division, there were two audits proposed: One audit for the Construction division and another for the Industrial, Environmental & Manufacturing division.

2.4 Review of existing systems & procedures

During the semi-structured interview (Interview 1; AG, 2010), it was determined that the company has already recorded enough information to assess its qualification in CRC, and had already taken several steps for CRC compliance utilising its existing systems.

Existing systems in the company

This section provides information about the systems already in place at the company, which are in use to gather information related to company energy use. The section also includes the initiatives that were already being undertaken by the company to meet the requirements of CRC.

- Information Systems

The information on existing information systems within the company was also obtained from the Engineering Manager via interview.

Dataserve

Dataserve is an energy metering service, which is also Barr Holdings' appointed meter operator for electricity supplies. All permanent sites of the company with regular operations, but without an existing half-hourly meter, have been fitted with AMR meters. The data for both AMR and half-hourly metered sites was available to Barr Holdings through an online Dataserve portal.

Table 6: Existing information systems

Information System	**Information available for Carbon Trust Standard**	**Information available for CRC**
Dataserve	Site Name, Electricity Consumption (kWh)	Site Name, Electricity Consumption (kWh)
Fueltek	- Diesel use (litres) by company vehicles - Petrol use (litres) by company vehicles - Site Name, Orders (litres) for Industrial, Manufacturing and Environmental Divisions, for Gas Oil, Kerosene and LFO / Burning Oil	Site Name, Orders (litres) for Industrial, Manufacturing and Environmental Divisions, for Gas Oil, Kerosene and LFO / Burning Oil
QR3	- External hauliers' travel for Barr (miles)	None
COINS	Turnover information (£), Gas oil use (litres) for Construction division, Business travel information (miles) for Construction division	Turnover information (£), Gas oil use (litres) for Construction division
Construction kWh tool (spreadsheet)	Site Name, Electricity Consumption (kWh), Gas Consumption (kWh) for Construction division sites	Site Name, Electricity Consumption (kWh), Gas Consumption (kWh) for Construction division sites
Expenses tool (spreadsheet)	Business travel information (miles) for Industrial, Environmental and Manufacturing divisions	None

Fueltek

Fueltek is a fuel management information system, which records diesel use by company-owned vehicles.

QR3

QR3 is an internally developed information system, which records the sales of quarry' products (i.e. aggregate; asphalt/coated material and ready-mix concrete). As part of the haulage operation is arranged through external hauliers, their diesel usage is estimated from the number of miles they travel to deliver Barr products as available in QR3.

COINS

COINS are a financial management information system, which can provide company turnover information. This system is also used to provide fuel purchase and business travel information at Barr.

Spreadsheet based systems

There were a number of spreadsheet based tools in use at Barr to record information such as:

- Construction-related energy use;
- Expenses.

In terms of the information required for CRC, these systems provide the information presented in table 6.

- Energy Use and Turnover: Barr carbon footprint tool

The company was using an internally modified version of the Carbon Trust's footprint tool. This spreadsheet tool was being used to copy and paste all the energy use and turnover information from the systems mentioned in table 6, process it to calculate the total and normalised (to the turnover) carbon emissions of the company. The company was recording data into this tool on a monthly basis to obtain the inputs required by CRC.

- Qualification in CRC

After realising its possible inclusion in the mandatory CRC scheme, the company allocated its Engineering Manager responsibility to deal with the scheme. This person identified from the electricity bills that the half-hourly electricity for the company in 2008 was 7,765 MWh, which was reasonably above the 6,000 MWh qualification threshold. Initiatives such as Carbon Trust Standard accreditation and installation of AMR meters were then taken by the company to prepare for the first phase of the scheme.

- Carbon Trust Standard

The company adopted a proactive approach to get the benefit of CRC's Early Action Metric and revenue recycling feature. For this purpose, the company applied for and achieved Carbon Trust Standard accreditation in 2009. In order to achieve the Carbon Trust Standard, the company started recording its 'Level 1' emissions and process emissions. While recording the 'Level 1' emissions, the company included its use of transport fuels, which are not in the scope of CRC. The company decided to include its process emissions in its first Carbon Trust Standard certification due to inclusion of these emissions sources in CRC.

- AMR Metering

For the same reasons as the Carbon Trust Standard, the company initiated a roll-out of AMR metering on all of its major electricity consuming sites, except temporary sites for the construction division. The information from all AMR meters, as well as half-hourly meters on the company’s permanent sites, can be downloaded from the Dataserve Website. However, the AMR metering does not cover any natural gas usage, and also some electricity use in sites with temporary or no operations due to little use.

Existing procedures in the company

As identified from interview, there were no existing procedures in the company designed specifically for CRC. However, due to holding Carbon Trust Standard, there was an unwritten procedure being followed by the Engineering Manager to collect energy and turnover information and populate this into the Barr footprint tool. A flowchart (figure 9) was then developed, to shows the flow of information within the company.

- Record keeping

Record keeping in the company was reviewed. In the Industrial, Manufacturing and Environmental divisions, only 61 out of 105 requested invoices were provided in a timely manner. In the Fueltek system, the ‘ordered’ quantities for Gas Oil, Kerosene, LFO and Derv were recorded instead of ‘delivered’ quantities, which could be different (e.g. at times when the on-site tank could take less than the ordered quantity). Electricity and Gas bills were also found misfiled in the archive. However, the invoices and bills in the construction division were complete and accurate.

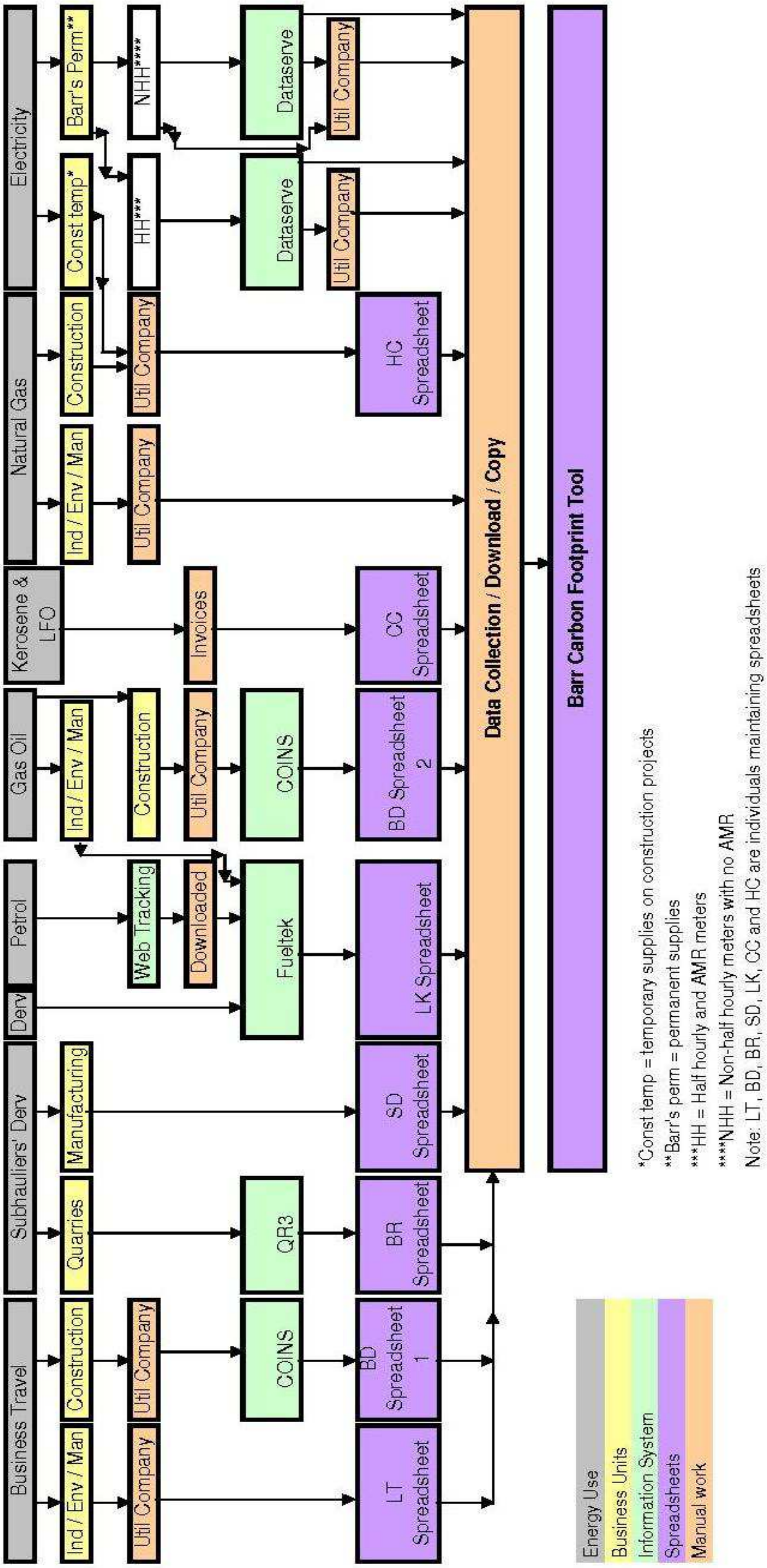

Figure 9: Energy information sources

2.5 Identification of required systems & procedures

As obvious from the discussion, the existing systems and procedure at the company provided considerable information. However, this information was still incomplete in terms of CRC, and more information was required to be recorded to comply with the scheme. These additional information requirements are discussed below.

Barr's CRC reporting tool

A CRC Reporting Tool was proposed. This tool was then implemented as a spreadsheet constructed on the basis of the information gap between that available from the existing Carbon Footprint Tool and the information required to meet the requirements of CRC. Rather than using several different tools, this tool includes major transport fuels due to their inclusion in the scope of the Carbon Trust Standard (or equivalent). The main features of this spreadsheet, excluding those data already available in the existing Carbon Footprint Tool, are as follows.

- Supply characteristics

As identified in section 2.3, the CRC tool must be able to include additional information about supplies, such as electricity profile types, estimated/actual supplies *etc*. This additional information, available in the form of bills, invoices and annual statements, required manual reworking. The tool must also be able to apply a 10% uplift on estimated supplies.

Though the CRC Source List tool from the Environment Agency can perform this task, there is a need, as explained below, to do more than this - using the Source List tool only for supply characteristics will not solve the remaining issues. The source list tool is a 'read only' spreadsheet, and cannot be tailored to meet organisation-specific requirements, such as site specific CRC costs, carbon footprint *etc*.

- CRC Costs

The tool must be able to calculate the expected CRC costs. Similar to Barr's existing footprint tool, the tool provides month-by-month information of CRC costs.

- Allocation of costs

As agreed with the Finance Manager, it would help to allocate the costs of CRC to the operational sites where these emissions are emitted. The tool must therefore be able to calculate site specific CRC costs.

- CRC year

Since the CRC year runs from April to March, the information in the CRC tool is recorded month-by-month over this period.

- Separation of same fuel supplies in or out of CRC

Due to CRC rules about core and residual supplies, same fuel supplies may be part included and part excluded in CRC. The tool is able to separate core and residual supplies to calculate the residual percentage, and to keep information for external audits.

- Transport fuels

Rather than using several different tools, this tool also includes major transport fuels due to their inclusion in the scope of the Carbon Trust Standard (or equivalent). It is able to help in a number of areas, such as to monitor & target the overall carbon emissions of the company and identify potential savings in transport fuels, which are the greatest proportion of the company's energy costs as shown in table 5, section 2.2.

CRC Team

A CRC team was proposed to deal with the requirements of CRC. It was proposed that the team should comprise of mandatory team members (as required by CRC rules) and organisation specific team members.

Mandatory Team members

- Senior Officer: Chairman or Director of the company
- Primary Contact: Chairman or Director of the company
- Secondary Contact: Chairman or Director of the company
- Account Representative: An Accountant well versed with company financial

Organisation specific team members

The following additional members were proposed for the CRC team at Barr.

- Divisional Senior Officers: Divisional Managing Directors were proposed to be the Divisional Senior Officers, to take responsibility for their division's compliance in CRC. Divisional Senior Officers were required to sign the internal audit certificates/evidence pack relevant to their divisions.

- CRC Manager: It was suggested to appoint a CRC Manager, with responsibilities to assess the liabilities of the company in CRC, to gather the data and information from all team members, to inform them of their duties to meet the requirements of CRC, to collect & collate data for the organisation's carbon footprint, and to conduct internal audits. A CRC procedure was proposed (discussed below) for compliance. It was proposed that the CRC Manager should take the lead to ensure that the procedure is followed. It was also proposed that the CRC Manager should be responsible for implementation or continuation of initiatives such as the Carbon Trust Standard (or equivalent), AMR metering *etc*.

- Environment Agency Online Account Manager: It was proposed that a person in the company with good knowledge of using Government online service systems should be given the responsibility to manage the company's Web-based CRC account on the Environment Agency Website. This account is required in the scheme for registration, changes and submission of reports, which was proposed to be done on the basis of information from the CRC Manager.

- Electricity/Gas/Fuels Invoice contacts: It was proposed to identify among the employees, those who deal with bills and invoices. These employees were proposed to be given the responsibility to provide the CRC Manager with electricity/gas/fuel invoice data.

- Transport Fuels contact: It was proposed that the person managing the Fueltek software in the company should be given the responsibility to provide the CRC Manager with transport fuels usage data.

- Turnover Information contact: It was proposed that a person with access to turnover information should be given the responsibility to provide the company's annual turnover information to the CRC Manager.

CRC Procedure

A CRC procedure was developed to carry out the tasks for CRC in a timely manner (Appendix 27-A). The tasks were identified for the CRC Manager to take the lead on CRC compliance and ensure that the team is informed and updated about their responsibilities. The CRC procedure ensures that

- monthly energy usage data is populated in the CRC tool;
- CRC team members provide data and information on time;
- the evidence pack is maintained;
- internal audits are conducted and signed.

Evidence pack

Since the scheme rules do not provide a defined format for an evidence pack, the evidence pack at Barr was proposed to consist of two parts: evidence in electronic and paper forms. The evidence pack at Barr was proposed to contain the following information.

- Organisational structure and responsibility allocation.
- Location of records which are not contained in the evidence pack.
- Special events.
- Internal & external communication for CRC.
- EAM records.
- Internal audit records.
- Excluded supplies records.
- Source list tool and CRC reporting tool.

Due to problems identified in record keeping, hard copy files were proposed for the following bills/invoices.

- Fuel quantities delivered on Industrial, Environmental and Manufacturing division sites.
- Electricity and natural gas bills of Industrial, Environmental and Manufacturing division sites.

Internal audits

Since being a CRC participant, the company is required to conduct internal audits at regular intervals. As with the evidence pack, CRC rules do not provide a format for internal audits. An internal audit process was therefore developed for the company to match key requirements of the scheme, such as:

- to ensure the accuracy of information that is submitted to the Environment Agency;
- to bring relevant energy information to the attention of senior management.

It was proposed that the CRC Manager would be required to conduct internal audits. These audits involve scrutiny of data accuracy and ensuring the required inputs to the evidence pack. The audit certificate is then signed by the Divisional Senior Officers. A sample audit sheet, as developed for the company, is given in Appendix 26.

2.6 CRC Financial Impacts

In previous sections of this chapter, the impacts such as systems and procedural requirements for CRC have been discussed as required to comply with the mandatory scheme. However, it was also found important to understand the financial impacts of the scheme, since after the removal of revenue recycling, financial impact is the main driver for carbon reduction. The research on CRC reported in section 1.2 showed that the financial impacts of CRC had not yet been quantified.

Before discussing the various carbon reduction opportunities, it is helpful to understand the financial impacts of the scheme. A number of areas where CRC has introduced additional costs to a participant organisation are discussed in the following sub-sections.

Allowance purchase

As identified in section 1.2, each participant is required to purchase carbon allowances on the basis of their annual CRC emissions. As the sale of CRC allowances was delayed after the initial review of the scheme, the first year of allowance purchase was 2011-12, and the proposed carbon allowance price was £12 per tonne of CO_2e.

Based on the company's energy use in 2008 (Interview 1, AG, 2010), the energy supplies included in CRC were used to provide a tentative cost of CRC allowances to the company. Table 7 shows the company's CRC eligible energy supplies in 2008 when converted into CO_2 equivalents using the CRC emission conversion factors (Appendix 28).

Company's CRC Eligible Supplies in 2008	**2008 utilisation**	**CO_2 conversion factor**	**CO_2 emission in tonnes** **(1 tonne = 1,000 kg)**
Gas Oil	4,558,680 litres	2.762 $kgCO_2$/litre	12,591.07
Kerosene / LFO / Heating Oil	1,048,206 litres	2.532 $kgCO_2$/litre	2,654.06
Electricity	10,640,139 kWh	0.541 $kgCO_2$/kWh	5,756.32
Gas	533,769 kWh	0.1836 $kgCO_2$/kWh	97.99
		A. Grand total	**21,099.44**
		B. CRC Allowance Price (£ per tonne of CO_2)	**£12.00**
		Total CRC Allowance Cost (C = A x B)	**£253,193.28**
		CRC Allowance cost for 90% of above emissions (90% x C)	**£227,873.95**

Table 7: 2008 supplies under scope of CRC.

It was identified that if the company emits the same amount of CRC eligible emissions in 2011-12 as in 2008 then their total costs to purchase carbon allowances will be £253,193 for the year. It should be noted that this figure does not exclude the 10% excess residual supplies, which can be excluded after using the 90% rule (Section 1.2). If 10% of the emissions are deducted from the 21,099.44 tonnes of CO_2 referenced in table 7, the CRC allowance cost is reduced from £253,193.28 to £227,873.95 as shown in table 7.

Cost of man-hours to meet individual responsibilities in CRC

Another source of additional cost to the company due to CRC is the cost of the time of employees, who will take part in various tasks of the scheme. This cost will depend on factors such as employee salary and the time required carrying out the tasks.

Employees' salary

Due to data confidentiality issues, access to 'employees wage statistics' was not possible as required to calculate the actual cost of the CRC-related person-hours. Instead, lower and upper salaries costs were obtained (Interview 3, LM, 2010), as given in table 8 and table 9.

Expected time requirements

While the time that any CRC team member might take to carry out a specific CRC task is highly variable, based on observation of CRC team members, the data of table 8 and table 9 was determined.

CRC Team Member	Expected time requirement (per annum)	Annual salary (lower band)	Man-hours cost for CRC (per annum)
Mandatory Team:			
Senior Officer	1 week	£100,000	£1,923.08
Primary Contact	½ week	£100,000	£961.54
Secondary Contact	¼ week	£100,000	£480.77
Account Representative	½ week	£40,000	£384.61
Organisation Specific Team:			
2 x Divisional Senior Officer	2 x ½ week = 1 week	£80,000	£1,538.46
CRC Manager	3 months	£30,000	£7,500.00
Online Account Manager for CRC	½ week	£40,000	£384.61
6 x Accountants / Purchase Ledger Clerks	6 x 2 weeks = 12 weeks	£20,000	£4,615.38
1 x Accountant	1 day	£40,000	£153.85
		Total annual cost	£17,942.30

Table 8: CRC man-hours costs – lower band.

CRC Team Member	Expected time requirement (per annum)	Annual salary (higher band)	Man-hours cost for CRC (per annum)
Mandatory Team:			
Senior Officer	1 week	£180,000	£3,461.54
Primary Contact	½ week	£180,000	£1,730.77
Secondary Contact	¼ week	£180,000	£865.38
Account Representative	½ week	£80,000	£769.23
Organisation Specific Team:			
2 x Divisional Senior Officer	2 x ½ week = 1 week	£150,000	£2,884.61
CRC Manager	3 months	£50,000	£12,500
Online Account Manager for CRC	½ week	£80,000	£769.23
6 x Accountants / Purchase Ledger Clerks	6 x 2 weeks = 12 weeks	£30,000	£6,923.08
1 x Accountant	1 day	£80,000	£307.69
		Total annual cost	£30,211.53

Table 9: CRC man-hours costs – higher band.

Cost of Early Action Metric

To achieve a good score for the CRC 'Early Action Metric', the company adopted both suggested initiatives, which were Carbon Trust Standard accreditation and AMR metering. The costs of these initiatives were as follows.

Carbon Trust Standard (or equivalent)

The company achieved Carbon Trust Standard accreditation in 2009. Though the company paid £12,000 for the 'Assisted Certification' (i.e. assisted by a third party consultant), it was expected to pay at least £8,000 to the issuer every second year to recertify. Therefore, the annual cost of the standard can be taken as £6,000 for assisted certification, and £4,000 for non-assisted certification. The costs of the person-hours required for Carbon Trust Standard (or equivalent) related tasks have already been included in the total CRC person-hour costs, as given in table 8 and table 9.

AMR Metering

As AMR meters were installed at the company to take the benefit of CRC's Early Action Metric, there was an annual cost to be paid to the meter operator (Dataserve) for the operation of meter and online data services. The annual cost of these meters within Barr was £1,606 (Interview 3, LM, 2010) as summarised in table 10. In addition to this service, the company had also chosen to remotely monitor the electricity consumption of its half-hourly metered sites, using the same Dataserve platform; for this service the company paid an additional sum of £2,293 as summarised also in table 10.

Meter type and services	**Unit cost (A)**	**Number of meters (B)**	**Total (A x B)**
AMR Annual Meter operation, Communication, Lease & Maintenance Charges	£146.00	11	**£1,606.00**
HH Meter Annual Meter operation & Communication charges	£254.80	9	£2,293.20
		Total charges	£3,899.20

Table 10: AMR metering costs

Cost Type	**Annual Cost**
Digital certificate for Account Representative	£35.00
Registration Cost	£316.66 (£950 per phase of CRC)
Annual Subsistence Cost	£1,290.00
Total	**£1,641.66**

Table 11: CRC – Other costs

Other Costs

Other costs were identified associated with scheme registration and subsistence costs (Environment Agency, 2012); these are presented in table 11.

Total Financial Impact

Based on the costs identified above, the total financial impact of CRC on the company was estimated. Due to the assumptions involved during the cost identification process, lower and upper CRC cost values are given in table 12.

Cost Type	Minimum annual cost	Maximum annual cost
Allowance Purchase	£227,873.95	£253,193.28
Person-hours	£17,942.30	£30,211.53
Early Action Metric – Carbon Trust Standard	£4,000.00	£6,000.00
Early Action Metric – AMR Metering	£1,606.00	£1,606.00
Other Costs	£1,641.66	£1,641.66
Total Cost	£253,063.91	£292,652.47

Table 12: CRC – Total financial impact on Barr Ltd

Impact on company's existing energy costs

For Barr Limited, the total money spent on energy is summarised by year in table 13.

Year	Energy Spend
2009*	£4,549,631
2010*	£4,129,161
2011**	£5,042,214

Table 13: Annual energy costs

(*source: email communication with SP, Group Financial Accountant, Barr Limited, 19-Apr-11, **source: email communication with SP, Group Financial Accountant, Barr Limited, 22-Feb-12)

Based on these data, an annual energy spend of £5,000,000 and assuming the CRC minimum and maximum annual costs as shown in table 12, it was concluded that there will be an extra 5.06% to 5.85% cost to the company due to CRC.

Cost of non-compliance

If a CRC participant fails to meet its legal responsibilities in the scheme, punitive fines may be imposed. The details of these fines are given in appendix 4, obtained from the CRC's latest published consolidated guidance (Environment Agency, 2012).

Sensitivity Analysis

To establish a final tentative, the elemental breakdown of table 14 was assumed.

Cost Type	Cost Profile	Maximum Annual Cost (% of total)
Allowance Purchase	Covering 90% emissions	£227,873.95 (87.91%)
Man-hours	Average of minimum and maximum	£24,076.91 (9.29%)
Early Action Metric – Carbon Trust Standard	Non-assisted certification cost	£4,000.00 (1.54%)
Early Action Metric – AMR Metering	Cost is constant	£1,606.00 (0.62%)
Other Costs	Cost is constant	£1,641.66 (0.63%)
	Total Cost	£259,198.52

Table 14: CRC costs for sensitivity analysis

As shown, the major impact on the total costs stems from the purchase of allowances and the cost of employee time.

Allowance price

As shown in table 14, it is estimated that Barr would be liable to pay a significant amount of money (i.e. £227,874) to purchase carbon allowances in a year for its 90% emissions (i.e. 21,099.44 x 0.9 = 18,989.50 tonnes of CO_2). If the price of carbon allowances change, it will impact the overall cost of CRC to Barr. For example, based on the above information, if the price of the carbon allowance rises to £15 per tonne of CO_2e in the next CRC year, this will increase the total financial cost of scheme to £212,500. Table 15 shows the impact on the company of changes in the carbon price.

CRC Allowance Price	CRC Allowance Cost to the company	Overall CRC costs for the company	Impact on overall CRC costs for the company
£12	£227,874	£259,199	0%
£10	£189,895	£221,220	- 14.65%
£15	£284,842	£316,167	+ 21.98%
£20	£379,790	£411,115	+ 58.61%

Table 15: Impact of change in carbon allowance price

However, since the price of allowances is driven by the market mechanisms, and not by an individual CRC participant, the company cannot take steps to directly reduce it.

As mentioned in section 1.2, if the CRC consultation proposals are implemented then there should be 2 sales in each year, a low price sale and a comparatively higher price sale thereafter. Since the proposals were not implemented by the end of this research, and the price difference between low price and high price sale was unknown, no analysis was carried out in this regard. However, it was identified that participants with good energy management will receive the incentive as they can ascertain their total emissions rapidly and therefore buy allowances at the lower price.

Carbon reduction

As shown in table 14, 88% of the cost of CRC will arise from the purchase of allowances and the number of allowances to be purchased is dependant on the carbon emissions by the company during a CRC year. Therefore, reducing carbon emissions will reduce the cost of the allowances purchased. Table 16 shows the impact of a change in the company's carbon emissions on its CRC costs.

% Change in Carbon Emissions	Carbon Emissions (tonnes of CO_2)	CRC Allowance Cost to the company	Overall CRC costs for the company	Impact on overall CRC costs for the company
0%	18,989	£227,874	£259,199	0%
-10%	17,090	£205,080	£236,405	-8.79%
-20%	15,191	£182,292	£213,617	-17.58%
+10%	20,888	£250,656	£281,981	+8.79%
+20%	22,787	£273,444	£304,769	+17.58%

Table 16: Impact of change in company's carbon emissions

Person-hours costs

An increase in person-hour costs may occur due to an inexperienced person conducting a task, or an unexpected bottle-neck in getting information from external sources. However, since the person-hour costs are directly proportional to the effort of CRC team members, a well-designed information system can result in a significant cost reduction. Table 17 shows the impact of changes to the person-hour costs on overall CRC costs.

% change in Man-hours cost	Total Man-hours cost	Overall CRC costs for the company	Impact on overall CRC costs for the company
0%	£24,077	£259,199	0%
+25%	£30,096.25	£265,218.25	+2.32%
-25%	£18,057.75	£253,179.75	-2.32%
-50%	£12,038.50	£247,160.50	-4.64%
-75%	£6,019.25	£241,141.25	-6.97%

Table 17: Impact of change in man-hours costs

As it was hypothesised that the costs of person-hours of individual responsibilities could be reduced by implementing an information system, the features of such a system were researched and the outcome presented in section 3.2.

2.7 Chapter summary

In this chapter, the impacts of CRC on a participant company were analysed. Through observation and interviews, it was identified that there are a number of systems already present in the company providing information related to energy. Initiatives such as Carbon Trust Standard certification and AMR metering had already been taken by the company to achieve a good score for the CRC's early action metric. However, it was established that the company still required improved systems and procedures to completely meet its liabilities in the CRC scheme.

The financial impacts of the scheme have been analysed in this chapter and this identified that the main significant cost in CRC was the cost to purchase allowances. The second major cost was the cost of the personnel effort required to meet the company's obligations under CRC. It was identified that the scheme will add an extra 5.06% to 5.85% cost to company's existing energy costs.

3 SYSTEMS & PROCEDURE

As identified in chapter 2, the company required improved systems and procedures to meet its liabilities under the CRC scheme. This chapter presents the development and implementation of the required systems and procedures. The chapter also includes information on the corrective actions that were taken after implementation. At the chapter's end, the characteristics of an information system to assist in reducing the person-hour costs are presented.

3.1 Implementation of systems & procedures

CRC Footprint Tool

A spreadsheet based tool was developed to enable the allocation of CRC costs to specific company activities and identify the monthly information required for CRC reporting (snapshots of the tool are presented in Appendix 25). The tool has the following features.

- Records supply characteristics such as half-hourly, AMR metered or non-half-hourly supply on all electricity supplies.
- Records if a supply shows Estimated or Actual consumption to enable a 10% uplift to be applied where appropriate.
- Records the profile type of a supply to identify if it is residual or business operation related.
- Provides the monthly CRC costs for all major sites, for each division and for the company as a whole.
- The carbon footprint is recorded over a CRC year (i.e. April to March).
- Due to the flexibility of the spreadsheet approach, supplies may be discounted if excluded from the CRC scheme.
- Includes Derv and Petrol record.

In addition to these features, a summary report is included, which provides the final information that must be submitted to the CRC registry for annual reporting. A two-step exclusion is possible: to fuels that are out of scope of CRC (e.g. transport) and to residual supplies that are additional to the required 90% residual percentage.

Figure 10 shows the updated flow of information at the company. Business travel has not been included due to being only 0.21% of the company's carbon footprint (derived from figures shown in figure 8. section 2.3) but requiring significant compilation time due to the multiplicity of information sources.

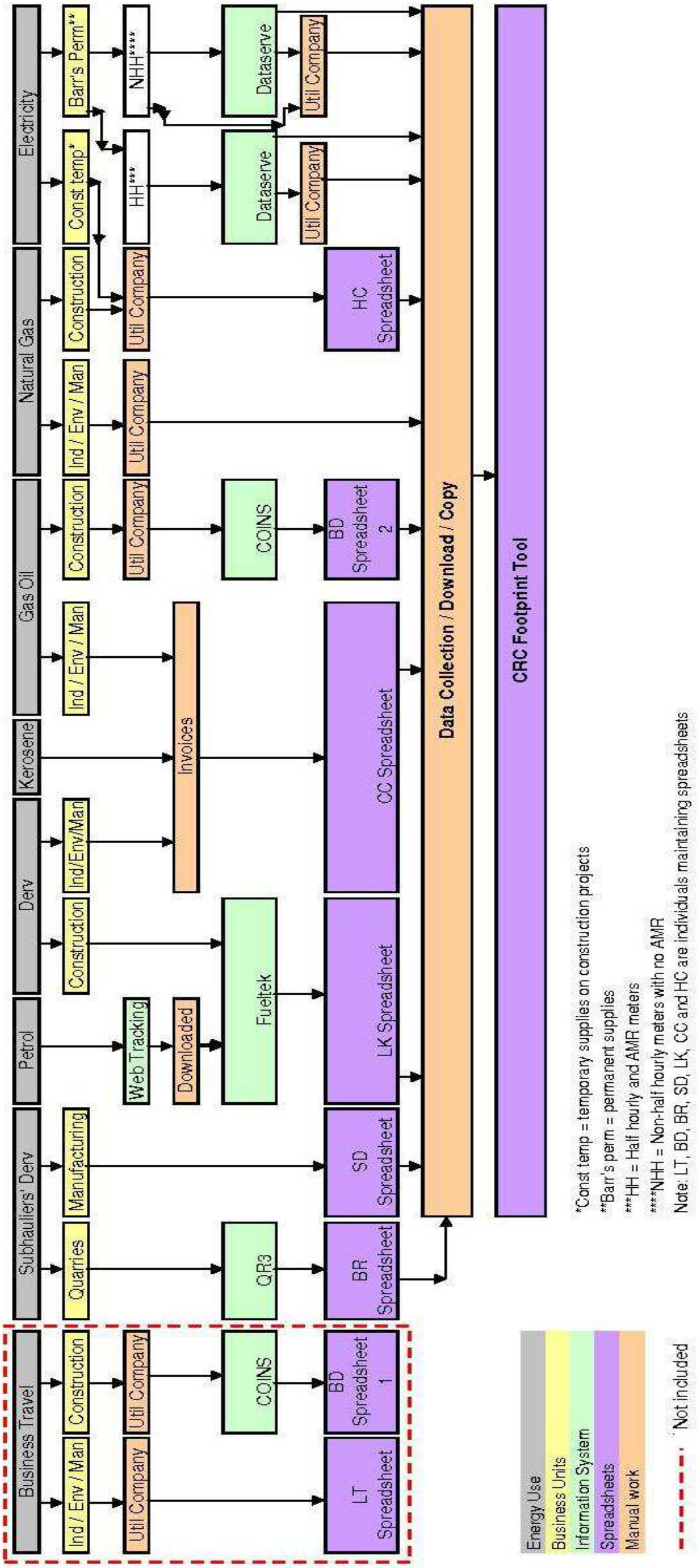

Figure 10: Energy information sources – updated

CRC Team

The CRC Team was set up as proposed and a management level focus group established to monitor the company's CRC performance and agree/implement mitigation opportunities. The focus group comprised company employees with authority to approve and implement the project, and to strategically review the proposals. These employees included the following.

- Managing Director
- General Manager
- Engineering Manager
- Operations Manager
- Finance Manager
- CRC Manager

CRC Procedure

While the CRC procedure was initially implemented as proposed, the following issues were identified after implementation.

- The existing CRC procedure shows the tasks that are required to meet the requirements of CRC. It will help to allocate the resources if the time required for each task is also known. Based on CRC Manager's experience of carrying out the tasks, the 'effort time' for each task should be included in the CRC Procedure.
- By categorising the CRC tasks in the CRC Procedure, it will help in identifying which tasks relate to which of the requirements in CRC scheme. It was appreciated that the tasks need to be categorised to provide a better indication of their relevance to the requirements of CRC.
- The task related to the 'collection and population of fuels data for Industrial, Environmental & Manufacturing divisions' should be scheduled later in the month (after the 3rd week) since the confirmed invoices for the previous month are only then available.
- After the development of company's own CRC Footprint Tool as part of this research, the 'Source List Tool' provided by the Environment Agency is not required any more for very little tasks that it performed. The tasks related to 'Source List Tool' should now be performed using company's own CRC Footprint Tool.
- It was scheduled to check the CRC Performance League Table publication in late September but, as observed, this cannot be published before November due to the surrender of allowances being required by the end of September. The check should instead be scheduled for late November.
- Since the surrender of allowances is now required in the end of September, the tasks involving these should be moved to later in the procedure.

Based on above observations, the procedure was updated (available in Appendix 27-B) using the research outcomes. There follows the key changes to the CRC procedure.

- The tasks have now been categorised, as

- Data download/duplication
- Internal communication
- External communication
- Internal audit
- Evidence Pack update
- Tool update
- Data analysis & reporting

- Tasks referring to the 'source list tool' have been updated to refer to the 'CRC Footprint Tool'.
- Improvements related to the correction of the task schedule have also been implemented.
- The 'effort time' for CRC tasks has been identified. The total effort time has been identified as 57 days, which is close to the assumed 3 months in section 2.6.

CRC Evidence Pack

The evidence pack was prepared as proposed. The divisional managing directors review and sign the audit certificates, and also the main page of the hard copy evidence pack, every 3 months. The hard copy files for the following bills/invoices were set up, as proposed, to improve record keeping, and the respective administrative assistants were given the responsibility to maintain and update these files on a monthly basis:

- fuel quantities delivered to Industrial, Environmental and Manufacturing division sites;
- electricity and natural gas bills for Industrial, Environmental and Manufacturing division sites.

CRC Internal Audits

Internal audits were being conducted as proposed. Due to availability of hard copy folders for fuel invoices and the set-up of an Intranet-based folder for the Construction Division's electricity and gas bills, the time required for auditing was reduced. This reduction in time requirement was considered when updating the CRC procedure (Appendix 27-B).

3.2 Characteristics of a future CRC Information system (CRCIS)

As identified in section 2.6, the costs associated with individual responsibilities in a CRC participant organisation are significant. It was hypothesised that these costs can be reduced by implementing an IT information system. The characteristics of this proposed CRC Information System are discussed in this section.

- Sources of information

The basic information required by the company for the assessment of its CRC qualification as well as the annual and footprint reports and evidence pack are presented in table 18. This table has been developed on the basis of following information

- The categories in the table have been identified as follows.
  - Energy sources (electricity, gas *etc.*) were identified initially through interview (Interview 1, AG, 2010) and subsequently by monitoring.
  - ‘Communication with Environment Agency’ was identified from the CRC Evidence Pack requirements.
  - The remaining categories were identified through review of the CRC scheme (section 1.2).
- Information under the columns ‘Required Information’, ‘CRC Qualification Assessment’, ‘CRC Annual/Footprint Reports’ and ‘CRC Evidence Pack’ was identified through review of the CRC Scheme (section 1.2)
- The information sources were identified by internal interviews with the Engineering (Interview 1, AG, 2010) and Finance Managers (Interview 3, LM, 2010), and through observation at the company.

Category	Required Information	CRC Qualification Assessment	CRC Annual / Footprint Reports	CRC Evidence Pack	Information Source/s
Electricity	Site Name		☑	☑	Electricity Bill / Annual Statement / Dataserve
	Supply Type	☑	☑	☑	Electricity Bill
	Settled / Non-settled	☑		☑	Supplier
	Consumption (kWh)	☑	☑	☑	Electricity Bill / Annual Statement / Dataserve
	Estimated / Actual		☑	☑	Electricity Bill / Annual Statement / Dataserve
	AMR / Non-AMR		☑	☑	Electricity bill & Dataserve
	Supply installation / termination records	☑		☑	Installation / Termination letter
Gas	Site Name		☑	☑	Gas Bill / Annual Statement

	Meter type		☑	☑	Supplier
	Consumption profile		☑	☑	Gas Bill / Annual Statement
	Consumption (kWh)		☑	☑	Gas Bill / Annual Statement
	Estimated / Actual		☑	☑	Gas Bill / Annual Statement
	AMR / Non-AMR		☑	☑	Gas Bill
	Supply installation / termination records			☑	Installation / Termination letter
Gas Oil	Site Name		☑	☑	Monthly site / report / Invoice
	Consumption / Delivery (litres)		☑	☑	Monthly site / report / Invoice
	Estimated / Actual		☑	☑	Monthly site / report / Invoice
Kerosene	Site Name		☑	☑	Monthly site / report / Invoice
	Consumption / Delivery (litres)		☑	☑	Monthly site / report / Invoice
	Estimated / Actual		☑	☑	Monthly site / report / Invoice
LFO / Burning Oil	Site Name		☑	☑	Monthly site / report / Invoice
	Consumption / Delivery (litres)		☑	☑	Monthly site / report / Invoice
	Estimated / Actual		☑	☑	Monthly site / report / Invoice
Derv	Consumption / Delivery (litres)		☑	☑	Monthly site / report / Invoice / FuelTek
Organisational structure		☑		☑	Organogram
Internal data audits				☑	Audit certificates
Employees Accommodation supplies liability			☑	☑	Accommodation agreement
Residual supplies			☑	☑	RML

PFI supplies liability			☑	☑	PFI contract terms
Early Action Metric	AMR installation record		☑	☑	Dataserve/AMR agreement
	CT Standard or equiv. Evidence		☑	☑	Standard certificate
	Standard's emissions coverage boundary		☑	☑	Standard certificate / Audit report
	Standard's period of coverage		☑	☑	Standard certificate
Growth Metric	Annual turnover of the whole group		☑	☑	Finance report
Communication with Environment Agency				☑	Emails, letters

Table 18: CRC Information System - Information table

The Information System for CRC must be capable of taking information from the above-mentioned, diverse range of sources.

- Manual entered / AMR energy consumption information

The energy usage information for different sites was available in different formats. As in 2010, the company had 26 permanent sites, and 17 temporary construction division sites. Of these sites, there were 9 with half-hourly electricity meters and 8 with AMR electricity meters. The remaining 12 permanent sites accounted for less than 1% of the company's total electricity consumption, and their consumption was available as monthly or quarterly electricity bills. There were another 17 temporary sites (within the construction division) where the company was found liable for the electricity use. The electricity usage at these sites was only recorded from monthly or quarterly bills. 4 sites had gas supplies, with consumption information also available only from monthly or quarterly bills. Liquid fuels information was also recorded from invoices: this provided the quantities of fuel delivered rather than consumed, but this was identified as the easiest approach acceptable in terms of CRC requirements.

The CRC information system (CRCIS) should be capable of interfacing with the half-hourly meters, AMR meters and electronic fuel meters, and should also provide a user input mechanism, such as forms, where the energy usage data for both monthly and quarterly billed sites can be entered into the system.

- Conversion into emissions

The CRCIS should be able to convert the energy usage figures into equivalent carbon emissions and be able to accept the CO_2e conversion factors suggested by the Environment Agency for CRC (Appendix 28).

- Residual percentage exclusion

The CRCIS should provide the ability to exclude single or multiple sites accounting for 10% of the excludable emissions. This feature will not be required if the proposal to remove the residual percentage rule, introduced in the 2012 consultation, is approved.

- Manually entered supply characteristics

The CRCIS should record the characteristics of each supply, such as type, settled/non-settled, estimated/non-estimated, AMR/non-AMR for electricity. For gas, it should record the meter type, consumption profile, AMR/non-AMR and whether estimated or actual. For other fuels, it should record whether the data is estimated or non-estimated. For CRC qualification assessment and footprint/annual reports, the CRCIS should be able to sort the supplies on the basis of supply characteristic as well as separating out core and residual supplies.

- Storage of records

The CRCIS should be able to store the records required for each of the following categories, and any other categories that may be identified later, in a universally readable electronic format. This information will service both internal and external audits.

- Organogram
- Internal Audits
- Employees Accommodation Agreement
- PFI Agreement
- Residual Supplies Information
- EAM Record
- Growth Metric Record
- Communication with Environment Agency

- Frequency of information capture

The CRCIS should be capable to record the information at a frequency that facilitates annual reporting. The CRC year runs from April to March and reports are required to be submitted by the last working day of July. For improved energy management, the system should be able to record information on a monthly basis. Such information may also help in

- reporting for Carbon Trust Standard (or equivalent), which requires calendar year information;
- allocation of CRC costs to operational sites and divisions where the costs can be accrued on a monthly basis.

- Allowance purchase

The CRCIS should be able to determine the number of allowances that need to be purchased to meet the regulatory requirement. This information can be obtained by calculating the company's emissions in tonnes of CO_2e after meeting the residual percentage rule.

- Task reminders

There should be a feature in the information system to allocate responsibility, to a person or group, to enter data. The CRCIS should be able to email task reminders to such people or groups, with reminders based on the timeline identified in the CRC procedure (Appendix 27-B).

- Changes to CRC in 2012 Consultation

If the changes proposed in the CRC 2012 consultation (DECC, 2012) are implemented then the following adaptations of the CRCIS specification will be required.

- The system will not be required to separate the 10% residual supplies as no footprint report will be required to be submitted.
- Domestic Electricity supplies (Profile Class '01' and '02') and Gas (non daily metered and having supply of 73,200 kWh per annum or less) will be excluded and their monitoring will not be required for CRC.
- The use of Gas Oil and Kerosene will be required to be separated in terms of their end use. For example, if the company used 'x' litres of Gas Oil, it will be required to record how much of that has been used for heating and how much for power requirements.

The above-mentioned requirements of the CRCIS are the minimum requirements that must be met for compliance. However, to attain best practice the CRCIS should be able to do more than just demonstrate compliance. Additional features are suggested below.

- CRC cost allocation

A key requirement in a complex CRC participant organisation is to allocate the CRC costs to individual sites. From monthly energy usage information, the CRCIS should be able to provide a site's monthly carbon footprint and CRC cost. The monthly carbon footprint of each site can be used to obtain a CRC cost for the month to that site. These costs can be accrued on a month by month basis through the company's Finance Department, instead of charging full year's CRC costs to a site at the end of CRC year. This will avoid a financial burden on each site at the end of CRC year, and also increase awareness in Site Managers about CRC costs, as they will pay their monthly CRC cost bills to the Finance department.

- Information on individual entities

Energy use information may also be captured at the entity level, through metering entities such as crushers, coating plants *etc*. As discussed in the transport reporting system case study (Section 5.7), monitoring individual entities can significantly improve energy management by helping to identify the reason of energy wastage.

- Information for monitoring & verification

As will be discussed in Chapter 5, the monitoring and verification by the CRCIS of implemented carbon reduction opportunities is necessary. An opportunities database, with accompanying MACC/ERIC plotting, should be included in the CRCIS, with a feature to compare the initially anticipated and actual performance of implemented opportunities.

- Overall reduction and savings

Through monitoring and verification of implemented carbon reduction opportunities, the CRCIS should be able to generate the reports of carbon reduction, energy savings and energy cost savings over any arbitrary period of time.

- Integration with other information systems

The CRCIS should support interfacing with other information systems to ensure that relevant information held elsewhere can be readily obtained. Interfacing with sales and production information systems, for example, will enable the determination of key performance indicators such as kWh per tonne in support of benchmarking exercises. Identifying the energy cost per unit of product also enables the company to transfer the CRC costs to the customer where appropriate.

3.3 Chapter Summary

In this chapter, new and improved systems and procedures were implemented at the company to work in line with some existing systems to completely meet the CRC liabilities. In addition to the proposals in chapter 2, support actions were also undertaken such as the setting up of a CRC focus group and the implementation of revised CRC procedures. In this chapter, the characteristics of a proposed information system CRCIS (CRC Information System) were also identified based on the learning stemming from the work reported in chapters 1 through 3.

4 CARBON REDUCTION OPPORTUNITIES

The impacts of CRC on Barr were discussed in detail in chapter 2. Various information and procedural requirements were described that a CRC participant must meet to assess its qualification for the scheme and to stay compliant within the scheme. In the financial impacts analysis section, it was identified that the impacts of CRC are not only derived from information management and evidence keeping; a participant organisation must also reduce its carbon emissions while a major source of CRC cost is the purchase of allowances on the basis of the company's carbon emissions. In addition to fuel price rises, market competition and stakeholder pressure, CRC introduces another driver to reduce carbon emissions and energy costs. Since all companies operating in a particular sector are not liable to CRC, those who are participating risk losing competitiveness in their sectors if the CRC costs are not driven down.

This chapter includes the identification of the carbon reduction opportunities available at Barr and the development of management support information (in the form of MACC and ERIC curves) on the basis of data collected about these opportunities, and then the development of a new CALoRIC (Carbon Abatement Low Risk Investment Curve) curve to address the issues identified in using MACC/ERIC curves. The chapter also includes the response from the CRC participant company to the information inherent in these curves.

The following approach was used to assess and implement the carbon reduction opportunities at the company.

- Establishment of an energy/carbon baseline.
- Identification of carbon reduction opportunities.
- Use of MACC and ERIC tools to analyse opportunities.
- Development and use of CALoRIC tool to analyse opportunities.
- Implementation of opportunities based on organisation specific criteria.

4.1 Establishment of energy / carbon baseline

Chapter 2, table 4 showed energy consumption data for Barr in the CRC qualification year 2008. In terms of carbon emissions, these figures were graphically expressed in chapter 2, figure 8, derived on the basis of company's 2008 carbon footprint breakdown (Interview 1, AG, 2010).

The energy usage figures, by source, suggest the need to target reduction in the use of Gas Oil, Derv, Electricity and burning fuels (Kerosene and Coating plant fuels / LFO). In terms of costs of fuel usage, which also affect the competitiveness of the organisation, figure 11 shows the breakdown of costs among these energy sources as in 2008.

Figure 11 shows that the biggest proportions of energy costs are associated with Derv, Gas Oil and Electricity consumption. Therefore, both in terms of carbon emissions and energy costs, the use of these energy sources provide substantial opportunities. Though Derv is not included in the scope of CRC, it is vital to include it when developing long term strategies and carbon reduction goals.

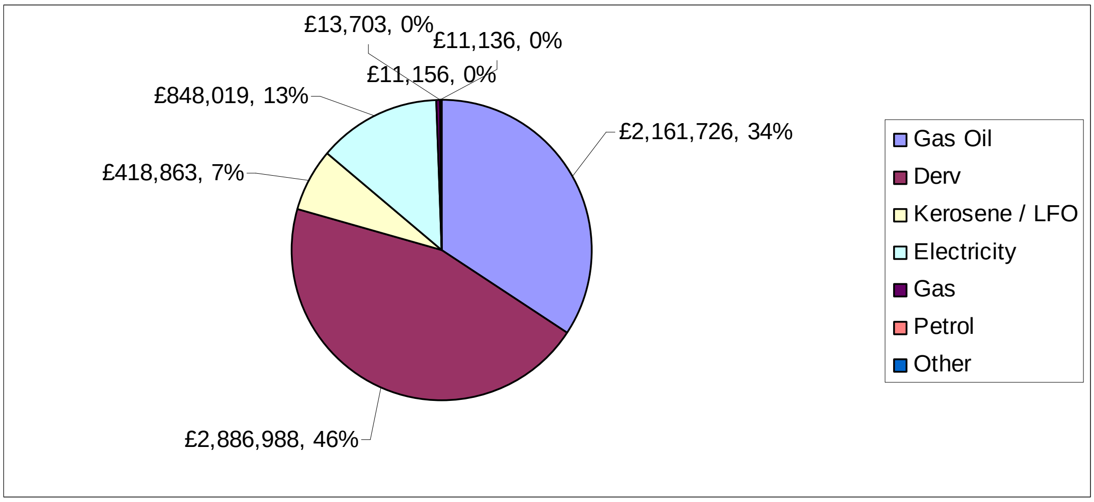

Figure 11: 2008 energy costs by fuel type

To elaborate the opportunities, available information was used to identify division specific emissions at Barr. This information provided insight into areas that need to be tackled for reduction in carbon emissions.

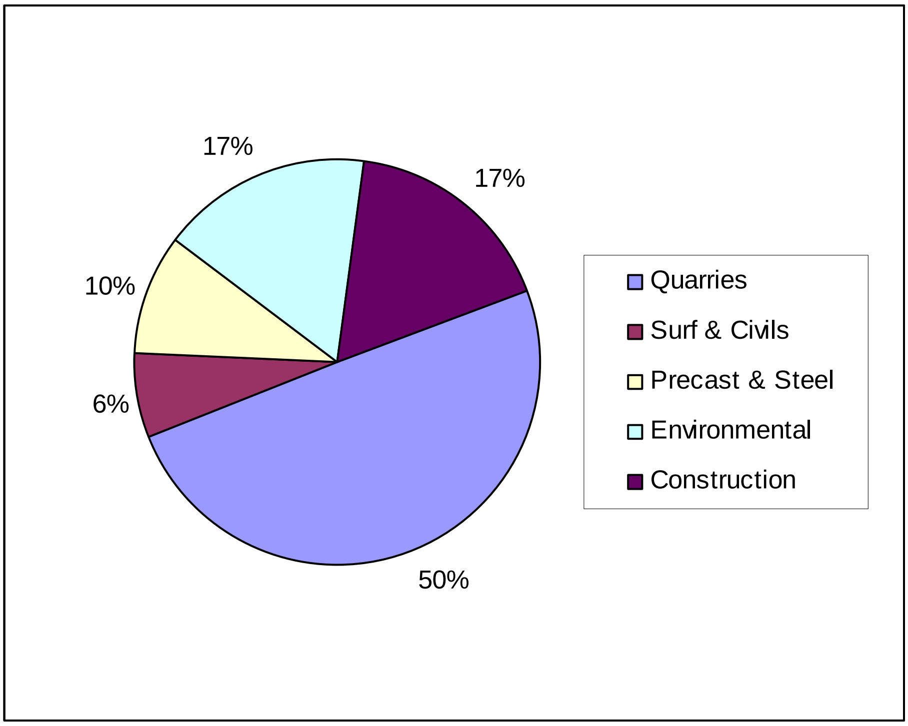

Figure 12: Pie chart: Carbon emissions by division

Figure 12 suggests that energy consumption in Quarries (i.e. Aggregates sector) should be focussed on since this accounts for half of the organisation's total emissions.

Based on the available information, a realistic target of 15% reduction by 2018 from the 2008 base level was set by the company which means that 4,281 tonnes of CO_2e were to be reduced in the 10 years from 2008.

4.2 Identification of carbon reduction opportunities

The carbon reduction opportunities within the company include the opportunities that were previously identified and a further 10 identified during the course of this research. A spreadsheet tool (Somar, 2010) was adapted for use to prepare MACC curves. The opportunities were as follows.

Previously identified opportunities

At the start of the research, there were three energy saving opportunities, that the company was considering for implementation, as follows.

IT Server Room

It was proposed by the company's Information Systems Manager to introduce passive cooling of the server room with the recovered heat used in the adjacent stores. Appendix 29 provides details of this proposal.

A spreadsheet was developed to analyse the viability of this system (Appendix 9), which indicated that this option would result in a reduction of 43.7 tonnes of CO_2e per annum.

Vertical Bitumen tanks

Bitumen tanks are used at Barr's Asphalt/coating plants to store the bitumen at desired temperatures. Depending on the grade of bitumen, it must be kept between 150^{o}C and 180^{o}C to ensure that it does not solidify and mixes effectively with aggregate during the production of Asphalt and other bituminous products (Personal communication with GK, Quarry Manager at Tormitchell Quarry, Barr Limited, 01-Mar-2010).

Traditionally, horizontal cylindrical tanks were used to store the bitumen. However, vertical tanks are now becoming more popular because there is less surface area available, resulting in reduced oxidation. Vertical tanks also provide a higher capacity to hold the bitumen safely (Personal communication with AG, Engineering Manager, Barr Limited, 01-Mar-2010).

A spreadsheet tool, developed by the Energy Systems Research Unit at the University of Strathclyde for Cormac bitumen tanks was used to model the benefits of possible replacement of Barr's existing bitumen tanks with electrically heated vertical tanks (Appendix 10). On the basis of results from this tool, it was proposed to replace two existing 52.8 m^3 horizontal cylindrical tanks with Cormac's 77 m^3 vertical tanks; and to replace the 46.8 m^3 horizontal square tank with a 55 m^3 Cormac tank. An additional spreadsheet (Appendix 11) was developed to prepare a business case for cumulative costs and potential savings. It was estimated that, at a cost of £161,387, such tank replacement can reduce CO_2e emissions by 222 tonnes at a saving of £36,133 per annum.

Coating plant burner replacement

Burner replacement (or optimisation) can result in significant savings in a coating plant's energy use. Using a Vulcan burner, Cemex has reduced its energy consumption of its asphalt plant by over 20% (Hub-4, 2011).

A burner replacement was proposed for Barr's Quarry coating plant. The plant needed a burner replacement as it had significantly passed its projected lifetime (Interview 2, AG, 2010). The cost of replacement was quoted as £30,000. For a projected production of 20,000 tonnes per year, and achieving a saving of 1.5 litres per tonne of fuel, a reduction of 83.45 tonnes of CO_2e is expected per annum (Appendix 16 presents the business case calculations).

New carbon reduction opportunities

These opportunities were identified through the analysis of data obtained from a number of sources such as existing metering, site surveys and existing information systems, which will be discussed in detail in the following sections. The opportunities include a mix of renewable energy deployments and energy efficiency measures.

- New opportunities on the company's most energy intensive site

Killoch is the main depot of Barr Holdings, being the head office of Barr's three main divisions, which are Barr Industrial, Barr Environmental and Barr Manufacturing. From the company's 2008 carbon footprint (Interview 1, AG, 2010), it was identified that this site was the highest electricity consuming site of the company, accounting for 15.34% of company's electricity consumption.

As identified later in by the company's CRC footprint tool, which was developed during this project, the carbon intensity of the company's sites in CRC year 2011-12 was as presented in table 19.

The following step-by-step approach was taken to identify the opportunities at the site.

- Analysis of the site's main meter half-hourly electricity data.
- Analysis of sub-metered data.
- Site surveys.

Site specific carbon emissions (Apr-11 to Mar-12)		
Division	**Site**	**CO_2 emissions (tonnes)**
Industrial	Killoch Depot	3,657
	Barlockhart Quarry	1,949
	Tormitchell Quarry	1,723
	Tongland Quarry	1,208
	Sorn Quarry	897
	Swinlees Quarry	825
	Clayshant Quarry	407
	Moorfield Concrete	263
	Beatockhill Quarry	81
	Ardeer Quarry	44
	Surfacing & Civil operations	42
Environmental	Garlaff Landfill	1,186
	Auchencarroch Landfill	1,176
	Heathfield Recycling Centre	745
	Southhook Waste Transfer	68
Manufacturing	Solway Precast	1,509
	Solway Steel	719
Construction	Construction – All	2,249

Table 19: Carbon intensity of company's sites

Site Details

On the basis of installed electricity sub-meters, Killoch depot can be divided into 6 areas, which are a main office building (locations 1 and 4 in figure 13), IT office (location 3), fabrication workshop (location 5 and 6), ready-mix concrete plant (location 19), coating (asphalt) plant location 16, 17 and 18), and garage (location 2 and all of the brown area).

Analysis of half-hourly data

To understand the electricity consumption at Killoch depot, half-hourly electricity data was sourced from the Dataserve Web-based system. Table 20 presents the daily electricity consumption for the month of February 2010.

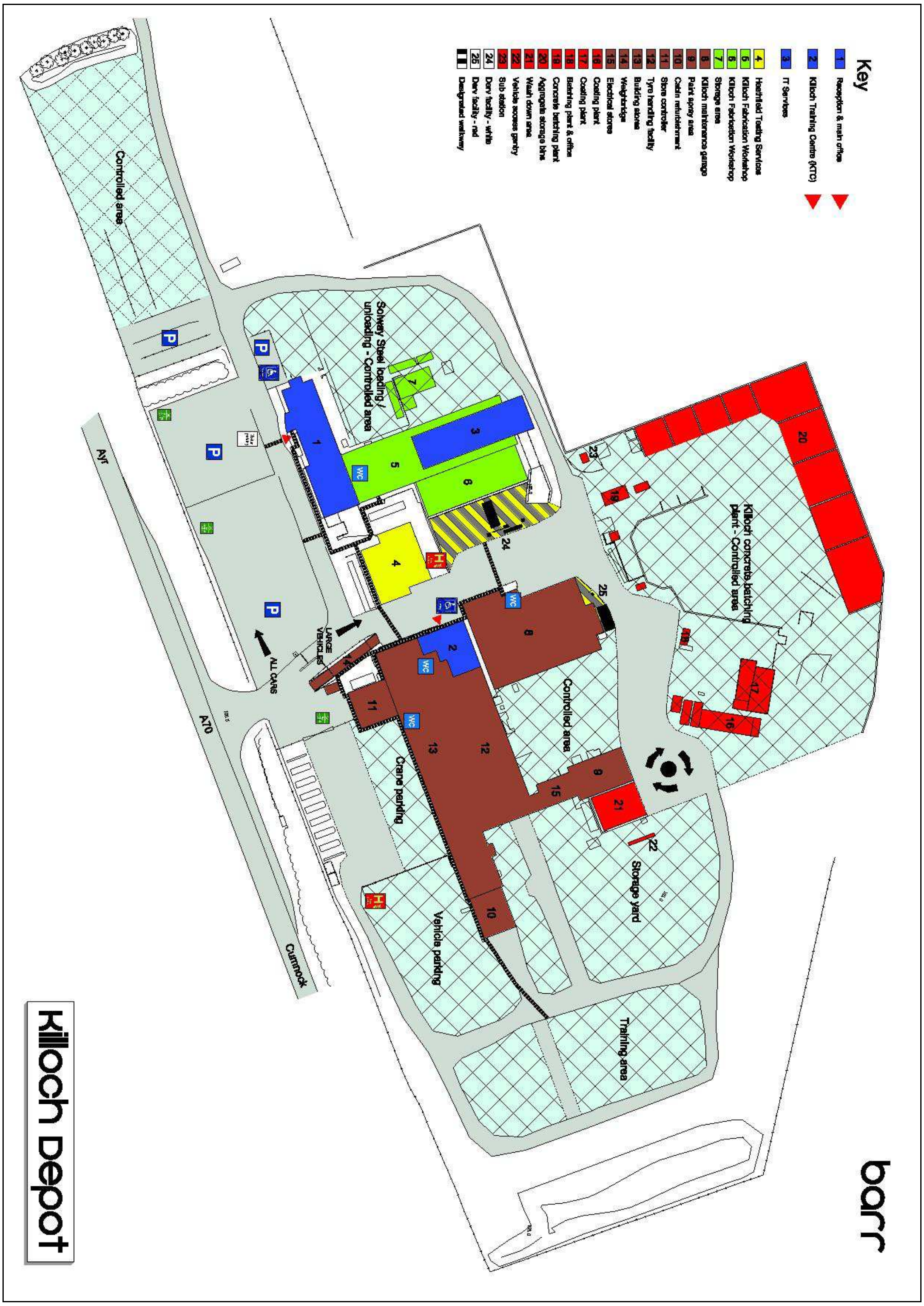

Figure 13: Killoch Depot

Date	kWh	kVArh
1 February 2010	5025	1546
2 February 2010	4838	1469
3 February 2010	5155	1588
4 February 2010	5124	1596
5 February 2010	4728	1496
6 February 2010	3688	933
7 February 2010	3361	659
8 February 2010	4873	1496
9 February 2010	4857	1580
10 February 2010	5026	1786
11 February 2010	4645	1482
12 February 2010	4238	1449
13 February 2010	3566	952
14 February 2010	3480	866
15 February 2010	4746	1442
16 February 2010	4584	1438
17 February 2010	4535	1404
18 February 2010	4666	1488
19 February 2010	4492	1437
20 February 2010	3913	1153
21 February 2010	3475	723
22 February 2010	4761	1453
23 February 2010	5109	1693
24 February 2010	4824	1212
25 February 2010	4831	1376
26 February 2010	4908	1692
27 February 2010	3873	1082
28 February 2010	3430	733

Table 20: Killoch half hourly electricity data – Feb 2010

The highlighted rows in table 20 represent Weekends. Electricity consumption over 3,000 kWh on a Saturday or Sunday indicates that the base load of this site is over 60%, which is typically high. As observed, there is normally only one person (the security guard) present on site 24 at all times. The coating plant or concrete plant may be operated part-time at the Weekend in case of an increased product demand. Table 20 shows less reactive load on some Saturdays and all Sundays in February 2010. This is due to zero usage of concrete and coating plants, as confirmed by the sales team (personal communication, 15-Mar-2010). Figure 14 shows the electricity consumption (kWh) for February 2010 over the 48 half-hourly periods, which clearly identifies the issue of high base load at night.

Sub-meters data analysis

To understand the electricity consumption at Killoch depot, data sourced from manual readings of the sub-meters was analysed. The 6 sub-meters (of type Carlo Gavazzi EM25-96) were manually read and the data analysed via a custom spreadsheet (Figure 15). The aim was to understand the specific electricity consumption of each of the 6 units during and outwith working hours (7:30 a.m. to 5 p.m.) and at Weekends.

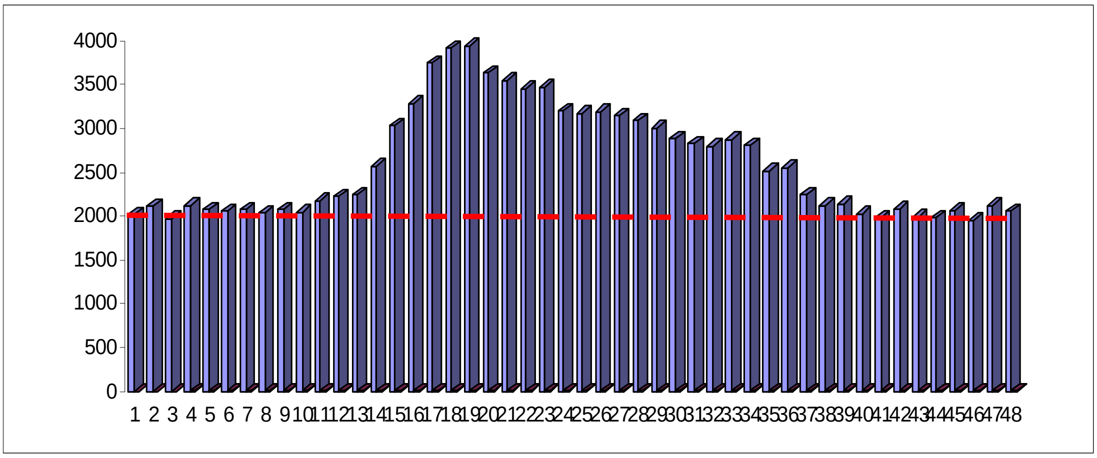

Figure 14: High base load

Sub-meters at Killoch

Meter	Reading 1(10 am)	Reading 2(2 pm)	Diff (1-2)	Reading 3(4 pm)	Diff (2-3)	Diff (1-3)	Reading 4(7:30 am)	Diff (3-4)	Diff (1-4)	Reading 5(10 am)	Diff (4-5)	Diff (1-5)
Ready mix plant	8826.1	8830.8	4.7	8831.3	0.5	5.2	8836	4.7	9.9	8837.6	1.6	11.5
Coating plant	19518.4	19550.5	32.1	19558.1	7.6	39.7	19615.1	57	96.7	19642.7	27.6	124.3
Garrage	27006.3	27028.4	22.1	27038.6	10.2	32.3	27087.5	48.9	81.2	27101.7	14.2	95.4
Main office	32193.8	32218.5	24.7	32230.6	12.1	36.8	32285.6	55	91.8	32300.7	15.1	106.9
KFW	16929	16929.5	0.5	16929.8	0.3	0.8	16932.8	3	3.8	16933.2	0.4	4.2
IT	47484.8	47498	13.2	47504.4	6.4	19.6	47549.9	45.5	65.1	47557.8	7.9	73
Submeters Sum	-	-	97.3	-	37.1	134.4	-	214.1	348.5	-	66.8	415.3
Main meter	60429	60528	99	60566	38	137	60786	220	357	60854	68	425
DataServ	-	-	98.7	-	38.1	-	-	217.2	-	-	70.4	424.4

Location	Electric load (kW) Between 10 am and 2pm	Between 2pm and 4pm	Between 4pm and 7	Between 7:30am and 10am
Ready mix plant	11.7	2.5	3.0	6.4
Coating plant	80.2	38.0	36.8	110.4
Garrage	55.3	51.0	31.5	56.8
Main office	61.8	60.5	35.5	60.4
KFW	1.3	1.5	1.9	1.6
IT	33.0	32.0	29.4	31.6
Total	243.2	185.5	138.1	267.2

Note: Timings are GMT based.
This electricity monitoring exercise was conducted on 21st and 22nd April 2010.

Figure 15: Comparison of Killoch electricity data from various sources

Meter readings were taken 5 times between 10 a.m. on 21 April 2010 and 10 a.m. on 22 April 2010. The electric load identified during these periods is shown in table 21.

Electric Load (kW)				
Location	Between 10 am and 2pm	Between 2pm and 4pm	Between 4pm and 7:30am	Between 7:30am and 10am
Ready mix plant	11.7	2.5	3.0	6.4
Coating plant	80.2	38.0	36.8	110.4
Garage	55.3	51.0	31.5	56.8
Main office	61.8	60.5	35.5	60.4
KFW	1.3	1.5	1.9	1.6
IT	33.0	32.0	29.4	31.6
Total	243.2	185.5	138.1	267.2

Table 21: Killoch sub-metered half-hourly electricity data

The high electricity load in the coating plant is due to bitumen heating programmed to switch on at night. As the servers at Killoch run constantly, the IT office load remains essentially constant 24 hours a day. However, no reason could be found for the high night time load in the main office and garage.

Day and night time surveys

After the analysis of half-hourly and sub-metered electricity data, it was identified that the base load of the site was higher than expected and that there was a need to identify entities that might be switched off to reduce this load. To identify these entities, day and night time surveys were conducted. A survey sheet was designed for this purpose as shown in figure 16. Support was given by the company's electrician to help identify the power rating of each energy consuming entity.

Table 22 shows the survey results, which indicates that the high night time load in the main office and garage is due mainly to IT equipment, lights and heaters being left on overnight.

Possible energy saving opportunities were identified as:

- installation of plug-in-timers to confine available power to working hours;
- replacement of luminaries with energy efficient alternatives.

As observed during the surveys, the site offered space for possible wind or solar installations as an approach to reducing carbon emissions. It was therefore proposed to investigate the feasibility of the following technologies.

- solar photovoltaic (PV).
- wind turbine.

Electricity Audit

Zone:	**Garrage**	**Annual -**				
Working hours:		Working days		pence/kWh (day)		
Occupants:		Holidays		pence/kWh (night)		
Infiltration:		Off-hours weekdays		kWh saving (day)	0	
Insulation:		Off-hours holidays		kWh saving (night)	0	(only considering yellow boxes)
		Total off-hours (day)		£ saving	£0	
		Total off-hours (night)				

1~2.49 kW
2.5 ~ 10 kW
>10 kW

	Type	Model	Qty	Qty night	Rating (kW)	Rating kW Night	Total kW	Night Total kW	Normal/Standby
Lights									
	Tubes								
	Tubes								
	Spots								
	Security lights								
	Any other								
Computers									
	Laptops								90/3 watts?
	Desktops								100/10 watts?
	Servers								300/30 watts?
	Battery banks								
	Monitors-TFT								35/1 watts?
	Monitors-LCD								35/1 watts?
	Monitors-CRT								80/5 watts?
	Docking stations								
Office Mac.									
Printers	Printer-Deskjet								20/1.5 watts?
	Printer-Inkjet								30/3 watts?
	Printer-Laser								400/40 watts?
	Printer-Dot matrix								60/18 watts?
	Scanners								
	Plotters								
	Fax machine								120/3 watts?
	Combo								120/3 watts?
	Paper shredder								
	Projectors								240/1 watts?
	Paper consumption / day								
	Tea/coffee mac.								
	Microwave								
Heating/Cooling									
	Kerosene heater (w'shop)								(assumed)
	Kerosene heater (paintshop)								
	Split air-con								standby 10%??
	Split air-con								standby 10%??
	Split air-con								standby 10%??
	2kW electric heaters (resistance)								
	Wall mounted fans								
	Fan-heater								
	wall mounted tube-heaters								
	Fridge								
	Hot water (toilet/kitchen)								
Any other mac.									
	Compressor (15 kW)								
	Washer motor								
	Exhaust fan								
	Radio								
	Vehicle lifting motor								
	Vehicle rolling road motor								
	Roller door motor								
	Extractor fans								
	110V transformer								
	Tyre fitting motors								
	Grill								
	Welding machine								
Plant Equipment									
				Total	**0**	**kW**	**Total**	**0**	**kW**

Figure 16: Killoch Survey Sheet

	Quantity			Load (kW)		
Garage	Total	Night	% of total at night	Total	Night	% of total at night
Lights	301	18	5.98%	25.62	3.22	12.57%
IT and Utilities	257	35	13.62%	19.13	0.21	1.10%
Heating/Cooling	52	12	23.08%	121.88	19.34	15.87%
Other	32	3	9.38%	136.08	6.03	4.43%
Main Office	Total	Night	% of total at night	Total	Night	% of total at night
Lights	672	77	11.46%	70.83	13.01	18.37%
IT and Utilities	264	62	23.48%	40.11	1.24	3.09%
Heating/Cooling	135	22	16.30%	380.91	34.2	8.98%
Other	65	1	1.54%	130.99	2	1.53%
Both Locations	Total	Night	% of total at night	Total	Night	% of total at night
Lights	973	95	9.76%	96.45	16.23	16.83%
IT and Utilities	521	97	18.62%	59.24	1.45	2.45%
Heating/Cooling	187	34	18.18%	502.79	53.54	10.65%
Other	97	4	4.12%	267.07	8.03	3.01%

Table 22: Killoch survey results

Plug in timers (PIT)

During the day- and night-time audits, it was identified that some space and water heaters were operating when not required.

A spreadsheet tool was established to assess the case for plug in timers (Appendix 5). It was identified that if 10 of the continuously running space heating units were fitted with plug-in-timers, this would result in a saving of £4,950 and a reduction of 27 tonnes of CO_2e per annum. A programmable weekly timer was proposed (OWL, 2010). It was proposed that, if implemented successfully, the use of these PIT units would be disseminated throughout the company. However, there were some issues identified which will be discussed in Chapter 5 section 5.1.

Energy Efficient Lighting

As identified during the surveys, 17% of the night time load of the site arose from lighting (Table 22). This provided the opportunity to replace existing conventional lamps (high power Sodium-vapor, metal halide and fluorescent) with energy efficient alternatives.

Since LED is a relatively new technology, there is less confidence over its suitability and reliability in certain environments. It was not clear how the LED lights will work in different working environments, and also if the lights really deliver the savings as claimed. It was therefore proposed that lamps should be replaced with LED alternatives in the vehicle repair workshop, paint-shop and car parking area. It was proposed to undertake a partial replacement to ensure that the technology is suited to the activities being undertaken, and it can deliver the energy savings as anticipated.

Table 23 shows the light fittings as proposed for trial replacement. Appendix 6 provides the technical specification of the LED light fittings along with results from the spreadsheet tool as used to analyse quotations.

	Existing Lighting		**Replacement Lighting**	
Location	Model	Power (Watt)	Model	Power (Watt)
Paint-shop	SON	300	SUN48	64
Workshop	Metal Halide	300	SUN48	64
Workshop	Twin Fluorescent	168	VP24	32
Car Park	SON	300	Jupiter36	50

Table 23: Existing vs. Replacement Lighting (LED)

Solar PV

A simulation was carried out using the PVSYST simulation tool (Appendix 7) to identify the Solar PV potential of the site. This indicated an estimated yield of 779 kWh per kW_p installed. The system as analysis corresponded to the following assumptions.

- System is grid connected
- Weather data from Glasgow Airport
- PV tilt angle of 30˚
- South facing
- No over-shading
- Kyocera KC 200GHT 200 Wp Panels * 13 modules in series * 4 modules in parallel = 52 modules producing a nominal power of 10.4 kWp
- Sunny Boy SB 6000 U-208 5.2 kW Inverter * 2

Quotations were invited from MCS approved suppliers/installers for 10 KWp, 30 kWp and 50 kWp systems. A spreadsheet tool was developed to analyse alternative configurations (figure 17), with outcomes as shown in table 24. Based on these results, a 50 kWp PV system was proposed to be installed on the roof of the stores building at Killoch. As observed during site surveys, this roof (location numbers 12 and 13 in figure 13) was found to be suitable. It is situation at a reasonable distance from a near-by coal storage site that it was considered unlikely that panel efficiency would be reduced due to coal dust deposition. Also, since the roof faces a highway, as shown in figure 18, the possibility existed to make the installation visible to the public as a marketing instrument. The lower floors of the building were in minimal use as a storage area, and only a small portion of the upper floor was being used to archive files. There was no long term plan to adapt the building to any other use, making it easier to install Solar PV without affecting any other operations on site. The roof construction comprised a concrete post and beam construction overlaid with 25 mm insulation and a double-ply bitumen/foil type material (Personal Communication with CS, Assistant MD, Barr Industrial, 11-May-2011).

Solar PV installation:

Total solar power	50	kWp	(Hyundai 250Watt, 1645x983mm)		
Total panels required	200	panels			
Each kWp cost	£2,700	GBP			
Total cost	£135,000	GBP			
Each kWp produces	779	kWh	(annual production assumption / PVSYST)		
Saving of kgCO2/kWh	0.541	kgCO2/kWh			
Total annual electricity production	38950	kWh			
Total annual CO2 saving	21.07	tonne			
Total annaul Carbon tax saving	£0.00		CRC Carbon credit cost	£0.00	per tonne of CO2
Day time rates	10	pence/kWh	(which is	100%	of time)
Night time rates	8	pence/kWh	(which is	0%	of time)
Annual electricity cost avoidance	£3,895	GBP	(Assuming 100% of generated electricity is consumed by ourselves)		
FIT rate	32.9	pence/kWh	(if joined by 31-July-2012)		
FIT annual income	£12,815	GBP			
FIT duration	25	years			
Total income (over FIT period)	£417,739	GBP			
Net profit (over FIT period)	£282,739	GBP			
Total annual benefit	£16,710	GBP			
Pay back period	**8**	**years**			

Figure 17: Solar PV Business case

Solar PV system	10 kWp	20 kWp	30 kWp	50 kWp
Total cost (exc. VAT)	£45,000	£85,000	£108,000	£135,000
Earning per annum	£3,724	£6,684	£10,026	£16,710
Profit over 25 years FIT duration	£48,091	£82,096	£142,643	£282,739
Payback years	12	13	11	8
ROI	4.27%	3.86%	5.28%	8.38%

Table 24: Solar PV – comparison of various scheme sizes

Figure 18: Killoch depot – Google Maps View

Wind Turbine

As a potential opportunity was spotted during the site surveys, a feasibility analysis was carried out for the installation of a wind turbine at Killoch depot.

To build confidence in this opportunity, average wind speed was identified using DECC's wind speed estimation tool (http://www.decc.gov.uk/en/windspeed/default.aspx). The average wind speed at 10 m at Killoch was found to be 6.1 m/s (figure 19). The wind data from DECC's database indicated a reasonable potential for wind power generation – Killoch is a large site (Figure 13) with ample space to install a wind turbine.

A 75 kW wind turbine (Vestas V17) was proposed by the supplier to suit the site location and available space. To analyse the technical, financial and ecological aspects, a spreadsheet tool was developed (Appendix 8).

Technical Aspects

To calculate the power captured and annual energy yield, the following formulae was used:

$$P_{captured} = \frac{1}{2}\, \eta_g \eta_b \rho A C_p V^3 T_A$$
$$E_{ya} = \int P_{captured}\, dt$$

Where;
$P_{captured}$ = Captured electrical power from the wind turbine
η_g = Generator Efficiency
η_b = Gearbox / Bearing efficiency
ρ = Air density
A = Swept area
C_p = Power Coefficient
V = Average wind speed
E_{ya} = Annual energy yield
t = time period in hours

The following data was assumed based on standard values used by the supplier.

ρ = 1.225 kg/m3
C_p = 0.59
η_g = 80%
η_b = 90%
T_A = 90%

WINDSPEED DATABASE QUERY RESULTS

FOR THE 1KM GRID SQUARE 248 620 (NS4820)

Wind speed at 45m agl (in m/s)

7.5	7.4	7.1
7.6	7.5	7.2
7.3	7.3	7.2

Wind speed at 25m agl (in m/s)

6.9	6.8	6.4
7	6.9	6.6
6.6	6.6	6.5

Wind speed at 10m agl (in m/s)

6	6	5.5
6.2	6.1	5.8
5.7	5.8	5.7

Blank squares indicate areas outside the land area of the UK - i.e. areas at sea or of neighbouring countries.

Figure 19: Killoch wind speed data

Integration limit was taken as $t_i = 0$ for start and $t_f = 8{,}760$ for the total number of hours in a year.

As shown in appendix 8, the annual energy yield at 6.1 m/s was estimated to be 105,728 kWh.

However, it was estimated using the same tool that, if the average wind speed of 6.9 m/s is experienced by the wind turbine at 25 m agl, it will increase the annual energy yield to 153,020 kWh, which is an increase of 45%. Also, if the turbine up-time reduces to 70%, the annual energy yield will reduce by 22% to 82,233 kWh.

Financial Aspects

The supply, installation & commissioning (SIC) cost of the wind turbine provided by the supplier was £120,000. It was identified that a network upgrade would be required, resulting in an estimated £200,000 of grid connection cost. The annual O&M (operation & maintenance) cost was assumed to be 3% of the SIC cost, based on supplier's experience.

The feed-in-tariff rate available for this size of a wind turbine was 25.4 pence per kWh. For each kWh of exported electricity, another 3 pence was also paid by the grid operator.

Considering the base load of the site, as shown in table 21, it was assumed that 100% of the generated electricity will be consumed on site. It was estimated that a total financial benefit of £31,713 will be achieved via the feed-in-tariff and the money saved in electricity purchase cost. After excluding the annual O&M cost of £3,600, the net annual benefit was estimated as £28,113.

However, if the feed-in-tariff is reduced to 22 pence per kWh by the connection time, the net annual benefit will reduce by 13% to £24,518. Also, if the site's average electricity purchase cost is increased by 10%, the net annual benefit will increase by 3% to £28,959.

Ecological Aspects

In terms of ecological aspects, only carbon emission reduction was considered. It was estimated that at a 6.1 m/s average wind speed, 57.2 tonnes of CO_2 will be reduced per annum, which will reduce the site's carbon footprint by 1.56% from 2011-12 level. However, if an average wind speed of 6.9 m/s is experienced by the wind turbine at 25 m agl, it will result in a reduction of 82.8 tonnes of CO_2, which will reduce the site's carbon footprint by 2.26% from 2011-12 level.

Based on the above analysis, a 75 kW wind turbine was proposed for installation at Killoch.

- New opportunities in energy intensive processes

As shown previously in figure 12, the most energy intensive operation at Barr is the Quarries division (a major subdivision of Industrial division). In addition to aggregates, quarries generally include ready-mix concrete and asphalt production plant. In a survey conducted under the Energy Efficiency Best Practice Programme, the specific energy consumption of quarry processes was identified (ECG070, 1998), with bituminous products (asphalt and other road pavement products) identified as the most energy intensive processes. According to the resulting guide, the average specific energy consumption of quarry products is as shown in table 25.

Product	Average specific energy consumption (kWh/tonne)
Crushed rock – Igneous/Metamorphic	15.4
Sand & gravel	10.0
Ready-mixed concrete	3.6
Bituminous products	108.2

Table 25: Specific Energy Consumption in Quarries

In addition to asphalt and other bituminous coated products, transport is a key aspect to target due to its significant share in Barr's energy use. As shown in figure 8 and figure 11, in 2008 diesel use at Barr accounted for 26% of the company's carbon footprint and 46% of the company's energy cost.

On the basis of these data, opportunities for energy/carbon reduction in transport and coated products were considered as follows.

Transport Fleet Management

Barr's transport fleet mainly consists of tippers & mixers, vans and cars. A breakdown of emissions from each of these during 2009 is given in table 26.

Emissions source	Proportion
Trucks	26.81%
Tippers & mixers	27.,20%
Cars & vans	14.25%
External hauliers	31.74%

Table 26: Derv use by usage type (Source: Fueltek software at Barr Limited, 2010)

Excluding the fuel used by external hauliers to deliver Barr's products, the total Derv used by the company's own vehicles was around 68%. Based on the company's 2008 carbon footprint, the company used around 2 million litres of fuel in its own vehicles.

Software	Purpose	Database
FuelTek	Records diesel usage, diesel cost and total miles for all company owned vehicles.	SQL
QR3	Records sales, delivery miles and delivery costs for company owned and external haulage vehicles in Barr Quarries.	SQL
LS3	Can be used to record intake quantity of waste for Barr Environmental, and also the delivery miles and delivery costs for waste transferring vehicles.	SQL
CO5	Records sales, delivery miles and delivery costs for company owned and external haulage vehicles in Solway Steel and Solway Precast.	SQL
COINS	Financial management, costs and earnings.	SQL

Table 27: IT systems at Barr

There were a number of IT systems operating at Barr (see Table 27), which recorded data related to transport fuel, including the quantities of products which were delivered associated with this fuel use. Brief details of each IT system are presented in table.

It was proposed to develop a reporting system based on information available from these systems. The data as required from these IT systems was proposed to be routed to a data warehouse, from where it could be sourced to generate management reports in the required format. The required inputs and outputs of the reporting system, summarised in Figure 20, were discussed and agreed with the company.

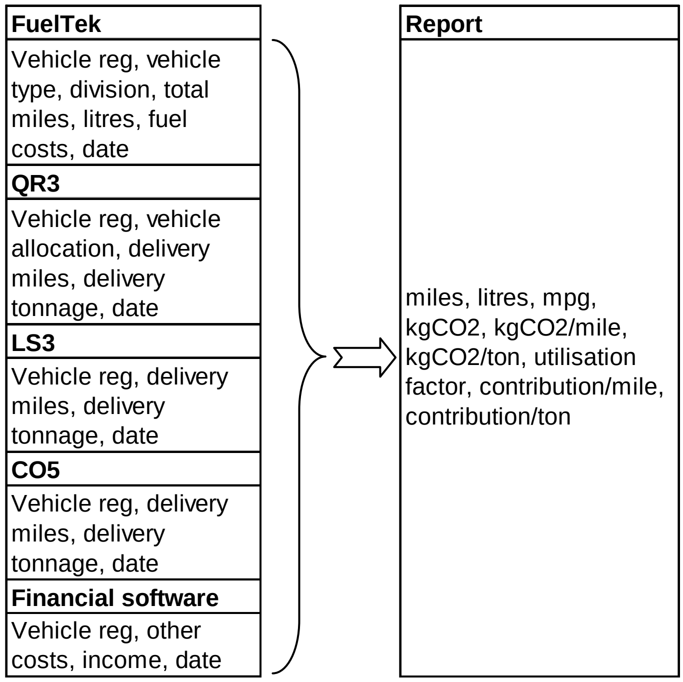

Figure 20: Transport reporting system – inputs and outputs

A sample of proposed management reports are given in appendix 12. These consist of division-, quarries- and vehicle-based key performance indicators. The reports would be automatically emailed to relevant site and division managers as a mechanism to reduce fuel use through management intervention. A development cost of £25,000 was estimated (Source: Meeting with General Manager and IT developer, Barr Limited, 14-Jun-2010), mainly in terms of development time and support costs. An additional £15,000 annual cost was estimated in relation to managers' time to go scrutinise, discuss and act on these reports.

It was estimated that a conservative target of 2% reduction in fuel use would be achievable – equivalent to an annual reduction of 105.2 tonnes of CO_2e and a saving of £56,000 in fuel costs (Table 28).

A document 'Information System Requirement Specifications' was constructed to provide information to the company's in-house IT systems developer (available in Appendix 12).

Fleet Management Program		
Fuel	Derv	
Annual usage by Barr	2,000,000	Litres
CO_2e conversion factor	2.63	$kgCO_2$/litre
Fuel Price	£1.40	£ / litre
Target reduction – percentage	5%	
Target reduction - CO_2e	263	Tonnes- CO_2e
Target reduction - fuel costs	£140,000	
	Transport Reporting System	
Capital cost	£25,000	
Annual running cost	£15,000	
Target reduction – percentage	2%	
Target reduction - CO_2e	105.2	Tonnes- CO_2e
Target reduction - fuel costs	£56,000	

Table 28: Transport energy reporting system savings

Aggregates Storage Shed

It has long been established that reducing the moisture content in dust and sand can result in a significant reduction in the energy consumption of an asphalt/coating plant. To establish confidence in this claim, two company coating plants were compared with similar characteristics other than that one plant had no shed to keep the dust and sand dry. Production and fuel use data were obtained from each site's monthly records and the key performance indicator (litres per tonne) calculated as shown in table 29.

	Plant A (no shed)	**Plant B (with shed)**
Annual Asphalt / Coated Production (tonnes)	17,496	9,173
Annual fuel use (litres)	205,753	79,475
KPI (litres per tonne)	11.76	8.66

Table 29: 'Litres per tonne' comparison (Source: Site based monthly record)

The plant with shed consumed 8.66 litres of fuel per tonne of coated products to dry the aggregate while the other plant consumed 11.76 litres of fuel per tonne of coated products. This indicated that the plant with shed consumed 26.36% less fuel than the other plant. It should be noted that the specific fuel consumption would normal reduce with increased production levels.

A pair of sheds was subsequently proposed for coating plant A at a cost of £25,000 (Source: Solway Steel, 2011). The project was expected to result in an annual reduction of 110 tonnes of CO_2e and a cost saving of £19,770 per annum (see Appendix 15 for the business case calculations).

Drying room improvements

A drying room is an integral part of every construction, quarry and process site in the UK, where personnel can leave wet clothing to be dried for shift use. Generally, these drying rooms are temporary cabins with space heaters fitted to elevate the indoor temperature. During non-working hours, usually during night-time, construction sites have been observed to require energy only for drying room heaters and security lights. In the quarries, it was observed that drying rooms are the second highest load during non-working hours after bitumen tank heating. The non-working hours at Barr normally total 123 hours per week (based on 15 hours a day operation for weekdays and 48 hours for the weekend).

During energy management discussions, it was agreed to trial the replacement of part of the space heating load with a dehumidifier (Personal Communication with BW, Managing Director, Barr Limited, 03-Nov-2010). To establish confidence in this option, an experiment was conducted in a drying room located at one of Barr's quarries. Energy consumption was then compared over a one month period between a traditional set-up (2 space heaters) and a mixed set-up 1 space heater and 1 compressor-based dehumidifier). Two Energenie Ener007 Data Loggers (Energenie Ener 007, 2010) were used to log the electricity consumption. The dehumidifier used for this experiment was a De'Longhi DEM10 (Appendix 13). The results are presented in table 30.

Case	**kWh consumption**	**kg CO_2e emissions**	**Energy cost**	**CRC cost**
Scenario A: 2 heaters	2,880	1,558	£288	£19
Scenario B: 1 heater + 1 dehumidifier	1,728	935	£173	£11
Reductions: (1 Month)	1,152	623	£115	£7
Reductions: (1 Year)	13,824	7,479	£1,382	£90

Table 30: Results of drying rooms experiment

As observed there exists the possibility of using a mix of heating and dehumidification processes to dry operatives' wet clothes. Traditionally, in a construction/quarrying drying room 4-6 kW of resistive heating is used continuously (24 hours a day, 7 days a week) to dry the clothes. The process becomes less efficient as the room humidity increases over time. Using a mix of dehumidification and heating was expected improve the heating effectiveness due to the humidity control and the compressor-based dehumidification process which works better at higher ambient temperatures.

This process can be made even more energy efficient by adding control to discontinue the energy supply when the desired dryness level has been attained.

Based on initial experimentation results, it was proposed to modify five drying rooms at Barr to use the heater and dehumidifier combination. This action was predicted to result in an annual reduction of 37.39 tonnes of CO_2e and a saving of £6,912 per annum (Appendix 14).

Carbon reduction opportunities at Barr

Table 31 presents the findings of a cost/benefit exercise addressing the opportunities identified at Barr.

Opportunity	Capital Cost (£)	Annual Benefit (£)	Annual Costs (£)	Project life time (years)	Annual carbon reduction (tonne-CO_2)
Plug-in timers	250	4,950	40	3	27
LED Lighting	22,010	3,390	500	15	20
Solar PV	135,000	16,710	500	25	21
Wind turbine	320,000	31,713	3,600	20	57
Transport reporting	25,000	56,000	15,000	10	105
Storage sheds	25,000	19,770	0	25	110
Drying room improvements	575	6,912	150	3	37
Vertical bitumen tanks	161,387	36,133	600	15	222
Burner replacement	30,000	22,500	500	10	83
IT server room improvements	15,000	4,827	200	10	44

Table 31: Cost / Benefit Analysis for opportunities at Barr

Uncertainties in the carbon reduction potential

A number of uncertainties were identified during the project, which can affect the above costs and benefits. There follows a brief discussion of these uncertainties, with some overlaps (e.g. between capital cost and inflation rate).

Cost variations

Costs related to an opportunity are an important function to calculate the position of an opportunity in the MACC and ERIC curves. However, the capital and running costs may change over time for a number of reasons. As observed during the formulation of the Solar PV business case (section 5.3 and section 6.6), the capital cost continuously reduced due to a reduction in the price of the technology because of increased market competition. In the calculation of the person-hour costs in the Transport energy reporting system, it was challenging to find the required data. This cost is also uncertain due to employee and salary changes over time. Therefore, it is important to revise the MACC and ERIC curves at regular intervals to include the most up-to-date costs related to each opportunity.

Estimated savings

The estimated savings may change for a number of reasons such as those that follow.

- Weather (including moisture): The energy consumption of an entity may change significantly due to weather changes. In the projects involving IT server room improvements, drying room improvements and plug-in timers, it was not possible to quantify exactly how much the energy consumption would reduce. Also, in the project addressing storage sheds, where the moisture content of dust and sand plays a vital role, it was difficult to quantify the moisture reduction as the moisture content of fresh dust and sand depends on the ambient conditions whether external or intra-shed.

- Production levels: In some projects, such as burner replacement and storage sheds, the financial benefits are dependant on production levels. It is difficult to predict these levels as they continually change due to new contracts secured and load sharing between different asphalt plants.

- Human behaviour: It is unlikely that different personnel when undertaking the same job, such as lorry driving, asphalt plant operation *etc*. will do their tasks consuming the same amount of energy. It is therefore impossible to estimate the exact amount of energy saving in projects that depend on human behaviour (such as in the case of the transport energy reporting system).

- Working hours: The working hours at the company vary depending on product demand and the work load of an employee. The working hours can also impact the savings from advanced technology. As observed during the deployment of innovative switching based on passive infra-red detectors (section 5.1), the energy savings depend on the usage pattern which itself is uncertain.

- Available incentives: A change in available incentives could significantly impact the business case of a carbon reduction opportunity - as observed in the Solar PV project (section 5.4) where the unexpected reduction in the available incentive changed the business case significantly.

- Energy prices: Energy price change is another significant uncertainty. As energy prices generally follow an upward trend, the expected energy cost savings will rise with the passage of time.

- Historic information on renewable energy systems: The energy yield from the renewable energy systems is estimated using historic data, such as embodied in the PVSyst tool and DECC database. It is likely that the actual energy yield will be significantly different from the predicted value and that this residual will vary over time.

Inflation & discount rate

The rate of inflation and the discount rate are both uncertain and this will affect the time value of money and the financial benefits.

Information from experience

Another uncertainty relates to the information that was obtained from employees on the basis of their experience, such as the kW rating of electric appliances from the company Electrician and the benefits of vertical bitumen tanks from the Quarry Manager.

Commercial literature & green-washing

Information obtained from the commercial literature may be skewed or exaggerated for commercial reasons. As mentioned in section 1.3, green-washed products have introduced a significant uncertainty to the market making it difficult for decision-makers to decide if a product can actually attain the carbon emission reductions as claimed.

Sensitivity Analysis

To identify the impacts of these uncertainties, a sensitivity analysis was conducted for each of the identified carbon reduction opportunities. In the analysis, the impacts of uncertainties were analysed on key figures derived from individual business cases, which were the capital cost, annual cost/benefit, and CO_2 reduction. These figures were important to be considered as they decide the position of each opportunity in MACC and ERIC curves, which were later developed as presented in section 4.3.

Opportunity	**Uncertainties**					
Transport	Development cost (±20%)	Fuel price (±10%)	Estimated Reductions (±25%)	Running cost (±20%)	Annual usage (±20%)	x
PIT	Capital cost (±10%)	Electricity Price (±10%)	Day-hours saved (±1 hour)	Winter weeks (±20%)	x	x
Coating burner	Capital cost (±20%)	Fuel price (±10%)	On-site Production (±50%)	Exp. lit/ton (±10%)	x	x
Drying room	Capital cost (±20%)	Electricity Price (±10%)	Saving Measurement Error (±10%)	x	x	x
Solar PV	Capital cost (±20%)	Electricity Price (±10%)	Energy Yield (±10%)	Incentive (±20%)	x	x
Sheds	Capital cost (±20%)	Fuel price (±10%)	On-site Production (±50%)	Exp. lit/ton (±10%)	x	x
Vertical bitumen tank	Capital cost (±20%)	Electricity Price (±10%)	Weather (±2^{o}C)	Heat Loss (±20%)	x	x
IT Server	Capital cost (±20%)	Electricity Price (±10%)	Est. Cooling Load (±10%)	x	x	X
LED lighting	Capital cost (±10%)	Electricity Price (±10%)	Existing Lighting Load (±10%)	x	x	X
Wind turbine	Capital cost (±20%)	Electricity Price (±10%)	Wind Speed (±15%)	Turbine Uptime (±5%)	Incentive (±20%)	Export (25~50%)

Table 32: Uncertainties in Carbon Reduction Opportunities

Table 32 shows the uncertainties that were considered for each opportunity. The limits mentioned in the table were applied to the spreadsheet tools which were used to develop the business case for each opportunity. After analysing the impact of each individual uncertainty on a carbon reduction opportunity, the outcomes were summarised and used to identify best and worst case figures. Appendix 33 provides summaries of uncertainty analysis for each individual carbon reduction opportunity.

From the analyses of uncertainties, a comparison was carried out among standard case, best case and worst case scenarios, as shown in table 33, to establish the overall potential impact of these uncertainties.

Opportunity	Standard case			Best case			Worst case		
	Capital cost	Annual benefit/cost	CO_2 Red.	Capital cost	Annual benefit/cost	CO_2 Red.	Capital cost	Annual benefit/cost	CO_2 Red.
Transport	£25,000	£41,000	105	£20,000	£80,400	158	£30,000	£12,240	63
PIT	£250	£4,910	27	£225	£6,890	34	£275	£3,308	20
Coating burner	£30,000	£22,000	83	£24,000	£62,995	213	£36,000	£2,560	13
Drying room	£575	£6,762	37	£460	£8,213	41	£690	£5,449	34
Solar PV	£135,000	£16,210	21	£108,000	£21,139	23	£162,000	£11,873	19
Sheds	£25,000	£19,770	110	£20,000	£46,334	234	£30,000	£5,157	32
Vertical bitumen tank	£161,387	£35,533	222	£129,110	£40,473	230	£193,664	£30,862	215
IT Server	£15,000	£4,627	44	£12,000	£6,828	54	£18,000	£3,103	33
LED lighting	£22,010	£2,890	20	£19,809	£3,561	23	£24,211	£2,288	18
Wind turbine	£320,000	£28,113	57	£256,000	£60,518	91	£384,000	£7,072	33

Table 33: Sensitivity Analysis for uncertainties in opportunities

As shown in table 33, opportunities differ from each other to the extent that they are susceptible to these uncertainties. Some opportunities show lesser potential change in financial benefits and CO_2 reductions, and some show higher differences due to the different nature of the uncertainties. To highlight this difference further, graphs were plotted as shown in figure 21 and figure 22.

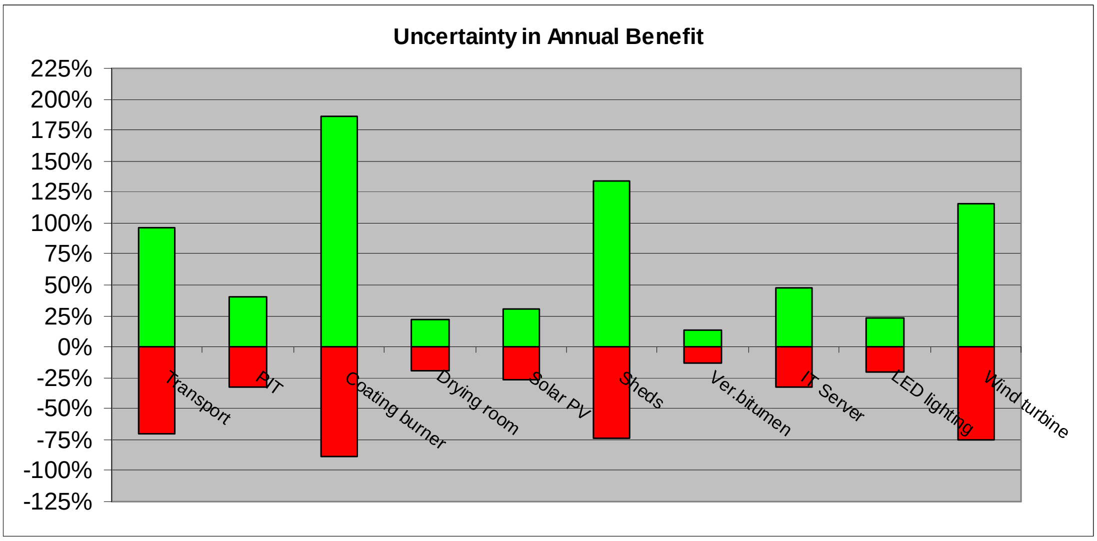

Figure 21: Uncertainties in Annual Benefit

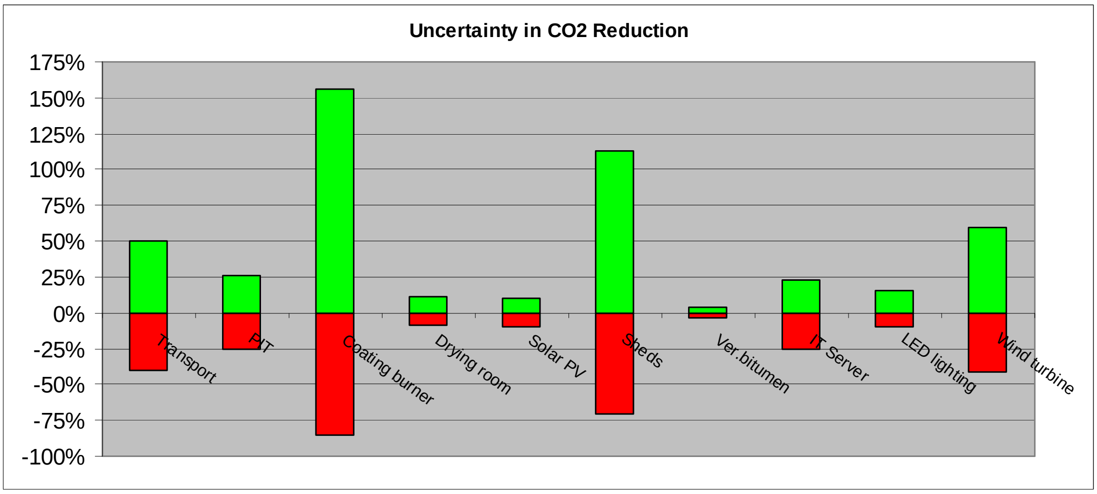

Figure 22: Uncertainties in Annual CO_2 reduction

Based on observations in figure 21 and figure 22, the opportunities can be divided into 3 categories: highly susceptible, medium susceptible and less susceptible (to uncertainties) carbon reduction opportunities.

The opportunities in Transport, coating plant burner, storage sheds and wind turbine fall into the first category. For the 'coating plant burner' and 'sheds' projects, the main reasons for this high susceptibility to uncertainties are the market situation in terms of production level requirement and the uncertainty in specific fuel consumption level that can be achieved. In the 'transport' project, the uncertainties in achievable reduction in fuel use and the market situation in terms of annual transportation requirements are the main reasons to assign this carbon reduction opportunity to the 'highly susceptible' category. In the 'wind turbine' project, the results are highly sensitive to wind speed, as even a 15% change in wind speed can provide a significant difference in power output. As 'wind turbine' is a high capital project, the uncertainty in capital cost is another major factor.

The opportunities in 'IT server room' and 'plug-in timers' are assigned to the medium susceptible carbon reduction opportunities category. In the 'IT server room' project, the main reason for this susceptibility is due to uncertainty in the estimated cooling load, which itself will be dependant on several variables such as weather, work load, job patterns *etc*. In the 'plug-in timers' project, the main reasons for the susceptibility are possible fluctuations in electricity price and the weather uncertainty which will dictate the number of weeks in winter when the heaters will be required for space heating. The remaining carbon reduction opportunities, which are opportunities in Solar PV, LED lights, vertical bitumen tanks and drying room, fall into the less susceptible category.

4.3 Assessment of carbon reduction opportunities

The available carbon reduction opportunities were compared by plotting MACC and ERIC curves and the outcomes delivered to senior management to assist their decisions on the selection and implementation of suitable carbon reduction measures.

On presentation of these curves, the senior management was interviewed to identify the usefulness of these decision support tools.

MACC

Figure 24 summarises the carbon reduction opportunities available at Barr. The information was obtained from the business cases of each of the opportunities, and populated into the MACC spreadsheet tool. The tool calculated the NPV (Net Present Value) and marginal abatement cost for each of the opportunities. A discount rate of 6% was assumed corresponding to company policy.

After populating information into the MACC spreadsheet tool, the opportunities were then sorted in the traditional order, so the opportunity with lowest marginal abatement cost was on the left and opportunity with highest marginal abatement cost was on the right.

Figure 23 shows the MACC plot for these opportunities. The plot showed that all identified opportunities had negative abatement cost, which implies that all of these opportunities would be viable even if the company did not participate in a carbon trading scheme. Transport reporting system had the lowest carbon abatement cost (i.e. -£263.1 per tonne-CO_2) which meant that by the implementation of this system, the company was expected to annually reduce 105 tonnes of CO_2, and also save £263.10 for each tonne of CO_2 reduction per annum. The plot showed the wind turbine at Killoch as the least attractive among all the opportunities. However, even in the wind turbine's case, the implementation was expected to annually reduce 57 tonnes of CO_2, and also save £2.10 for each tonne of CO_2 reduction per annum.

All the carbon reduction opportunities included in this MACC analysis had a negative marginal abatement cost. However, if there was an opportunity with a marginal abatement cost of £15 per tonne of CO_2, it would have meant that after its implementation, besides annually reducing the suggested tonnes of CO_2, it will cost the company £15 for each tonne of CO_2 reduction per annum. Such an opportunity would be unlikely to be implemented, and the company would be financially better off to pay the £12 per tonne of CO_2 as CRC tax rather than implementing this opportunity.

The dashed vertical line on the graph shows the carbon reduction target of 500 tonnes. It shows that the company will cross its carbon reduction target by implementing the first seven opportunities from left to right.

The MACC helps to compare the carbon reduction opportunities, and is also helpful to devise a carbon reduction strategy to achieve a certain target.

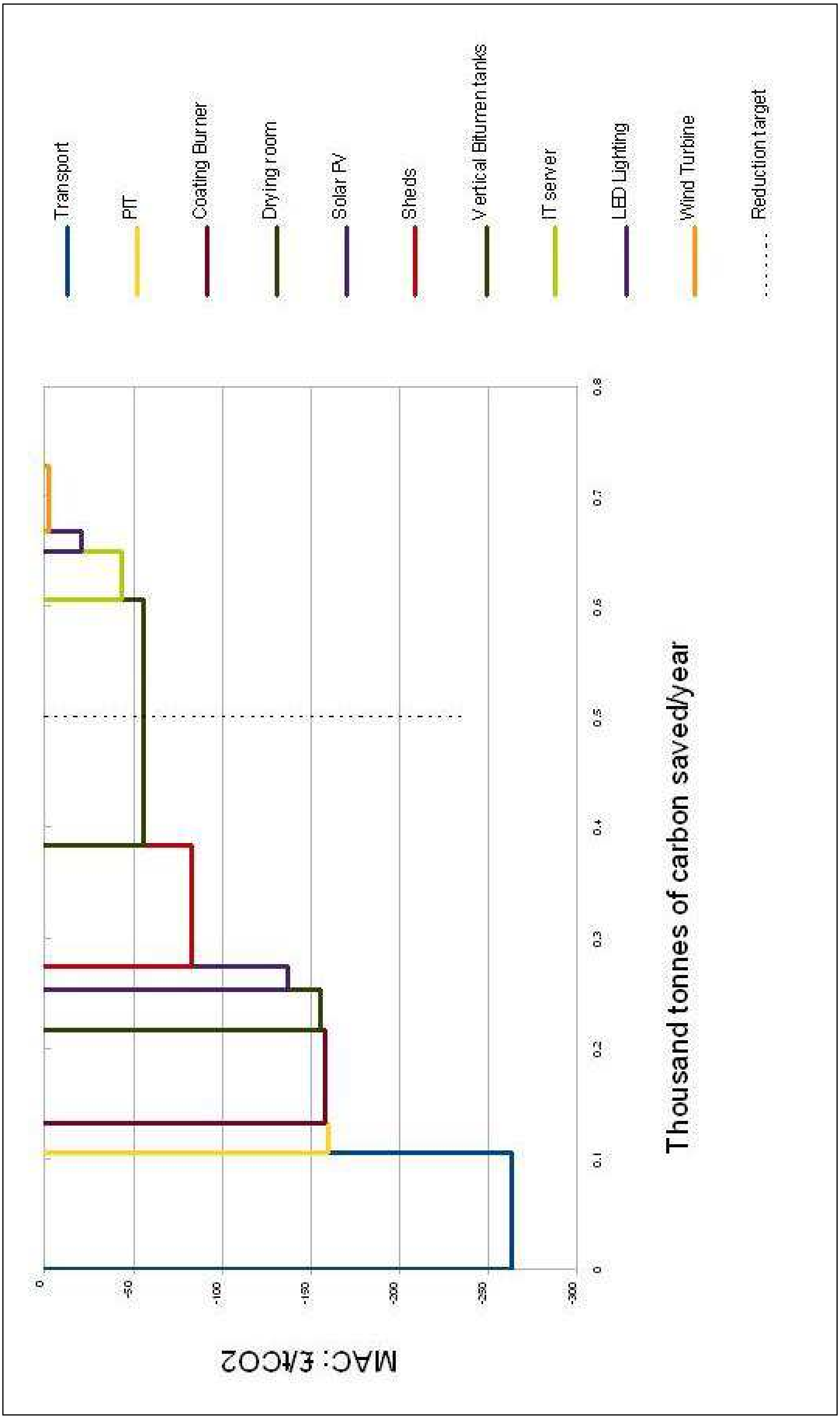

Figure 23: Marginal Abatement Cost Curve for Barr

Marginal Abatement Cost (MAC) Curve Calculator

somar™

Discount rate	6%											
Reduction target (thousand tonnes)	0.5											
Project name			Transport	PIT	Coating Bu	Drying room	Solar PV	Sheds	Vertical Bit	IT server	LED Lightir	Wind Turbi
Capital cost	(£)		25,000	250	30,000	575	135,000	25,000	161,387	15,000	22,010	320,000
Annual benefit/cost	(£)		41,000	4,910	22,000	6,762	16,210	19,770	35,533	4,627	2,890	28,113
Annual average CO_2 savings for project	(tonnes/year)		105	27	83	37	21	110	222	44	20	57
Project life	(years)		10	3	10	3	25	25	15	10	15	20
NPV	(£)		-276,764	-12,874	-131,922	-17,500	-72,218	-227,727	-183,718	-19,055	-6,058	-2,455
MAC (carbon not discounted)	(£/tonne)	0	-263.1	-160.3	-158.1	-156.0	-137.1	-82.9	-55.2	-43.6	-20.1	-2.1
Discounted life savings of carbon	(tonnes)	0	774	72	614	100	269	1,405	2,156	322	195	656
MAC (carbon discounted)	(£/tonne)	0	-357.4	-179.9	-214.8	-175.1	-268.1	-162.1	-85.2	-59.2	-31.1	-3.7
Cumulative savings for all projects	(thousand tonnes/year)	0	0.1	0.1	0.2	0.3	0.3	0.4	0.6	0.6	0.7	0.7

Figure 24: Carbon reduction opportunities at Barr

Present Value of Investment - Costs & Income subject to inflation

Proposal 1:	Swinlees coating plant
Purchase cost	-£20,000
Interest Rate	6.00%
Inflation	2.50%

Yr	Factor	R+M Cost	Income	Cash Flow	PV Cash Flow	Runng total cash flow	Running NPV
0	1	£0	£0	-£20,000	-£20,000	-£20,000	-£20,000
1	0.943	£0	£22,500	£22,500	£21,226	£2,500	£1,226
2	0.890	£0	£23,063	£23,063	£20,526	£25,563	£21,752
3	0.840	£0	£23,639	£23,639	£19,848	£49,202	£41,600
4	0.792	£0	£24,230	£24,230	£19,192	£73,432	£60,792
5	0.747	£0	£24,836	£24,836	£18,559	£98,267	£79,351
6	0.705	£0	£25,457	£25,457	£17,946	£123,724	£97,297
7	0.665	£0	£26,093	£26,093	£17,353	£149,817	£114,650
8	0.627	£0	£26,745	£26,745	£16,780	£176,563	£131,431
9	0.592	£0	£27,414	£27,414	£16,226	£203,977	£147,657
10	0.558	£0	£28,099	£28,099	£15,691	£232,076	£163,348
11	0.527	£0	£28,802	£28,802	£15,172	£260,878	£178,520
12	0.497	£0	£29,522	£29,522	£14,672	£290,400	£193,192
13	0.469	£0	£30,260	£30,260	£14,187	£320,660	£207,379
14	0.442	£0	£31,016	£31,016	£13,719	£351,676	£221,097
15	0.417	£0	£31,792	£31,792	£13,266	£383,468	£234,363
16	0.394	£0	£32,587	£32,587	£12,828	£416,055	£247,191
17	0.371	£0	£33,401	£33,401	£12,404	£449,456	£259,595
18	0.350	£0	£34,236	£34,236	£11,995	£483,693	£271,589
19	0.331	£0	£35,092	£35,092	£11,598	£518,785	£283,188
20	0.312	£0	£35,970	£35,970	£11,216	£554,755	£294,403
21	0.294	£0	£36,869	£36,869	£10,845	£591,624	£305,248
22	0.278	£0	£37,791	£37,791	£10,487	£629,414	£315,735
23	0.262	£0	£38,735	£38,735	£10,141	£668,150	£325,876
24	0.247	£0	£39,704	£39,704	£9,806	£707,853	£335,682
25	0.233	£0	£40,696	£40,696	£9,482	£748,550	£345,164
			Total	**£748,550**			
			NPV		**£345,164**		

Present Value of Investment - Existing method in MACC tool

Proposal 1:	Swinlees coating plant
Purchase cost	-£20,000

Yr	Factor	R+M Cost	Income	Cash Flow	PV Cash Flow	Runng total cash flow	Running NPV
0	1	£0	£0	-£20,000	-£20,000	-£20,000	-£20,000
1	0.943	£0	£22,500	£22,500	£21,226	£2,500	£1,226
2	0.890	£0	£22,500	£22,500	£20,025	£25,000	£21,251
3	0.840	£0	£22,500	£22,500	£18,891	£47,500	£40,143
4	0.792	£0	£22,500	£22,500	£17,822	£70,000	£57,965
5	0.747	£0	£22,500	£22,500	£16,813	£92,500	£74,778
6	0.705	£0	£22,500	£22,500	£15,862	£115,000	£90,640
7	0.665	£0	£22,500	£22,500	£14,964	£137,500	£105,604
8	0.627	£0	£22,500	£22,500	£14,117	£160,000	£119,720
9	0.592	£0	£22,500	£22,500	£13,318	£182,500	£133,038
10	0.558	£0	£22,500	£22,500	£12,564	£205,000	£145,602
11	0.527	£0	£22,500	£22,500	£11,853	£227,500	£157,455
12	0.497	£0	£22,500	£22,500	£11,182	£250,000	£168,636
13	0.469	£0	£22,500	£22,500	£10,549	£272,500	£179,185
14	0.442	£0	£22,500	£22,500	£9,952	£295,000	£189,137
15	0.417	£0	£22,500	£22,500	£9,388	£317,500	£198,526
16	0.394	£0	£22,500	£22,500	£8,857	£340,000	£207,383
17	0.371	£0	£22,500	£22,500	£8,356	£362,500	£215,738
18	0.350	£0	£22,500	£22,500	£7,883	£385,000	£223,621
19	0.331	£0	£22,500	£22,500	£7,437	£407,500	£231,058
20	0.312	£0	£22,500	£22,500	£7,016	£430,000	£238,073
21	0.294	£0	£22,500	£22,500	£6,618	£452,500	£244,692
22	0.278	£0	£22,500	£22,500	£6,244	£475,000	£250,936
23	0.262	£0	£22,500	£22,500	£5,890	£497,500	£256,826
24	0.247	£0	£22,500	£22,500	£5,557	£520,000	£262,383
25	0.233	£0	£22,500	£22,500	£5,242	£542,500	£267,626
			Total	**£542,500**			
			NPV		**£267,626**		

Figure 25: Financial Assessment Model at Barr

Issues identified in using MACC

The senior management in the focus group was interviewed to identify the usefulness of MACC as a decision support tool (Appendix 32). In addition to the previously known issues (the presented data being counter-intuitive and so less useful at CEO/CFO level as discussed in section 1.2), additional issues, as follows, were identified where MACC data would be employed for decision support.

- Impact of inflation on annual costs / benefits

It was identified that the existing MACC model does not take into account the impact of inflation on financial costs and benefits of a scheme over its life time; rather it assumes that cost and benefits remain constant over the life of a carbon reduction project. Since energy prices and the cost of operation and maintenance generally increase in line with inflation, so the additional benefit of energy cost savings over time and the additional disbenefit of increased operation and maintenance costs should also be included. To illustrate this, a spreadsheet tool was developed which uses the company's existing financial assessment model (Figure 25). As can be seen from the presented data, there is a significant difference in the Net Present Value (NPV) derived from each method. For the scheme considered, a difference of £17,746 in the NPV was demonstrated over a 10 years period of the scheme and with a £20,000 capital cost. Should the scheme have a 25 year life time, the difference would become £77,539, which is most significant. However, since inflation itself is uncertain, it is difficult to implement corrective action to the existing MACC method.

- Impact of project's life time

The MACC tool calculates the NPV on the basis of a project's stated life time. However, the project life time is likely to change over time depending on outcome success and external factors. An opportunity may be beneficial for less than its stated life time due to technological changes, such as vertical bitumen tanks replacement because a better option becomes available that presents significant savings potential. On the other hand, an opportunity may continue benefiting after the end of its stated life time if it remains in good condition, such as a coating plant burner which will typically last more than 20 years.

ERIC

The ERIC approach can be used to deal with some of the issues identified with MACC. There is no negative scaling. There is no counter-intuitive part and the Internal Rate of Return (IRR) is more useful to the company management team. ERIC shows the IRR of individual projects as well as the cumulative IRR and therefore, like MACC, can depict the impact of multiple projects. Since there is no assumption of discount rate, the risk level in a project can be chosen by the decision makers.

No existing tool was available to plot ERIC outcomes. Therefore, two existing tools, Barr's NPV tool and Somar's MACC tool, were modified. The former was updated to calculate the IRR for normal cash flow and present value cash flow (figure 26). The latter was modified to provide cumulative capital, running costs & benefits and IRR. (The MACC tool was also modified to plot ERIC data.) To ensure positive and consistent cumulative IRR values, it was assumed that all schemes will continue for a minimum of 10 years.

An ERIC was then plotted for the same opportunities at Barr, as shown in figure 27. After populating information into the spreadsheet tool designed for plotting ERIC, the opportunities were then sorted in the traditional order, so the opportunity with highest IRR was on the left and opportunity with the lowest IRR was on the right.

Figure 27 shows the ERIC plot for these opportunities. As per nature of ERI curves, there was no unviable opportunity, and every opportunity was either less or more viable in comparison to the other opportunity, based on the IRR it offered. Plug-in-timers had the highest IRR (i.e. 1,849%). The installation of plug-in-timers was the second best option in the MACC analysis.

Figure 28 lists the IRR calculated from the updated NPV (net present value) tool, and other data for each of the opportunity that was used to plot the curve. Transport reporting system, which was the most attractive option as suggested by MACC, had the third best IRR of 151%. The plot showed the LED Lighting with 6% IRR as the least attractive among all the opportunities.

As an investing stakeholder’s point of view, all the carbon reduction opportunities which were considered here had an IRR of 6% of above. However, if there was an opportunity with an IRR less than the interest rate offered by the bank, the opportunity would be unlikely to be implemented, and the investor would be financially better off to put the available funds in a bank rather than investing it into this opportunity. On the other hand, if the company invests in an opportunity by taking a loan, then the IRR of the opportunity must be reasonably higher than the interest rate on the loan.

Similar to MACC, the dashed vertical line on the graph shows the carbon reduction target of 500 tonnes. It shows that the company will cross its carbon reduction target by implementing the first seven opportunities from left to right.

Opportunity	ERIC	MACC
PIT	1	2
Drying room dehumidifier	2	4
Transport Fleet Mgmt	3	1
Aggregate sheds	4	6
Coating plant burner	5	3
IT server room	6	8
Vertical Bitumen tanks	7	7
75 kW Wind Turbine	8	10
50 kW Solar PV	9	5
LED Lighting	10	9

Table 34: Best opportunities from MACC and ERIC

The dialogue boxes on the graph can be manually edited, to show the cumulative benefit of implementing a number of opportunities. In the present case, the implementation of first three opportunities will reduce 169 tonnes of CO_2 per annum, and have a cumulative IRR of 189.11%. The implementation of first six opportunities will reduce 406 tonnes of CO_2 per annum, and have a cumulative IRR of 94.14%. The implementation of first seven opportunities will reduce 628 tonnes of CO_2 per annum, and have a cumulative IRR of 45.22%.

The best opportunities as identified from MACC and ERIC were compared as shown in table 34. As can be seen the positions of these opportunities vary between the two techniques. The biggest change of position was for Solar PV, because it offers a poorer rate of return than most of the other opportunities.

Issues identified in using ERIC

Like MACC, the usefulness of ERIC as a decision support tool was questioned from the senior management in the focus group (Appendix 32). It was identified that ERIC can deal with the negative scale and comfort zone issues, while inflation may also be considered when calculating IRR and cumulative IRR. However, other issues were identified that would act as a barrier to the use of such a standalone graphical tool for carbon abatement decision making. These issues are discussed below.

- No indication of abatement cost

ERIC does not give an indication of an opportunity's value (abatement cost in £ per tonne of CO_2e) against the carbon allowance price. For this reason it is not possible to use ERIC to identify the allowance price that would make an opportunity viable when participating in an emissions trading scheme.

- Range of IRR on logarithmic scale

Due to the range of IRR observed in the ERIC data – from 6% to 1849% - a logarithmic y-axis scale was adopted. However, due to having a logarithmic scale, this makes it difficult to easily spot the difference between the IRR of two opportunities when comparing them. As shown on the ERIC graph in figure 27, the wind turbine (IRR 8.44%) and IT Server Room (IRR 23.22%) do not appear to have as much difference in their IRR (shown by the height of their respective bars) as it actually is, and it is difficult to highlight that the latter is 3 times the former.

- Impact of project's life time

IRR in ERIC is dependent on a project's stated life time. However, the project life time may well change over and an opportunity become more or less beneficial due to technological change or institutional/market factors.

Present Value of Investment - Costs & Income subject to inflation

Proposal 1:	LED Lighting
Purchase cost	-£25,000
Interest Rate	6.00%
Inflation	2.50%

Yr	Factor	R+M Cost	Income	Cash Flow	PV Cash Flow	Runng total cash flow	Running NPV	IRR-CF	IRR-PVCF
0	1	£0	£0	-£25,000	-£25,000	-£25,000	-£25,000	-	-
1	0.943	£0	£19,770	£19,770	£18,651	-£5,230	-£6,349	-20.92%	-25.40%
2	0.890	£0	£20,264	£20,264	£18,035	£15,034	£11,686	37.87%	30.07%
3	0.840	£0	£20,771	£20,771	£17,440	£35,805	£29,126	61.28%	52.15%
4	0.792	£0	£21,290	£21,290	£16,864	£57,095	£45,989	71.49%	61.78%
5	0.747	£0	£21,822	£21,822	£16,307	£78,918	£62,296	76.33%	66.35%
6	0.705	£0	£22,368	£22,368	£15,769	£101,286	£78,065	78.77%	68.65%
7	0.665	£0	£22,927	£22,927	£15,248	£124,213	£93,313	80.05%	69.86%
8	0.627	£0	£23,500	£23,500	£14,744	£147,713	£108,057	80.73%	70.50%
9	0.592	£0	£24,088	£24,088	£14,258	£171,801	£122,315	81.11%	70.86%
10	0.558	£0	£24,690	£24,690	£13,787	£196,491	£136,101	81.32%	71.05%
11	0.527	£0	£25,307	£25,307	£13,332	£221,798	£149,433	81.43%	71.16%
12	0.497	£0	£25,940	£25,940	£12,891	£247,738	£162,324	81.50%	71.22%
13	0.469	£0	£26,588	£26,588	£12,466	£274,327	£174,790	81.53%	71.26%
14	0.442	£0	£27,253	£27,253	£12,054	£301,580	£186,844	81.55%	71.28%
15	0.417	£0	£27,934	£27,934	£11,656	£329,514	£198,500	81.57%	71.29%
16	0.394	£0	£28,633	£28,633	£11,271	£358,147	£209,772	81.57%	71.29%
17	0.371	£0	£29,349	£29,349	£10,899	£387,496	£220,671	81.58%	71.30%
18	0.350	£0	£30,082	£30,082	£10,539	£417,578	£231,210	81.58%	71.30%
19	0.331	£0	£30,834	£30,834	£10,191	£448,413	£241,401	81.58%	71.30%
20	0.312	£0	£31,605	£31,605	£9,855	£480,018	£251,256	81.58%	71.30%
21	0.294	£0	£32,395	£32,395	£9,529	£512,413	£260,785	81.58%	71.30%
22	0.278	£0	£33,205	£33,205	£9,215	£545,619	£270,000	81.58%	71.30%
23	0.262	£0	£34,035	£34,035	£8,910	£579,654	£278,910	81.58%	71.30%
24	0.247	£0	£34,886	£34,886	£8,616	£614,540	£287,526	81.58%	71.30%
25	0.233	£0	£35,759	£35,759	£8,332	£650,299	£295,858	81.58%	71.30%
			Total	**£650,299**					
			NPV		**£295,858**				

Figure 26: NPV Model with IRR calculation

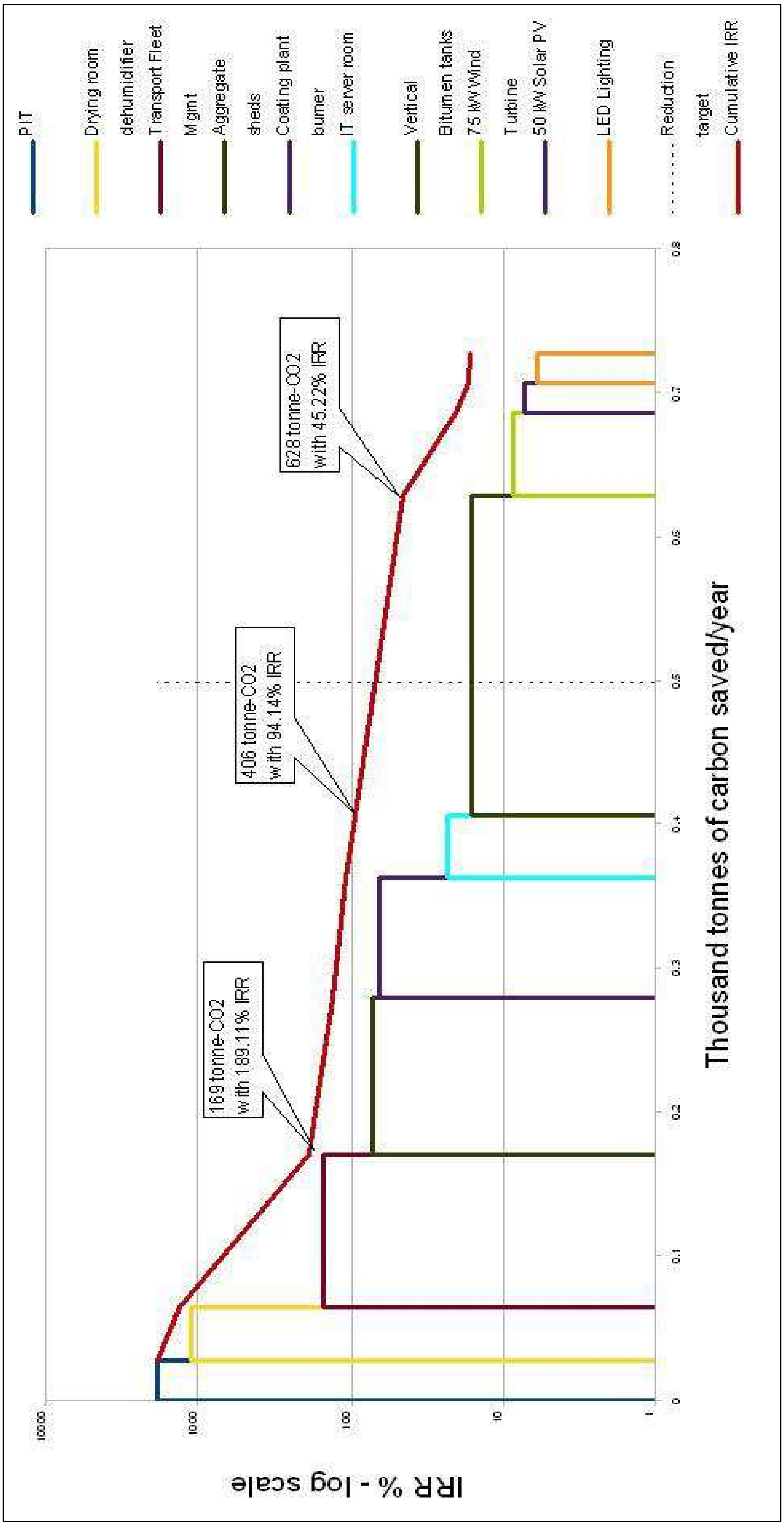

Figure 27: ERIC for Barr

Marginal Abatement Cost (MAC) Curve Calculator

Discount rate	6%										
Reduction target (thousand tonnes)	0.5										
Project name		PIT	Drying room deh	Transport f	Aggregate sheds	Coating pla	IT server ro	Vertical Bit	75 kW Win	50 kW Sola	LED Lightir
Capital cost	(£)	£250	£575	£25,000	£25,000	£30,000	£15,000	£161,387	£320,000	£135,000	£22,010
Annual benefit/cost	(£)	£4,910	£6,762	£41,000	£19,770	£22,000	£4,627	£35,533	£28,113	£16,210	£2,890
Annual average CO_2 savings for project	(tonnes/year)	27	37	105	110	83	44	222	57	21	20
Project life	(years)	3	3	10	25	10	10	15	20	25	15
NPV	(£)	-£12,874	-£17,500	-£276,764	-£227,727	-£131,922	-£19,055	-£183,718	-£2,455	-£72,218	-£6,058
IRR	(%)	1849%	1106%	151%	71%	66%	23%	16%	8%	7%	6%
Cumulative IRR	(%)	1849%	1331%	189%	131%	107%	94%	45%	20%	17%	16%
Discounted life savings of carbon	(tonnes)	72	100	774	1,405	614	322	2,156	656	269	195
MAC (carbon discounted)	(£/tonne)	-£180	-£175	-£357	-£162	-£215	-£59	-£85	-£4	-£268	-£31
Cumulative CO2 savings for all projects	(thousand tonnes/year)	0.027	0.064	0.169	0.279	0.363	0.406	0.628	0.686	0.707	0.727
MAC (carbon not discounted)	(£/tonne)	-£160	-£156	-£263	-£83	-£158	-£44	-£55	-£2	-£137	-£20
Cumulative Capital	(£)	£250	£825	£25,825	£50,825	£80,825	£95,825	£257,212	£577,212	£712,212	£734,222
Minimum project life	(years)	3	3	3	3	3	3	3	3	3	3
Cumulative benefit/cost	(£)	£4,910	£11,672	£52,672	£72,442	£94,442	£99,069	£134,602	£162,715	£178,925	£181,815
Cumulative CO2 red.	(tonnes)	27	64	169	279	363	406	628	686	707	727
IRR	(%)	1849.30%	1105.56%	151.40%	71.05%	65.56%	23.22%	16.14%	8.44%	7.16%	5.93%
Cumulative IRR	(%)	1849.30%	1331.40%	189.11%	131.14%	106.88%	94.14%	45.22%	20.30%	16.82%	16.40%

Figure 28: Carbon reduction opportunities at Barr for ERIC

MACC or ERIC

As noted from discussions within the CRC focus group, the decision to utilise MACC or ERIC as the basis of decision-making will likely vary from one organisation to the other. There are more elements that would also influence such decision-making; these include the following.

- Benefit & value created for stakeholders

Investments in energy efficiency and renewable energy systems may not be made solely for corporate social responsibility, but the financial value of such a project could be vital. Companies with ‘investing stakeholders’ would prefer to make decisions on opportunities suggested by ERIC as they give a better indication of benefit and value for the stakeholders. There may be other opportunities (but not in Barr’s case) with a high potential of carbon reduction but not comparatively offering a good IRR. These opportunities will become more financially viable if the price of carbon increases in CRC or EU ETS. For example, if an opportunity has an IRR of 3% or lesser, and a carbon abatement cost of £30/ tonne of CO_2e, it would only become viable when the price of carbon allowance rises above £30.

- Response to less acknowledged and innovative technologies

There are many new and innovative technologies available in the market, which offer emission reduction through energy efficiency or renewable energy generation. As identified in section 1.3, there are certain risks associated with these such as exaggerated performance claims or unexpected operational flaws. This makes the job even more difficult for decision makers, especially when it comes to relying on new and innovative technologies where performance evidence is obscure. In such cases it is usually helpful to trial the opportunity first, and perform monitoring & verification before a full implementation.

- Must-do Projects

An organisation may have an energy saving project that must be implemented due to other operational requirements, irrespective of its risks, IRR and carbon abatement costs. At Barr, the ‘IT Server Room’ project was the same, as it required an immediate solution to reduce the cooling load on existing twin AC system, or it could have risked the whole group’s IT system.

CALoRIC

Based on focus group interview outcomes (Appendix 32) and other observed issues, a blended approach to carbon abatement assessment was identified as necessary. A simple tool, named as CALoRIC (Carbon Abatement Low Risk Abatement Curve), was developed. CALoRIC is based on information obtained from multiple sources that also include MACC and ERIC tools.

A CALoRIC is produced from the carbon abatement cost and IRR data that is obtained via MACC and ERIC tools: the x-axis shows the carbon abatement cost and the y-axis shows the IRR. A line perpendicular to the x-axis is drawn, which shows the Minimum Carbon Abatement Cost (MCAC) that the company is aiming to achieve. Another line parallel to the x-axis is drawn, which shows the Minimum Internal Rate of Return (MIRR) that the company is aiming for. Additionally, any low risk opportunities and must-do opportunities can be highlighted out of the chosen bands of IRR and carbon abatement cost.

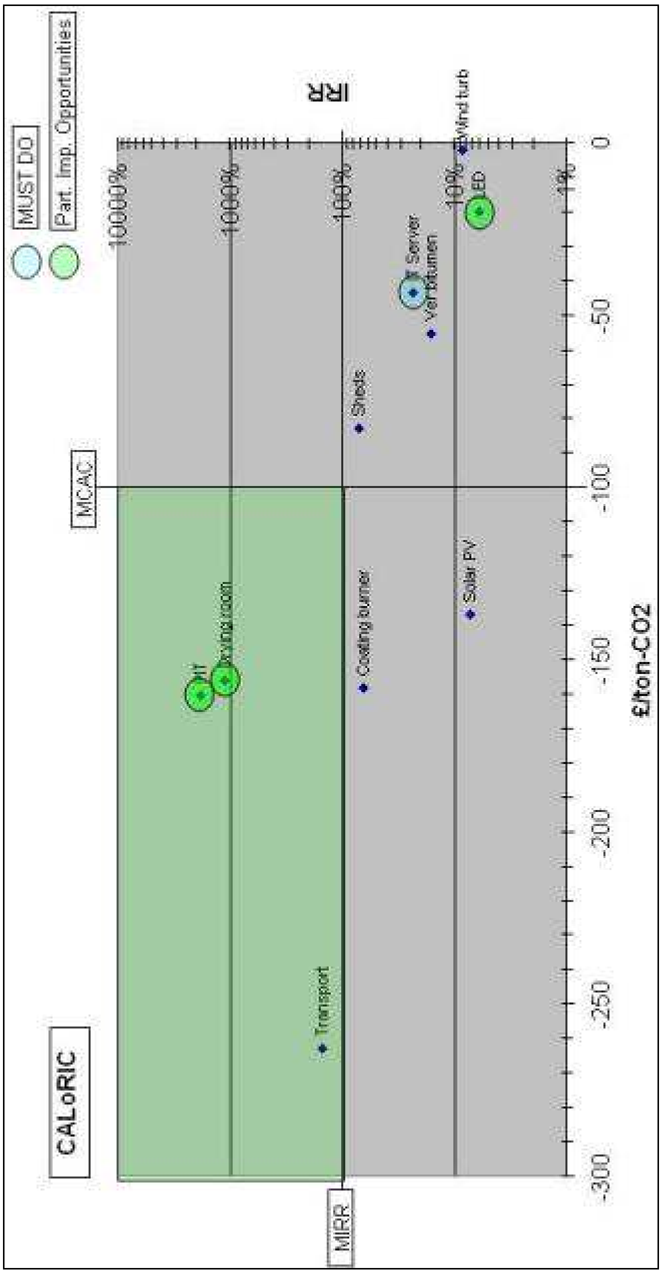

Figure 29: CALoRIC Curve

CALoRIC is a flexible tool designed to show organisation specific results in identifying the most suitable carbon reduction opportunities. It gives information for both CEO/CFO and investing stakeholders in terms of IRR, and the information for CRC returns in terms of £/tonne-CO_2. MCAC and MIRR are flexible, and can be assigned values to provide the ability to choose opportunities on either or both criteria.

CALoRIC was plotted for the identified carbon reduction opportunities at Barr, as shown in figure 29.

Like MACC and ERIC, the usefulness of CALoRIC as a decision support tool was questioned from the senior management in the focus group (Appendix 32). It was identified that CALoRIC is a better decision support tool than MACC and ERIC. The flexibility in CALoRIC to adjust the required IRR and carbon abatement cost was found very useful. Though like ERIC, it had a logarithmic scale, but since the required IRR (or MIRR) is adjusted by the user, there is less chance of ignoring the fact that it is a logarithmic scale. The main purpose of such tools is to reduce the risks and uncertainties when making decisions, and it was found that highlighting opportunities with possible ‘partial implementation’ was a very good idea to pick opportunities with less risk / uncertainty. The ‘must do’ opportunities were highlighted, which also saved time. This tool can be even more helpful when there is a very large number of available opportunities.

4.4 Chapter Summary

In this chapter, carbon reduction opportunities were identified at the CRC participant company through observation from surveys, analysis of metered data and interviews. After the establishment of a company energy and carbon baseline, carbon reduction opportunities were identified in two parts. First, the opportunities that the company was already working on were scrutinised. These included passive cooling and heat recovery in the company’s IT office, energy efficient bitumen tanks and coating (asphalt & bituminous products) plant burner replacement. Second, more opportunities were identified, which include plug-in-timers, LED lighting, aggregate storage sheds, drying room improvement, better transport reporting, solar PV and wind power.

After the identification of opportunities, and calculation of their business case, uncertainties in the calculation were considered. It was observed that these uncertainties can be mitigated through the implementation of a reliable information procurement and analysis system.

MACC and ERIC curves were plotted on the basis of information available about these opportunities, and presented to the CRC focus group. While acknowledging the suitability and benefits of the data for decision making, a number of issues were also identified. It was considered important to devise a method to factor in the likelihood that the identified benefits will likely be time invariant due to the uncertainties involved. An issue with MACC is that it does not take into account the variation of inflation over a project’s life time. An issue with ERIC is that it does not provide a carbon abatement cost to compare the opportunity against the carbon allowance price.

ERIC may also require a logarithmic scale for plotting, which can give rise to incorrect user perception. ERIC also requires project's life time data to calculate IRR.

In addition to the issues identified in using MACC and ERIC, other company specific factors also affect decision making, such as the reliability of new technologies, and the benefit and value to stakeholders.

As a solution to these issues, a blended approach was identified using information from MACC and ERIC models. A simple tool, named as CALoRIC (Carbon Abatement Low Risk Abatement Curve), was developed. CALoRIC was identified as a useful decision support tool than MACC and ERIC. The flexibility in CALoRIC to adjust the required IRR and carbon abatement cost was found helpful. The tool passed the main test, which is to reduce the risks and uncertainties, as it allowed highlighting the opportunities with possible 'partial implementation'. Specific to Barr, the 'must do' opportunities were also highlighted to save time. This tool can become even more helpful when there is a very large number of available opportunities.

5 MONITORING & VERIFICATION

In the previous chapter, an energy usage baseline was established for Barr, and a number of carbon reduction opportunities identified. These opportunities were then assessed by plotting MACC, ERIC and later CALoRIC curves from which the opportunities that might be implemented to reduce company's carbon emissions were assessed. On this basis, and other company specific factors, some of the opportunities were subsequently implemented. In this chapter, the monitoring and verification of implemented opportunities are discussed. The chapter also includes the information on corrective actions taken and the improvement of the MACC, ERIC and CALoRIC analysis approach.

5.1 Plug-in-timers

Implementation

Plug-in-timers were identified as a top energy saving opportunity in both MACC and ERIC, and among the top 3 opportunities in CALoRIC. As proposed, 10 OWL plug-in-timers were installed on the identified space heaters.

Monitoring & verification

The energy consumption of the timers was proposed to be verified by connecting a suitable energy use monitor (Energenie Ener 007, 2010). However, at the end of one week following installation, it was identified that only 3 timers were still operating as programmed. Of the remaining 7 timers, 3 were missing, 2 had been switched off and 2 had been reprogrammed.

Corrective action

An alternative product to plug-in timers was identified to provide a solution to these issues. The product was PSX switches. Powersol PSX 135 and Powersol PSX 125 (Appendix 17) are power switches that can be permanently fixed and are tamper proof.

The MACC and ERIC curves were updated to reflect the use of these products resulting in a marginal abatement cost of -£143.80 per tonne of CO_2e and an IRR of 301.24%, which was still impressive (Appendix 18).

PSX 135 and PSX 125 units were installed on the space heaters and wall mounted hot water units as proposed. During weekdays the units were programmed to switch on at 6:00 am, switch off at 11:00 am, switch on again at 12 noon, and switch off at 6:30 pm. During weekends, the units were programmed to stay off completely.

The monitoring & verification of these units proved to be difficult. Since the units are hardwired, a plug-in-meter such as the Energenie Ener007 cannot be installed. The units were installed in different areas, so the savings could not also be quantified via one meter. The monitoring & verification was therefore carried out through daily checks on the units, to ensure that they performed as programmed. In the first 2 weeks of operation, the units were inspected 3 times per day as follows.

- **1st check:** 8:30 am to ensure all units are working and have heated the space enough to make it comfortable for people working in the area.
- **2nd check:** 11:00 am to ensure that units are switching off as programmed.
- **3rd check:** 12:00 noon to check that the units are switching on again as programmed.
- **4th check:** Random timings to see that the units in the toilets with PIR sensors are switching the unit on after sensing movement.

In the 8 weeks thereafter, only the 2nd, 3rd and 4th checks were performed, with some additional random check at other times. The units were always found to be operating as programmed.

After 10 weeks of monitoring & verification, it was proven that the units offered enhanced energy savings. Due to the PIR-supported control in the toilets and two rarely used rooms, the heating units were switched off even during the day time when there was no occupancy. This resulted in an extra 30% energy saving during the working hours. Instead of 19,800 kWh, a saving of 23,220 kWh was observed during the 10 week monitoring period. This equated to a saving of over £2,300, which meant that the units had already reached payback.

Though the PSX controls offered energy savings as expected, they gave rise to issues as discussed below.

- Need for a programming PC

These units require a computer with corresponding software installed in order to program the. On Windows XP, the software failed to work unless another driver was installed later. The software interface is simple, and does not require specialist training.

- Need for a qualified electrician

For Health & Safety reasons, it was a requirement at Barr that the installation of these units be carried out by a qualified electrician, who can isolate the electricity supply, install the unit and then re-energise the circuit. This is different from an ordinary plug-in-timers which can be installed by a lay person.

- USB port is hidden once fitted

In the PSX switches, the USB programming port is hidden inside the spur once the unit is installed on the wall. This means that even a minor change to the program requires an electrician.

- Built-in thermostat only suitable for 1.5 kW appliances

As informed by the supplier, the built-in thermostat is unable to work with appliances above 1.5 kW. In such cases, the built-in thermostat becomes hot and gives false readings (i.e. higher temperature).

- Cost of units

The units 10 to 15 times more expensive than a typical plug-in-timer, and there is the additional cost of the electrician and programmer's time. The first installation required almost an hour of electrician and programmer time. Also, a trivial change to the program required half an hour of electrician and programmer time. Since an electrician will not normally have a laptop, a programmer will be required during every installation and maintenance activity.

- Human behaviour

People are characteristically reluctant to change. As expected, there were complaints such as hot water not dispensing quickly enough from wall-mounted units. On inspection, only a small difference was detectable between the time for hot water from units with and without PSX 125. Another complaint related to a rarely used meeting room where a PSX 135 with PIR had been installed. This room was found to be cold for a meeting at 2 pm even though it was warm enough within 10 minutes. If energy waste is to be reduced then the meeting room cannot be kept warm all day for a meeting that may or may not happen.

Based on partial implementation of these units, findings were noted and discussed within the CRC focus group. MACC, ERIC and CALoRIC were also updated, identifying a marginal abatement cost of -£143.80 per tonne of CO_2e and an IRR of 301.24%.

5.2 Energy Efficient Lighting

Implementation

Though LED lighting was not the best available opportunity according to the results from MACC, ERIC or CALoRIC, but LED lighting was implemented due to it being a low risk option with partial implementation possibility. As an initial trial, it was decided to replace 1 fitting in each proposed area and monitor & verify performance before progressing to full replacement.

One hi-bay fitting was replaced in the paint-shop with a SUN48 LED lamp, one twin tube was replaced in the workshop stores with a VP24 LED lamp, and one parking area light was replaced with a Jupiter 36 LED lamp. There was a mixed outcome for these replacements.

Monitoring & verification

The energy consumption of these replacements was verified before installation by connecting an 'Energenie Ener 007' energy monitor (Energenie Ener 007, 2010) and the lights were found to be working within 5% of their stated consumption. Despite that, there were other issues identified after installation. In the parking area, the luminosity of the light was not observed to be as effective as the conventional SON light, although it was still acceptable for a car park. In the paint-shop, there was a complaint from company's painter because the illumination level was less than acceptable for the task – this was subsequently confirmed by lux level measurement.

In the workshop stores, the LED twin tube lamp was found to be acceptable although the light distribution was not as effective as a fluorescent tube.

In an on-going research on energy efficient lighting at University of Strathclyde, it has been identified that, while purchasing LED lights, the housing and capacitor quality must be assured in order to avoid failure before the end of the LED service life. (Ref: Personal communication with JA, University of Strathclyde, 21-Mar-2011)

Corrective action

The trial highlighted the need for LED lights of higher luminance (at higher cost). Induction lights were proposed by a supplier as an alternate technology against the claim that these offer better illumination, are omni-directional, have a 6 times longer life than LED lights and are almost half the price. Research revealed that induction lights offer higher pupil lumens (EcoNext, 2012) making them look brighter than conventional lights. It was proposed by the supplier to install induction lights in the workshop/paintshop to monitor & verify performance at no cost if users were dissatisfied.

Characteristics	**LED**	**Induction**
Lux levels*	Standard	Standard
Direction*	Uni-directional	Omni-directional
Energy / CO_2e reduction**	40-50%	40-50%
Rated life (hours)***	60,000	100,000
Price difference from traditional lights***	400% high	200% high
Warranty (years)***	3	5
For 100 units installed:		
Capital cost***	£50,000	£20,000
CO_2e reduced / year (tonne)**	57.94	29.79
Cost saving/ year**	£11,405	£5,865
Pupil luminous efficacy (lumens/ Watt)	165*****	129****
Note: *As observed during trials **As measured by Energenie Ener 007 meter ***Based on information from suppliers ****Reference: (Econext, 2012) *****Reference: (MyLEDLightingGuide, 2012)		

Table 35: Comparison of LED and Induction lights

The installation of a test induction lamp was subsequently carried out in the workshop area: a Matsushima MAT-F05 200 W hi-bay induction lamp (Matsushima, 2011).

The energy consumption of the induction lamp was verified before installation by connecting an Energenie Ener 007 energy monitor (Energenie Ener 007, 2010) and the lights were found to be working within 10% of their stated consumption. After installation, the performance was satisfactory. Based on these trials, a comparison of LED and induction lamps was undertaken as shown in table 35.

Induction lights require less capital and are more acceptable to the users. For these reasons, the lighting in the workshop, paint-shop and parking area were also proposed to be replaced with induction lights. Appendix 30 shows the business case calculations. The MACC, ERIC and CALoRIC were updated, showing a carbon abatement cost of -£33.40 per tonne of CO_2e and an IRR of 3.1%: the low return on investment caused the cancellation of further deployments. Likewise, the replacement of fluorescent tubes with LED lights was postponed until a more cost-effective solution was found.

In this research, problems in installation were also found to be significantly time consuming. However, there are induction and LED lights available in the international market (Source: EBay search, 2011) in T5-T9, E26-E40 and R7 fitting types, which would fit into the existing housings to make these lamps simpler and quicker to install/ replace, with easy availability of alternatives in the case of a failure.

5.3 Transport Fleet

Implementation

The transport energy reporting system was implemented as proposed after development by the company’s internal IT developer. Several issues arose both during and after the system deployment. On the positive side, the IT developer was well versed with existing systems and had access to the resources to do the job quicker than an externally sourced developer. On the negative side, the IT developer was already engaged in multiple internal projects for sales and financial systems. In addition, there were errors found in the early developed version, such as utilisation factor unavailability and incorrect previous month and year-to-date data. For such reasons it took 12 months to develop the system. Once operational, the system was presented to the CRC focus group and fully implemented. A typical report from the system is shown in Appendix 22.

Monitoring & verification

During the first 3 months of use, it proved difficult to get the transport managers go scrutinise the monthly transport reports due to their busy schedule. As a result no remedial actions were initiated. Further, since the reports were generated at monthly frequency, managers found it difficult to identify reasons for energy wastage.

Within the environmental division, trucks move between fixed locations and the opportunity for energy saving was low. The remaining significant energy users in the company's transport fleet were tippers and mixers for asphalt, concrete and dry aggregates, and significant savings were expected.

Corrective action

To solve the observed issues, an off-the-shelf telematics system was implemented, which was offered at low cost (Appendix 23). The Tom-Tom telematics system was expected to provide daily alerts on fuel consumption and waste, and deliver a behavioural change in drivers of tippers and mixers. By providing daily alerts and detailed information about fuel use, fuel waste, speeding data and routes, it was also expected to become simpler for the transport managers to identify the source of a problem and possible solutions.

The telematics system was trialled for a month to build confidence in its performance; it was then fully implemented in the Quarries Division's tippers and mixers vehicles at a capital cost of £6,000 and an annual running cost of £3,750. Since the system generates auto alerts and reports, a lower annual management involvement cost of £3,000 was assumed.

The savings from the system were monitored and verified on a monthly basis by using the fuel consumption figures available from the previously developed reporting system. From the results shown in the fuel efficiency comparison of Appendix 24, a 3.48% reduction in fuel usage was identified, corresponding to a saving of 15,829 litres of fuel per annum (approximately £22,160 at £1.40 per litre) and a reduction of 41.77 tonnes of CO_2e per annum. MACC, ERIC and CALoRIC were updated to show a carbon abatement cost of -£282.10 per tonne of CO_2e and an IRR of 451.26%.

5.4 Solar PV

Implementation

A 50 kWp solar PV system was proposed for installation on the stores roof at Killoch. For several reasons, such as project cost and Health & Safety issues, it took 5 months to complete the paperwork required to obtain internal approval. In November 2011, the UK government dramatically reduced the feed-in-tariff with effect from 12 December 2011. This resulted in the tariff for a 50 kWp scheme being reduced from 32.9 to 15.2 pence/kWh. Due to the time scale associated with such scheme (the negotiation with the grid operator can take around 45 days) it was impossible for the company to complete the project by the December deadline.

Corrective Action

The viability of the project was reanalysed using the spreadsheet tool (Appendix 19) and payback period increased to 12 years from the previously estimate of 8 years. The updated MACC and ERIC predictions then showed a carbon abatement cost of -

£14.80 per tonne of CO_2e and an IRR of -6.78%, which made the proposal the least attractive of all the proposals being considered for investment by the company, and pushed the project out of given range in ERIC and CALoRIC.

The CRC focus group decided to shelf the project and mark it for reconsideration at a later stage should the price of solar panels fall or the subsidy situation change.

5.5 Wind turbine

Likewise, the company decided not to proceed with the proposed wind turbine installation because the option was a low scoring opportunity in CALoRIC, MACC and ERIC. In addition, the capital required for the scheme was high and the planning application process was expected to protract due to the site's close proximity to a highway and airport. Again the opportunity was marked for a later reassessment.

5.6 IT Server Room

Implementation

Although passive cooling and heat recovery in the IT server room was considered a priority the initial plan entailed only passive server cooling with the captured heat passed to the adjacent IT store.

Monitoring & verification

As with plug-in timers, monitoring & verification proved to be problematic. The process was therefore implemented and the outcome determined by visual observation: a significant reduction in cooling unit operation was observed as summarised in table 36.

Observation per AC Unit	AC 1 observed operation	AC 2 observed operation
10	0	0
10	2	1
10	3	2
10	6	5
10	8	6
10	10	9
10	9	10
10	8	7
10	8	7
10	6	5
10	4	3
10	0	0
SUM: 120	64	55
	Load	**49.58%**

Table 36: AC Units running observations

As can be seen the AC units were observed to be running for 50% of the time, whereas previously they were operating for 100% of the time. These data were used to recalculate the savings from this opportunity (Appendix 20) and MACC and ERIC were updated providing a carbon abatement cost of -£36.50 per tonne of CO_2e and an IRR of 18.12%. CALoRIC was also updated to show the position of opportunity, in comparison to other carbon reduction options, after monitoring & verification.

5.7 Bitumen Tanks

Implementation

The company decided not to purchase vertical bitumen tanks due to their weak case in CALoRIC, attached to the high capital required. Instead, it was decided to meet the operational requirement by replacing 3 tanks with refurbished electrically heated horizontal tanks, which were readily available at a lower cost of £10,000 each. There was no technical information available on tank energy use.

Monitoring & verification

After installation, an Elcomponent SPC Pro 3 phase data logger (Elcomponent, 2010) was installed on a refurbished and an existing bitumen tank both operated under similar weather conditions. The cost saving was then estimated from the result (Appendix 21) and MACC, ERIC and CALoRIC were updated. The carbon abatement cost was identified as -£25.20 per tonne of CO_2e with an IRR of 9.51%.

5.8 Drying Rooms

Implementation

Drying room project was among the top 3 opportunities as suggested by CALoRIC. Five drying rooms were fitted with a combination of heaters and dehumidifiers as proposed.

Monitoring & verification

Since the project was proposed after initial trial, therefore no further monitoring & verification was carried out. However, there were discussions with the site manager where these units were deployed to confirm satisfactory operation. All five unit managers reported better quality of drying post deployment.

5.9 Storage Sheds

The company decided not to implement the storage sheds project due to their weak case in CALoRIC, attached to the high capital required. It was decided to shelf the project and mark it for reconsideration at a later stage.

5.10 Burner Replacement

The proposed burner replacement was also postponed due to its weak case in CALoRIC, attached to the high capital required. The business case was revised with updated fuel cost figures, but due to no significant difference in the project's position in CALoRIC, it was decided to shelf the project and mark it for reconsideration at a later stage.

After monitoring & verification and revision of the carbon reduction opportunities, final costs and benefits were obtained, as shown in table 37.

Opportunity	**Capital Cost (£)**	**Annual Benefit (£)**	**Annual Costs (£)**	**Project life time (years)**	**Annual carbon reduction (tonne-CO_2)**
Tamper-proof PSX switches	1,775	5,805	75	3	31
Induction Lighting	15,033	2,655	500	25	15
Solar PV	120,000	10,498	500	25	21
Wind turbine	320,000	31,713	3,600	20	57
Transport fleet management	6,000	22,160	6,750	5	42
Storage sheds	25,000	19,770	0	25	110
Drying room improvements	575	6,912	150	3	37
Refurbished bitumen tanks	30,000	6,324	600	10	48
Burner replacement	30,000	15,000	500	10	83
IT server room improvements	15,000	4,138	200	10	38

Table 37: revised costs and benefits associated with the carbon reduction opportunities.

5.11 Impacts of implementation on the Company

As observed during this research, the decision makers in an organisation do not only require reliable information on potential carbon reduction opportunities and their comparison to implement the most suitable ones, but they also require information on the impact of implementations to decide their further carbon reduction strategy. After the monitoring & verification, trust can be established on potential savings from the carbon reduction opportunities, but it still remains a question if these savings are enough to achieve organisational targets, and to what extent other factors can affect reduction in carbon emissions.

In addition to the energy efficiency and renewable energy initiatives, absolute carbon emissions in a company may reduce due to a number of factors, such as reduced business activity, an increase in energy awareness or indirect impact from other activities such as maintenance *etc*. During this project, the company was operating in a recessed market, and the business activity went down. Also, as the project progressed, the buy-in from the employees at all levels in the company was achieved by sharing with them the information on impacts of CRC through Focus group communication, energy newsletters (see Appendix 34), energy toolbox talks (see Appendix 35) *etc*. Though all of this resulted in reduced absolute carbon emissions, it identified a new challenge of how to identify where the change in the company's carbon emissions is coming from.

Due to the monitoring & verification of implemented carbon reduction opportunities, the first part of the challenge was easily dealt with. Based on the verified carbon reduction potential of the opportunity and the time of implementation, it can be readily quantified how much carbon emissions have been reduced due to its implementation over a period of time. The remaining reductions in carbon emissions are due to reduced business activity, increased energy awareness or other activities indirectly affecting the energy use.

Impact of energy awareness is a subjective matter, and the most difficult to quantify in such a large company such as Barr which has several operational sites and over 600 employees. Similarly, there are hundreds of daily activities of varying scale which can indirectly affect energy use, and it is difficult to quantify their impact.

However, the impact of reduced business activity could be normalised by using a sensible benchmark and key performance indicators.

It was difficult to identify and use benchmarks and key performance indicators for different businesses of the company. Since the main focus of the project remained on the quarries (i.e. industrial division) due to their carbon intensity, and also because sensible key performance indicators (KPI) and benchmark levels were already available (Banes & Fifer, 2011), this analysis was focused on the company's quarries only.

Energy Benchmarking

Table 38 shows the KPI that were identified for Barr's Quarry products using the Energy Consumption Guide (DETR, 1998).

Product	Key Performance Indicator	Unit
Aggregates	Energy per unit produced	kWh/tonne
Coated Products	Energy per unit produced	kWh/tonne
Concrete	Energy per unit produced	kWh/metre-cube

Table 38: Quarry Products' Latest KPI

It was decided to introduce benchmarking/KPI sheets to be completed by Quarry Managers, to increase their awareness about energy use of their products, and also the CRC costs of them. Appendix 36 shows the sheets that were introduced to the Quarry

Managers. The following challenges were identified after introducing the benchmarking/KPI sheets.

- The Quarry Managers found it time-consuming to complete these paper based sheets once every month.
- In the quarries that produce more than one of the products shown in table 38, it was not possible for the Quarry Managers to split electricity consumption due to the absence of sub-metering. The electricity consumption was being split based on a simple fraction of the products that were being produced. So, if a quarry produced 5 tonnes of aggregates, 3 tonnes of coated products and 2 m^3 of concrete, the electricity was then divided as 50% for aggregates, 30% for coated products and 20% for concrete.

The first challenge was dealt with by providing Quarry Managers with a similar but spreadsheet based tool. For the second issue, the best solution is sub-metering, but due to time and cost constraints, it was decided that quarries would continue to split electricity use in the above manner. Since this had introduced a problem, there was another technique used at divisional level to quantify carbon emissions that have changed due to business activity.

At divisional level, the number of tonnes of aggregate and coated material produced was converted into equivalent units of concrete. The equivalency was decided on the basis of energy intensity of each of these products based on the latest published benchmarks (Banes & Fifer, 2011). Table 39 shows that benchmark levels for these products and their equivalent number of units of concrete per unit of product.

Product	**Specific energy consumption**	**Equivalence to units of concrete**
Aggregates	14.2 kWh/unit (A)	A / C = 7.474
Coated Products	117.6 kWh/unit (B)	B / C = 61.895
Concrete	1.9 kWh/unit (C)	C / C = 1

Table 39: Energy equivalent production units

For example, if a site produced 5 tonnes of aggregates, 3 tonnes of coated products and 10 m^3 of concrete products, its total equivalent production (TEP) was given as:

TEP = (5 x 7.474) + (3 x 61.895) + (10 x 1)
= 233.05 units

If the total carbon emissions during the production of these materials were 1 tonne-CO_2, then the KPI here can be given as:

KPI = (CO_2 emissions x 1000) / TEP
= (1 x 1000) / 233.05
= 4.29 $kgCO_2$/unit

CO_2 Reductions at Barr Industrial

Table 40 shows the verified reduction in carbon emissions in Barr's Industrial division.

Implemented Projects	CO_2 savings per implementation	No of units implemented	Annual CO_2 saving (tonnes)	Cumulative CO_2 saving to date
PSX Switches	3.1	10	31.4	41.3
Drying room dehumidifiers	7.5	5	37.4	64.2
IT server room improvements	38.3	1	38.3	89.5
Transport - telematics system	41.8	1	41.8	48.9
Refurbished bitumen tanks	16.0	3	48.0	128.1
Energy Efficient Lighting (LED & Induction trials only)	1.2	1	1.2	1.8
Total Implemented		**41.10%**	**198.1**	**373.8**
Total Proposed		**100.00%**	**482.0**	**-**

Table 40: Verified CO_2 Reductions in Barr Industrial

As shown in table 40, the verified savings were 198 tonnes of CO_2 per annum. Cumulative verified savings up to the closing of research work were 374 tonnes of CO_2.

To understand how the other emission reduction factors affected the division during the same period, the carbon emissions, equivalent production and KPI figures, before and after the research project, were populated in table 41.

Factor		**Pre-Implementation (2009)**	**Project End (Dec11-Nov12)**	**Change**
Absolute annual CO_2 reduction - Reductions from Implemented projects - Reductions from other factors	(A)	10,768 - -	9,771 -198 -799	-997 -198 (i.e. '-20%') -799 (i.e. '-80%')
Total Equivalent Production	(B)	11,611,007	10,934,515	-676,492 (i.e. '-6%')
KPI ($kgCO_2$/unit)	(Ax1000)/B	0.927	0.894	-0.034 (i.e. '-4%')

Table 41: CO2 emissions Pre- and Post-Project

Table 41 shows an interesting comparison: of the 997 tonnes reduction in the company's carbon emissions, 80% of these came from factors other than the implemented & verified carbon reduction opportunities. However, this is not true. The business activity significantly reduced during this period. As shown in table 41, the equivalent production levels reduced by 6% in this period. Therefore, it is unfair to comment on absolute reductions without considering the benchmarked energy consumption, which showed to be reduced by 4%.

The benchmarking also provided a fair method to estimate reduction in carbon emissions from factors other than business activity and implemented carbon reduction opportunities. It was assumed that, if none of the carbon reducing factor was there in the company's division, its KPI would have remained constant. Based on this assumption, it was estimated what the carbon emissions would have been if the KPI remained constant (i.e. remained at 0.927).

Factor	Unit	Pre-Implementation	Project End	
			Actual	If KPI remained constant
Absolute Annual CO_2 emissions	(tonnes-CO_2)	10,768	9,771	10,141
Total Reductions	(tonnes-CO_2)	-	997	370
CRO* based reductions	(tonnes-CO_2)	-	198	198
Reductions from other factors	(tonnes-CO_2)	-	799	172
Equivalent production units	(production units)	11,611,007	10,934,515	10,934,515
KPI	(kgCO_2/Unit)	0.927	0.894	0.927
*CRO = Carbon Reduction Opportunities				

Table 42: CO2 reductions with Constant KPI

Table 42 shows that the carbon emissions of the division at the project's end would have been 10,141 tonnes of CO_2 {i.e. (0.927 x 10,934,515) / 1000} instead of 9,771 tonnes if the KPI remained constant. If also suggests that, effectively, the company has reduced 370 tonnes of its carbon emissions instead of 997 tonnes. Of these 370 tonnes of emission reductions, 198 tonnes came from the implemented initiatives (assuming that the verified savings were unaffected by the change in business activity). As this analysis is based on normalised emissions, the following conclusions can be made.

- 370 tonnes of CO_2 was reduced at the division during the research project.
- 198 tonnes of this reduction came from the implemented carbon reduction projects, which was monitoring & verified. This was 54% (i.e. 198 out of 370) of the effective reductions.
- 172 tonnes of this reduction came through an increase in energy awareness or indirect impact from other activities such as maintenance *etc*. This was 46% of the effective reductions.
- Specific energy consumption reduced by 4% (i.e. from 0.927 kgCO_2/unit to 0.894 kgCO_2/unit).

Sensitivity Analysis

At this point, it should be noted that there will always be an element of uncertainty for reasons as follows.

- Energy performance of a resource (such as plant, machinery, operative) is not constant.
- The results from monitoring & verification have their limitations, and the simultaneously occurring maintenance activities, energy awareness campaigns and so on may also impact these results.
- Fuel and electricity use is converted into equivalent carbon emissions based on conversion factors, which change over time and may be revised every year.

- The equivalent production levels are based on industry averages for the three major products from the quarries, and it is difficult to find exact product specific energy use/carbon emissions without appropriate sub-metering in place.

Sensitivity analysis was carried out to determine the impacts of uncertainties in verified savings and product specific energy benchmarks as given below.

Factor		0%		+10%		-10%	
Total Reductions	(tonnes-CO_2)	370	100%	370	100%	370	100%
CRO* based reductions	(tonnes-CO_2)	198	54%	218	59%	178	48%
Reductions from other factors	(tonnes-CO_2)	172	46%	152	41%	192	52%
*CRO = Carbon Reduction Opportunities							

Table 43: Impact of uncertainty in verified savings

As shown in table 43, the share of reduction from the implemented carbon reduction opportunities and other factors may individually change by up to 6% due to uncertainty in monitoring & verification. To analyse the impact of uncertainty in product benchmarks (or specific energy consumption), a 10% change was assumed for each individual product as shown in table 44 (aggregates), table 45 (coated products) and table 46 (concrete). As known already, coated products are the most energy intensive of quarries products. As shown in table 45, coated products can impact the share of reduction up to 10% of its value.

Product	Unit	0%		+10%		-10%	
Aggregates	(kWh/unit)	14.2		15.62		12.78	
Equivalent production units	(production units)	Initial	Final	Initial	Final	Initial	Final
		11,611,007	10,934,515	12,077,411	11,315,279	11,144,604	10,553,751
Total Reductions	(tonnes-CO_2)	370	100%	317	100%	426	100%
CRO based reductions	(tonnes-CO_2)	198	54%	198	62%	198	46%
Reductions from other factors	(tonnes-CO_2)	172	46%	119	38%	228	54%

Table 44: Impact of uncertainty in Aggregates benchmark

Based on this research, it was identified that the company's most energy intensive division has reduced its specific carbon emissions. More than half (i.e. 54%) of these reductions came from the implemented carbon reduction opportunities, and the rest were from other factors such as increasing energy awareness and maintenance.

If all of the carbon reduction opportunities proposed during this research were implemented, the division would have achieved a reduction of 654 tonnes (i.e. reductions from carbon reduction opportunities + reductions from other factors = 482

+ 172 = 654 tonnes) of normalised carbon emissions, and the share of reductions from carbon reduction opportunities would have been 74% instead of 54%. The reduction in specific energy consumption, in this case, would have been 6% instead of the 4% that was actually achieved.

Product	**Unit**	**0%**		**+10%**		**-10%**	
Coated	**(kWh/unit)**	**117.6**		**129.36**		**105.84**	
Equivalent production units	(production units)	**Initial**	**Final**	**Initial**	**Final**	**Initial**	**Final**
		11,611,007	10,934,515	12,299,246	11,642,033	10,922,769	10,226,996
Total Reductions	(tonnes-CO_2)	370	100%	422	100%	311	100%
CRO based reductions	(tonnes-CO_2)	198	54%	198	47%	198	64%
Reductions from other factors	(tonnes-CO_2)	172	46%	224	53%	113	36%

Table 45: Impact of uncertainty in Coated Products benchmark

Product	**Unit**	**0%**		**+10%**		**-10%**	
Concrete	**(kWh/unit)**	**1.9**		**2.09**		**1.71**	
Equivalent production units	(production units)	**Initial**	**Final**	**Initial**	**Final**	**Initial**	**Final**
		11,611,007	10,934,515	10,561,333	9,945,167	12,893,943	12,143,718
Total Reductions	(tonnes-CO_2)	370	100%	369	100%	370	100%
CRO based reductions	(tonnes-CO_2)	198	54%	198	54%	198	54%
Reductions from other factors	(tonnes-CO_2)	172	46%	171	46%	172	46%

Table 46: Impact of uncertainty in Concrete Products benchmark

In order to devise a strategy to achieve its 15% carbon reduction target, a spreadsheet tool was developed based on the analysis. As shown in chapter 6, section 6.6, the company may either chose to implement the top 6 carbon reduction opportunities or all 10 proposed opportunities. From other factors, the reductions have been quantified in this analysis to be 172 tonnes. Three different scenarios were assumed on the basis of this.

Scenario 1: Company implements the top 6 opportunities and the reductions from other factors remain constant (i.e. 172 tonnes).

Scenario 2: Company implements the top 6 opportunities and the reductions from other factors are doubled (i.e. 172 x 2 = 344 tonnes).

Scenario 3: Company implements the top 10 opportunities and the reductions from other factors remain constant (i.e. 172 tonnes).

To predict absolute carbon emissions in future years, it was assumed that in each year absolute carbon emission will be the total emission without any implementation (i.e. total production units in the year x KPI before the project) minus carbon reduction opportunities based reductions minus reductions from other factors. For example, if the company has the following figures for year X, then its absolute emissions for the year should be [{(A x B)/1000} - C -D] where:

A = Total production units: 15,000,000 units;
B = KPI before the project: 0.927 kgCO_2/unit;
C = CRO based reductions by this year: 985 tonnes;
D = other factors based reductions by this year: 344 tonnes.

Therefore, in the given case, the absolute emissions of the company in year X will be 12,582 tonnes and KPI for the year will be 0.839 (i.e. a 10% reduction in specific energy consumption). Table 47 shows the same calculations performed for various stages including before project, after project and given different scenarios for the future.

Factor	Unit	Before Project	This Project	Future		
		Actual	Actual	Scenario 1	Scenario 2	Scenario 3
Absolute Annual CO_2 emissions	(tonnes-CO_2)	10,768	9,771	12,754	12,582	11,853
CRO based reductions	(tonnes-CO_2)	0	198	985	985	1886
Reductions from other factors	(tonnes-CO_2)	0	172	172	344	172
Equivalent production units	(production units)	11,611,007	10934515	15,000,000	15,000,000	15,000,000
KPI	(kgCO_2/Unit)	0.927	0.894	0.850	0.839	0.790
Reduction from base	(%)	-	4%	8%	10%	15%

Table 47: Scenarios to achieve CO_2 reduction in future

Based on this analysis, it was concluded that the company must implement all of the suggested CRO to achieve its 15% reduction target. The lack of implementation of CRO may be overcome by increasing energy awareness, management control, improved maintenance procedures and the like.

5.12 Chapter Summary

The carbon reduction opportunities were implemented after taking into consideration the information from CALoRIC, MACC and ERIC. In order to reduce the risk, CALoRIC helped in picking the opportunities to implement in a staged manner and undertake monitoring & verification in a progressive manner. The outcome showed that even a top energy saving opportunity may not work as expected due to practical factors. Plug in timers, which could be applied to space and water heaters, did not work initially due to their vulnerability (staff tampered or theft). The replacement product was tamper-proof and worked, but then other issues arose such as the need for programming, the added time of a qualified electrician, and human factors.

With lighting, after the trial implementation of LED lighting in three test areas, it was demonstrated that while the approach can offer savings in electricity consumption, there are also negative factors. For example, illuminance levels were not as good as that provided by of conventional SON light although still acceptable for a car park. In the paint shop, the illuminance levels were not acceptable for the work task while in the workshop stores the light levels were acceptable although not as omni-directional as a fluorescent tube. It was also found that when purchasing LED lamps, the housing and capacitor quality is a critical issue to avoid premature failure. Induction lighting was also tested and found to offer good illuminance levels, omni-directional performance and long life.

For Solar PV, the reduction in the feed-in-tariff reduced the Company's motivation to install this renewable energy source. It also decreased the confidence in Government incentive schemes.

It was difficult to get the Company's transport managers go scrutinise the monthly transport reports due to their busy schedule. Since these reports were being generated at monthly frequency, it proved difficult to drill down into energy waste issues. A telematics system was therefore tried, which proved to be an effective solution.

In case of the bitumen tanks, the important lesson to emerge is that the capital cost of a new system may result in the selection of a refurbished product that offers a lesser carbon reduction and return on investment.

Based on the revised figures obtained through the monitoring & verification of opportunities, updated MACC, ERIC and CALoRIC curves were constructed as shown in figure 30 (CALoRIC), figure 31 (MACC) and figure 32 (ERIC).

It was also identified that, in addition to the energy efficiency and renewable energy initiatives, absolute carbon emissions in a company may reduce due to a number of factors, such as reduced business activity, an increase in energy awareness or indirect impact from other activities such as maintenance *etc*. Decision makers in an organisation require this information to understand the real impact of implemented carbon reduction opportunities and to decide their further carbon reduction strategy.

Based on the analysis, it was concluded that the company must implement all of the suggested carbon reduction opportunities to achieve its 15% reduction target. The lack of implementation of suggested carbon reduction opportunities may be overcome by increasing energy awareness, management control, improved maintenance procedures and the like.

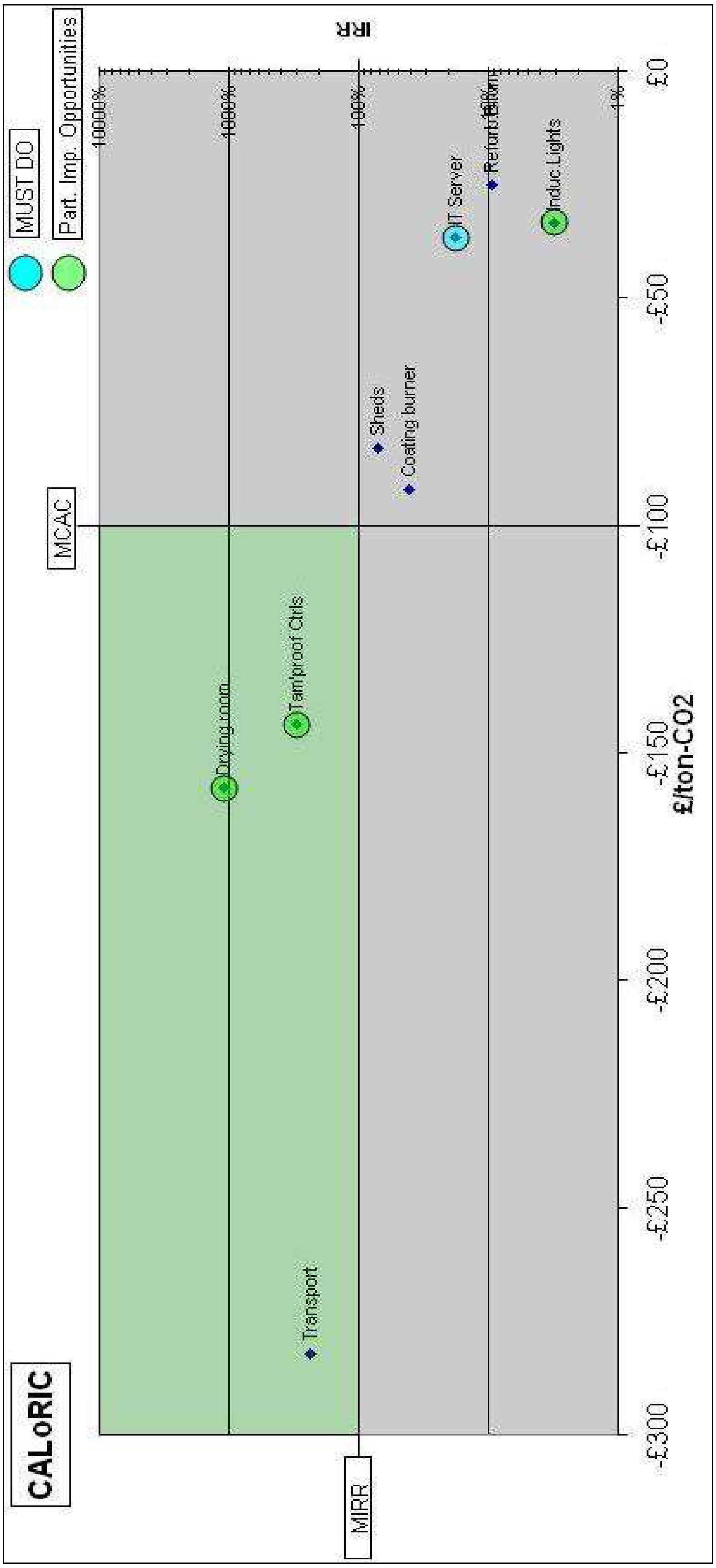

Figure 30: Revised CALoRIC for Barr

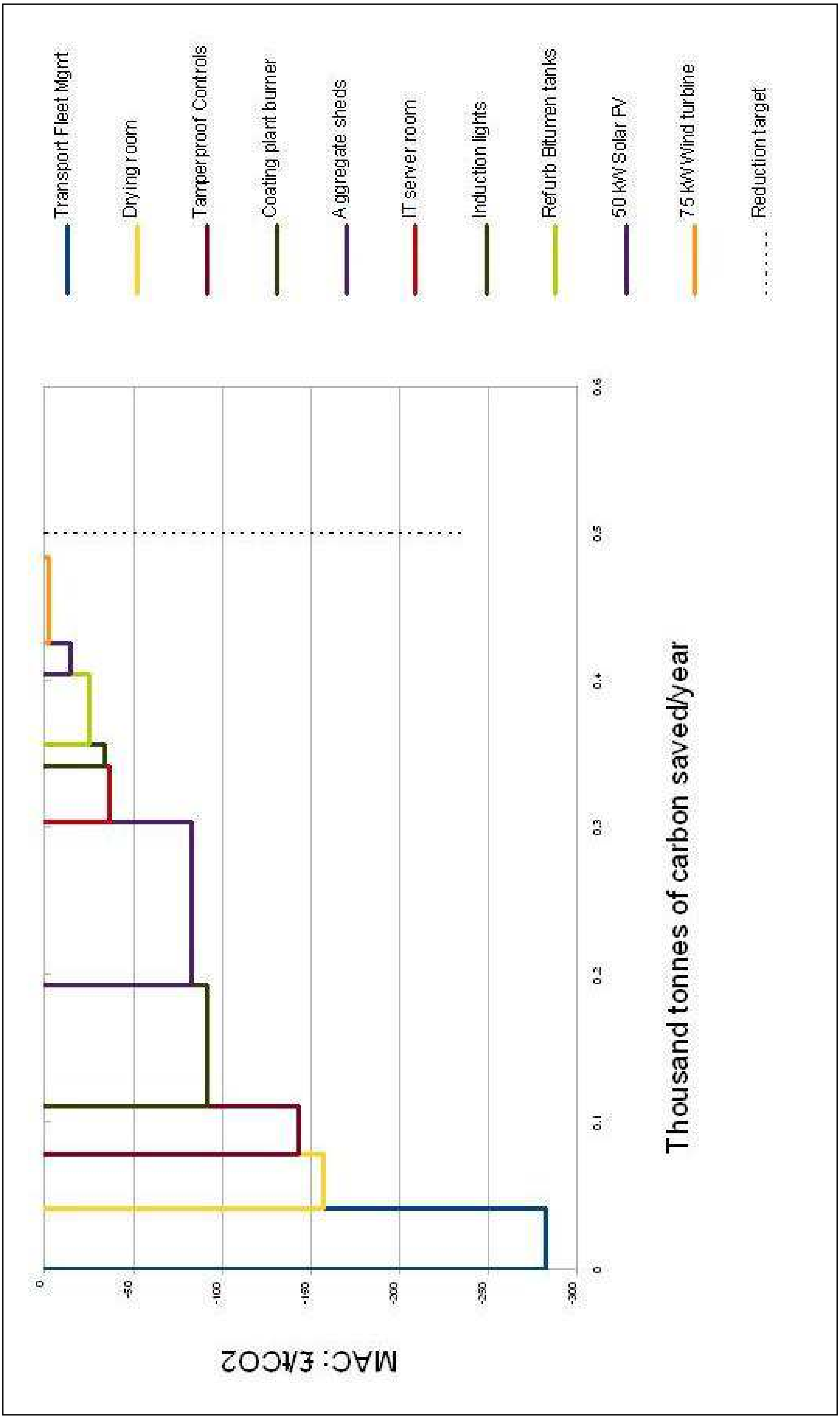

Figure 31: Revised MACC for Barr

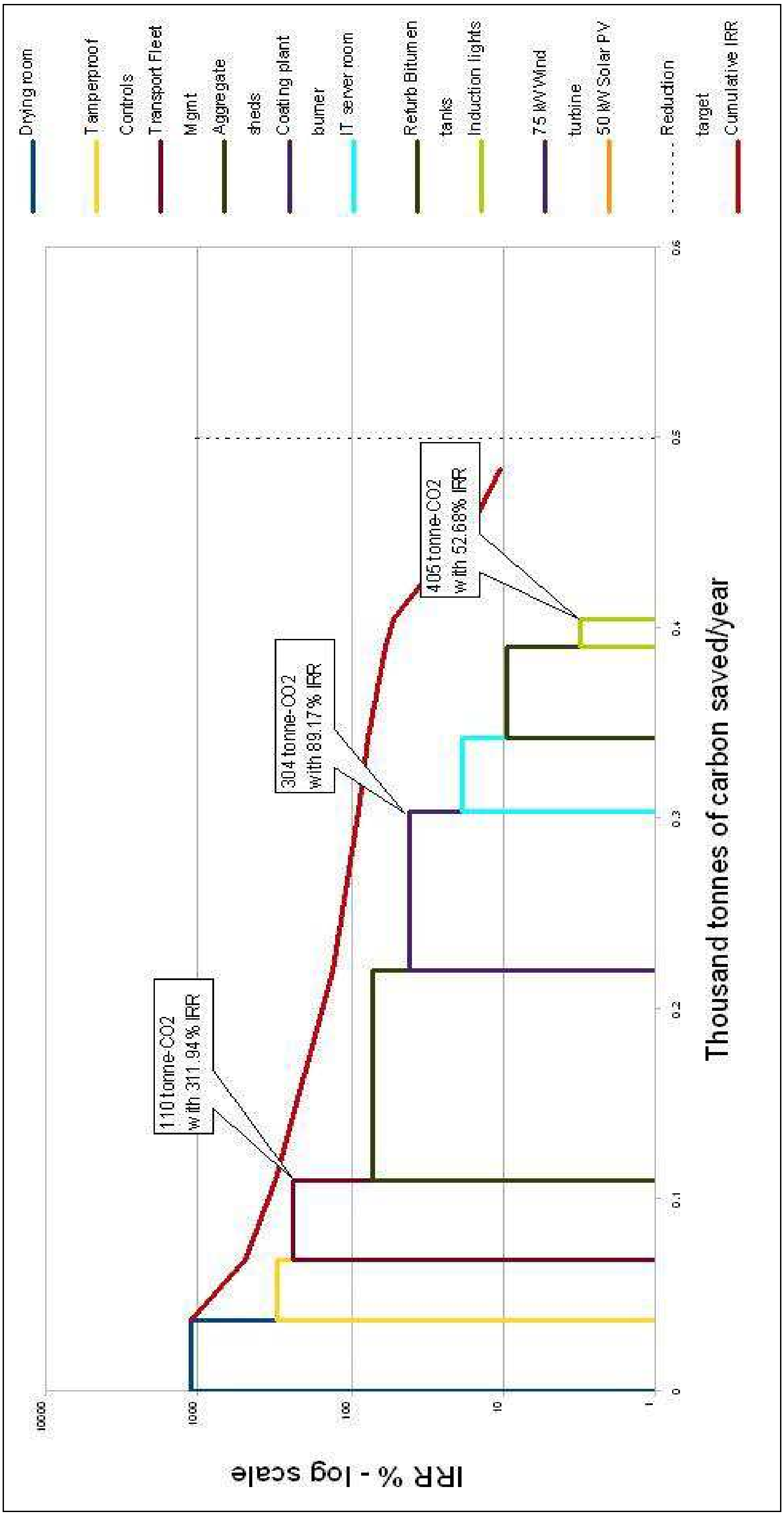

Figure 32: Revised ERIC for Barr

6 CONCLUSIONS & FUTURE WORK

A number of drivers such as rising energy prices, maintaining competiveness and stakeholders requirements are now pushing businesses to reduce their energy usage and carbon emissions. Initiatives introduced by the UK government such as CRC Energy Efficiency Scheme have increased this pressure. This research addressed the gap between available and required information on the impacts of CRC and possible ways to mitigate them. A company with a diverse range of operations, but mainly Aggregates and Construction, was chosen as a means to investigate CRC impacts and mitigation approaches. This chapter summarises the research findings and possible future work.

6.1 Impacts of CRC on the Company

Some researchers have examined how CRC has affected participants in general or those in particular sectors such as Health, Water, Commercial Property etc. They identified the problems initially faced by Energy/Facility Managers to assess their qualification for the scheme. For organisations that are already part of CCA/ EUETS the problem is even more difficult. Any quantification of the financial impacts associated with the scheme could not be found in the available research. For the mitigation of impacts of CRC, tools have been suggested such as the Marginal Abatement Cost Curve (MACC) and the Emission Reduction Investment Curve (ERIC). Little information was available on how the approaches compare and how effectively they are when applied.

In this research, the impacts of CRC were analysed for a company operating in Aggregates and Construction sectors. It was observed that CRC has significantly impacted the company. Due to the nature of the company’s activities, energy information was available in different formats and held within IT systems distributed across business divisions. The complexity of the information, required by CRC for qualification assessment and to meet liabilities, has introduced new challenges in sourcing, recording and analysing data. Identification and implementations of new systems & procedures were found to be essential for the CRC participant to meet its regulatory requirements. The following key steps were taken to ensure that the company was able to meet the requirements:

- design and implementation of CRC spreadsheet tool;
- set up of a CRC team and focus group;
- set up and maintenance of a CRC Evidence Pack;
- design and implementation of internal audits;
- improved data sourcing.

CRC has introduced significant financial burden on its participants. A major share of the CRC costs arises from the purchase of carbon allowances, 88% of the total CRC cost in this case. A significant number of person-hours are also being consumed to meet the requirements of CRC, 9.3% of the total CRC cost in this case. The overall financial impact of CRC on the company was in the range of £253,064 to £292,652, i.e. a 5.06% to 5.85% addition to the company's energy cost due to CRC. Huge fines are imposed in cases of non-compliance. Due to the significance of the person-hour costs, it was identified that a new CRC Information System would significantly reduce the financial impact.

6.2 Identification of opportunities – Use of MACC and ERIC tools

Based on company energy usage information, an energy baseline was established. This information highlighted the need to focus on the quarries, which are responsible for more than half the company's energy costs and carbon emissions. Diesel for transport, which is out of scope of CRC, was found to be the biggest energy cost to the company.

After an initial analysis, a mix of renewable energy and energy efficiency opportunities were identified as candidates for deployment. Some of these opportunities, such as IT server room improvement, coating plant burner replacement and bitumen tanks replacement, were already being considered by the company. Additional opportunities were identified, such as a transport reporting system, new aggregate storage sheds and drying room improvements, through analysis of existing data and discussion within the CRC focus group. Analysis of metered data and day-time and night-time surveys were also carried out at the company's main premises to identify energy saving opportunities such as plug-in timers, energy efficient lighting, solar PV and local wind turbine deployment.

A business case was developed for each of the identified carbon reduction opportunities, and a number of uncertainties were quantified, such as cost variation over time and changes in energy/financial savings due to factors such as weather, market situation, energy prices, available incentives, human behaviour etc. Unverified and green-washed information also added uncertainty. To assess and implement the opportunities, MACC and ERIC curves were plotted and shared within the company's CRC focus group.

MACC was found to be counter-intuitive due to positive carbon reduction opportunities falling in the negative axis of the plotted curve, and it also does not consider the internal rate of return of the opportunities, which is considered a more reliable measure for the CEO and CFO. The counter-intuitiveness is an unavoidable aspect of this tool; otherwise it would not be able to let the user compare the abatement cost against a carbon allowance price.

In addition to such previously identified issues, more issues emerged during this research. The existing MACC model does not take into account the impact of inflation on the costs and benefits of a scheme over its life time, which reduces the robustness of the data obtained. Due to the uncertainties identified during the development of business cases for the opportunities, it was highlighted that a careful approach is needed when using this tool.

The other tool, ERIC, emphasises the IRR of projects but does not give an indication of the carbon abatement cost, such as in £ per tonne of CO_2e, against the carbon allowance price. Due to the large range of IRR from 6% to 1849% for the actions considered in this research, a logarithmic scale was necessary on the y-axis, which makes it difficult to compare opportunities. Both MACC and ERIC are dependant on a project's life time value in calculating the outcome, which itself is another uncertainty. As with MACC, it was identified that a careful approach is needed while using this tool.

In terms of comparison of opportunities, it was identified that both tools mostly provide similar ranking of the available opportunities. However, this may change with time for some opportunities. Decision makers must decide whether they wish to proceed on the basis of value for stakeholders or abatement cost. In ERIC, all opportunities are viable, either less or more, whereas MACC can help to choose those opportunities that are viable for a CRC participant or, conversely, which opportunities should be implemented to achieve a certain emissions reduction target. There are also other organisation specific factors which influence the decision, such as availability of capital, and the level of risk that can be taken for innovative technologies. In addition to the uncertainties associated with carbon reduction opportunities, there are certain risks associated with innovative technologies, such as being scammed or green-washed. Therefore, it was identified that an improved approach is needed for implementing the identified opportunities to reduce the risk.

To address the issues identified in using MACC and ERIC, a blended approach was identified during the research. A simple tool, named CALoRIC (Carbon Abatement Low Risk Abatement Curve), was developed to show organisation specific results in identifying the most suitable carbon reduction opportunities. This tool provided information for both CEO/CFO and investing stakeholders in terms of IRR, and the information for CRC returns in terms of £ per tonne of CO_2e. The plot includes flexible vertical and horizontal lines, allowing the user to choose their desired carbon abatement cost (MCAC) or minimum IRR (MIRR), or both. In addition, it also allows the highlighting of low risk opportunities and must-do projects. In this manner it helps the company to choose the low risk and must do opportunities out of these MCAC and MIRR bands. A company may also highlight opportunities that are out of its available capital budget and ignore these opportunities even if these are within the chosen bands of MCAC and MIRR.

It was demonstrated in practice that CALoRIC is a better decision support tool than MACC and ERIC alone or together. The flexibility in CALoRIC to adjust the required IRR and carbon abatement cost was found to be useful. Though like ERIC, it had a logarithmic scale, but since the required IRR (or MIRR) is adjusted by the user, there is less chance of ignoring the fact that it is a logarithmic scale. The main purpose of these tools is to reduce the risks and uncertainties when making decisions, and it was found that highlighting opportunities with possible 'partial implementation' was a very good idea to pick opportunities with less risk/uncertainty. The 'must do' opportunities were highlighted, which also saved time. This tool can be even more helpful when there are a large number of available opportunities.

Use of the CALoRIC tool is the recommended outcome of this research. However, MACC and ERIC may also be provided to the decision makers for further reference, or to look at the cumulative impact of implementing multiple projects.

6.3 Lessons Learnt from the Implementation of Opportunities

In order to reduce the risk, it was decided to implement the opportunities partially where possible. After implementation, monitoring & verification was carried out and some interesting findings are presented below.

Plug-in timers

Plug-in timers, which were assumed suitable to save energy consumed by electric space and water heaters, could not work due to their vulnerability to be easily tampered or removed. The other product, innovative PSX switches were tamper-proof and provided energy savings, but then other issues emerged such as the need for a programming PC, a qualified electrician, a hidden USB port, as well as reprogramming costs and human behaviour issues. It showed that even a top energy saving opportunity may not work as expected due to simple operational factors.

Energy Efficient Lighting

After the trial implementation of LED lighting in three test areas, it was realised that LED lighting can offer savings in electricity consumption, but there are other issues with the technology. In the parking area, the luminosity of the lamps was not observed to be as good as a conventional Sodium lamp, although still acceptable for a car park. In the paint shop, the painter complained that the luminosity level was less than acceptable for the work task, which was later confirmed by a lux level check. In the workshop stores, the light level was found to be acceptable though it was not as omni-directional as a fluorescent tube. It was also identified that, while purchasing LED lights, the housing and capacitor quality must be assured since there is a danger of their failure much before the end of their stated life.

Another energy efficient lighting solution, induction lighting, was also tested. The lamps were claimed to offer improved lux levels, omni-directional cover and longer life. The initial tests confirmed a better performance of induction lights over LED lighting. A comparison has been shown in section 5.2, table 35.

Energy efficiency versus renewable energy

The project provided an insight into the comparison between energy efficiency and renewable energy systems' opportunities. It was identified that even low cost and quick solutions can produce effective results. For a CRC participant, renewable energy systems will become more viable if the energy and carbon prices increase further, or if the incentives are increased, or if the cost of the technology is reduced.

Despite the results from MACC / ERIC or CALoRIC, it was observed that due to government's actions within incentive schemes, such as repeatedly changing CRC and Feed-in-tariffs, there is an environment of uncertainty and businesses are finding it difficult to place confidence in such schemes. It becomes even more difficult if there is a high capital involvement.

Transport energy savings

In transport energy systems, after the initial trials, it was found difficult to get the transport managers go through the monthly transport reports due to their busy schedule. Since the reports were being generated with a monthly frequency, the transport managers found it difficult to drill down into energy wastage issues. An entity-based telematics system was tried and then implemented, which has proved successful.

Bitumen tanks

In the case of bitumen tanks, the proposal was not implemented due to its weak position in CALoRIC based on high capital involved, and refurbished tanks were purchased to meet the immediate demand. The important point to note here is that the capital cost of the system may push the organisation to go for refurbished products that offer a lesser carbon impact and return on investment.

6.4 Monitoring & Verification

The outcomes of this research indicate the importance of monitoring & verification procedures after the implementation of opportunities. The challenge however is that it may not always be possible to exactly measure a deployment in every case. However, with careful planning, a pre- or post-installation monitoring & verification scheme can be designed.

Improved approach for carbon reduction

A traditional approach in the implementation of energy saving and carbon reduction opportunities is the use of a 'Plan-Do-Check-Act' model. This is a basic model and requires further expansion to identify the best practise approach for carbon abatement opportunities. The following approach was used to implement the carbon reduction opportunities at Barr.

- Establishment of energy/carbon baseline.
- Identification of carbon reduction opportunities.
- Use of decision support tools to analyse the opportunities.
- Implementation of opportunities based on organisation specific criteria.

However, during the project it was identified that there were further steps required before and during the implementation, that were critical to the successful outcome from these opportunities. The importance of partial implementation and monitoring & verification (M&V) were realised. It was identified that there is a need for an enhanced approach rather than a simple Plan-Do-Check-Act model to ensure that carbon reduction opportunities result in real emissions reduction. It was identified that without a better approach there is a danger of being green-washed by using some of the new/innovative technologies.

In addition to the dangers associated with new and innovative technologies, there are also issues with existing technologies, as their financial impacts change with time due to changes in the incentivising schemes and other uncertainties, and their emissions impacts may also change as more knowledge becomes available. The approach practised during this research has proven efficient since it saved the company from fully implementing the opportunities that would not work, helped the company track its real carbon reductions against targets, provided decision making models to identify the most viable opportunities, and helped to assess the impact of implementing opportunities in terms of CRC and long term carbon reduction targets. Figure 33 represents a model of this approach, according to which an opportunity can perform as expected (‘OK’ in the model), better than expected (‘Over-perform’ in the model), slightly poorer than expected (‘Under-perform’ in the model), or unacceptably poorer than expected (‘Disaster’ in the model). Red arrows are followed when an opportunity does not perform as expected.

6.5 Real reduction in emissions

It was also identified that, in addition to the energy efficiency and renewable energy initiatives, absolute carbon emissions in a company may reduce due to a number of factors, such as reduced business activity, an increase in energy awareness or indirect impact from other activities such as maintenance *etc*. Decision makers in an organisation require this information to understand the real impact of implemented carbon reduction opportunities and to decide their further carbon reduction strategy.

Due to the monitoring & verification of implemented carbon reduction opportunities, it was already quantified how much carbon emissions had reduced due to them over a period of time. However, there were other initiatives such as energy awareness through Focus group communication, energy newsletters, energy toolbox talks *etc*, which resulted in an increase in energy awareness. During this project, the market conditions were also recessed which provided further reductions in carbon emissions.

The Energy Benchmarking / Key Performance Indicators were initially introduced in company’s most energy intensive Industrial division to raise awareness. However, to quantify the carbon emission reductions due to these other factors, the emissions were normalised using existing benchmarks / key performance indicators.

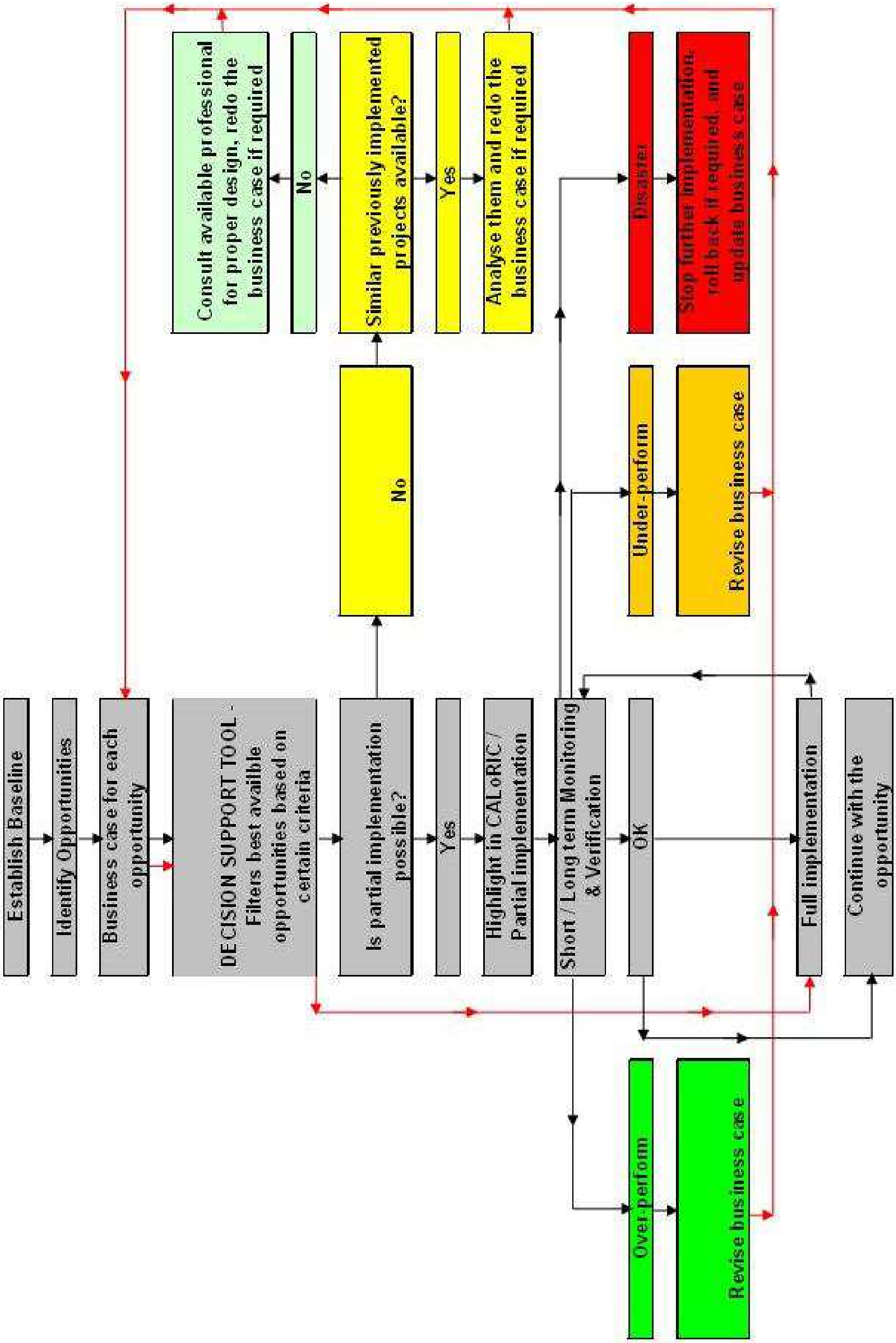

Figure 33: Improved approach for carbon reduction opportunities

Following conclusions were made on the basis of this analysis.

- 370 tonnes of CO_2 was reduced at the division during the research project.
- 198 tonnes of this reduction came from the implemented carbon reduction projects, which was monitoring & verified. This was 54% (i.e. 198 out of 370) of the effective reductions.
- 172 tonnes of this reduction came through an increase in energy awareness or indirect impact from other activities such as maintenance *etc*. This was 46% of the effective reductions.
- Specific energy consumption reduced by 4% (i.e. from 0.927 $kgCO_2$/unit to 0.894 $kgCO_2$/unit).

It was also concluded that the company must implement all of the suggested carbon reduction opportunities to achieve its 15% reduction target. The lack of implementation of CRO may be overcome by increasing energy awareness, management control, improved maintenance procedures and the like.

6.6 Next steps for the CRC participant

The next steps will include further dissemination of previously implemented opportunities that proved their ability to reduce carbon emissions, and the implementation of opportunities which were previously postponed for miscellaneous reason. Business cases for the suggested projects were re-assessed on the basis of latest available information. Table 48 shows these proposed projects. CALoRIC (Figure 36), MACC (Figure 37) and ERIC (Figure 38) for the next steps have also been developed on the basis of learning outcomes from this research. As suggested earlier, the position of renewable energy systems has improved due to reducing technology price and new incentives.

The top six opportunities in table 48 will cost £231,600 (i.e.18.06% of the total cost), but will reduce carbon emissions by 985 tonnes (i.e. 52.23%). Although the IT server room project does not occupy an impressive position in both MACC (9^{th} rank) and ERIC (6^{th} rank), the project was implemented due to its required impact on the server room. The top six opportunities will also save £11,820 annually in CRC costs at £12 per tonne of CO_2 (i.e. 12 x 985). In total, the top six opportunities will save the company £192,144 per annum (i.e. CRC saving + annual benefit – annual cost). Implementing all of the opportunities will cost the company more than 5 times the cost of implementing the top six but will save only £22,632 annually in CRC costs at £12 per tonne of CO_2 (i.e. 12 x 1886). In total, implementing all 10 opportunities will save the company £401,089 per annum (i.e. CRC saving + annual benefit – annual cost).

As concluded in section 6.5, the company must implement all of the suggested carbon reduction opportunities to achieve its 15% emissions reduction target. However, due to significant costs of the last 4 opportunities, the company should consider other options such as increasing energy awareness, management control, improved maintenance procedures and the like.

Opportunity	Capital Cost (£)	Annual Benefit (£)	Annual Cost (£)	Project life time (years)	Annual carbon reduction (tonne-CO_2)
Tamper proof PSX controls (50 units)	8,875	29,025	375	3	157
Transport Energy Management	6,000	22,160	6,750	5	42
Drying room improvements (15 units)	1,725	20,736	450	3	111
Burner replacement (5 units)	150,000	75,000	2,500	10	417
Aggregate sheds (2 units)	50,000	39,540	0	25	220
IT Server room	15,000	4,138	200	10	38
Energy Efficient Lighting (3 times implementation)	45,099	7,965	1,500	25	45
Vertical bitumen tanks (10 units)	500,000	120,000	2,000	10	740
100 kW Solar PV	137,500	20,692	100	20	42
100 kW wind turbine	368,201	57,573	4,497	20	74
Totals	**1,282,400**	**396,829**	**18,372**		**1,886**

Table 48: Next steps: Proposed carbon reduction projects

Table 49 shows a comparison of various opportunities that achieved a different rank suggested by MACC and ERIC over the duration of this research. The rank of the opportunities varied mainly after the monitoring & verification, in addition to the factors such as reducing technology price and changes in available incentives.

Comparison of position of opportunities						
	Pre-Implementation		**After M&V**		**Future Plan**	
Opportunities	**MACC**	**ERIC**	**MACC**	**ERIC**	**MACC**	**ERIC**
Transport management	1	3	1	3	1	3
Drying room modification	4	2	2	1	3	1
Heater controls	2	1	3	2	4	2
Coating plant burner	3	5	4	5	6	5
Aggregate sheds	6	4	5	4	7	4
IT server room	8	6	6	6	9	6
Energy efficient lighting	9	10	7	8	10	10
Bitumen tanks	7	7	8	7	8	7
Solar PV	5	9	9	10	5	8
Wind turbine	10	8	10	9	2	9

Table 49: Comparison of position of opportunities from MACC and ERIC

Table 50 shows the changing positions of opportunities in MACC only, and table 51 shows the same for ERIC only.

Opportunities MACC Position	Pre Implementation	After M&V	Future Plan
Transport management	1	1	1
Heater controls	2	3	4
Coating plant burner	3	4	6
Drying room modification	4	2	3
Solar PV	5	9	5
Aggregate sheds	6	5	7
Bitumen tanks	7	8	8
IT server room	8	6	9
Energy efficient lighting	9	7	10
Wind turbine	10	10	2

Table 50: Comparison of position of opportunities from MACC

Opportunities ERIC Position	Pre Implementation	After M&V	Future Plan
Heater controls	1	2	2
Drying room modification	2	1	1
Transport management	3	3	3
Aggregate sheds	4	4	4
Coating plant burner	5	5	5
IT server room	6	6	6
Bitumen tanks	7	7	7
Wind turbine	8	9	9
Solar PV	9	10	8
Energy efficient lighting	10	8	10

Table 51: Comparison of position of opportunities from ERIC

However, the CALoRIC curve remained fairly consistent for the opportunities within the selected MIRR and MCAC. The top three opportunities remained the top three throughout, and nature of partially implementable and must-do projects remained same any way. Based on its policy and stakeholders' needs, the company can adjust either the MIRR or MCAC, or both, until sufficient carbon reduction opportunities have been chosen to achieve the organisational targets.

6.7 Extrapolation to other CRC Participants

This research has focussed in one company (Barr) to identify and quantify the impacts of CRC and the mitigation opportunities. As identified in the research, aggregate sector companies are experiencing adverse impact due to the CRC scheme, but the scheme also brings opportunities to not only reduce carbon emissions but also the costs associated with energy use.

At this point, it was considered appropriate to speculate on how the observed impacts may be translated to other organisations. Clearly this task is easier for organisations similar to Barr (i.e. with major energy use related to aggregates) than to organisations operating in other sectors.

A step-by-step approach was used to extrapolate the results of this project to other CRC participants. A brief description of each step follows.

Step 1: From the only available CRC Performance League table for the year 2010-11, 30 companies were randomly selected from 10 different sectors (i.e. 3 companies from each sector). Table 52 shows the selected companies and their CRC emissions.

Organisation Name	Sector	Emissions (Tonnes of CO_2)
MIDLAND QUARRY PRODUCTS LIMITED	Aggregates	38,006
LAFARGE BUILDING MATERIALS LIMITED	Aggregates	88,052
ANGLO AMERICAN PLC	Aggregates	40,337
Bank of England	Banking	18,906
ROYAL BANK OF SCOTLAND PLC-THE	Banking	350,145
Santander UK Plc	Banking	111,856
SKANSKA CONSTRUCTION HOLDINGS UK LIMITED	Construction	15,793
CARILLION PLC	Construction	51,831
BAM GROUP (UK) LIMITED	Construction	41,808
Preston City Council	Councils	6,328
Salford City Council	Councils	33,453
Manchester City Council	Councils	78,220
NEWS INTERNATIONAL LIMITED	Media	58,283
BRITISH SKY BROADCASTING GROUP PLC	Media	77,219
British Broadcasting Corporation	Media	152,661
SIEMENS HOLDINGS PLC	Manufacturing	92,267
DYSON JAMES GROUP LIMITED	Manufacturing	3,577
TOYOTA(G.B.) PLC	Manufacturing	5,040
The Queen Elizabeth Hospital	NHS	7,334
Bradford Teaching Hospitals NHS Foundation Trust	NHS	13,543
Imperial College Healthcare NHS Trust	NHS	45,451
J SAINSBURY PLC	Supermarkets	961,782
TESCO PLC	Supermarkets	1,562,532
BROADSTREET GREAT WILSON EUROPE LIMITED	Supermarkets	794,029
MARKS AND SPENCER GROUP P.L.C.	Retail	410,369
NEXT PLC	Retail	151,480
DEBENHAMS PLC	Retail	163,254
SCOTTISH POWER UK PLC	Utility	58,882
SEVERN TRENT PLC	Utility	487,889
CENTRICA PLC	Utility	25,371

Table 52: CRC Participants and their emissions

Step 2: From the list of carbon reduction opportunities identified at Barr, possible opportunities were assigned to each sector. For example:

- all carbon reduction opportunities that have been identified at Barr can be implemented in all other aggregate sector companies;
- for Councils, the carbon emissions some opportunities as implemented at Barr, such as energy efficient lighting, PSX tamperproof switches, renewable energy systems (Wind and Solar PV), drying room dehumidification and transport energy reporting system were deemed relevant.

Table 53 shows the carbon reduction opportunities from the Barr study that may be implemented in other sectors. The following assumptions were made while extrapolating the results from this research to other organisations.

- These opportunities have not already been implemented.
- The opportunities have the potential to reduce emissions in other organisations by the same percentage as realised at Barr

Sector	Implementable opportunities from Barr
Aggregates	All
Banking	Energy efficient lighting, Tamperproof controls, IT cooling load reductions
Construction	Energy efficient lighting, Tamperproof controls, Renewable energy systems, Drying room improvements
Councils	Energy efficient lighting, Tamperproof controls, Renewable energy systems, Drying room improvements, Transport reporting system
Media	Energy efficient lighting, Tamperproof controls, Renewable energy systems, IT cooling load reductions, Transport reporting system
Manufacturing	Energy efficient lighting, Tamperproof controls, Renewable energy systems, Drying room improvements, Transport reporting system
NHS	Energy efficient lighting, Tamperproof controls, Renewable energy systems, IT cooling load reductions
Supermarkets	Energy efficient lighting, Tamperproof controls, Renewable energy systems, Transport reporting system
Retail	Energy efficient lighting, Tamperproof controls, Renewable energy systems, Transport reporting system
Utility	Energy efficient lighting, Tamperproof controls, Renewable energy systems, IT cooling load reductions, Drying room improvements

Table 53: Opportunities from Barr to other sectors

Step 3: For each sector, the following three values were calculated as shown in figure 34.

- The percentage of CO_2 emissions that can be reduced by implementing the suggested opportunities. To obtain this value, the estimated CO_2 reductions from the suggested opportunities were divided by the total CRC related carbon footprint of Barr (see column F in figure 34).
- The CO_2 reduction cost per tonne of CO_2 reduced. To obtain this value, the capital costs to reduce these emissions were normalised to the amount of emissions they reduce (see column G in figure 34).
- Annual financial benefit per tonne of CO_2 reduced. To obtain this value, the estimated financial benefits when reducing these emissions were normalised to the amount of emissions that can be reduced (see column H in figure 34).

For example, in aggregate sector companies, where all opportunities can be implemented, these were estimated to reduce their CRC related carbon footprint by the same percentage (i.e. 13.19%) as determined for Barr. In Councils, it was assumed that the suggested opportunities can reduce 3.29% of their CRC related carbon footprint, as would result at Barr from these opportunities.

Sector	Capital Cost	Annual Income	Annual Cost	Annual Benefit	Annual carbon reduction	Overall CO2 Reduction	CO2 reduction cost/tonne-CO2	Annual benefit/tonne-CO2 reduced
	A	B	C	D = (B-C)	E	F = (E/14296)	G = (A / E)	H = (D / E)
Aggregates	£1,282,400	£396,829	£18,372	£378,457	1,886	13.19%	£679.96	£200.67
Banking	£68,974	£41,128	£2,075	£39,053	240	1.68%	£287.39	£162.72
Construction	£561,400	£135,991	£6,922	£129,069	429	3.00%	£1,308.62	£300.86
Councils	£567,400	£158,151	£13,672	£144,479	471	3.29%	£1,204.67	£306.75
Media	£580,675	£141,553	£13,422	£128,131	398	2.78%	£1,458.98	£321.94
Manufacturing	£567,400	£158,151	£13,672	£144,479	471	3.29%	£1,204.67	£306.75
NHS	£574,675	£119,393	£6,672	£112,721	356	2.49%	£1,614.26	£316.63
Supermarkets	£565,675	£137,415	£13,222	£124,193	360	2.52%	£1,571.32	£344.98
Retail	£565,675	£137,415	£13,222	£124,193	360	2.52%	£1,571.32	£344.98
Utility	£576,400	£140,129	£7,122	£133,007	467	3.27%	£1,234.26	£284.81

Figure 34: CO2 reductions for CRC Participants

Step 4: The percentage reductions in each sector were then applied to the CRC related carbon emissions of each selected CRC participant to quantify the reducible emissions (see column D in figure 35).

Organisation Name	Sector	Emissions (Tonnes of CO2)	CRC cost	Est. CO2 reduction %	CO2 Red (tonnes)	CO2 reduction cost/tonne-CO2 reduced	CO2 reduction cost	Annual benefit/tonne-CO2 reduced	Annual benefit	Net Income
		A	B	C	D = (A x C)	E	F = (D x E)	G	H = (D x G)	I = (B + (D x 12) + H)
MIDLAND QUARRY PRODUCTS LIMITED	Aggregates	38,006	-£456,072	13.19%	5,014	-£679.96	-£3,409,268	£200.67	£1,006,130	£610,225
LAFARGE BUILDING MATERIALS LIMITED	Aggregates	88,052	-£1,056,624	13.19%	11,616	-£679.96	-£7,898,565	£200.67	£2,330,994	£1,413,766
ANGLO AMERICAN PLC	Aggregates	40,337	-£484,044	13.19%	5,321	-£679.96	-£3,618,367	£200.67	£1,067,839	£647,652
Bank of England	Banking	18,906	-£226,872	1.68%	318	-£287.39	-£91,282	£162.72	£51,684	-£171,377
ROYAL BANK OF SCOTLAND PLC-THE	Banking	350,145	-£4,201,740	1.68%	5,882	-£287.39	-£1,690,563	£162.72	£957,195	-£3,173,956
Santander UK Plc	Banking	111,856	-£1,342,272	1.68%	1,879	-£287.39	-£540,061	£162.72	£305,782	-£1,013,940
SKANSKA CONSTRUCTION HOLDINGS UK LIMITED	Construction	15,793	-£189,516	3%	474	-£1,308.62	-£620,013	£300.86	£142,545	-£41,286
CARILLION PLC	Construction	51,831	-£621,972	3%	1,555	-£1,308.62	-£2,034,820	£300.86	£467,816	-£135,496
BAM GROUP (UK) LIMITED	Construction	41,808	-£501,696	3%	1,254	-£1,308.62	-£1,641,329	£300.86	£377,351	-£109,294
Preston City Council	Councils	6,328	-£75,936	3.29%	208	-£1,204.67	-£250,802	£306.75	£63,863	-£9,575
Salford City Council	Councils	33,453	-£401,436	3.29%	1,101	-£1,204.67	-£1,325,865	£306.75	£337,610	-£50,619
Manchester City Council	Councils	78,220	-£938,640	3.29%	2,573	-£1,204.67	-£3,100,146	£306.75	£789,401	-£118,358
NEWS INTERNATIONAL LIMITED	Media	58,283	-£699,396	2.78%	1,620	-£1,458.98	-£2,363,942	£321.94	£521,624	-£158,328
BRITISH SKY BROADCASTING GROUP PLC	Media	77,219	-£926,628	2.78%	2,147	-£1,458.98	-£3,131,980	£321.94	£691,099	-£209,769
British Broadcasting Corporation	Media	152,661	-£1,831,932	2.78%	4,244	-£1,458.98	-£6,191,886	£321.94	£1,366,294	-£414,711
SIEMENS HOLDINGS PLC	Manufacturing	92,267	-£1,107,204	3.29%	3,036	-£1,204.67	-£3,656,880	£306.75	£931,164	-£139,613
DYSON JAMES GROUP LIMITED	Manufacturing	3,577	-£42,924	3.29%	118	-£1,204.67	-£141,770	£306.75	£36,099	-£5,413
TOYOTA(G.B.) PLC	Manufacturing	5,040	-£60,480	3.29%	166	-£1,204.67	-£199,754	£306.75	£50,864	-£7,626
The Queen Elizabeth Hospital	NHS	7,334	-£88,008	2.49%	183	-£1,614.26	-£294,790	£316.63	£57,822	-£27,994
Bradford Teaching Hospitals NHS Foundation Trust	NHS	13,543	-£162,516	2.49%	337	-£1,614.26	-£544,360	£316.63	£106,775	-£51,694
Imperial College Healthcare NHS Trust	NHS	45,451	-£545,412	2.49%	1,132	-£1,614.26	-£1,826,901	£316.63	£358,342	-£173,489
J SAINSBURY PLC	Supermarkets	961,782	-£11,541,384	2.52%	24,237	-£1,571.32	-£38,083,922	£344.98	£8,361,261	-£2,889,280
TESCO PLC	Supermarkets	1,562,532	-£18,750,384	2.52%	39,376	-£1,571.32	-£61,871,970	£344.98	£13,583,888	-£4,693,987
BROADSTREET GREAT WILSON EUROPE LIMITED	Supermarkets	794,029	-£9,528,348	2.52%	20,010	-£1,571.32	-£31,441,365	£344.98	£6,902,899	-£2,385,335
MARKS AND SPENCER GROUP P.L.C.	Retail	410,369	-£4,924,428	2.52%	10,341	-£1,571.32	-£16,249,484	£344.98	£3,567,547	-£1,232,785
NEXT PLC	Retail	151,480	-£1,817,760	2.52%	3,817	-£1,571.32	-£5,998,191	£344.98	£1,316,893	-£455,060
DEBENHAMS PLC	Retail	163,254	-£1,959,048	2.52%	4,114	-£1,571.32	-£6,464,409	£344.98	£1,419,250	-£490,430
SCOTTISH POWER UK PLC	Utility	58,882	-£706,584	3.27%	1,925	-£1,234.26	-£2,376,498	£284.81	£548,388	-£135,091
SEVERN TRENT PLC	Utility	487,889	-£5,854,668	3.27%	15,954	-£1,234.26	-£19,691,367	£284.81	£4,543,875	-£1,119,345
CENTRICA PLC	Utility	25,371	-£304,452	3.27%	830	-£1,234.26	-£1,023,982	£284.81	£236,289	-£58,208

Figure 35: Reducible emissions and financial benefit

Step 5: The CO_2 reduction cost per tonne of CO_2 reduced, identified in step 3, was applied to the reducible emissions identified in Step 4 to calculate the total CO_2 reduction cost to the company for implementing suggested opportunities (see column F in figure 35).

Step 6: The annual financial benefit per tonne of CO_2 reduced, identified in step 3, was applied to the reducible emissions identified in Step 4 to calculate the total annual financial benefit to the company for implementing suggested opportunities (see column H in figure 35).

Step 7: Total financial benefit to each selected CRC participant, after implementing the opportunities, was calculated by adding the costs and benefits for the year (see column I in figure 35). The figure in this column does not include the capital expenditure, but the annual benefit can indicate the return on invested money.

Carbon abatement opportunities for other participants

As observed in this analysis, some or all of the carbon reduction opportunities identified at Barr can be applied to organisations operating in other sectors. In the aggregates sector two major companies, Lafarge and Anglo American (Tarmac), can reduce almost 17,000 tonnes of CO_2 by implementing the same opportunities. In sectors other than aggregates, significant reductions can be achieved mainly in large emitters. The CO_2 reductions indicated in the analysis range from 1.68% in the Banking sector to 3.29% in Councils.

Though the calculations were based on a number of assumptions, implementing the opportunities are highly likely to result in significant savings.

Financial impacts of CRC on other participants

An effective way to compare the financial implications with and without implementation of suggested carbon reduction opportunities is to compare columns B and I in the figure 35. Column B shows the CRC allowance costs when no action is taken to reduce emissions, whereas column I shows the costs related to CRC emissions when suggested opportunities have been implemented.

Due to the maximum opportunities available for Aggregate sector companies, they can expect maximum benefit from these opportunities. The companies can actually save more money than they will normally lose in paying the CRC allowance costs. There are also significant benefits for other large emitters, such as retail and supermarkets, as the annual benefit to them by implementing suggested opportunities range from £1.3 million to £13.6 million.

The current analysis for CRC participants other than Barr does not include other CRC related costs to them, such as costs in data collection & collation, person-hours, early action metric, expert support, *etc*. However, these costs would vary by organisation as each organisation has different systems, procedures and available resources.

Use of approach for other participants

The approach identified in this project can be used by other CRC participants to identify the impacts of CRC on their business, to investigate potential carbon reduction opportunities, and to establish the systems & procedures required for compliance in the scheme. Even companies not participating in CRC can benefit from the tools identified in this research and used for the analysis of opportunities to inform decision making.

6.8 Future work

Though every effort was made to carry out the research as one project, the work still had limitations, such as:

- Private sector participant: The research was carried out in a private company, so the research does not provide an insight into how the scheme may affect a public sector participant. A public sector participant may use the same approaches as used in this project, although the systems and procedures may be different.

- EU ETS / CCA emissions: The research was carried out in a company that does not participate in EU ETS, and is also not a part of any Climate Change Agreement. The systems & procedures required for other companies may be different. However, the MACC can be more helpful for EU-ETS participants, as the market drives the carbon allowances price in the scheme.

- Though every effort was made to use the latest available data and information where possible, it was not possible to keep up to date with the latest information about all of the systems and opportunities in a project with such a large scope.

The following future work is proposed.

- **Development of CRCIS**

  It is proposed to develop the information system whose characteristics have been identified in this research in chapter 3, section 3.2.

- **Use of MACC / ERIC / CALoRIC for greater carbon reduction targets**

  It is proposed to use the method identified in the project to analyse the impacts & mitigation opportunities of CRC on more organisation, such as

  - a public sector organisation;
  - organisations with different levels of emissions;
  - organisations with emissions partially covered by EU-ETS / CCA;
  - organisations that hold some other equivalent of Carbon Trust Standard.

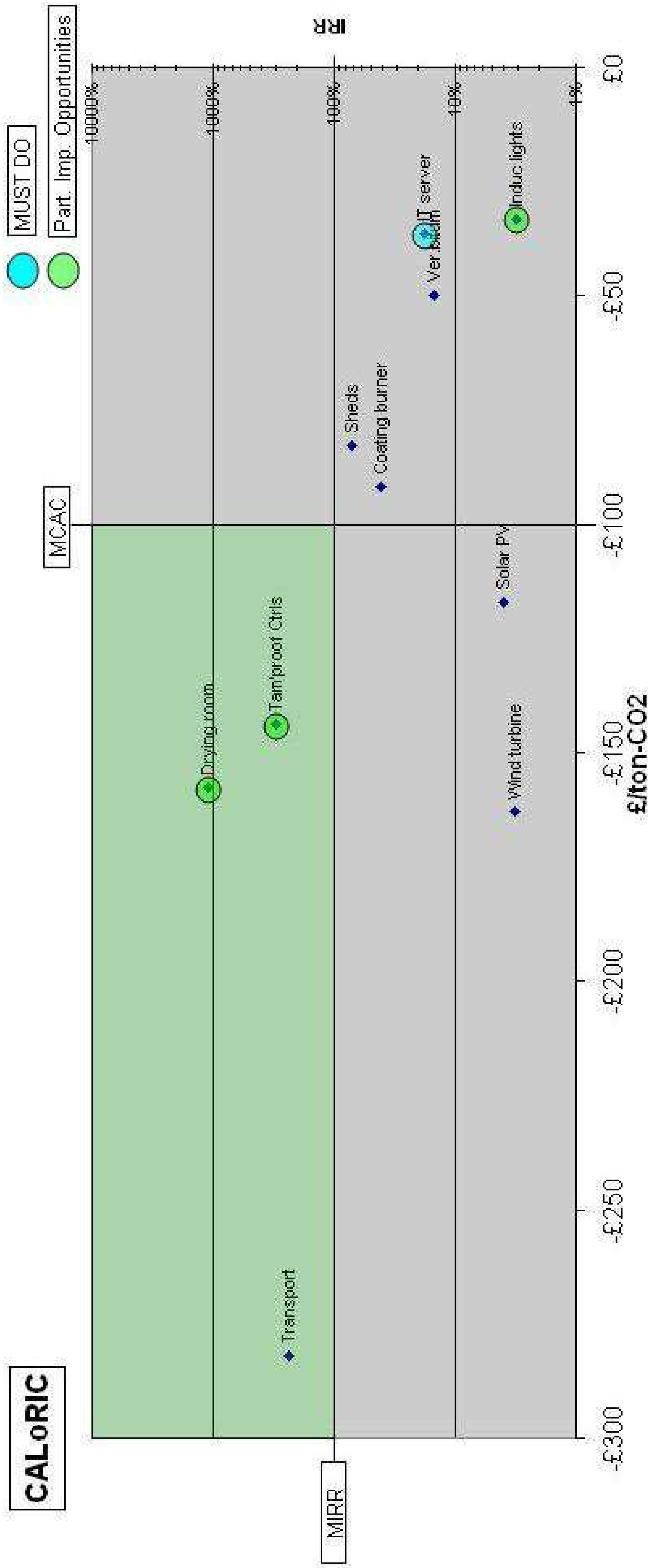

Figure 36: CALoRIC for future steps

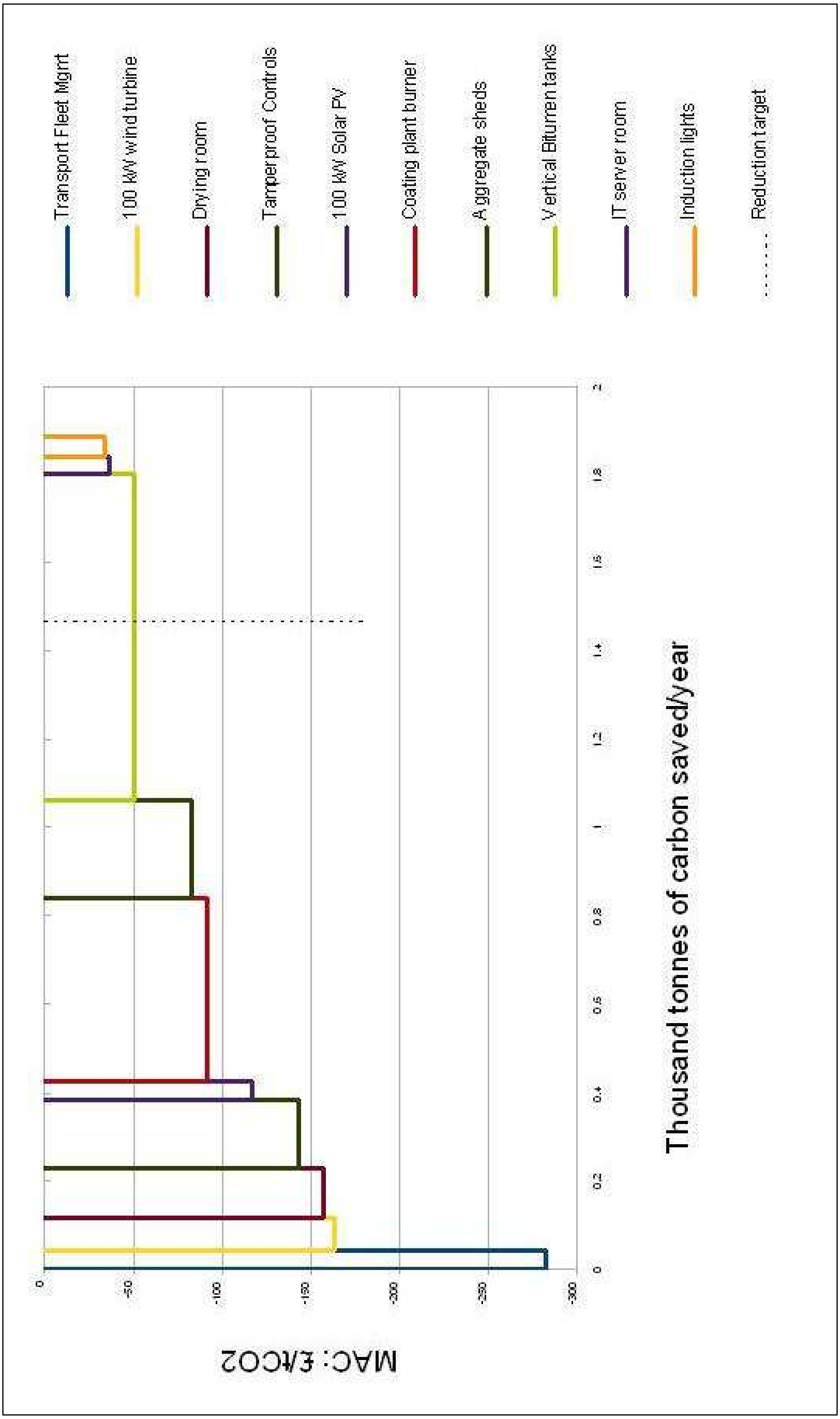

Figure 37: MACC for future steps

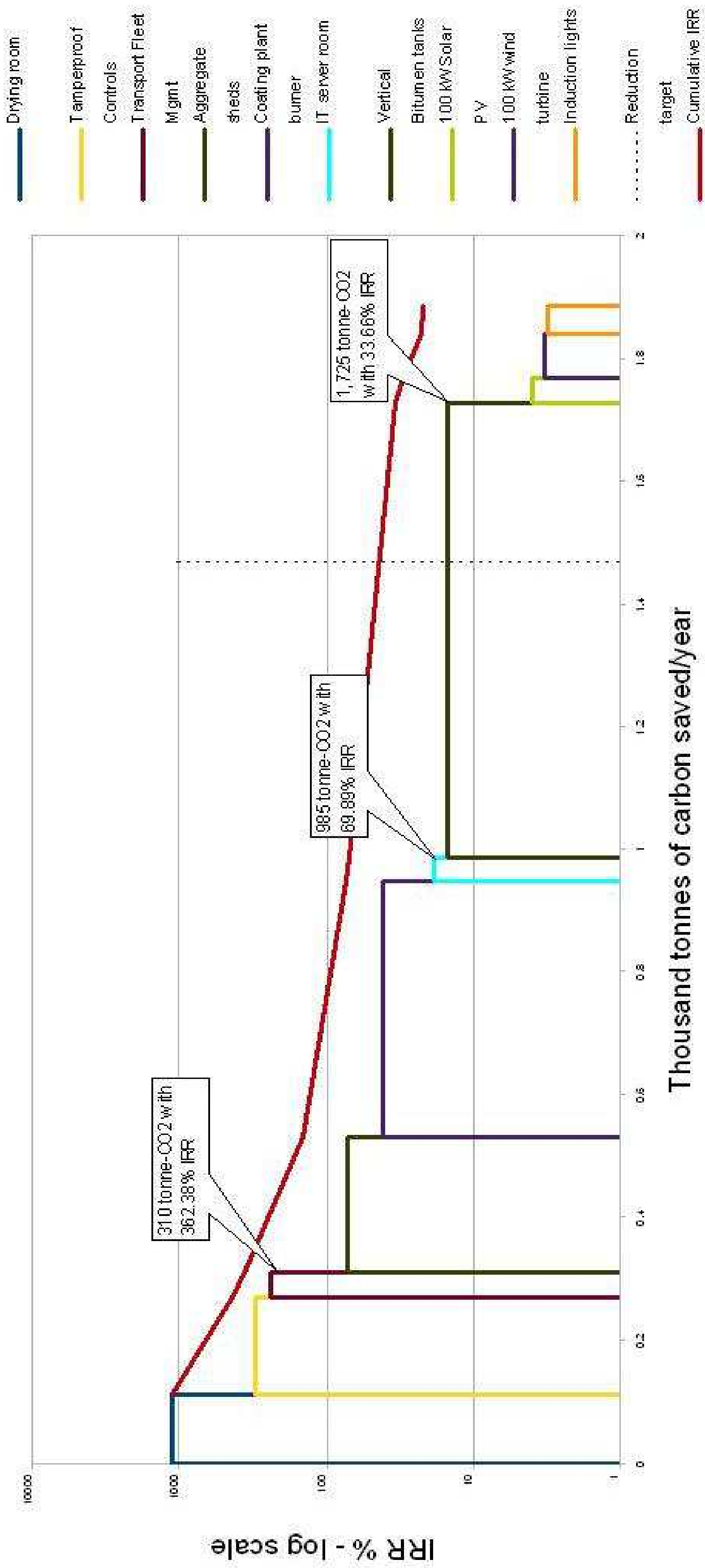

Figure 38: ERIC for future steps

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9 APPENDICES

APPENDIX 1: Interview 1 – Organisation & Impacts of CRC

Interview 1: Company's energy use and its participation in CRC

Date: 15-Feb-2010
Job Title: Engineering Manager

Part 1: Organisational structure and operations

Q. Is this company a public / private sector participant in CRC?

Answer - We are a private sector organisation participating in CRC.

Q. What are company's main operations?

Answer - The Company operates in a diverse range of business sectors such as aggregates, construction, landfill sites, waste recycling, steel fabrication, and agricultural precast. However, the major businesses of the company are construction, aggregates and landfill.

Q. Does the company operate at more than one site / buildings?

Answer - Yes

Q. How many sites does the company operate at? Are these all permanent locations?

Answer - At the moment, the company has 17 permanent operational sites, which include 3 head offices in different parts of Scotland, i.e. Cumnock, Paisley and Livingston. There are also 17 temporary construction sites, and 9 permanent but non-operational sites for other divisions (such as offices not in use and temporary accommodations for employees).

Q. What are the geographical boundaries of company's business?

Answer - We operate mainly within South West of Scotland, with our Construction division operating all across UK.

Q. Please explain the organisational structure of your company.

Answer - Barr Holdings is owned by Trench Holdings. There are four main divisions of Barr Holdings, which are Industrial, Construction, Environmental and Manufacturing.

Barr Industrial: Industrial division is mainly operating in Aggregates sector, which includes quarrying, asphalt production, readymix concrete production and road surfacing & civil engineering works.

Barr Construction: Construction division has a big portfolio of complete construction management for projects such as hospitals, schools, retail stores, stadia, wind-farms, leisure centres, residential and industrial buildings, etc.

Barr Environmental: Environmental division includes landfill, waste recycling / transfers and skip for hire.

Barr Manufacturing: Manufacturing division includes Precast concrete production and Steel fabrication businesses.

The Chairman of Barr Holdings has appointed two Managing Directors, BW and BC. BW is the Managing Director for Barr Industrial, Barr Environmental and Barr Manufacturing, whereas BC is the Managing Director for Barr Construction.

Part 2: Company's participation in CRC

Q. Does the company know its Half Hourly electricity supply during the first CRC qualification year (i.e. 2008)?

Answer - Yes

Q. How much Half Hourly electricity was the company supplied with during the first CRC qualification year (i.e. 2008)?

Answer - 7,765 MWh

Q. How was the half hourly and non half hourly supply differentiated to calculate the qualification period half hourly supply?

Answer - Based on information from our electricity suppliers

Q. Is there a record of information received from electricity suppliers?

Answer - Yes
(Note: This information record was requested, but was not available during the course of this research project)

Q. Have you already registered in the CRC Scheme?

Answer - No, but we aim to register before the July 2010 deadline.

Q. Is your organisation participating in CRC as a single entity?

Answer - Yes

Q. Does your company hold a Climate Change Agreement?

Answer - No

Q. Is your company participating in EU ETS?

Answer - No

Q. Does your company generate any renewable energy?

Answer - No. Our Landfill sites generate biogas but the operational control of gas use / electricity generation has been sold to another company.

Q. What is your understanding of the CRC scheme?

Answer - We understand that it is a mandatory scheme where companies reducing their carbon emissions and taking responsible action, such as achieving Carbon Trust Standard and rolling out voluntary AMR meters, will be rewarded from CRC's money recycling pot.

Q. What are the key challenges the company is facing in understanding the CRC scheme?

Answer - We need to understand how the scheme will impact us in the longer term. We need to understand the financial impacts of the scheme to reduce any possible financial risk, and also how the revenue recycling opportunity can be best utilised to gain the financial benefit. We need to see the impact of scheme on our existing energy costs. We also need to understand what we should be doing to fully comply with the scheme and avoid the risk of fines / penalties.

<u>Part 3: Company's early action in CRC</u>

Q. Has the company taken any steps to comply with CRC?

Answer - In a workshop organised by Carbon Trust, we realised the need for Carbon Trust Standard certification and roll out of AMR meters as the first steps. I was then given the responsibility to achieve these. Due to our efforts, we achieved the Carbon Trust Standard certification in 2009. We started rolling out AMR metering as well, and aim to complete installation of AMR metering on all of our major electricity consumption sites by April 2010.

Q. Has a person been appointed to take the lead in responsibility for company's participation in CRC?

Answer - I have been taken the lead in terms of Carbon Trust Standard certification and AMR metering so far. We hope to gain valuable information from this research project, and it will help us decide how we allocate our resources to participate in CRC.

Q. Has the company nominated its Senior Officer, Primary Contact, Secondary Contact and Account Representative/s in CRC?

Answer - No

Q. Has the company been accredited with Carbon Trust Standard certificate or equivalent covering all of its emissions?

Answer - Yes, we hold Carbon Trust Standard since last year (i.e. 2009).

Q. Has the company rolled out AMR metering across all of its electricity and gas consumption sites?

Answer - For our electricity use, some of our sites are already fitted with half hourly meters. We are rolling out AMR metering on our remaining major sites. But it is not possible for us to install AMR meters on our temporary sites (i.e. construction projects). Due to the cost of installing and maintaining the meters, we also don't aim to install AMR meters on our sites with little energy use, less than 2,000 ~ 3,000 kWh a year.
For our gas use, we do not aim to install AMR metering due to negligible use.

Part 4: Sources of energy

Q. Which fuels / energy sources are currently used by the company?

Answer - The answer has been recorded in table AA.

Q. Could you please identify the main uses of each of these fuels / energy sources?

Answer - The answer has been recorded in table AA.

Energy Source	**Uses**
Electricity	Lighting, Space heating, Motors / Drives in the Quarries, IT equipment
Natural Gas	Negligible use in office stoves
Gas Oil	Mobile plant and machinery on construction sites and quarries, standby / temporary electricity generators on construction sites, Heating in asphalt / coated aggregates production plants
Kerosene	Space heating, Heating in asphalt / coated aggregates production plants
Light Fuel Oil / Burning Oil	Heating in asphalt / coated aggregates production plants
Derv (Diesel)	Company's road-going vehicles (cars, vans, lorries, road going tippers & mixers), external haulier's vehicles
Petrol	Negligible use in cars

Table AA

Part 5: Energy Information Management

Q. Do you record your total energy use? If yes, then how?

Answer – Yes. We have modified the spreadsheet tool from Carbon Trust Standard to develop our carbon footprint tool. We record the information obtained from all information sources into this spreadsheet to provide us with our overall energy use and carbon footprint.

Q. How do you record your Electricity use?

Answer - We have an agreement with Dataserve, who are our appointed meter operators. The information of all AMR meters as well as half hourly meters on company's permanent sites can be read online or downloaded from the Dataserve website. For the remaining sites, the data is recorded from their monthly / quarterly bills. At our construction division, the kWh usage from all sites is recorded into a spreadsheet. From these sources, we copy the information in our carbon footprint tool.

Q. What information do you currently record for your Electricity use?

Answer - We record the 'kWh' use on each of our sites, and we also record from the bill if a supply is half hourly / non half hourly

Q. How do you record Natural Gas use?

Answer - The information is recorded from the monthly / quarterly site bills. At our construction division, the kWh usage from all sites is recorded into a spreadsheet. From these sources, we copy the information in our carbon footprint tool.

Q. What information do you currently record for your Natural Gas use?

Answer - We record the 'kWh' use on each of our sites.

Q. How do you record Gas oil use?

Answer - For Industrial, Manufacturing & Environmental divisions, the orders for Gas oil are recorded in a fuel management software called 'Fueltek'. This information is then exported as a spreadsheet to copy into our carbon footprint tool. At construction division, the fuel deliveries are recorded in a financial management software called 'Coins'. Again, from 'Coins' software, the information is exported as a spreadsheet to copy it into our carbon footprint tool.

Q. What information do you currently record for your Gas oil use?

Answer - In our footprint tool, we copy the information of the litres ordered / delivered on each of our site on a monthly basis. For construction division, due to large number of sites with negligible supplies, we record the total gas oil 'litres' ordered / supplied for the division on a monthly basis.

Q. How do you record Kerosene use?

Answer - From the invoices, the orders of Kerosene are recorded into a spreadsheet, from where it is copied into the footprint tool.

Q. What information do you currently record for your Kerosene use?

Answer - We record the 'litres' of Kerosene ordered for each site on a monthly basis.

Q. How do you record light fuel oil / coating plant fuel use?

Answer - From the invoices, the orders of light fuel oil / coating plant fuel are recorded into a spreadsheet, from where it is copied into the footprint tool.

Q. What information do you currently record for your fuel oil / coating plant fuel use?

Answer - We record the 'litres' of light fuel oil / coating plant fuel ordered for each site on a monthly basis.

Q. How do you record Derv (Diesel) use?

Answer - The fuel management system 'Fueltek' records the derv use by all of the company vehicles, as the company uses its own tag and terminal system purchased from 'Fueltek'. This information is then exported as a spreadsheet to copy into our carbon footprint tool.

The derv used by external hauliers is recorded in the form of miles travelled. The external hauliers' miles for company's quarries are recorded by our internal developed sales IT system 'QR3', and exported to a spreadsheet. The external hauliers' miles for Manufacturing division are recorded on a spreadsheet. From both these spreadsheets, the information is copied into our carbon footprint tool.

For the business travel not covered in 'Fueltek' such as air, train and ferry travel, the 'miles' are also recorded as follows:

- 'miles travelled' for construction division are recorded in 'Coins' software, and then exported to a spreadsheet from where it is copied into our footprint tool
- 'miles travelled' for Industrial, Manufacturing & Environmental division are recorded in a spreadsheet from where it is copied into our footprint tool

We don't record business travel in the form of buses and taxes as this is negligible.

Q. What information do you currently record for your Derv (Diesel) use?

Answer - For company's own vehicles, 'Fueltek' records information such as litres and miles travelled for each vehicle. However, in our carbon footprint tool, we only copy the 'litres' use by division on a monthly basis.

For external hauliers, as mentioned, the 'miles travelled' are recorded for the external hauliers, which are then converted into 'litres' of derv in our footprint tool.

For business travel, as mentioned, the 'miles travelled' are recorded, which are then converted into emissions using the conversion factors from Carbon Trust Standard.

Q. How do you record Petrol use?

Answer - The company provides a card for petrol purchases, and the purchases on these cards are recorded online by the card providers. These transaction are downloaded into 'Fueltek' from where it can be exported into a spreadsheet. The information is then copied into our footprint tool.

Q. What information do you currently record for your Petrol use?

Answer - We record 'litres' of petrol purchased on a monthly basis

Q. Could you provide / arrange to provide a demonstration of information systems currently in use for Energy Management?

Answer - (A demonstration was provided by the company, and the information provided in the demonstration has been summarised in table BB).

Information System	Information available for carbon footprint tool
Dataserve - online meter reading	Site Name, Electricity Consumption (kWh)
Fueltek - Fuel management information system	- Diesel use (litres) in company vehicles - Petrol use (litres) in company vehicles - Site Name, Orders (litres) for Industrial, Manufacturing and Environmental Divisions, for Gas Oil, Kerosene and LFO / Burning Oil
QR3 - Internal sales information system	- External hauliers' travel for Barr (miles)
COINS - Financial management information system	Turnover information (£), Gas oil use (litres) for Construction division, Business travel information (miles) for Construction division
Construction kWh tool - spreadsheet	Site Name, Electricity Consumption (kWh), Gas Consumption (kWh) for Construction division sites
Expenses tool - spreadsheet	Business travel information (miles) for Industrial, Environmental and Manufacturing divisions

Table BB

Q. Is energy use reported to the senior management? If yes, what is the frequency of reporting?

Answer - The energy use is reported as and when required.

Q. Are you aware of the CRC source list tool?

Answer - No

Q. Do you know the 'Profile type' of each of your electricity and gas supply?

Answer - No

Q. Do you understand how CRC defines a core or residual supply?

Answer - No

Q. Do you understand how CRC defines an actual or estimated supply?

Answer - No

Part 6: Company's carbon footprint

Q. Does the company record its annual carbon footprint?

Answer - Yes

Q. Which is the latest complete annual carbon footprint year for the company?

Answer - 2008

Q. What was company's annual carbon footprint in 2008?

Answer - According to out 2008 carbon footprint, our operations resulted in 28,537 tonnes of CO_2

Q. What is company's annual carbon footprint breakdown by fuel type?

Answer - (The answer has been summarised in table CC)

2008				
Energy			**Carbon emissions**	
Energy Source	**Unit**	**Unit**	**CO_2 conversion factor**	**tonne-CO_2**
Gas Oil	**Litres**	4,558,680	2.762	12,591
Derv	**Litres**	2,783,444	2.639	7,346
Kerosene / LFO	**Litres**	1,048,206	2.532	2,654
Electricity	**kWh**	10,640,139	0.541	5,756
Gas	**kWh**	533,769	0.1836	98
Petrol	**Litres**	14,421	2.3035	33
Other				59
			Total Emissions	**28,537**

Table CC

Q. What is company's annual carbon footprint breakdown by site / divisions?

Answer - At the moment, we are able to record footprint breakdown per division only and not for each site or each product type. The footprint breakdown for the divisions is as follows:

Quarries: 50%
Construction: 17%
Environmental: 17%
Precast & Steel: 10%
Surfacing & Civil Engineering: 6%

Q. Does the company currently monitor individual carbon footprint or energy use of products?

Answer - Only in the quarries, a monthly stock reconciliation report is produced each month by the Accounts team, which shows fuel use and production tonnages.

Q. Does the company normalise its carbon emissions with its turnover?

Answer - Yes, as required in the Carbon Trust Standard tool

Q. What is the latest value of company's carbon emissions normalised to the turnover?

Answer - 100.87 kg of CO_2 per turnover (in £ million)

Q. Does the company maintain an evidence pack for CRC?

Answer - No

Q. For every site, could you provide me a bill / invoice for all the fuels / energy sources on that site in the following months? (Months randomly chosen).

Answer - In response to this request, 61 out of 105 requested bills were provided in a month's time.

Q. Where are all the energy related invoices / bills kept? Could you show me the location?

Answer - The bills are kept in files by the Accounts management teams. Any bills older than 2 years are archived.

Q. Does the company conduct internal audits for CRC? Also, is there a CRC audit procedure available?

Answer - No, we have not started any such audits, and there is no such procedure available.

APPENDIX 2: Interview 2 – Carbon Reduction

Interview 2: Carbon reduction at the company

Date: 01-Mar-2010
Job Title: Engineering Manager

Q. Does the company have a carbon / energy use reduction target?

Answer - Yes, we aim to reduce our energy consumption by 15% from the 2008 base level, by the year 2020.

Q. Is there a carbon reduction strategy in place for the company?

Answer - We aim to continually reduce our carbon emissions. A carbon reduction strategy will be devised on the basis of outcomes from this research project.

Q. What are the key challenges in devising your carbon reduction strategy?

Answer - It is hard to believe the benefits of energy saving opportunities and renewable energy systems as claimed by the suppliers of these services and technologies. We need to understand realistic impacts of various opportunities that are available in today's world, so that we could base our strategy on the real evidence.

Q. Could you tell us about the energy saving / carbon reduction opportunities that are available to the company, or that have been implemented by the company?

Answer - There are a number of opportunities that we have considered, such as
- Power Factor Correction
- Aggregate Storage Sheds
- IT Server Room
- Vertical Bitumen Tanks
- Coating Plant Burner Replacement
- Roofs Insulation at Killoch
- Wind Turbine at Tormitchell, Killoch and Clayshant
- Solar PV at Killoch

Q. What steps has the company taken, or intends to take to reduce energy use / carbon emissions from 'Power Factor Correction'?

Answer - We have installed power factor correction units on all of our major energy consuming sites, except Barlockhart Quarry, Moorfield Concrete Plant and temporary sites.

Q. What steps has the company taken, or intends to take to reduce energy use / carbon emissions from 'Aggregate Storage Sheds'?

Answer - We have built sheds at our Killoch depot and Barlockhart Quarry to reduce the moisture in dust and sand.

Q. What steps has the company taken, or intends to take to reduce energy use / carbon emissions from 'IT Server Room'?

Answer - A modification plan has been proposed by our Information Systems Manager to improve the energy performance of our IT server room.
(A document was shown with below details, written by SD, Information Systems Manager, Barr Limited, 2009)

The server AC units system is comprised of two independent 12 kVA heating / cooling inverted systems with a combined capacity of 23 kVA. These systems are linked using a shared duty automatic switching system which allows system to swap between the two independent systems sharing the cooling requirements and load. However, it was observed that these AC units are now running in excess of 60% of their duty, generally cooling, in order to maintain the required temperature. Due to increased load on servers, the current system now requires that both the 11.5 kVA units are now operating at all times.

A system has been proposed with these features:

- Partial passive cooling of the server
- Heat recovery from the server room

It has been proposed to bring cold fresh air directly below the server from the adjoining corridor. The fresh air supply must be filtered to remove the possible incoming coal dust. Hot air will be removed from the top end of the servers' cabinets at the same time. The recovered heat will be directed to an IT store to reduce humidity and avoid damage to the IT equipment. The proposed system would provide ducted hoods set on the top of the existing cabinets, with individual balanced dampers, to ensure that all cabinets have equal volumes of air removed. Likewise the replacement air would be forced through a double filter system which would have the ability to have additional cooling connected at a later stage, should it be required. It has been estimated that the existing cooling systems would run on average 25% of their duty, resulting in a 58% reduction their load.

Q. What steps has the company taken, or intends to take to reduce energy use / carbon emissions from 'Vertical Bitumen Tanks'?

Answer - We aim to replace some of our bitumen tanks with the latest vertical bitumen tanks. Traditionally horizontal cylindrical tanks were used for storing bitumen. However, vertical tanks are now becoming more popular. This is because in vertical tanks, there is less surface area available, which results in reduced oxidation. Vertical tanks provide a higher capacity to hold the bitumen safely. We intend to replace 3 tanks at first.

Q. What steps has the company taken, or intends to take to reduce energy use / carbon emissions from 'Coating Plant Burner Replacement'?

Answer - Burner replacement can significantly reduce energy consumption in a coating plant. We intend to replace one of our plants' burner soon as it is has already passed a significant period after its projected life time. This plant is expected to produce an average of 20,000 tonnes of coated / asphalt products every year. The cost of replacement has been quoted as £20,000.

Q. What steps has the company taken, or intends to take to reduce energy use / carbon emissions from 'Roofs insulation at Killoch'?

Answer - We have insulated the roofs of our main office and testing lab at Killoch depot.

Q. What steps has the company taken, or intends to take to reduce energy use / carbon emissions from 'Wind Turbine at Killoch, Tormitchell and Clayshant'?

Answer - Our sites at Killoch, Tormitchell and Clayshant are very windy, and seem to have a good potential for wind turbines. There is actually a whole wind-farm next to Tormitchell due to the area being very windy.

Q. What steps has the company taken, or intends to take to reduce energy use / carbon emissions from 'Solar PV at Killoch'?

Answer - The old stores building at Killoch is not in any use. The building has a large roof, with a flat surface. Also, the southern side of the roof is obstruction free. These qualities may help in installing Solar panels on this roof, subject to confirmation of their viability in all aspects.

Q. Could you provide following details. Where available, of the project considered by the company to reduce its energy use / carbon emissions?

- **Name of the project**
- **Capital cost**
- **Annual operating / running cost**
- **Annual saving**
- **Annual average CO_2 (i.e. CO_2e) savings**
- **Project life**

Answer - Response to the above question has been summarised in table EE.

Project Name	Capital Cost (£)	Op / Running Cost (£ / annum)	Savings (£ / annum)	CO_2 Reduction (tonne-CO_2)	Project Life (Years)
IT Server Room	£15,000	£200	£4,80	43.7	10
Bitumen Tanks	£161,387	£600	£36,133	222	15
Burner Replacement	£30,000	£500	£15,000	83.45	10

Table EE

APPENDIX 3: Interview 3 – Financial views of company's energy and CRC

Interview 3: Financial view of company's energy and CRC

Date: 15-Mar-2010
Job Title: Finance Manager

Part 1: Energy Costs

Q. Does the company record its total energy costs?

Answer - Yes

Q. What is the best source to obtain company's total energy costs?

Answer - The annual energy costs figures can be obtained from the Group Financial Accountant.

Q. What is your latest available annual energy cost figure?

Answer - Our total energy costs in 2009 were £4,549,631.

Q. What is your latest available energy cost breakdown?

Answer - Our energy costs breakdown in 2009 was as follows:

Gas, Electricity & Water:	£1,226,627
Fuel / Oil:	£3,323,004

Q. Does the company get reimbursed for any of its energy supplies?

Answer - Yes, we are in a PFI (Private Finance Initiative) project, where we get reimbursed for the utility costs as per agreement.

Part 2: Turnover Information

Q. What is the best source to obtain company's turnover information?

Answer - Company's turnover information can be obtained from the Group Financial Accountant.

Part 3: Financial impact of CRC

Q. Could you provide the annual salary figures for the following? (Salary figures for all CRC team members were requested)

Answer - No, we are not allowed to share this, as this is confidential information

Q. Could you give us a rough idea of salaries' range for the following? (Salary range for all CRC team members were requested)

Answer - Yes, we can agree with a lower and upper band of salaries to give an idea. (The information has been summarised in table DD).

Designation	**Annual Salary**	
	Lower Band	Higher Band
Chairman or Director of the company	£100,000	£180,000
Accountant	£40,000	£80,000
Divisional Managing Director	£80,000	£150,000
CRC Manager	£30,000	£50,000
Administrative Assistant	£20,000	£30,000

Table DD

Q. Could you provide with the annual cost of Carbon Trust Standard that the company is currently paying?

Answer - We have paid £12,000 for the assisted certification, where £8,000 is the fee for the standard, and £4,000 for the assistance provided to us by a third party consultant. This standard is valid for 2 years, and then we would be required to renew it again. We assume that we shall not need assisted certification again, which would mean a cost of £8,000 for two years (i.e. £4,000 per year).

Q. What is the cost of AMR and Half-Hourly metering that the company is currently paying?

Answer - We currently pay £146 for each AMR meter, which includes the meter operation, communication, lease & maintenance charges, and we currently pay for 11 such meters (invoice shown to the interviewer) in total on 8 of our sites. In addition to that, we also pay £254.80 for the metering and communication of data for our 9 half-hourly meters on 9 of our permanent sites (invoice shown to the interviewer).

<u>Part 4: CRC financial impact mitigation</u>

Q. How does the company intend to mitigate any additional costs introduced by CRC?

Answer - Due to already challenging markets and tough competition, we are unable to transfer the extra costs of CRC towards our customers. Therefore, the only way we see for reducing costs is by reducing our carbon emissions.

Q. Would it help to allocate the costs of CRC to the sites / operations where the CRC emissions are coming from?

Answer - Yes, definitely. It will make it simpler and effective.

Q. What frequency of CRC cost information would be helpful?

Answer - If a monthly CRC cost could be accrued for each site, it will make it much easier to purchase allowances in the end of CRC year. It will also help in increasing CRC cost awareness among site managers.

Q. Does the company have an agreed discount rate to assume when assessing the financial viability of purchasing new systems and services?

Answer - We normally assume a discount rate of 6% while assessing the financial viability of new systems.

APPENDIX 4: CRC Fines

Non-compliance	CRC Order	Penalties
Failure to register	Article 95	• Immediate fine of £5,000 for failure to register by the deadline • Further £500 per working day for each subsequent working day of delay up to a maximum of 80 working days • Publication of non-compliance
Failure to disclose information on registration	Article 95	• £500 per meter not reported in the registration • Publication of non-compliance
Failure to submit a Footprint Report on time	Article 96	• Immediate fine of £5,000 for failure to report by the deadline • Further £500 per working day for each subsequent working day of delay up to a maximum of 40 working days • Publication of the non-compliance After 40 working days delay: • Total accumulated daily rate is doubled to £40,000
Failure to submit an Annual Report on time	Article 97	• Immediate fine of £5,000 for failure to report by the deadline • Further £500 per working day for each subsequent working day of delay up to a maximum of 40 working days • Publication of non-compliance After 40 working days delay: • Total accumulated daily rate is doubled to £40,000 • CRC emissions to which the Annual Report relates are double the CRC emissions reported in the previous year's report, or where no such report exists, double the CRC emissions determined by the administrator • Participant must immediately purchase and surrender allowances equal to the CRC emissions (including the doubling). • £40 per tCO_2 penalty for each allowance

		not surrendered by the deadline (penalty is only applicable to the CRC emissions before the figure is doubled) • Participant is ranked bottom of the performance tables. • Transfer of any allowances to third parties is blocked. • If the participant fails to comply with the penalty requirement to purchase and surrender allowances by 31 March after the Annual Report was due and continues in the scheme, the un-surrendered allowances will be added to the surrender requirement for the next year.
Failure to provide accurate information or notifications (in relation to CCA status changes and designated change)	Article 98	• £5,000 fine • Publication of non-compliance
Inaccurate Footprint and Annual Reports (that is, supplies or emissions differ by more than 5 per cent to those which should have been reported)	Article 99	• £40 per tCO_2 of so much of those supplies or emissions that were inaccurately reported • Publication of non-compliance Note: Where the provision of an inaccurate Footprint Report causes a participant to provide an inaccurate Annual Report, a penalty can only be applied in respect of the Footprint Report.

Failure to surrender allowances	Article 100	• Participant must immediately acquire allowances equal to the allowances that should have been surrendered. • Participant must surrender the shortfall in allowances. • £40 per tCO_2 penalty per shortfall allowance • Publication of non-compliance • Transfer of any allowances to third parties is blocked. • If the participant fails to comply with the penalty requirement to surrender sufficient allowances and continues in the scheme, the shortfall allowances will be added to the surrender requirement for the next year.
Later discovered failures to surrender allowances	Article 101	Where it is discovered within five years of the deadline for submitting an Annual Report that the participant reported fewer allowances than it should have and in consequence has surrendered too few allowances: • Shortfall allowances will be added to the quantity of allowances required to be surrendered in the next reporting year. • Publication of the non-compliance • Where the non-compliant organisation is no longer a participant, a fine is imposed that represents the value of the shortfall allowances (value means the value of the allowances in the sale of allowances immediately before the shortfall was found).
Failure to comply with an information notice served under Article 90	Article 102	• £40 per tCO_2 of CRC emissions of the participant in the annual reporting year immediately preceding the year in which the non-compliance is discovered
Failure to keep records of residual measurement list or public disclosure	Article 102	• Immediate fine of £5,000 • Publication of the non-compliance

APPENDIX 5: Plug-in-timers Business Case

Electric heaters				
Power rating	2	kW		
Number of units	10	units		
Total Power	20	kW		
Weekdays day-rate saving hours	6.5	hours		
Weekdays night-rate saving hours	6	hours		
Weekend day-rate saving hours	18	hours		
Weekend night-rate saving hours	6	hours		
Day rate:	10	pence/kWh		8.729
Night rate:	10	pence/kWh		5.228
kgCO2/kWhe	0.541	kgCO2/kWh		
Weekly savings				
Working days per week	6	days		
Total kWh to be saved	1980	kWh		
CO2 emissions to be saved	**1071**	kg		
Total day hours to be saved	57	hours	=	£114.00
Total night hours to be saved	42	hours	=	£84.00
	Total money saved / week			**£198.00**
Yearly savings				
Working weeks per year	25	weeks	(i.e. assumed winter 5.5 months only)	
Total kWh to be saved	49500	kWh		
CO2 emissions to be saved	**26780**	kg		
Total day hours to be saved	1425	hours	=	£2,850.00
Total night hours to be saved	1050	hours	=	£2,100.00
	Total money saved / year			**£4,950.00**
Power saving unit	**OWL TSE007-040**			
Unit price	£10			
Installation price per unit	£15	(assumed for 10 units combined installation)		
Annual maintenance cost	£40	(assuming 1 unit failed, replacement time 1 hour)		
Total Cost	£289.89			
Payback period:	**1.5**	weeks	(i.e. in Winter)	

APPENDIX 6: LED Lighting Business Case and Technical Specs

Project - Car Park

Energy Unit Cost - (Pence per kWh) 6 p
Annual Inflation Estimate - (%) 3.70 %

Make changes in "pink" cells

Existing Lighting Usage
Hours per day 12 hrs
Days per week 7 days
Weeks per year 25 weeks

Replaced Lighting Usage
Hours per day 12 hrs
Days per week 7 days
Weeks per year 25 weeks

Existing Lighting Plan

Number of fittings	Type of Fitting	Fitting Cost	Total Cost	Fitting Wattage	Annual kWh	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
					Rate (Pence)	6	6.222	6.452	6.691	6.939	7.195	7.461	7.738	8.024	8.321
22	250W SON Streetlight			300	13,860	£832	£862	£894	£927	£962	£997	£1,034	£1,072	£1,112	£1,153
	Sub Total:		£0		13,860	£832	£862	£894	£927	£962	£997	£1,034	£1,072	£1,112	£1,153
	Climate Change Levy:					£65	£68	£70	£73	£75	£78	£81	£84	£87	£90
	Total Energy Cost:					£897	£930	£964	£1,000	£1,037	£1,075	£1,115	£1,156	£1,199	£1,244

Replacement Lighting Plan

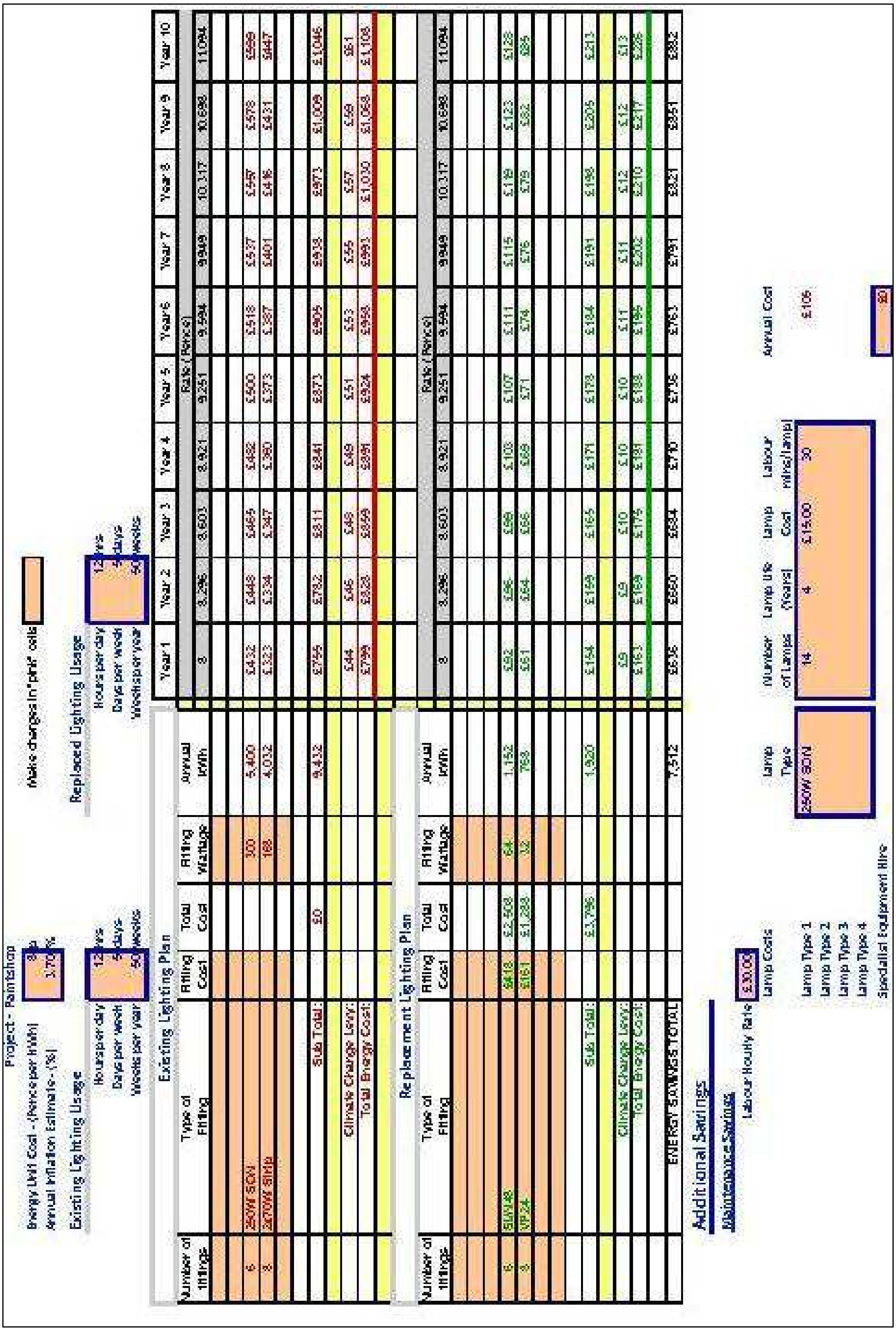
Number of fittings	Type of Fitting	Fitting Cost	Total Cost	Fitting Wattage	Annual kWh	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
					Rate (Pence)	6	6.222	6.452	6.691	6.939	7.195	7.461	7.738	8.024	8.321
22	Jupiter 35 Streetlight	£366	£8,052	50	2,310	£139	£144	£149	£155	£160	£166	£172	£179	£185	£192
	Sub Total:		£8,052		2,310	£139	£144	£149	£155	£160	£166	£172	£179	£185	£192
	Climate Change Levy:					£11	£11	£12	£12	£13	£13	£14	£14	£15	£15
	Total Energy Cost:					£149	£155	£161	£167	£173	£179	£186	£193	£200	£207
	ENERGY SAVINGS TOTAL				11,550	£747	£775	£804	£833	£864	£896	£929	£964	£999	£1,036

Additional Savings

Maintenance Savings

Labour Hourly Rate £30.00

Lamp Costs	Lamp Type	Number of Lamps	Lamp life (Years)	Lamp Cost	Labour mins/lamp	Annual Cost
Lamp Type 1	250W SON	22	4	£15.00	30	£165
Lamp Type 2						
Lamp Type 3						
Lamp Type 4						
Specialist Equipment Hire						£0



Project - Paintshop

Energy Unit Cost - (Pence per kWh): 8 p
Annual Inflation Estimate - (%): 3.70 %

Make changes in "pink" cells

Existing Lighting Usage		Replaced Lighting Usage	
Hours per day	12 hrs	Hours per day	12 hrs
Days per week	5 days	Days per week	5 days
Weeks per year	50 weeks	Weeks per year	50 weeks

Existing Lighting Plan

Number of fittings	Type of Fitting	Fitting Cost	Total Cost	Fitting Wattage	Annual kWh	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
						Rate (Pence)									
						8	8.296	8.603	8.921	9.251	9.594	9.949	10.317	10.698	11.094
6	250W SON			300	5,400	£432	£448	£465	£482	£500	£518	£537	£557	£578	£599
8	2x70W Strip			168	4,032	£323	£334	£347	£360	£373	£387	£401	£416	£431	£447
	Sub Total:		£0		9,432	£755	£782	£811	£841	£873	£905	£938	£973	£1,009	£1,046
	Climate Change Levy:					£44	£46	£48	£49	£51	£53	£55	£57	£59	£61
	Total Energy Cost:					£799	£828	£859	£891	£924	£958	£993	£1,030	£1,068	£1,108

Replacement Lighting Plan

Number of fittings	Type of Fitting	Fitting Cost	Total Cost	Fitting Wattage	Annual kWh	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
						Rate (Pence)									
						8	8.296	8.603	8.921	9.251	9.594	9.949	10.317	10.698	11.094
6	SLW48	£418	£2,508	64	1,152	£92	£96	£99	£103	£107	£111	£115	£119	£123	£128
8	VP24	£161	£1,288	32	768	£61	£64	£66	£68	£71	£74	£76	£79	£82	£85
	Sub Total:		£3,796		1,920	£154	£159	£165	£171	£178	£184	£191	£198	£205	£213
	Climate Change Levy:					£9	£9	£10	£10	£10	£11	£11	£12	£12	£13
	Total Energy Cost:					£163	£169	£175	£181	£188	£195	£202	£210	£217	£226
	ENERGY SAVINGS TOTAL				7,512	£636	£660	£684	£710	£736	£763	£791	£821	£851	£882

Additional Savings

Maintenance Savings

Labour Hourly Rate: £30.00

Lamp Costs	Lamp Type	Number of Lamps	Lamp Life (Years)	Lamp Cost	Labour mins/lamp	Annual Cost
Lamp Type 1	250W SON	14	4	£15.00	30	£105
Lamp Type 2						
Lamp Type 3						
Lamp Type 4						
Specialist Equipment Hire						£0

Project - Workshop

Energy Unit Cost - (Pence per kWh) 8 p
Annual Inflation Estimate - (%) 3.70 %

Make changes in "pink" cells

Existing Lighting Usage			Replaced Lighting Usage		
Hours per day	12	hrs	Hours per day	12	hrs
Days per week	5	days	Days per week	5	days
Weeks per year	50	weeks	Weeks per year	50	weeks

Existing Lighting Plan

Number of fittings	Type of Fitting	Fitting Cost	Total Cost	Fitting Wattage	Annual KWh	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
					Rate (Pence)	8	8.296	8.603	8.921	9.251	9.594	9.949	10.317	10.698	11.094
22	250W Metal Halide			300	19,800	£1,584	£1,643	£1,703	£1,766	£1,832	£1,900	£1,970	£2,043	£2,118	£2,197
6	2x70W Strip Light			168	3,024	£242	£251	£260	£270	£280	£290	£301	£312	£324	£335
	Sub Total:		£0		22,824	£1,826	£1,893	£1,964	£2,036	£2,112	£2,190	£2,271	£2,355	£2,442	£2,532
	Climate Change Levy:					£107	£111	£115	£120	£124	£129	£133	£138	£143	£149
	Total Energy Cost:					£1,933	£2,005	£2,079	£2,156	£2,236	£2,318	£2,404	£2,493	£2,585	£2,681

Replacement Lighting Plan

Number of fittings	Type of Fitting	Fitting Cost	Total Cost	Fitting Wattage	Annual KWh	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
					Rate (Pence)	8	8.296	8.603	8.921	9.251	9.594	9.949	10.317	10.698	11.094
22	SLN48	£418	£9,196	64	4,224	£338	£350	£363	£377	£391	£405	£420	£436	£452	£469
6	VP24	£161	£966	32	576	£46	£48	£50	£51	£53	£55	£57	£59	£62	£64
	Sub Total:		£10,162		4,800	£384	£398	£413	£428	£444	£460	£478	£495	£514	£533
	Climate Change Levy:					£23	£23	£24	£25	£26	£27	£28	£29	£30	£31
	Total Energy Cost:					£407	£422	£437	£453	£470	£488	£506	£524	£544	£564
	ENERGY SAVINGS TOTAL				18,024	£1,527	£1,583	£1,642	£1,702	£1,765	£1,831	£1,898	£1,969	£2,042	£2,117

Additional Savings

Maintenance Savings

Labour Hourly Rate £30.00

Lamp Costs	Lamp Type	Number of Lamps	Lamp Life (Years)	Lamp Cost	Labour mins/lamp)	Annual Cost
Lamp Type 1	250W SON	28	4	£15.00	30	£210
Lamp Type 2						
Lamp Type 3						
Lamp Type 4						
Specialist Equipment Hire						£0

LED Lighting - Total Savings

Site:	**Killoch**				
	Location:	**Car Park**	**Paint-shop**	**Workshops**	**Grand Total**
Capital Cost	(GBP)	£8,052	£3,796	£10,162	£22,010
R&M Cost*	(GBP)	£200	£100	£200	£500
Annual kWh Savings	(kWh)	11,550	7,512	18,024	37,086
Annual CO2 Reduction	(tonne-CO	6.24855	4.063992	9.750984	20
Annual Cost Savings	(GBP)	£912	£741	£1,737	£3,390

*Running & Maintenance costs assumed as £500 for year, assuming 20 hours of job

Jupiter 24 XL100 - LED Street Light

Jupiter LED Street Light Range

Jupiter 24 XL100 AC
Jupiter 24 XL100 DC

Jupiter 36 XL100 AC
Jupiter 36 XL100 DC

Jupiter 48 XL100 AC
Jupiter 48 XL100 DC

Jupiter 60 XL100 AC
Jupiter 60 XL100 DC

The ***Jupiter 24 XL100*** luminaire is a street and area lamp ready for connection to either AC mains power supply or our Mercury solar power management unit, which provides a flexible lighting solution where mains power is not available or desired.

The Jupiter 24's applications range from lighting roads to car parks, pathways and public areas, and when used with our Mercury solar powered management unit, the costs associated with mains powered lighting can be avoided.

Note: All LEDs are encased in a compound that will give them protection from any ingress of liquids or solids and all other electronic components are enclosed in an IP66 rated assembly.

Specifications: Jupiter 24 XL100 - LED Street Light

	AC	DC
Product Code	J-24-4-2A-B	J-24-4-1D-B
Power Consumption	28 Watts	24 Watts
Input Voltage	230V AC 50Hz / 110V AC 60Hz	12 VDC
Light Source	1W High Power LED	
LED QTY	24	
Total LED Output	2400 lm	
Operating Lumens at 25°c	1920 lm	
LED Colour	Cool White	
Colour Temp (K)	6300 degrees K	
CRI	Ra>70	
LED Lifespan	>50,000 Hours	
Operating Temperature	-30 degrees C to + 70 degrees C	
Working Humidity	0 ~ 95%	
Turn on time	100ms	
Product Size (mm)	865 x 300 x 100	
Unit colour	Silver	
Net Weight	8.55 Kg	
Mounting	Supplied with adjustable 'C' type clamps for Outreach Mounting Arms with a Min of 43mmØ and Max of 56mmØ (Standard)	
Protection Rate	IP66 (Light Engine & Power Supply)	
Certification	RoHS, CE	
Warranty	3 Years	

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Gemma LIGHTING LIMITED

Gemma LIGHTING LIMITED

Sun 48 XL110 - LED Flood Light

Sun - LED Flood Light Range

Sun 12 XL110 AC
Sun 12 XL110 DC

Sun 24 XL110 AC
Sun 24 XL110 DC

Sun 48 XL110 AC
Sun 48 XL110 DC

Sun 72 XL110 AC
Sun 72 XL110 DC

The ***Sun 48 XL110*** LED lighting solution is a environmentally friendly, energy saving, replacement for a traditional sodium, mercury and halogen style flood light.

This LED flood light is ready for connection to either AC mains power supply or our Mercury solar power management unit, which provides a flexible lighting solution where mains power is not available or desired.

These LED flood lights can be used singularly or in groups to provide lighting for applications ranging from recreation area lighting to warehouse lighting, sign lighting, building lighting, car park lighting and perimeter fence lighting.

Note: All LEDs are encased in a compound that will give them protection from any ingress of liquids or solids and all other electronic components are enclosed in an IP66 rated assembly.

Specifications: Sun 48 XL110 - LED Flood Light

	AC	DC
Product Code	S48-A001-E2	S48-D001-C1
Power Consumption LED's	54.72 Watts	
Power Consumption Driver	9 Watts	N/A
Total Power Consumption	63.72 Watts	54.72 Watts
Input Voltage	90 – 264Vac	12 VDC
Input Frequency	47 – 63Hz	N/A
Light Source	1.14W High Power LED	
LED QTY	48	
Total LED Output	5280 lm	
Operating Lumens at 25°c	4224 lm	
LED Colour	Cool White	
Colour Temp (K)	5400 - 6300 degrees K (Standard)	
CRI	Ra>70	
LED Lifespan	50,000 > 80,000 Hours	
Operating Temperature	-30 degrees C to + 50 degrees C	
Working Humidity	0 – 95%	
Turn on time	100ns	
Product Size (mm)	435mm x 435mm x 178mm	
Unit colour	Silver	
Net Weight	6.5 Kg	
Mounting	Chain Mounted Bracket (Standard) Pole and Wall Mounted versions available.	
Protection Rate	IP66 (Light Engine & Power Supply)	
Certification	RoHS, CE	
Warranty	3 Years	

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V005

Gemma LIGHTING LIMITED

VP 24.5 XL110 - LED Vapor Proof

Alternative Products

Industrial LED Bulkhead Range

Star 12 XL110 AC
Star 12 XL110 DC

Star 24 XL110 AC
Star 24 XL110 DC

This LED Vapor Proof is an IP65 weatherproof and anti-corrosive luminaire ready for connection to a 230 volt 50Hz supply or a 110 volt 60Hz supply.

This LED light fitting has been manufactured from corrosion resistant glass reinforced polyester and contains a high impact diffuser, with captive retention clips.

This LED light is suitable for illuminating multi-storey car parks, railways stations, tunnels, food preparation areas, cold stores and any moist or dusty environment.

Specifications: LED Vapor Proof

	VP 24.5 XL110 AC
Product Code	VPS5-24-A001-C2
Power Consumption LED's	27.36 Watts
Power Consumption Driver	4.5 Watts
Total Power Consumption	31.86 Watts
Input Voltage	90 – 264Vac
Input Frequency	47 – 63Hz
Light Source	1.14 W High Power LED
LED QTY	24
Total LED Output	2640 lm
Operating Lumens at 25°c	2112 lm
LED Colour	Cool White
Colour Temp (K)	5400 - 6300 degrees K (Standard)
CRI	Ra>70
LED Lifespan	50,000 > 80,000 Hours
Operating Temperature	-30 degrees C to + 50 degrees C
Working Humidity	0 – 95%
Turn on time	100ns
Product Size (mm)	1576 x 100 x 116
Net Weight	2 Kg
Protection Rate	IP65
Certification	RoHS, CE
Warranty	3 Years

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VG05

APPENDIX 7: Solar PV – PVSyst Simulation

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Grid-Connected System: Simulation parameters

Project :	**20101104_GBM_BARR_10kWp**			
Geographical Site	**Glasgow-Airport-MN60**		**Country**	**United Kingdom**
Situation	Latitude	55.9°N	Longitude	4.4°W
Time defined as	Legal Time	Time zone UT+0	Altitude	8 m
	Albedo	0.20		
Meteo data :	Glasgow-Airport-MN60, Meteonorm SYN File			
Simulation variant :	**20101104_GBM_BARR_10kWp_Simulation_variant_1**			
	Simulation date	04/11/10 08h44		

Simulation parameters

Collector Plane Orientation	Tilt	30°	Azimuth	0°
Horizon	Free Horizon			
Near Shadings	No Shadings			

PV Array Characteristics

PV module Si-poly	Model	**KC 200GHT-2**		
	Manufacturer	Kyocera		
Number of PV modules	In series	13 modules	In parallel	4 strings
Total number of PV modules	Nb. modules	52	Unit Nom. Power	200 Wp
Array global power	Nominal (STC)	**10 kWp**	At operating cond.	9.3 kWp (50°C)
Array operating characteristics (50°C)	U mpp	309 V	I mpp	30 A
Total area	Module area	**73.4 m²**		

PV Array loss factors

Heat Loss Factor	ko (const)	29.0 W/m²K	kv (wind)	0.0 W/m²K / m/s
=> Nominal Oper. Coll. Temp. (800 W/m², Tamb=20°C, wind 1 m/s)			NOCT	45 °C
Wiring Ohmic Loss	Global array res.	341.8 mOhm	Loss Fraction	3.1 % at STC
Serie Diode Loss	Voltage Drop	0.7 V	Loss Fraction	0.2 % at STC
Module Quality Loss			Loss Fraction	3.0 %
Module Mismatch Losses			Loss Fraction	2.0 % at MPP
Incidence effect, ASHRAE parametrization	IAM =	1-bo (1/cos i - 1)	bo Parameter	0.05

System Parameter	System type	**Grid-Connected System**		
Inverter	Model	**Sunny Boy SB 6000 U-208**		
	Manufacturer	SMA		
Inverter Characteristics	Operating Voltage	250-480 V	Unit Nom. Power	5 kW AC
Inverter pack	Number of Inverter	2 units	Total Power	10 kW AC
User's needs :	Unlimited load (grid)			

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Grid-Connected System: Main results

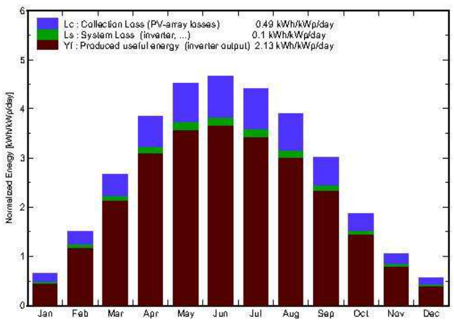
Project : **20101104_GBM_BARR_10kWp**

Simulation variant : **20101104_GBM_BARR_10kWp_Simulation_variant_1**

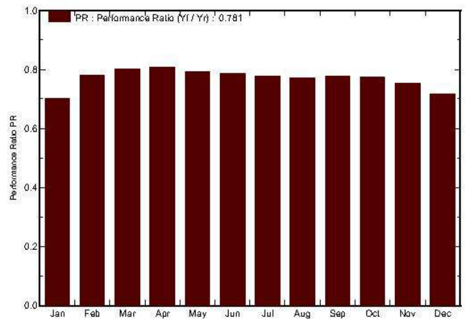
Main system parameters	System type	**Grid-Connected**		
PV Field Orientation	tilt	30°	azimuth	0°
PV modules	Model	KC 200GHT-2	Pnom	200 Wp
PV Array	Nb. of modules	52	Pnom total	**10 kWp**
Inverter	Model	Sunny Boy SB 6000 U-208	Pnom	5.2 kW ac
Inverter pack	Nb. of units	2	Pnom total	**10 kW ac**
User's needs	Unlimited load (grid)			

Main simulation results				
System Production	**Produced Energy**	**8098 kWh/year**	Specific	779 kWh/kWp/year
	Performance Ratio PR	78.1 %		

Normalized productions (per installed kWp): Nominal power 10 kWp



Performance Ratio PR



20101104_GBM_BARR_10kWp_Simulation_variant_1

Balances and main results

	GlobHor	T Amb	GlobInc	GlobEff	EArray	EOutInv	EffArrR	EffSysR
	kWh/m²	°C	kWh/m²	kWh/m²	kWh	kWh	%	%
January	12.6	4.41	20.5	19.7	162	149	10.76	9.94
February	28.5	4.66	42.4	40.9	364	344	11.71	11.07
March	61.4	6.35	82.7	80.0	722	689	11.90	11.36
April	102.6	8.03	115.2	111.1	1009	966	11.95	11.43
May	136.3	11.07	139.9	135.0	1203	1151	11.72	11.22
June	141.0	13.08	140.0	135.1	1196	1144	11.65	11.14
July	136.6	15.02	136.9	132.0	1157	1106	11.53	11.01
August	112.0	15.36	121.1	116.9	1016	970	11.43	10.92
September	72.7	13.04	90.2	87.1	764	728	11.55	11.01
October	40.1	9.62	58.3	56.3	495	469	11.57	10.98
November	17.7	6.86	31.8	30.7	266	249	11.37	10.67
December	8.6	4.37	17.6	17.0	141	131	10.91	10.16
Year	870.0	9.35	996.4	961.6	8494	8098	11.62	11.08

Legends:	GlobHor	Horizontal global irradiation	EArray	Effective energy at the output of the array
	T Amb	Ambient Temperature	EOutInv	Available Energy at Inverter Output
	GlobInc	Global incident in coll. plane	EffArrR	Effic. Eout array / rough area
	GlobEff	Effective Global, corr. for IAM and shadings	EffSysR	Effic. Eout system / rough area

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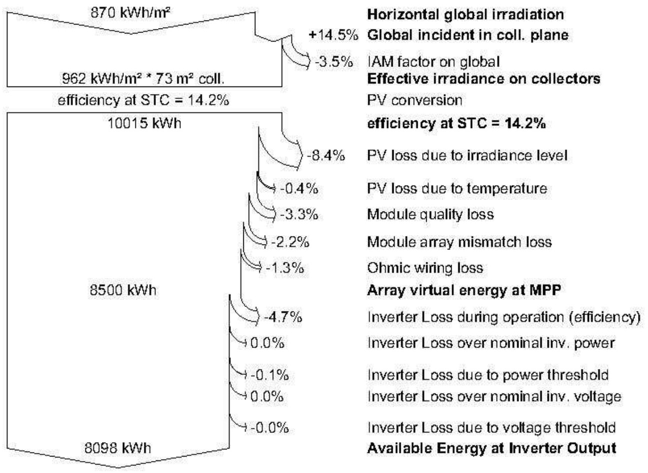
Grid-Connected System: Loss diagram

Project : **20101104_GBM_BARR_10kWp**

Simulation variant : **20101104_GBM_BARR_10kWp_Simulation_variant_1**

Main system parameters	System type	**Grid-Connected**		
PV Field Orientation	tilt	30°	azimuth	0°
PV modules	Model	KC 200GHT-2	Pnom	200 Wp
PV Array	Nb. of modules	52	Pnom total	**10 kWp**
Inverter	Model	Sunny Boy SB 6000 U-208	Pnom	5.2 kW ac
Inverter pack	Nb. of units	2	Pnom total	**10 kW ac**
User's needs	Unlimited load (grid)			

Loss diagram over the whole year



APPENDIX 8: Wind Turbines Business Case

Wind turbine

editable inputs
main outputs

Rating:	75	kW	(Assumed Vestas V17)
Grid connection cost	£200,000	GBP	(Assumed)
Turbine cost	£120,000	GBP	
Total capital cost	£320,000	GBP	
Annual O&M cost	£3,600	GBP	(Assumed: 3% of turbine cost)
kgCO2/kWh	0.541		(DECC)
CRC cost/tCO2	£0	GBP	
Rated Speed:	12	m/s	
Cut-in speed:	3.5	m/s	
Turbine uptime	90%		
Tower height:	n/a	m/s	
Rotor dia:	17	m	(upwind type)
Air density:	1.225	kg/m3	

AMWS*:	4	m/s	5	m/s	6.1	m/s	7	m/s	8	m/s	9	m/s
Sw.Area	227.07	m2	227.07	m2	227.07	m2	227.07	m2	227.07	m2	227.07	m2
Vel^3	64	(m/s)^3	125	(m/s)^3	226.981	(m/s)^3	343	(m/s)^3	512	(m/s)^3	729	(m/s)^3
Annual hours	8760	hours	8760	hours	8760	hours	8760	hours	8760	hours	8760	hours
Air density	1.225	kg/m3	1.225	kg/m3	1.225	kg/m3	1.225	kg/m3	1.225	kg/m3	1.225	kg/m3
Betz limit	0.59		0.59		0.59		0.59		0.59		0.59	
Ng (gen eff)	80%		80%		80%		80%		80%		80%	
Nb (gb/br eff)	90%		90%		90%		90%		90%		90%	
Turbine uptime	90%		90%		90%		90%		90%		90%	
Power:	3.40	kW	6.65	kW	12.07	kW	18.24	kW	27.22	kW	38.76	kW
Annual Energy:	29,811	kWh	58,225	kWh	105,728	kWh	159,769	kWh	238,490	kWh	339,568	kWh

*AMWS = Average mean wind speed

FIT Analysis (note: tariffs will be inflated annually)

FIT rate	25.4	p/kWh	(if generator starts producing energy by 31-Mar-2012)
			(if exported, can receive more by making agreement with an energy supplier.
Export rate	3	p/kWh	Consuming energy at own site can save 3 times per kWh)
Minimum Income	28.4	p/kWh	
Electricity purchase price	8	p/kWh	

If 100% exported:

AMWS	4	m/s	5	m/s	6.1	m/s	7	m/s	8	m/s	9	m/s
Annual energy	29,811	kWh	58,225	kWh	105,728	kWh	159,769	kWh	238,490	kWh	339,568	kWh
Avoided tCO2/year	16	ton	31	ton	57.20	ton	86.44	ton	129.02	ton	183.71	ton
CRC CO2 cost saved	£0.00	GBP	£0.00	GBP	£0.00	GBP	£0.00	GBP	£0.00	GBP	£0.00	GBP
Annual income	£4,866.39	GBP	£12,935.91	GBP	£26,426.70	GBP	£41,774.53	GBP	£64,131.08	GBP	£92,837.42	GBP
Payback years	65.76		24.74		12.11		7.66		4.99		3.45	
20-years income	£97,327.70	GBP	£258,718.17	GBP	£528,533.93	GBP	£835,490.66	GBP	£1,282,621.63	GBP	£1,856,748.37	GBP

editable inputs
main outputs

27066.31796

If 50% exported:

AMWS	4	m/s	5	m/s	6.1	m/s	7	m/s	8	m/s	9	m/s
Annual energy	29,811	kWh	58,225	kWh	105,728	kWh	159,769	kWh	238,490	kWh	339,568	kWh
Avoided tCO2/year	16	ton	31	ton	57.20	ton	86.44	ton	129.02	ton	183.71	ton
CRC CO2 cost saved	£0.00	GBP	£0.00	GBP	£0.00	GBP	£0.00	GBP	£0.00	GBP	£0.00	GBP
Annual income	£5,611.67	GBP	£14,391.53	GBP	£29,069.89	GBP	£45,768.77	GBP	£70,093.32	GBP	£101,326.63	GBP
Payback years	57.02		22.24		11.01		6.99		4.57		3.16	
20-years income	£112,233.31	GBP	£287,830.69	GBP	£581,397.83	GBP	£915,375.40	GBP	£1,401,866.49	GBP	£2,026,532.56	GBP

If 25% exported:

AMWS	4	m/s	5	m/s	6.1	m/s	7	m/s	8	m/s	9	m/s
Annual energy	29,811	kWh	58,225	kWh	105,728	kWh	159,769	kWh	238,490	kWh	339,568	kWh
Avoided tCO2/year	16	ton	31	ton	57.20	ton	86.44	ton	129.02	ton	183.71	ton
CRC CO2 cost saved	£0.00	GBP	£0.00	GBP	£0.00	GBP	£0.00	GBP	£0.00	GBP	£0.00	GBP
Annual income	£5,984.31	GBP	£15,119.35	GBP	£30,391.49	GBP	£47,765.89	GBP	£73,074.45	GBP	£105,571.23	GBP
Payback years	53.47		21.16		10.53		6.70		4.38		3.03	
20-years income	£119,686.12	GBP	£302,386.94	GBP	£607,829.78	GBP	£955,317.77	GBP	£1,461,488.92	GBP	£2,111,424.66	GBP

If 0% exported:

AMWS	4	m/s	5	m/s	6.1	m/s	7	m/s	8	m/s	9	m/s
Annual energy	29,811	kWh	58,225	kWh	105,728	kWh	159,769	kWh	238,490	kWh	339,568	kWh
Avoided tCO2/year	16	ton	31	ton	57.20	ton	86.44	ton	129.02	ton	183.71	ton
CRC CO2 cost saved	£0.00	GBP	£0.00	GBP	£0.00	GBP	£0.00	GBP	£0.00	GBP	£0.00	GBP
Annual income	£6,356.95	GBP	£15,847.16	GBP	£31,713.09	GBP	£49,763.01	GBP	£76,055.57	GBP	£109,815.84	GBP
Payback years	50.34		20.19		10.09		6.43		4.21		2.91	
20-years income	£127,138.92	GBP	£316,943.20	GBP	£634,261.73	GBP	£995,260.14	GBP	£1,521,111.35	GBP	£2,196,316.75	GBP

APPENDIX 9: IT Server Room Business Case

IT Server Room Heat Removal System

Proposed system costs:	Capital Cost	£15,000	
	O&M Cost	£200	
Load characteristics:	Cooling capacity	23	kVA
	Power Factor	0.99	
	Cooling Load	60%	
	Proposed cooling load	25%	
	Annual elec consumption	119,679	kWh
	Load reduction	58.3%	
Electricity Price:	Day time	7.48	pence/kWh
	Night time	5.22	pence/kWh
Server room savings:	Annual elec saving	69,809	kWh
	Annual cost saving	£4,827	
	CO2 reduced	38	tonne-CO2
Loading bay heat req.	No of Space heaters req	1	units
	Space heater rating	3	kW
	Daily usage	10	Hours
	Annual load	10,950	kWh
	CO2 emissions	6	tonne-CO2

Overall Savings	
Annual elec saving	**80,759 kWh**
Annual cost saving	**£4,827**
CO2 reduced	**43.7 tonne-CO2**

APPENDIX 10: Bitumen Tanks Tool

cormac Bitumen tank heat loss calculation tool v1.

Name of project	Barr Square tank 46.8 m3					
Height	3,000	mm				
Internal diameter	3,200	mm				
Storage temperature	150	C	Location	Edinburgh		
Capacity	24.13	m3	Electricity cost	7	p/kWh nigh	9 p/kWh day
External surface resistance	0.04	m2K/W		0.04	m2K/W	
Internal surface resistance	0.01	m2K/W		0.01	m2K/W	
Average ambient temperature	7.9	C		7.9	C	

Option:	**1. 25.0mm Rockwool RW3**		**2. 225.0mm Rockwool RW3 + 6.0mm Nansulate**	
Insulation inner layer				
Material	Rockwool RW3		Rockwool RW3	
Conductivity	0.045	W/mK	0.031	W/mK
Thickness	25	mm	225	mm
Thermal resistance	0.556	m2K/W	7.258	m2K/W
Insulation outer layer				
Material	Nansulate		Nansulate	
Conductivity	0.012	W/mK	0.017	W/mK
Thickness	0	mm	6	mm
Thermal resistance	0.000	m2K/W	0.353	m2K/W
Layer 1 diameter	3,225	mm	3,425	mm
Layer 2 diameter	3250	mm	3656	mm
External diameter	3250	mm	3662	mm
Internal surface resistance	0.000216	K/W	0.000216	K/W
Layer 1 resistance	0.011888	K/W	0.143139	K/W
Layer 2 resistance	0	K/W	0.006365	K/W
External surface resistance	0.000847	K/W	0.00072	K/W
Total thermal resistance	0.012951	K/W	0.15044	K/W
Heat loss	77.2	W/K	6.6	W/K

Heat losses kWh	*Daily avg.*	*Monthly*	*Daily avg.*	*Monthly*
Jan	278	8,611	24	741
Feb	275	7,690	24	662
Mar	270	8,376	23	721
Apr	263	7,889	23	679
May	258	7,991	22	688
Jun	254	7,627	22	657
Jul	248	7,686	21	662
Aug	250	7,761	22	668
Sep	254	7,633	22	657
Oct	261	8,083	22	696
Nov	267	8,011	23	690
Dec	282	8,755	24	754
Annual	263		23	
Annual heat loss		**96,111 kWh**		**8,274 kWh**
Cost	£18.44 /day	**£8,650** /year	£1.59 /day	**£745** /year

Annual saving
87,837 kWh
£7,905

APPENDIX 11: Bitumen Tanks Business Case

Old	Kwh / year saving opportunity	Cost saving on day rate only	New	Kwh / year running cost	Annual running cost night rate
Tank 1	161,542	£14,113.90	Tank 1	17,254	£900.85
Tank 2	161,542	£14,113.90	Tank 2	17,254	£900.85
Tank 3	87,837	£7,905.33	Tank 3	14,258	£744.42
Total	410,921	£36,133.14		48,767	£2,546.11

Tank Size	Budget cost	No of tanks	
77m3	£54,319.00	2	£108,638.00
55m3	£52,749.00	1	£52,749.00
	Project cost inc civils		£161,387.00
	Annual saving		£36,133.14
	Annual CO2 reduction		222
	Pay back	years	4.5

APPENDIX 12: Transport Energy Management System Specs

TRANSPORT FUEL CONSUMPTION REPORTING SYSTEM

This mini project aims to develop a reporting system to report the transport fuel key performance indicators on a monthly basis. The data will be sourced from the existing software. Brief details of each software have been presented in table A.

Software	**Purpose**
FuelTek	Records diesel usage, cost and total miles for all company owned vehicles.
QR3	Records sales, delivery miles and delivery costs for company owned and external haulage vehicles in Barr Quarries.
LS3	Can be used to record intake quantity of waste for Barr Environmental, and also the delivery miles and delivery costs for waste transferring vehicles.
CO5	Records sales, delivery miles and delivery costs for company owned and external haulage vehicles in Solway Steel and Solway Precast.
COINS	Financial management, costs and earnings.

Table A

The required data from the software will be routed to a data warehouse, from where it will be routed to the management report in the required format. A sample of proposed management reports is available in the appendix. The report consists of division based, quarries' site based and vehicle based KPI.

To make things more understandable, the input parameters in the reporting system are represented as 'x' and the output parameters are represented as 'y'. The data required from each of the software is given in table B.

Software	**Data required**							
FuelTek	Vehicle reg (x1)	Vehicle type (x2)	Division (x3)	Total miles (x4)	Litres (x5)	Fuel cost (x6)	Date (x7)	
QR3	Vehicle reg (x1)	Vehicle allocation (x8)	Delivery miles (x9)	Delivery tonnage (x10)	Date (x7)			
LS3	Vehicle reg (x1)	Delivery miles (x11)	Delivery tonnage (x12)	Date (x7)	-	-	-	
CO5	Vehicle reg (x1)	Delivery miles (x13)	Delivery tonnage (x14)	Date (x7)				
COINS	Vehicle reg (x1)	Other costs (x15)	Income (x16)	Date (x7)				
CO_2e conversion factor = x17 = 2.6304								

Table B

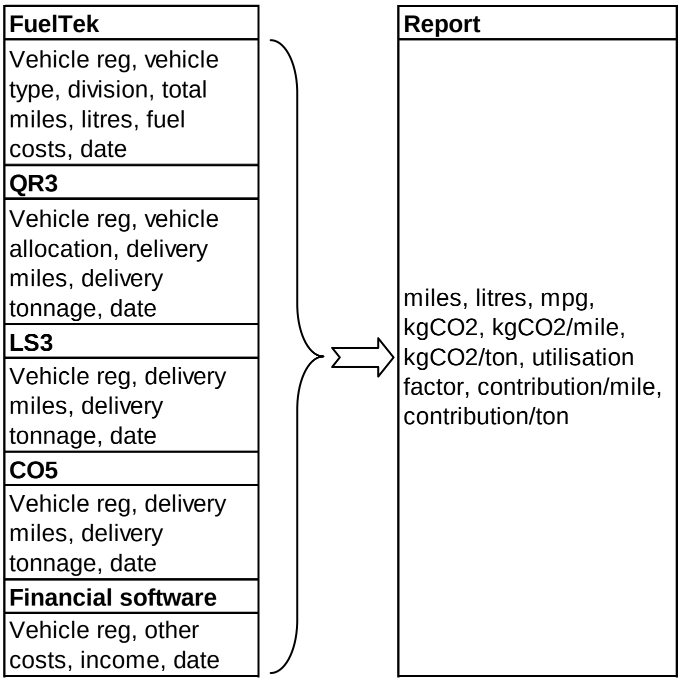


Figure. A

For each output parameter, various input parameters are required to sort and calculate. Figure B should be referred to understand it better.

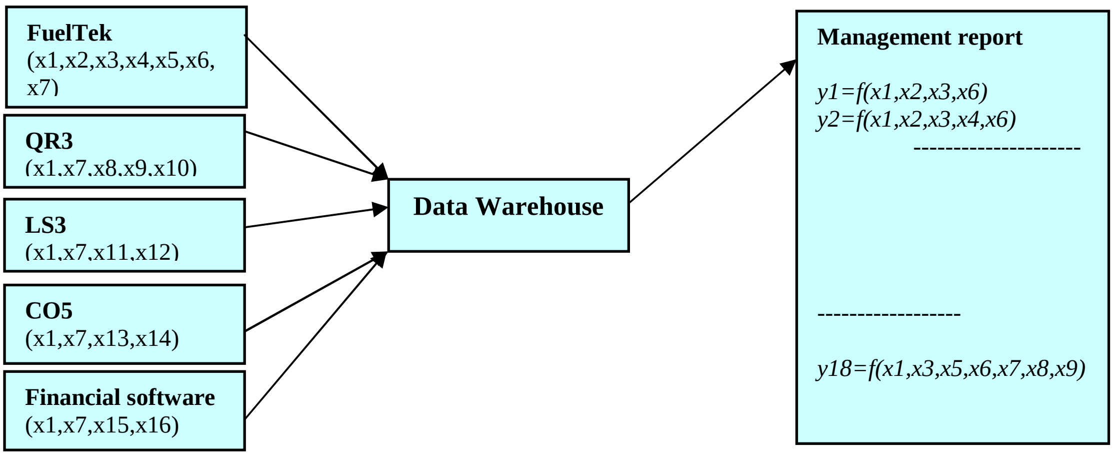


Figure B

Table C shows the relationship between input and output variables. The variables x1 (vehicle reg), x2 (vehicle type), x3 (division), x7 (date) and x8 (vehicle allocation) are identifiers. Remaining are the variables to be used in calculation of outputs to the report i.e. y1 to y18 (e.g. $y3 = f\{x1,x2,x3,x6,x7\}$. x1, x2 and x6 are used to identify vehicle, division and date respectively, where x6 and x7 are used to calculate the value of y3).

y1	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14	x15	x16	x17
y2	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14	x15	x16	x17
y3	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14	x15	x16	x17
y4	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14	x15	x16	x17
y5	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14	x15	x16	x17
y6	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14	x15	x16	x17
y7	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14	x15	x16	x17
y8	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14	x15	x16	x17
y9	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14	x15	x16	x17
y10	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14	x15	x16	x17
y11	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14	x15	x16	x17
y12	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14	x15	x16	x17
y13	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14	x15	x16	x17
y14	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14	x15	x16	x17
y15	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14	x15	x16	x17
y16	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14	x15	x16	x17
y17	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14	x15	x16	x17
y18	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14	x15	x16	x17
y19	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14	x15	x16	x17
y20	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14	x15	x16	x17
y21	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14	x15	x16	x17
y22	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14	x15	x16	x17
y23	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14	x15	x16	x17
y24	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14	x15	x16	x17
y25	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14	x15	x16	x17
y26	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14	x15	x16	x17
y27	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14	x15	x16	x17
y28	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14	x15	x16	x17

Table C (this table must be used as a guide only, actual input and output parameters may be different).

Management report format

Division based report												
Cars	**Feb miles**	**PM miles**	**YTD miles**	**Feb mpg**	**PM mpg**	**YTD mpg**	**Feb kgCO2**	**PM kgCO2**	**YTD kgCO2**	**Feb kgCO2/mile**	**PM kgCO2/mile**	**YTD gCO2/mile**
Quarries												
S & CE												
Construction												
Environmental												
Precast												
Steel												
Others												
Vans	**Feb miles**	**PM miles**	**YTD miles**	**Feb mpg**	**PM mpg**	**YTD mpg**	**Feb kgCO2**	**PM kgCO2**	**YTD kgCO2**	**Feb kgCO2/mile**	**PM kgCO2/mile**	**YTD gCO2/mile**
Quarries												
S & CE												
Construction												
Environmental												
Precast												
Steel												
Others												
Internal haulage	**Feb miles**	**PM miles**	**YTD miles**	**Feb mpg**	**PM mpg**	**YTD mpg**	**Feb utilization factor**	**PM utilization factor**	**YTD utilization factor**	**Feb kgCO2**	**PM kgCO2**	**YTD kgCO2**
Quarries												
Precast												
Steel												
Environmental												
	Feb kgCO2/mile	**PM kgCO2/mile**	**YTD kgCO2/mile**	**Feb kgCO2/ton**	**PM kgCO2/ton**	**YTD kgCO2/ton**	**Feb contribution/mile**	**PM contribution/mile**	**YTD contribution/mile**	**Feb contribution/ton**	**PM contribution/ton**	**YTD contribution/ton**
Quarries												
Precast												
Steel												
Environmental												

Quarries site based haulage	**Feb miles**	**PM miles**	**YTD miles**	**Feb mpg**	**PM mpg**	**YTD mpg**	**Feb utilization factor**	**PM utilization factor**	**YTD utilization factor**	**Feb kgCO2**	**PM kgCO2**	**YTD kgCO2**
Sorn												

Barlockhart												
Tormitchell												
Tongland												
Xx												
Xx												
Xxx												
Others												
	Feb kgCO2/mile	**PM kgCO2/mile**	**YTD kgCO2/mile**	**Feb kgCO2/ton delivered**	**PM kgCO2/ton delivered**	**YTD kgCO2/ton delivered**	**Feb contribution/mile**	**PM contribution /mile**	**YTD contribution /mile**	**Feb contribution/ ton**	**PM contribution/ton**	**YTD contribution/ton**
Sorn												
Barlockhart												
Tormitchell												
Tongland												
Xx												
Xx												
Xxx												
Others												

Individual vehicle based Cars & Vans	**Feb miles**	**PM miles**	**YTD miles**	**Feb litres**	**PM litres**	**YTD litres**	**Feb mpg**	**PM mpg**	**YTD mpg**			
AA08AXT												
AA08XHP												
AF08ETN												
AM08FMF												
XX123XX												
XX123XX												
XX123XX												
XX123XX												
XX123XX												
XX123XX												
XX123XX												
XX123XX												
XX123XX												
Individual vehicle based Tippers & Mixers	**Feb miles**	**PM miles**	**YTD miles**	**Feb litres**	**PM litres**	**YTD litres**	**Feb mpg**	**PM mpg**	**YTD mpg**	**Feb utilization factor**	**PM utilization factor**	**YTD utilization factor**
AA08AXT												
AA08XHP												
AF08ETN												
AM08FMF												

XX123XX												
XX123XX												
XX123XX												
XX123XX												
XX123XX												
XX123XX												
XX123XX												
XX123XX												
XX123XX												
	Feb kgCO2/mile	**PM kgCO2/mile**	**YTD kgCO2/mile**	**Feb kgCO2/ton delivered**	**PM kgCO2/ton delivered**	**YTD kgCO2/ton delivered**	**Feb contribution/mile**	**PM contribution /mile**	**YTD contribution /mile**	**Feb contribution/ ton**	**PM contribution/ton**	**YTD contribution/ton**
AA08AXT												
AA08XHP												
AF08ETN												
AM08FMF												
XX123XX												
XX123XX												
XX123XX												
XX123XX												
XX123XX												
XX123XX												
XX123XX												
XX123XX												
XX123XX												
Individual vehicle based Cranes & others	**Feb miles**	**PM miles**	**YTD miles**	**Feb litres**	**PM litres**	**YTD litres**	**Feb mpg**	**PM mpg**	**YTD mpg**	**Feb utilization factor**	**PM utilization factor**	**YTD utilization factor**
AA08AXT												
AA08XHP												
AF08ETN												
AM08FMF												
XX123XX												
XX123XX												
XX123XX												
XX123XX												
XX123XX												
XX123XX												
XX123XX												
XX123XX												
XX123XX												
	Feb kgCO2/mile	**PM kgCO2/m**	**YTD kgCO2/mile**	**Feb kgCO2/ton**	**PM kgCO2/ton**	**YTD kgCO2/ton**	**Feb contribut**	**PM contribution**	**YTD contribution**	**Feb contribution/**	**PM contribution/t**	**YTD contribution/to**

		ile		**delivered**	**delivered**	**delivered**	**ion/mile**	**/mile**	**/mile**	**ton**	**on**	**n**
AA08AXT												
AA08XHP												
AF08ETN												
AM08FMF												
XX123XX												
XX123XX												
XX123XX												
XX123XX												
XX123XX												
XX123XX												
XX123XX												
XX123XX												
XX123XX												

PM = Previous month
YTD = Year to date
mpg = miles per gallon

APPENDIX 13: De'Longhi DEM10 Dehumidifier

DEHUMIDIFIERS

Ariadry DEM 10

ADJUSTABLE HUMIDISTAT

The built-in humidistat lets you precisely set the relative humidity you wish in the house.

VISIBLE WATER LEVEL

With the transparent tank you can easily see the dehumidifier performance while it is working.

ELECTRONIC ANTIFREEZE

With the electronic antifreeze you can use the dehumidifier at ambient temperatures down to 2°C.

VERY QUIET OPERATION

Thanks to its high quietness DEM 10 doesn't disturb your sleep!

38 dB(A)

TECHNICAL DATA		
Dimensions (hxwxd)	mm	415x330x260
Weight	Kg	10
Voltage/Frequency	V~Hz	230 ~ 50
Dehumidifying capacity	l/24h	10
Input power	W	190
Air flow	m^3/h	100
Tank capacity	l	2
Noise level	dB(A)	38
Operation temperature range	°C	2-32

* 32°C/80%

DEM 10

- Pull up carry handle.
- Electronic antifreeze (down to 2°C).
- Humidistat to set the desired relative humidity level.
- Double condensate elimination system: the water can be either collected in a tank or eliminated through the provided discharge pipe.
- "Tank Control System": the unit stops when the tank is full.
- **Very quiet operation: only 38 dB(A)!**
- Washable air filter.
- Water tank capacity: 2 litres.
- Ecological Refrigerant Gas.

AIR CONDITIONING & AIR TREATMENT APPLIANCES

DeLonghi
Living innovation

Design and specifications subject to changes without notice.

APPENDIX 14: Dehumidifier Business Case

Standard Drying Room

Power rating	4	kW	
Number of units	5	units	(5 quarries)
Total Power	20	kW	
Annual kWh saving per unit	13824	kWh	
Cost of electricity	10	pence/kWh	
kgCO2/kWhe	0.541	kgCO2/kWh	
Annual CO2 saving per unit	7479	kgCO2	
Annual cost savings per unit	£1,382		
Cost of dehumidifier	£100		
Installation cost	£15		
Annual maintenance cost	£30		
Total capital cost	£575		
Total Annual Maintenance cost	£150		
Total Annual Electricity Saving	69,120	kWh	
Total Annual CO2 Saving	37.39	tonne-CO2	
Total Annual Cost Saving	£6,912		

APPENDIX 15: Fines Storage Sheds Business Case

Tongland coating plant sheds

Annual coated production	17,496	tonnes	(as in 2010)
Fuel Price	£0.50	£/litre	(Jan 2010)
Fuel consumption (before sl	11.76	litre/ton	
Fuel consumption (after she	9.5	litre/ton	
Annual fuel saving	39,541	litres	
CO2 reduction per litre	2.78165	kgCO2/litre	(assuming 50%Gasoil/50%Kerosene)
Annual cost saving	£19,770		
Annual CO2 reduction	110	tonne-CO2	

APPENDIX 16: Burner Replacement Business Case

Coating plant burner

Capital Cost	£30,000		
Annual O&M Cost	£500		
Annual coated production	20,000	tonnes	(estimated)
Fuel Price	£0.75	£/litre	
Fuel consumption (before)	12	litre/ton	
Fuel consumption (after)	10.5	litre/ton	
Annual fuel saving	30,000	litres	
CO2 reduction per litre	2.78165	kgCO2/litre	(assuming 50%Gasoil/50%Kerosene)
Annual cost saving	£22,500		
Annual CO2 reduction	83.45	tonne-CO2	

APPENDIX 17: Powersol PSX Power Switches

Powersol PSX 135 is suitable to be installed on a space heater. It is a fused spur that can be fitted permanently replacing the existing spur. It has a USB programming port, and these units are supplied with the programming software. It can be programmed as a weekly timer, and other features can also be included with it, such as switching on / off on thermostat or PIR (Passive InfraRed) sensors, and additional touch control to trigger / retrigger connected appliance. Figures AP17-A and AP17-B show the programming interfaces for this product, and the figure AP17-C shows the user guide for this product.

The other product, Powersol PSX 125, does not have a timer feature. It has a touch control, which can be programmed to switch the appliance on for a programmed period. Figure AP17-D shows the software interface when a PSX 125 is programmed, and the figure AP17-E shows the user guide for this product.

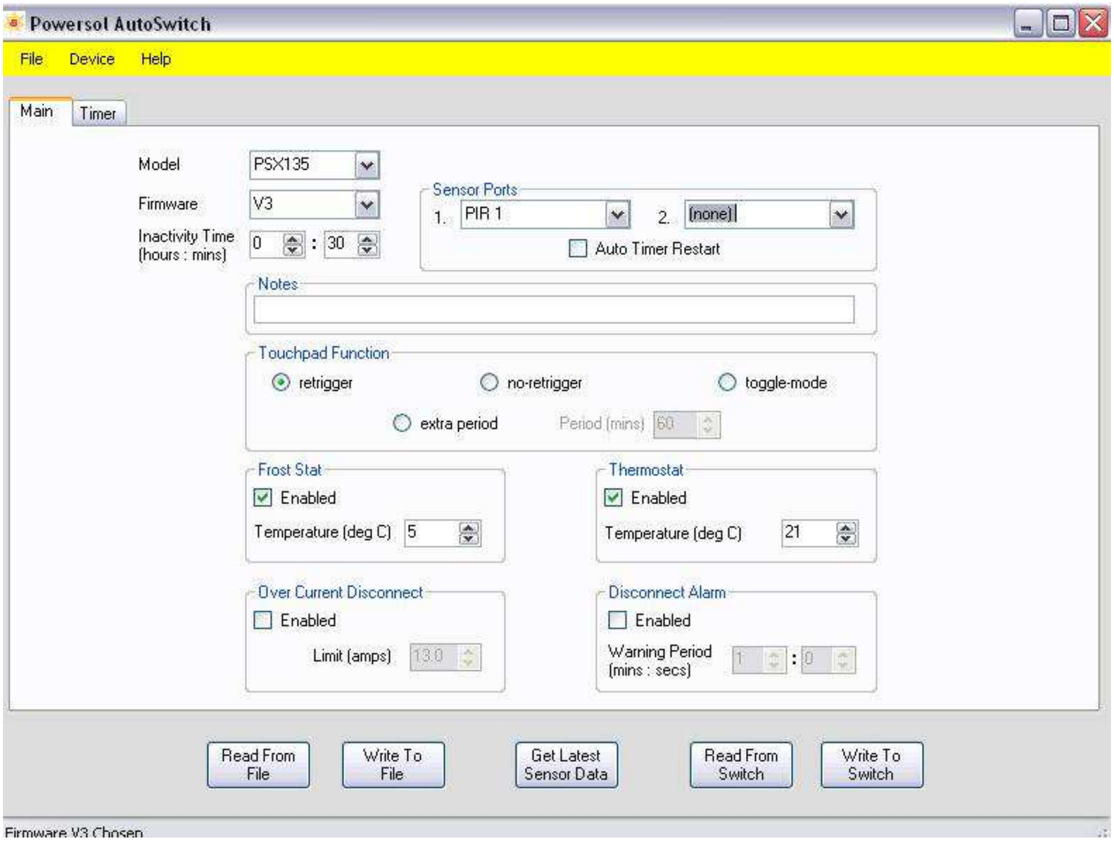


Figure AP17-A: Programming interface for PSX 135

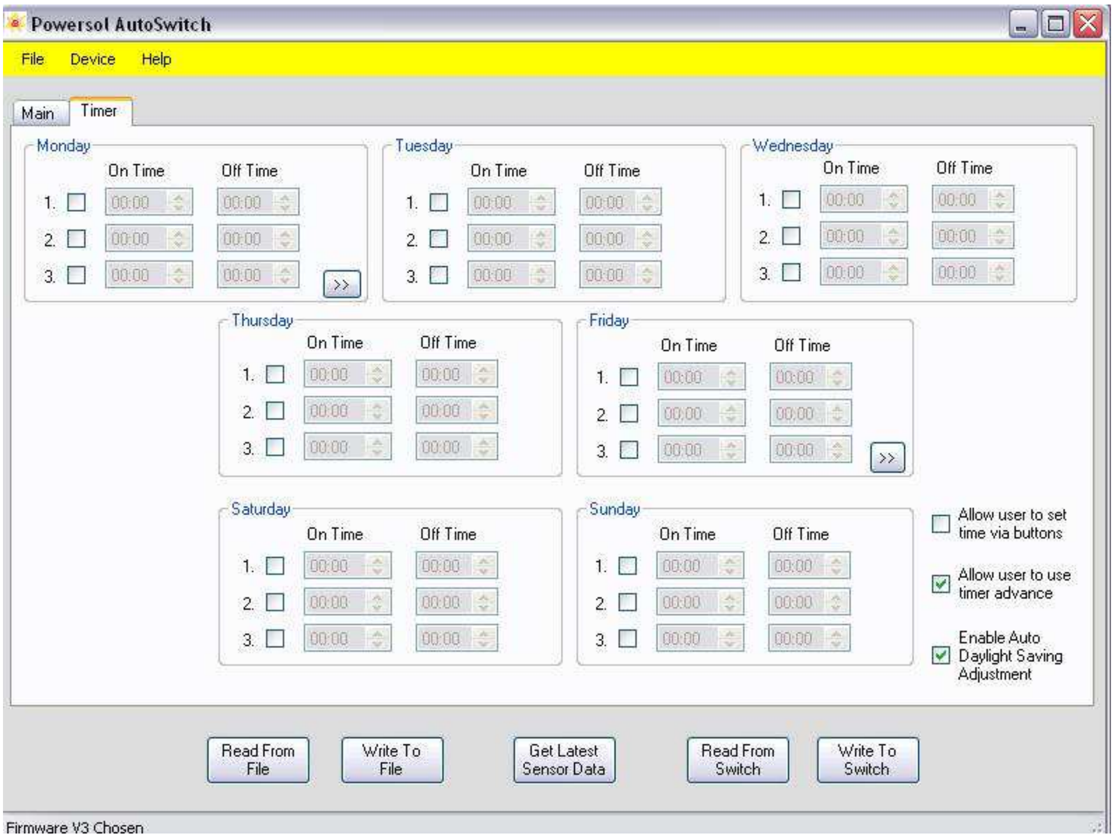


Figure AP17-B: Programming interface for PSX 135

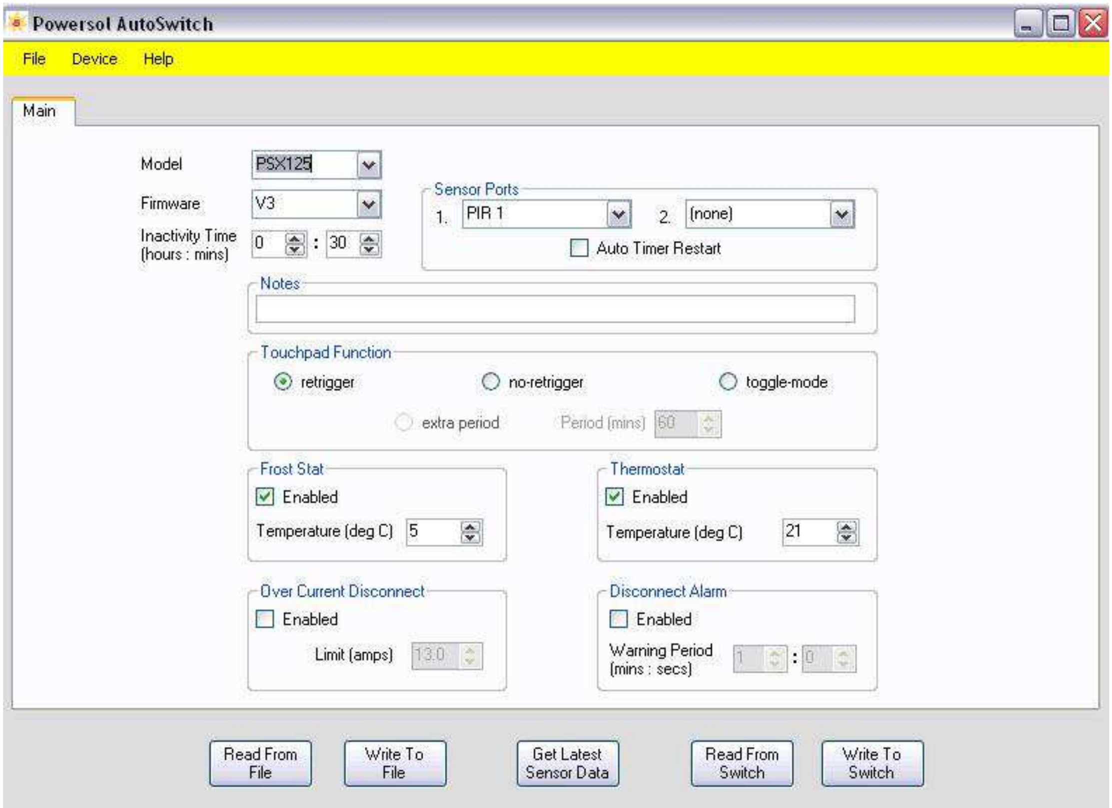
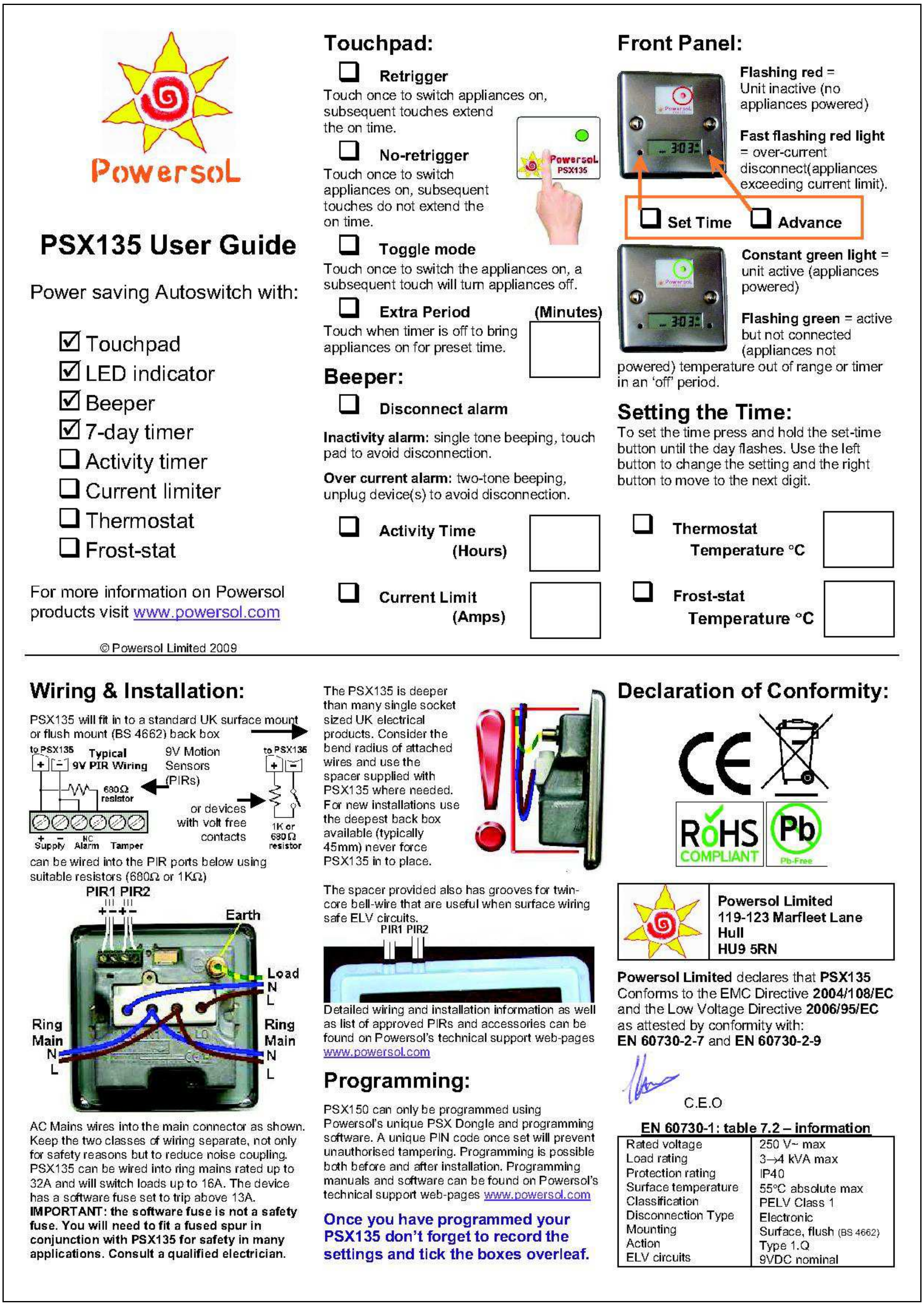


Figure AP17-D: Programming interface for PSX 125



Powersol

PSX135 User Guide

Power saving Autoswitch with:

- ☑ Touchpad
- ☑ LED indicator
- ☑ Beeper
- ☑ 7-day timer
- ❑ Activity timer
- ❑ Current limiter
- ❑ Thermostat
- ❑ Frost-stat

For more information on Powersol products visit www.powersol.com

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Touchpad:

❑ **Retrigger**
Touch once to switch appliances on, subsequent touches extend the on time.

❑ **No-retrigger**
Touch once to switch appliances on, subsequent touches do not extend the on time.

❑ **Toggle mode**
Touch once to switch the appliances on, a subsequent touch will turn appliances off.

❑ **Extra Period** **(Minutes)**
Touch when timer is off to bring appliances on for preset time.

Beeper:

❑ **Disconnect alarm**

Inactivity alarm: single tone beeping, touch pad to avoid disconnection.

Over current alarm: two-tone beeping, unplug device(s) to avoid disconnection.

❑ **Activity Time** **(Hours)**

❑ **Current Limit** **(Amps)**

Front Panel:

Flashing red = Unit inactive (no appliances powered)

Fast flashing red light = over-current disconnect(appliances exceeding current limit).

❑ **Set Time** ❑ **Advance**

Constant green light = unit active (appliances powered)

Flashing green = active but not connected (appliances not powered) temperature out of range or timer in an 'off' period.

Setting the Time:

To set the time press and hold the set-time button until the day flashes. Use the left button to change the setting and the right button to move to the next digit.

❑ **Thermostat** **Temperature °C**

❑ **Frost-stat** **Temperature °C**

Wiring & Installation:

PSX135 will fit in to a standard UK surface mount or flush mount (BS 4662) back box

to PSX135 Typical 9V PIR Wiring — 9V Motion Sensors (PIRs) — 680Ω resistor — or devices with volt free contacts — 1K or 680Ω resistor — + − Supply, NC Alarm, Tamper

can be wired into the PIR ports below using suitable resistors (680Ω or 1KΩ)

PIR1 PIR2 — Earth — Load N L — Ring Main N L — Ring Main N L

AC Mains wires into the main connector as shown. Keep the two classes of wiring separate, not only for safety reasons but to reduce noise coupling. PSX135 can be wired into ring mains rated up to 32A and will switch loads up to 16A. The device has a software fuse set to trip above 13A. **IMPORTANT: the software fuse is not a safety fuse. You will need to fit a fused spur in conjunction with PSX135 for safety in many applications. Consult a qualified electrician.**

The PSX135 is deeper than many single socket sized UK electrical products. Consider the bend radius of attached wires and use the spacer supplied with PSX135 where needed. For new installations use the deepest back box available (typically 45mm) never force PSX135 in to place.

The spacer provided also has grooves for twin-core bell-wire that are useful when surface wiring safe ELV circuits.

PIR1 PIR2

Detailed wiring and installation information as well as list of approved PIRs and accessories can be found on Powersol's technical support web-pages www.powersol.com

Programming:

PSX150 can only be programmed using Powersol's unique PSX Dongle and programming software. A unique PIN code once set will prevent unauthorised tampering. Programming is possible both before and after installation. Programming manuals and software can be found on Powersol's technical support web-pages www.powersol.com

Once you have programmed your PSX135 don't forget to record the settings and tick the boxes overleaf.

Declaration of Conformity:

CE — RoHS COMPLIANT — Pb Pb-Free

Powersol Limited
119-123 Marfleet Lane
Hull
HU9 5RN

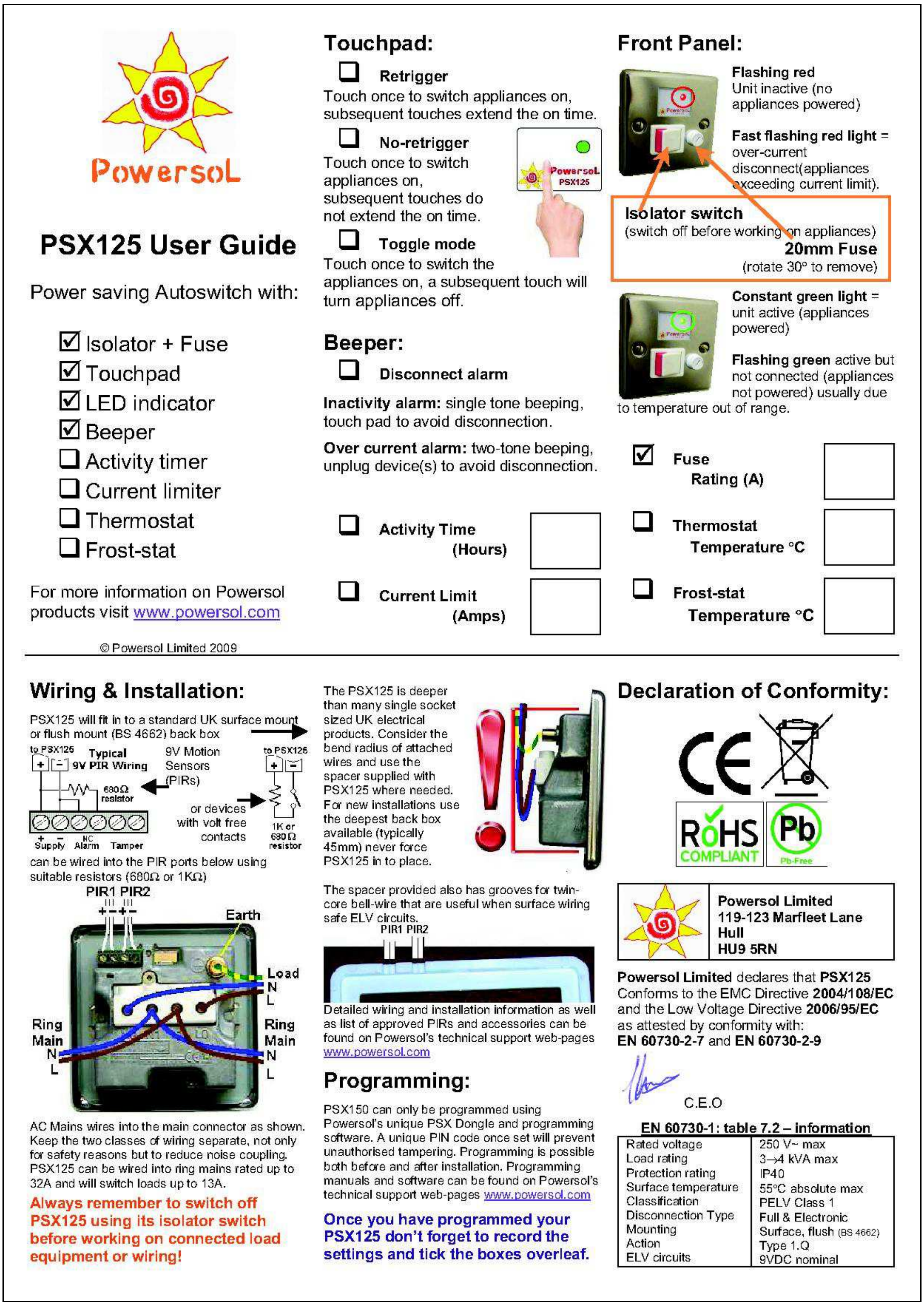
Powersol Limited declares that **PSX135** Conforms to the EMC Directive **2004/108/EC** and the Low Voltage Directive **2006/95/EC** as attested by conformity with: **EN 60730-2-7** and **EN 60730-2-9**

C.E.O

EN 60730-1: table 7.2 – information

Rated voltage	250 V~ max
Load rating	3→4 kVA max
Protection rating	IP40
Surface temperature	55°C absolute max
Classification	PELV Class 1
Disconnection Type	Electronic
Mounting	Surface, flush (BS 4662)
Action	Type 1.Q
ELV circuits	9VDC nominal

Figure AP17-C: User Guide for PSX 135



PowersoL

PSX125 User Guide

Power saving Autoswitch with:

- ☑ Isolator + Fuse
- ☑ Touchpad
- ☑ LED indicator
- ☑ Beeper
- ❑ Activity timer
- ❑ Current limiter
- ❑ Thermostat
- ❑ Frost-stat

For more information on Powersol products visit www.powersol.com

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Touchpad:

❑ **Retrigger**
Touch once to switch appliances on, subsequent touches extend the on time.

❑ **No-retrigger**
Touch once to switch appliances on, subsequent touches do not extend the on time.

❑ **Toggle mode**
Touch once to switch the appliances on, a subsequent touch will turn appliances off.

Beeper:

❑ **Disconnect alarm**

Inactivity alarm: single tone beeping, touch pad to avoid disconnection.

Over current alarm: two-tone beeping, unplug device(s) to avoid disconnection.

❑ **Activity Time (Hours)** ☐

❑ **Current Limit (Amps)** ☐

Front Panel:

Flashing red
Unit inactive (no appliances powered)

Fast flashing red light = over-current disconnect(appliances exceeding current limit).

Isolator switch
(switch off before working on appliances)
20mm Fuse
(rotate 30° to remove)

Constant green light = unit active (appliances powered)

Flashing green active but not connected (appliances not powered) usually due to temperature out of range.

☑ **Fuse Rating (A)** ☐

❑ **Thermostat Temperature °C** ☐

❑ **Frost-stat Temperature °C** ☐

Wiring & Installation:

PSX125 will fit in to a standard UK surface mount or flush mount (BS 4662) back box

to PSX125 + − Typical 9V PIR Wiring 680Ω resistor
+ − Supply NC Alarm Tamper
9V Motion Sensors (PIRs)
or devices with volt free contacts
to PSX125 + − 1K or 680Ω resistor

can be wired into the PIR ports below using suitable resistors (680Ω or 1KΩ)

PIR1 PIR2 + − + −
Earth
Load N L
Ring Main N L
Ring Main N L

AC Mains wires into the main connector as shown. Keep the two classes of wiring separate, not only for safety reasons but to reduce noise coupling. PSX125 can be wired into ring mains rated up to 32A and will switch loads up to 13A.

Always remember to switch off PSX125 using its isolator switch before working on connected load equipment or wiring!

The PSX125 is deeper than many single socket sized UK electrical products. Consider the bend radius of attached wires and use the spacer supplied with PSX125 where needed. For new installations use the deepest back box available (typically 45mm) never force PSX125 in to place.

The spacer provided also has grooves for twin-core bell-wire that are useful when surface wiring safe ELV circuits.

PIR1 PIR2

Detailed wiring and installation information as well as list of approved PIRs and accessories can be found on Powersol's technical support web-pages www.powersol.com

Programming:

PSX150 can only be programmed using Powersol's unique PSX Dongle and programming software. A unique PIN code once set will prevent unauthorised tampering. Programming is possible both before and after installation. Programming manuals and software can be found on Powersol's technical support web-pages www.powersol.com

Once you have programmed your PSX125 don't forget to record the settings and tick the boxes overleaf.

Declaration of Conformity:

CE RoHS COMPLIANT Pb Pb-Free

Powersol Limited
119-123 Marfleet Lane
Hull
HU9 5RN

Powersol Limited declares that **PSX125** Conforms to the EMC Directive **2004/108/EC** and the Low Voltage Directive **2006/95/EC** as attested by conformity with:
EN 60730-2-7 and **EN 60730-2-9**

C.E.O

EN 60730-1: table 7.2 – information

Rated voltage	250 V~ max
Load rating	3→4 kVA max
Protection rating	IP40
Surface temperature	55°C absolute max
Classification	PELV Class 1
Disconnection Type	Full & Electronic
Mounting	Surface, flush (BS 4662)
Action	Type 1.Q
ELV circuits	9VDC nominal

Figure AP17-E: User Guide for PSX 125

APPENDIX 18: Timer Switches – Revised Business Case

Power switches

Power rating	2	kW		
Number of units	10	units		
Total Power	20	kW		
Weekdays day-rate saving hours	6.5	hours		
Weekdays night-rate saving hours	6	hours		
Weekend day-rate saving hours	18	hours		
Weekend night-rate saving hours	6	hours		
Day rate:	10	pence/kWh		8.729
Night rate:	10	pence/kWh		5.228
kgCO2/kWhe	0.541	kgCO2/kWh		
Weekly savings				
Working days per week	6	days		
Total kWh to be saved	2322	kWh		
CO2 emissions to be saved	**1256**	kg		
Total day hours to be saved	74.1	hours	=	£148.20
Total night hours to be saved	42	hours	=	£84.00
	Total money saved / week			**£232.20**
Yearly savings				
Working weeks per year	25	weeks	(i.e. assumed winter 5.5 months only)	
Total kWh to be saved	58050	kWh		
CO2 emissions to be saved	**31405**	kg		
Total day hours to be saved	1852.5	hours	=	£3,705.00
Total night hours to be saved	1050	hours	=	£2,100.00
	Total money saved / year			**£5,805.00**
Power saving unit	**Powersol PSX-135 and PSX-125**			
Unit price	£145			
Installation price per unit	£25	(assumed for 10 units combined installation)		
Annual maintenance cost	£75	(assuming 1 unit failed, replacement time 1 hour)		
Total Cost	£1,775.00			
Payback period:	**7.6**	weeks	(i.e. in Winter)	

APPENDIX 19: Solar PV – Revised Business Case

Solar PV installation:

Total solar power	50	kWp	(Hyundai 250Watt, 1645x983mm)		
Total panels required	200	panels			
Each kWp cost	£2,400	GBP			
Total cost	£120,000	GBP			
Each kWp produces	779	kWh	(annual production assumption / PVSYST)		
Saving of kgCO2/kWh	0.541	kgCO2/kWh			
Total annual electricity production	38950	kWh			
Total annual CO2 saving	21.07	tonne			
Total annaul Carbon tax saving	£0.00		CRC Carbon credit cost	£0.00	per tonne of CO2
Day time rates	10	pence/kWh	(which is	100%	of time)
Night time rates	8	pence/kWh	(which is	0%	of time)
Annual electricity cost avoidance	£3,895	GBP	(Assuming 100% of generated electricity is consumed by ourselves)		
FIT rate	15.2	pence/kWh	(if joined by 31-July-2012)		
FIT annual income	£5,920	GBP			
FIT duration	25	years			
Total income (over FIT period)	£245,385	GBP			
Net profit (over FIT period)	£125,385	GBP			
Total annual benefit	£9,815	GBP			
Pay back period	**12**	**years**			

APPENDIX 20: IT Server room savings M&V

IT Server Room Heat Removal System

Proposed system costs:	Capital Cost	£15,000		**Overall Savings**	
	O&M Cost	£200		**Annual elec saving**	**70,790 kWh**
				Annual cost saving	**£4,138**
Load characteristics:	Cooling capacity	23	kVA	**CO2 reduced**	**38.3 tonne-CO2**
	Power Factor	0.99			
	Cooling Load	60%			
	Load timing	100%			
	Proposed cooling load	25%			
	Annual elec consumption	119,679	kWh		
	Load reduction	50.0%			
Electricity Price:	Day time	7.48	pence/kWh		
	Night time	5.22	pence/kWh		
Server room savings:	Annual elec saving	59,840	kWh	69809	
	Annual cost saving	£4,138			
	CO2 reduced	32	tonne-CO2		
Loading bay heat req.	No of Space heaters req	1	units		
	Space heater rating	3	kW		
	Daily usage	10	Hours		
	Annual load	10,950	kWh		
	CO2 emissions	6	tonne-CO2		

APPENDIX 21: Refurbished Bitumen Tanks Savings

Comparison of bitumen tanks : 24 hours periods

CO2 Conversions:

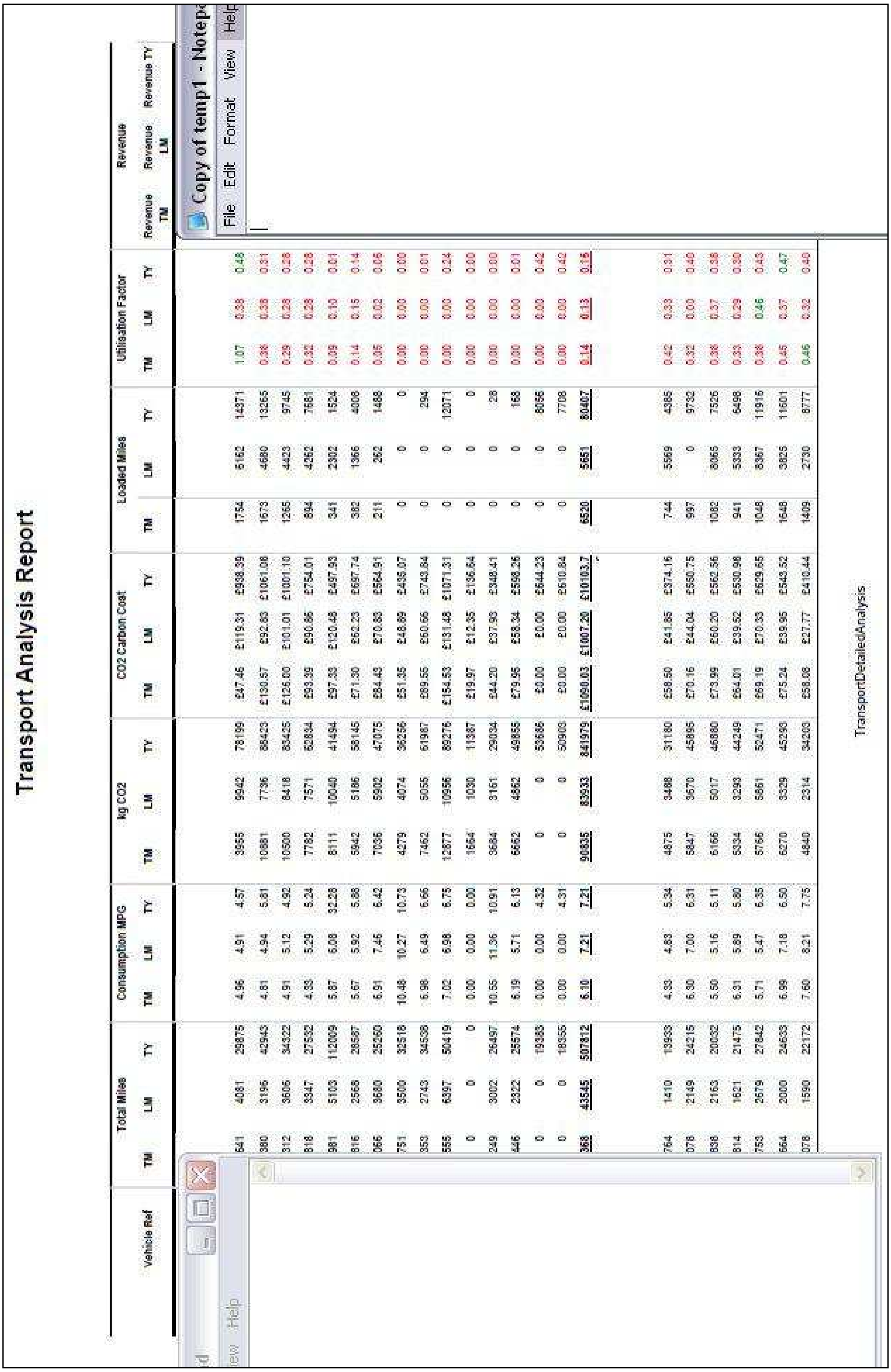
Electricity	0.541	kgCO2/kWh
Gas oil	2.762	kgCO2/litre

CRC Carbon credit charges £0.00 GBP/tonne-CO2 (not considered to calculate the carbon abatement cost)

	Barlockhart Refurbished					Killoch old electric			
Filled	60%	i.e.	19.2	tonnes	**Filled**	66%	i.e.	19	tonnes
Carbon emissions	66	kg-CO2			**Carbon emissions**	110	kg-CO2		
Electricity cost	£11.24	GBP			**Electricity cost**	£17.02	GBP		
CRC Cost	£0.00	GBP			**CRC Cost**	£0.00	GBP		

Emissions red	16.06	tonnes-year
Cost Saving	£2,108	per annum

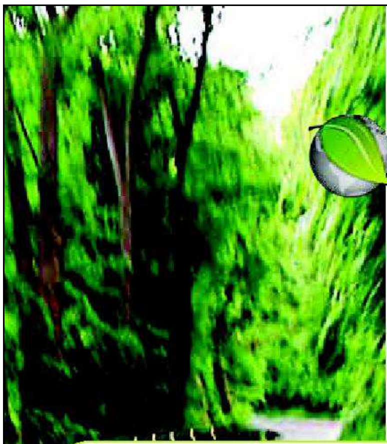
APPENDIX 22: Transport Energy Report



Transport Analysis Report

Vehicle Ref	Total Miles TM	Total Miles LM	Total Miles TY	Consumption MPG TM	Consumption MPG LM	Consumption MPG TY	kg CO2 TM	kg CO2 LM	kg CO2 TY	CO2 Carbon Cost TM	CO2 Carbon Cost LM	CO2 Carbon Cost TY	Loaded Miles TM	Loaded Miles LM	Loaded Miles TY	Utilisation Factor TM	Utilisation Factor LM	Utilisation Factor TY	Revenue TM	Revenue LM	Revenue TY
	641	4081	29875	4.96	4.91	4.57	3955	9942	78199	£47.46	£119.31	£938.39	1754	5162	14371	1.07	0.38	0.48			
	380	3196	42943	4.81	4.94	5.81	10881	7736	88423	£130.57	£92.83	£1061.08	1673	4680	13265	0.38	0.38	0.31			
	312	3606	34322	4.91	5.12	4.92	10500	8418	83425	£126.00	£101.01	£1001.10	1265	4423	9745	0.29	0.28	0.28			
	818	3347	27532	4.33	5.29	5.24	7782	7571	62834	£93.39	£90.86	£754.01	894	4262	7681	0.32	0.28	0.28			
	981	5103	112009	5.87	6.08	32.28	8111	10040	41494	£97.33	£120.48	£497.93	341	2302	1524	0.09	0.10	0.01			
	816	2568	28587	5.67	5.92	5.88	5942	5186	58145	£71.30	£62.23	£697.74	382	1366	4008	0.14	0.15	0.14			
	066	3680	25260	6.91	7.46	6.42	7036	5902	47075	£84.43	£70.83	£564.91	211	262	1488	0.05	0.02	0.06			
	751	3500	32518	10.48	10.27	10.73	4279	4074	36256	£51.35	£48.89	£435.07	0	0	0	0.00	0.00	0.00			
	353	2743	34538	6.98	6.49	6.66	7462	5055	61987	£89.55	£60.66	£743.84	0	0	294	0.00	0.00	0.01			
	555	6397	50419	7.02	6.98	6.75	12877	10956	89276	£154.53	£131.48	£1071.31	0	0	12071	0.00	0.00	0.24			
	0	0	0	0.00	0.00	0.00	1664	1030	11387	£19.97	£12.35	£136.64	0	0	0	0.00	0.00	0.00			
	249	3002	26497	10.55	11.36	10.91	3684	3161	29034	£44.20	£37.93	£348.41	0	0	28	0.00	0.00	0.00			
	446	2322	25574	6.19	5.71	6.13	6662	4862	49855	£79.95	£58.34	£598.26	0	0	168	0.00	0.00	0.01			
	0	0	19383	0.00	0.00	4.32	0	0	53686	£0.00	£0.00	£644.23	0	0	8056	0.00	0.00	0.42			
	0	0	18355	0.00	0.00	4.31	0	0	50903	£0.00	£0.00	£610.84	0	0	7708	0.00	0.00	0.42			
	368	43545	507812	6.10	7.21	7.21	90835	83933	841979	£1090.03	£1007.20	£10103.7	6520	5651	80407	0.14	0.13	0.16			
	764	1410	13933	4.33	4.83	5.34	4875	3488	31180	£58.50	£41.85	£374.16	744	5569	4385	0.42	0.33	0.31			
	078	2149	24215	6.30	7.00	6.31	5847	3670	45895	£70.16	£44.04	£550.75	997	0	9732	0.32	0.00	0.40			
	838	2163	20032	5.50	5.16	5.11	6166	5017	46880	£73.99	£60.20	£562.56	1082	8065	7526	0.38	0.37	0.38			
	814	1621	21475	6.31	5.89	5.80	5334	3293	44249	£64.01	£39.52	£530.98	941	5333	6498	0.33	0.29	0.30			
	753	2679	27842	5.71	5.47	6.35	5766	5861	52471	£69.19	£70.33	£629.65	1048	8367	11916	0.38	0.46	0.43			
	564	2000	24633	6.99	7.18	6.50	6270	3329	45293	£75.24	£39.95	£543.52	1648	3826	11601	0.45	0.37	0.47			
	078	1590	22172	7.60	8.21	7.75	4840	2314	34203	£58.08	£27.77	£410.44	1409	2730	8777	0.46	0.32	0.40			

APPENDIX 23: Telematics System

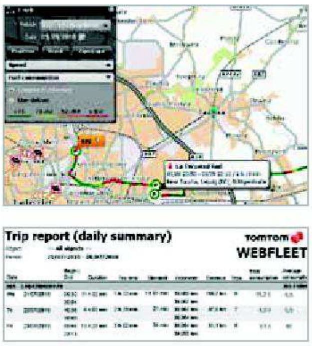


TomTom ecoPLUS™

For mobile businesses, controlling fuel consumption is paramount. But to control it, first you need to know how much fuel your operations are using.

It's easy to do this with TomTom ecoPLUS™. Part of TomTom WORKsmart™ solutions, this clever device is easily installed in the vehicle, providing accurate information on fuel efficiency which is presented through WEBFLEET®.

Armed with the facts, you can take action to reduce fuel consumption, cut idling time and manage your carbon footprint.



Reduce fuel consumption

ecoPLUS gives you a real-time view of the fuel efficiency of every vehicle in your fleet, at every point on their journey. The device continuously calculates the fuel consumption and presents this to you in WEBFLEET.

WEBFLEET lets you view the captured fuel efficiency data on the dashboard, in lists or on a live map, where you can compare vehicles with ease. You can also run a customised fuel consumption reports, such as:

- a daily summary report
- trips report by period or vehicle

Cut idling time

Fuel costs represent a major part of your expenses. But did you know that a significant amount of fuel is consumed when a vehicle is idling? To help you cut idling time, and lower your fuel costs and CO_2 emissions, ecoPLUS lets you see exactly how much fuel is being wasted – when, where and by whom.

ecoPLUS detects when a vehicle is idling. The device then calculates the fuel consumption when idling and sends this information to WEBFLEET, enabling you to view and build reports based on:

- Idle time per day
- Wasted fuel per day during idling
- Excessive idling

WEBFLEET gives you full control. You'll have all the insight you need at your fingertips to set a company-wide idling policy, and monitor adherence to it.

TOMTOM

Let's drive business™

www.tomtom.com/business

APPENDIX 24: Transport Fuel Efficiency Report

Barr XXTM Fuel Efficiency Report

Category	Period	No. of loads	Loaded miles	Units delivered	Units/Load	Diesel Used	lit/ton	Loaded mpg	Total mpg*	Litres at '2010 lit/ton'	Litred Saved	Diesel Price	Cost saving	tonne-CO2 Reduction**
Barr XXTM	2010 - Benchmark	26,090	349,763	404,559	15.51	651,458	1.610	2.032	4.886	651,458	0	£1.30	£0	0.00
Barr XXTM	2011	17,226	216,056	281,369	16.33	435,422	1.548	1.878	4.515	453,086	17,664	£1.40	£24,730	46.62
Barr XXTM	2012 - YTD	5,475	76,686	90,268	16.49	141,917	1.572	2.045	4.917	145,358	3,441	£1.49	£5,121	9.08
Barr XXTM	After-2010	22,701	292,742	371,637	16.37	577,339	1.554	1.919	4.614	598,444	21,105	£1.40	£29,547	55.70

*assuming XXTM were loaded 50% of the time

**Using a CRC CO_2 conversion factor '2.6390 $kgCO_2$/litre' for Diesel fuel

APPENDIX 25: Barr's CRC Reporting Tool

Organisational Information

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	Barr Holdings		CRC Year	2011-12											
2	Fuels	Units	April	May	June	July	August	September	October	November	December	January	February	March	Year-to-date
3	Kerosene	(litres)	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
4	Gas Oil (total)	(litres)	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
5	Gas Oil (CRC)	(litres)	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
6	Derv	(litres)	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
7	HH Electricity	(kWh)	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
8	NHH Electricity	(kWh)	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
9	Total Electricity	(kWh)	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
10	Total CRC Electricity	(kWh)	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
11	Natural Gas	(kWh)	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
12	Total CRC Nat. Gas	(kWh)	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
13	Petrol	(litres)	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
14															
15	Carbon Emissions & CRC Charges Report														
16	Fuels	Units	April	May	June	July	August	September	October	November	December	January	February	March	Year-to-date
17	Kerosene	(tonne-CO2)	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
18	Gas Oil (total)	(tonne-CO2)	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
19	Gas Oil (CRC)	(tonne-CO2)	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
20	Derv	(tonne-CO2)	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
21	HH Electricity	(tonne-CO2)	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
22	NHH Electricity	(tonne-CO2)	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
23	Total Electricity	(tonne-CO2)	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
24	Natural Gas	(tonne-CO2)	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
25	Petrol	(tonne-CO2)	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
26	Grand total	(tonne-CO2)	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
27	CRC total	(tonne-CO2)	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
28	CRC Bill	GBP	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
29	Updated CRC Bill*	GBP	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
30	*After excluding supplies on the basis of RML											Updated CRC Allowances			#REF!
31		CRC Allowance Price		£12.00	per tonne-CO2										
33		CO2 conversion factors													
34		Kerosene	2.5320	kgCO2/lit	Derv	2.6390	kgCO2/lit	Nat. Gas	0.1836	kgCO2/kWh					
35		Gas Oil	2.7620	kgCO2/lit	Electricity	0.5410	kgCO2/kWh	Petrol	2.3035	kgCO2/lit					
36															

Org / Env / Ind / Man / Con / QUALL / QUAD / QUBE / QUBH / QUCL / QUKI / QUKK / QUSL / QUSN / QUTL / QUTN / buf / elec11 / elec12 / Fuel Master 2011 / Fue

Site specific information sheet

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	Site	Swinlees Quarry			CRC Reporting Year		2011-12								
2	ENERGY REPORT														
3	Fuels delivered	Units	April	May	June	July	August	September	October	November	December	January	February	March	Year-to-date
4	Kerosene	(litres)	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	0
5	Gas Oil	(litres)	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	0
6	Derv	(litres)	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	0
7	HH Elect	(kWh)	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	0
8	NHH Elect	(kWh)	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	0
9	Total Elect	(kWh)	0	0	0	0	0	0	0	0	0	0	0	0	0
10															
11	CARBON EMISSIONS REPORT														
12	Fuels	Units	April	May	June	July	August	September	October	November	December	January	February	March	Year-to-date
13	Kerosene	(tonne-CO2)	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
14	Gas Oil	(tonne-CO2)	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
15	Derv	(tonne-CO2)	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
16	HH Elect	(tonne-CO2)	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
17	NHH Elect	(tonne-CO2)	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
18	Grand total		#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
19	CRC total		#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
20	CRC Bill	(GBP)	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
21															
22	KEY PERFORMANCE INDICATORS REPORT														
23	Product	Benchmarks	KPI (kWh/tonne) or (kWh/metre-cube)												
24	Dry	18	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
25	Coated	130	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
26	ReadyMix	5	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
27															
28	CO2 conversion factors									Conversions (litre to kWh)				Elec split	
29	Kerosene	2.5320	kgCO2/lit	Derv	2.6390	kgCO2/lit	Nat. Gas	0.1836	kgCO2/kW	Gas oil:		10.6	kWh/Lit	Dry	0.00%
30	Gas Oil	2.7620	kgCO2/lit	Electricity	0.5410	kgCO2/kW	Petrol	2.3035	kgCO2/lit	Kerosene:		10.6	kWh/Lit	Coated	85.00%
31										Lightblend RFO:		10.6	kWh/Lit	Readymix	10.00%
32															

Electricity and Natural Gas information sheet

H52 fx Excluded residual supplies

	A	B	C	D	E	F	G	
1	Site	Division	Billing	Estimated	Profile	MPAN	January	Fel
2	Creetown	Manufacturing	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{del
3	Creetown managers house	Manufacturing	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{del
4	Creetown 22 harbour street	Manufacturing	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{del
5	Barrhill common meter	Manufacturing	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{del
6	Barrhill 25 main street	Manufacturing	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{del
7	Killoch common meter	Industrial	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{del
8	Moorfield concrete plant	Industrial	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{del
9	Swinlees	Industrial	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{del
10	Tongland	Industrial	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{del
11	Tormitchell	Industrial	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{del
12	Barlockhart quarry	Industrial	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{del
13	Clayshant quarry	Industrial	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{del
14	Tincornhill (SORN) quarry	Industrial	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{del
15	Boreland fell quarry	Industrial	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{del
16	Beatockhill quarry	Industrial	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{del
17	Croach quarry, Cairnryan	Industrial	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{del
18	Breakers yard, Cairnryan	Industrial	{deleted}	{deleted}	{deleted}	{deleted}	{deleted}	{del

CRC Reporting Summary sheet

	A	B	C	D	E
1		Supplies	Actual Supply	Estimated Supply	tonne-CO2
2		Core electricity not covered by CCA	7577953.8	0.00	4099.673006
3		Core gas not covered by CCA / EU ETS	0	288240	52.920864
4					
5		Residual Measurement List:			
6		Included Gas oils	3087966		8528.962092
7					
8		Turnover expenditure:	£210,934,000		12,682
9					12808.37152
10		Emissions covered by vol. AMR	67%	(constant)	
11					
12		CSR questions:			
13		Discloses long term reduction targets	Undisclosed		
14		Discloses performance against above	Yes		
15		Responsibility of energy use	Yes		
16		engagement of employees in energy use	Yes		
17					
18		CRC 2012-13		Emissions	CRC Bill
19		Barr Holdings		12,687	£152,244.00
21		Construction		#REF!	#REF!
22		Environmental		#VALUE!	#VALUE!
23		Manufacturing		#VALUE!	#VALUE!
24		Industrial:		#REF!	#REF!
25		- Barlockhart Quarry		#VALUE!	#VALUE!
26		- Clayshant Quarry		#VALUE!	#VALUE!
27		- Killoch depot		#VALUE!	#VALUE!
28		- Moorfield Concrete		#VALUE!	#VALUE!
29		- Swinlees Quarry		#VALUE!	#VALUE!
30		- Sorn Quarry		#VALUE!	#VALUE!
31		- Tormitchell Quarry		#VALUE!	#VALUE!
32		- Tongland Quarry		#VALUE!	#VALUE!
33		- Surfacing & Civil Engg		#VALUE!	#VALUE!
35		Contingency (325 extra allowances)		13,012	£156,144.00
36					

QUKI / QUKK / QUSL / QUSN / QUTL / QUTN / buf / elec11 / elec12 / Fuel Master 2011 / Fuel Master 2012

APPENDIX 26: Internal Audit Form

CRC Audit

Electricity / Gas / Fuels Bills - Industrial / Environmental / Manufacturing **Frequency :** Quarterly

	Audit tasks	**Evidence Attached?** (Yes / No / Not Applicable)
A	**Location of Electricity & Gas Bills**	
1	Location of all the electricity / gas bills: ______	
2	Person responsible for the availability of electricity / gas bills: ______	
3	Bills audited up to (date): dd/mm/yyyy	
B	**Electricity / Gas bills availability and data check**	
1	Identify and make a list of missing bills	
2	Randomly pick minimum 10% of electricity bills since the last audit (minimum 3 site's bills) (Mix of online and other bills)	
3	Compare kWh values against values entered in CRC tool	
4	Pick one **HH** site and compare online kWh vs Billed kWh	
5	Pick one **NHH AMR** site and compare register readings online and in the bill	
6	Pick one estimated bill and check if it has been highlighted in the CRC tool	
7	Pick one random bill and compare its profile type against profile type entered in CRC tool	
8	Identify and make a list for errors identified from steps B2 to B7	
9	Correct the values in CRC tool	
10	Repeat the same procedure for Gas bills (minimum **1** site's bills) exc. Step B4, B5 and B7	
C	**Were any electricity / gas bills previously reported as missing or wrong? (Yes / No)**	
1	Identify the bills that were missing / wrong previously are now available in correct form	
2	Identify and make a list of bills that are still unavailable	
3	Pick minimum 25% of the previously missing bills (minimum **1** bill)	
4	Compare kWh values against values entered in CRC tool	
5	Highlight estimated bills in the CRC tool	
6	Compare profile type against profile type entered in CRC tool	
7	Identify and make a list of errors / wrong values	
8	Correct the values in CRC tool	
D	**Are there any new or removed elec / gas meters / sites? (Yes / No)**	
1	Verify and update the list of sites in operation	
2	Identify and record the availability of supply termination record for sites	
3	Identify and record the availability of new supply record for sites	
4a	Record the MPAN/profile type/supplier/CRN/meter number for new electricity supplies	
4b	Record the MPRN/supplier/CRN/meter number for new gas supplies	
5	Record meter start / meter removal dates	
E	**Were there any elec / gas meter failures since last audit? (Yes / No)**	
1	Record the report from meter service agent	
2	Check and update estimated supply values for unmetered period	
F	**Location of Fuel Bills**	
1	Location of all the fuel bills: ______	
2	Person responsible for the availability of fuel bills: ______	
3	Bills audited up to (date): dd/mm/yyyy	
G	**Fuels bills availability and data check**	
1	Identify and make a list of missing bills	
2	Randomly pick minimum 10% of Gas oil bills since the last audit (minimum 3 site's bills)	
3	Compare litres values against values entered in CRC tool	
4	Highlight estimated bills (if any) in the CRC tool	
5	Identify and make a list of errors / wrong values	
6	Correct the values in CRC tool	
7	Repeat the same procedure for Kerosene bills (minimum **1** site's bills)	
8	Repeat the same procedure for Derv bills (minimum **1** site's bills)	
H	**Were any fuel bills previously reported as missing or wrong? (Yes / No)**	
1	Identify the bills that were missing / wrong previously are now available in correct form	
2	Identify and make a list of bills that are still unavailable	
3	Pick minimum 25% of the previously missing bills (minimum **1** bill)	
4	Compare litres values against values entered in CRC tool	
5	Highlight estimated bills, if any, in the CRC tool	
6	Identify and make a list of errors / wrong values	
7	Correct the values in CRC tool	
I	**Was there any correspondence with SEPA/EA? (Yes / No)**	
1	copies of emails / letters	
J	**Summary of CRC emissions / costs**	
1	Verify that the CRC tool's summary report contains all information	
2	Identify and record missing bits of information allowing a one month lag	
3	Print summary report to be included in the audit certificate	
K	**Audit Certificate (including summary of CRC emissions / costs)**	
1	Audit conducted by: ______	
2	Date: ______	
3	Audit certificate signature:	4 Signatory: ______ 5 Date: ______

CRC Audit / rev. 0 / Sheikh Ali / 28-Mar-12

APPENDIX 27-A: CRC Procedure

CRC COMPLIANCE PROCEDURE

Month		Task
January	1st working day	Download HH electricity data and populate into CRC tool
	1st day week-2	Populate CRC tool with fuels data
	2nd day week-2	Download and populate external hauliers fuel for Quarries
	2nd day week-2	Request Quarries production data and populate into CRC tool
	2nd day week-2	Download and populate turnover information for Quarries
	3rd day week-2	Audit elec & gas bills: Const.
	4th day week-2	Request if missing / unavailable / incorrect bills
	1st day week-4	Confirm availability of complete / correct bills for next audit
	3rd day week-2	Audit fuels invoices: Construction
	3rd day week-2	Get audit certificate signed for Construction
	4th day week-2	Request if missing / unavailable / incorrect invoices
	1st day week-4	Confirm availability of complete / correct invoices for next audit
	4th day week-2	Request external hauliers fuel for Manufacturing
	4th day week-2	Request Derv card purchases and petrol data
	4th day week-3	Follow up on external hauliers fuel for Manufacturing
	4th day week-3	Populate Derv card purchases and petrol data into CRC tool
	4th day week-4	Download and populate external hauliers fuel for Manufacturing
	4th day week-2	Request Gas oil data for Construction
	4th day week-3	Follow up on Gas oil data for Construction
	4th day week-4	Download and populate Gas oil data for Construction
February	1st working day	Download HH electricity data and populate into CRC tool
	1st day week-2	Populate CRC tool with fuels data
	2nd day week-2	Download and populate external hauliers fuel for Quarries
	2nd day week-2	Request Quarries production data and populate into CRC tool
	2nd day week-2	Download and populate turnover information for Quarries
March	1st working day	Download HH electricity data and populate into CRC tool
	1st day week-2	Populate CRC tool with fuels data
	2nd day week-2	Download and populate external hauliers fuel for Quarries
	2nd day week-2	Request Quarries production data and populate into CRC tool
	2nd day week-2	Download and populate turnover information for Quarries
	3rd day week-2	Put NHH elec and gas sites data into CRC tool
	3rd day week-2	Audit elec & gas bills: Ind, Man, Env
	4th day week-2	Request if missing / unavailable / incorrect bills
	1st day week-4	Confirm availability of complete / correct bills for next audit
	3rd day week-2	Audit fuels invoices: Ind, Man, Env
	4th day week-2	Get audits certificate signed for Ind, Man, Env
	4th day week-2	Request if missing / unavailable / incorrect invoices
	1st day week-4	Confirm availability of complete / correct invoices for next audit
	1st day week-3	Ask relevant personnel to request Annual statements
	Last working day of March	Check if annual statements have been requested
	1st day week-1	Request Bills of new Constr. Sites
	1st day week-3	Follow up on bills of new Constr. Sites
	2nd day week-3	Update new sites / bills in evidence pack
	2nd day week-3	Update Special events/change database
	2nd day week-3	Update contacts/responsibilities list
	2nd day week-3	Update list of external records
	3rd day week-3	Update & record CRC policies / procedures
	3rd day week-3	Update records of exclusions
April	1st working day	Download HH electricity data and populate into CRC tool
	1st day week-2	Populate CRC tool with fuels data
	2nd day week-2	Download and populate external hauliers fuel for Quarries
	2nd day week-2	Request Quarries production data and populate into CRC tool

	2nd day week-2	Download and populate turnover information for Quarries
	2nd day week-2	Request turnover information for group
	2nd day week-2	Follow up on turnover information for group
	2nd day week-2	Populate turnover information for group into CRC tool
	3rd day week-2	Audit elec & gas bills: Const.
	4th day week-2	Request if missing / unavailable / incorrect bills
	1st day week-4	Confirm availability of complete / correct bills for next audit
	3rd day week-2	Audit fuels invoices: Construction
	3rd day week-2	Get audit certificate signed for Construction
	4th day week-2	Request if missing / unavailable / incorrect invoices
	1st day week-4	Confirm availability of complete / correct invoices for next audit
	4th day week-2	Request external hauliers fuel for Manufacturing
	4th day week-2	Request Derv card purchases and petrol data
	4th day week-3	Follow up on external hauliers fuel for Manufacturing
	4th day week-3	Populate Derv card purchases and petrol data into CRC tool
	4th day week-4	Download and populate external hauliers fuel for Manufacturing
	4th day week-2	Request Gas oil data for Construction
	4th day week-3	Follow up on Gas oil data for Construction
	4th day week-4	Download and populate Gas oil data for Construction
	Last working day of April	Check if annual statements have been received
	Last working day of April	Follow up if not.
	3rd day week-1	Update CRC tool for next CRC year
May	1st working day	Download HH electricity data and populate into CRC tool
	1st day week-2	Populate CRC tool with fuels data
	2nd day week-2	Download and populate external hauliers fuel for Quarries
	2nd day week-2	Request Quarries production data and populate into CRC tool
	2nd day week-2	Download and populate turnover information for Quarries
	2nd day week-1	Compare available annual statements with available HH data
	2nd day week-1	If more than 5% different, contact the supplier
	End of week 2 in May	Check if annual statements have been received
	End of week 2 in May	Follow up if not.
	1st day of week-3 in May	Compare available annual statements with available HH data
	1st day of week-3 in May	If more than 5% different, contact the supplier
	2nd day of week-3 in May	Check for installed / terminated supplies
	2nd day of week-3 in May	Request for first / last bill
	1st day of week-4 in May	Follow up on above bills
	2nd day of week-4 in May	Populate CRC Evidence pack with statements
	3rd day of week-4 in May	Populate data in to CRC source list tool
	4th day of week-4 in May	Populate data in to CRC source list tool
June	1st working day	Download HH electricity data and populate into CRC tool
	3rd day week-1	CRC source list tool final update
	4th day week-1	Update CRC evidence pack
	4th day week-1	Discuss and calculate number of allowances to buy
	1st day week-2	Populate CRC tool with fuels data
	2nd day week-2	Download and populate external hauliers fuel for Quarries
	2nd day week-2	Request Quarries production data and populate into CRC tool
	2nd day week-2	Download and populate turnover information for Quarries
	3rd day week-2	Put NHH elec and gas sites data into CRC tool
	3rd day week-2	Audit elec & gas bills: Ind, Man, Env
	4th day week-2	Request if missing / unavailable / incorrect bills
	1st day week-4	Confirm availability of complete / correct bills for next audit
	3rd day week-2	Audit fuels invoices: Ind, Man, Env
	4th day week-2	Get audits certificate signed for Ind, Man, Env
	4th day week-2	Request if missing / unavailable / incorrect invoices
	1st day week-4	Confirm availability of complete / correct invoices for next audit
	1st day week-1	Request Bills of new Constr. Sites
	1st day week-3	Follow up on bills of new Constr. Sites
	2nd day week-3	Update new sites / bills in evidence pack

	2nd day week-3	Update Special events/change database
	2nd day week-3	Update contacts/responsibilities list
	2nd day week-3	Update list of external records
	3rd day week-3	Update & record CRC policies / procedures
	3rd day week-3	Update records of exclusions
July	1st working day	Download HH electricity data and populate into CRC tool
	1st day week-2	Populate CRC tool with fuels data
	2nd day week-2	Download and populate external hauliers fuel for Quarries
	2nd day week-2	Request Quarries production data and populate into CRC tool
	2nd day week-2	Download and populate turnover information for Quarries
	3rd day week-2	Audit elec & gas bills: Const.
	4th day week-2	Request if missing / unavailable / incorrect bills
	5th day week-2	Compile data for footprint report
	5th day week-2	Compile data for annual report
	1st day week-4	Confirm availability of complete / correct bills for next audit
	3rd day week-2	Audit fuels invoices: Construction
	3rd day week-2	Get audit certificate signed for Construction
	4th day week-2	Request if missing / unavailable / incorrect invoices
	1st day week-4	Confirm availability of complete / correct invoices for next audit
	4th day week-2	Request external hauliers fuel for Manufacturing
	4th day week-2	Request Derv card purchases and petrol data
	4th day week-3	Follow up on external hauliers fuel for Manufacturing
	4th day week-3	Populate Derv card purchases and petrol data into CRC tool
	4th day week-4	Download and populate external hauliers fuel for Manufacturing
	4th day week-2	Request Gas oil data for Construction
	4th day week-3	Follow up on Gas oil data for Construction
	4th day week-4	Download and populate Gas oil data for Construction
	5th day week-2	Discuss and Calculate number of allowances to surrender
August	1st working day	Download HH electricity data and populate into CRC tool
	1st day week-2	Populate CRC tool with fuels data
	2nd day week-2	Download and populate external hauliers fuel for Quarries
	2nd day week-2	Request Quarries production data and populate into CRC tool
	2nd day week-2	Download and populate turnover information for Quarries
September	1st working day	Download HH electricity data and populate into CRC tool
	1st day week-2	Populate CRC tool with fuels data
	2nd day week-2	Download and populate external hauliers fuel for Quarries
	2nd day week-2	Request Quarries production data and populate into CRC tool
	2nd day week-2	Download and populate turnover information for Quarries
	3rd day week-2	Put NHH elec and gas sites data into CRC tool
	3rd day week-2	Audit elec & gas bills: Ind, Man, Env
	4th day week-2	Request if missing / unavailable / incorrect bills
	1st day week-4	Confirm availability of complete / correct bills for next audit
	3rd day week-2	Audit fuels invoices: Ind, Man, Env
	4th day week-2	Get audits certificate signed for Ind, Man, Env
	4th day week-2	Request if missing / unavailable / incorrect invoices
	1st day week-4	Confirm availability of complete / correct invoices for next audit
	1st day week-1	Request Bills of new Constr. Sites
	1st day week-3	Follow up on bills of new Constr. Sites
	2nd day week-3	Update new sites / bills in evidence pack
	2nd day week-3	Update Special events/change database
	2nd day week-3	Update contacts/responsibilities list
	2nd day week-3	Update list of external records
	3rd day week-3	Update & record CRC policies / procedures
	3rd day week-3	Update records of exclusions
	last working day	Check for league table publication

October	1st working day	Download HH electricity data and populate into CRC tool
	1st day week-2	Populate CRC tool with fuels data
	2nd day week-2	Download and populate external hauliers fuel for Quarries
	2nd day week-2	Request Quarries production data and populate into CRC tool
	2nd day week-2	Download and populate turnover information for Quarries
	3rd day week-2	Audit elec & gas bills: Const.
	4th day week-2	Request if missing / unavailable / incorrect bills
	1st day week-4	Confirm availability of complete / correct bills for next audit
	3rd day week-2	Audit fuels invoices: Construction
	3rd day week-2	Get audit certificate signed for Construction
	4th day week-2	Request if missing / unavailable / incorrect invoices
	1st day week-4	Confirm availability of complete / correct invoices for next audit
	4th day week-2	Request external hauliers fuel for Manufacturing
	4th day week-2	Request Derv card purchases and petrol data
	4th day week-3	Follow up on external hauliers fuel for Manufacturing
	4th day week-3	Populate Derv card purchases and petrol data into CRC tool
	4th day week-4	Download and populate external hauliers fuel for Manufacturing
	4th day week-2	Request Gas oil data for Construction
	4th day week-3	Follow up on Gas oil data for Construction
	4th day week-4	Download and populate Gas oil data for Construction
November	1st working day	Download HH electricity data and populate into CRC tool
	1st day week-2	Populate CRC tool with fuels data
	2nd day week-2	Download and populate external hauliers fuel for Quarries
	2nd day week-2	Request Quarries production data and populate into CRC tool
	2nd day week-2	Download and populate turnover information for Quarries
December	1st working day	Download HH electricity data and populate into CRC tool
	1st day week-2	Populate CRC tool with fuels data
	2nd day week-2	Download and populate external hauliers fuel for Quarries
	2nd day week-2	Request Quarries production data and populate into CRC tool
	2nd day week-2	Download and populate turnover information for Quarries
	3rd day week-2	Put NHH elec and gas sites data into CRC tool
	3rd day week-2	Audit elec & gas bills: Ind, Man, Env
	4th day week-2	Request if missing / unavailable / incorrect bills
	1st day week-4	Confirm availability of complete / correct bills for next audit
	3rd day week-2	Audit fuels invoices: Ind, Man, Env
	4th day week-2	Get audits certificate signed for Ind, Man, Env
	4th day week-2	Request if missing / unavailable / incorrect invoices
	1st day week-4	Confirm availability of complete / correct invoices for next audit
	1st day week-1	Request Bills of new Constr. Sites
	1st day week-3	Follow up on bills of new Constr. Sites
	2nd day week-3	Update new sites / bills in evidence pack
	2nd day week-3	Update Special events/change database
	2nd day week-3	Update contacts/responsibilities list
	2nd day week-3	Update list of external records
	3rd day week-3	Update & record CRC policies / procedures
	3rd day week-3	Update records of exclusions

APPENDIX 27-B: CRC Procedure – updated

CRC COMPLIANCE PROCEDURE FOR BARR HOLDINGS

Month	Week	Day	Task	Task Category	effort (days)
January	1	1	Download HH electricity data and populate into CRC tool	Data Download / Duplication	0.25
	2	1	Request Gas oil data for Construction	Internal Communication	0.05
	2	2	Download and populate external hauliers fuel for Quarries	Data Download / Duplication	0.1
	2	2	Request Quarries production data and populate into CRC tool	Internal Communication	0.4
	2	2	Download and populate turnover information for Quarries	Data Download / Duplication	0.1
	2	3	Audit elec & gas bills: Const.	Internal Audit	0.8
	2	3	Request if missing / unavailable / incorrect bills	Internal Communication	0.1
	2	4	Audit fuels invoices: Construction	Internal Audit	0.7
	2	4	Get audit certificate signed from BC	Internal Communication	0.1
	2	4	Request if missing / unavailable / incorrect invoices	Internal Communication	0.1
	2	5	Request external hauliers fuel for Manufacturing	Internal Communication	0.05
	2	5	Request Derv card purchases and petrol data	Internal Communication	0.05
	3	4	Follow up on external hauliers fuel for Manufacturing	Internal Communication	0.05
	3	4	Populate Derv card purchases and petrol data into CRC tool	Data Download / Duplication	0.1
	3	4	Follow up on Gas oil data for Construction	Internal Communication	0.05
	4	1	Populate CRC tool with fuels data	Data Download / Duplication	0.4
	4	1	Confirm availability of complete / correct bills for next audit	Internal Communication	0.1
	4	1	Confirm availability of complete / correct invoices for next audit	Internal Communication	0.1
	4	4	Download and populate external hauliers fuel for Manufacturing	Data Download / Duplication	0.1
	4	4	Download and populate Gas oil data for Construction	Data Download / Duplication	0.1
			January total CRC effort:		**3.8**
February	1	1	Download HH electricity data and populate into CRC tool	Data Download / Duplication	0.25
	2	2	Download and populate external hauliers fuel for Quarries	Data Download / Duplication	0.1
	2	2	Request Quarries production data and populate into CRC tool	Internal Communication	0.4
	2	2	Download and populate turnover information for Quarries	Data Download / Duplication	0.1
	4	1	Populate CRC tool with fuels data	Data Download / Duplication	0.4
			February total CRC effort:		**1.25**
March	1	1	Download HH electricity data and populate into CRC tool	Data Download / Duplication	0.25
	2	2	Download and populate external hauliers fuel for Quarries	Data Download / Duplication	0.1
	2	2	Request Quarries production data and populate into CRC tool	Internal Communication	0.4
	2	2	Download and populate turnover information for Quarries	Data Download / Duplication	0.1
	2	3	Copy NHH elec and gas sites data into CRC tool	Data Download / Duplication	1
	2	4	Audit elec & gas bills: Ind, Man, Env	Internal Audit	0.8
	2	4	Request if missing / unavailable / incorrect bills	Internal Communication	0.1
	2	5	Ask relevant personnel to request Annual statements	Internal Communication	0.1
	3	1	Audit fuels invoices: Ind, Man, Env	Internal Audit	0.7
	3	1	Request if missing / unavailable / incorrect invoices	Internal Communication	0.1
	3	1	Get audits certificate signed by BW	Internal Communication	0.1
	3	2	Update Special events/change database	Evidence Pack Update	1
	3	3	Update new sites / bills in evidence pack	Evidence Pack Update	0.1
	3	3	Update contacts/responsibilities list	Evidence Pack Update	0.1
	3	3	Update list of external records	Evidence Pack Update	0.1
	3	4	Update & record CRC policies / procedures	Evidence Pack Update	0.5
	3	4	Update records of exclusions	Evidence Pack Update	0.25
	4	1	Populate CRC tool with fuels data	Data Download / Duplication	0.4
	4	1	Confirm availability of complete / correct bills for next audit	Internal Communication	0.1
	4	1	Confirm availability of complete / correct invoices for next audit	Internal Communication	0.1
	4	5	Check if annual statements have been requested	Internal Communication	0.2
			March total CRC effort:		**6.6**
April	1	1	Download HH electricity data and populate into CRC tool	Data Download / Duplication	0.25
	1	3	Update CRC tool for next CRC year	Tool Update	1
	2	1	Request Gas oil data for Construction	Internal Communication	0.05
	2	2	Download and populate external hauliers fuel for Quarries	Data Download / Duplication	0.1
	2	2	Request Quarries production data and populate into CRC tool	Internal Communication	0.4
	2	2	Download and populate turnover information for Quarries	Data Download / Duplication	0.1
	2	3	Audit elec & gas bills: Const.	Internal Audit	0.8
	2	3	Request if missing / unavailable / incorrect bills	Internal Communication	0.1
	2	4	Request external hauliers fuel for Manufacturing	Internal Communication	0.05
	2	4	Request Derv card purchases and petrol data	Internal Communication	0.05
	3	2	Audit fuels invoices: Construction	Internal Audit	0.7
	3	2	Get audit certificate signed from BC	Internal Communication	0.1
	3	2	Request if missing / unavailable / incorrect invoices	Internal Communication	0.1
	3	4	Follow up on external hauliers fuel for Manufacturing	Internal Communication	0.05
	3	4	Populate Derv card purchases and petrol data into CRC tool	Data Download / Duplication	0.1
	3	4	Follow up on Gas oil data for Construction	Internal Communication	0.05
	4	1	Populate CRC tool with fuels data	Data Download / Duplication	0.4
	4	1	Confirm availability of complete / correct bills for next audit	Internal Communication	0.1
	4	1	Confirm availability of complete / correct invoices for next audit	Internal Communication	0.1
	4	4	Download and populate external hauliers fuel for Manufacturing	Data Download / Duplication	0.1
	4	4	Download and populate Gas oil data for Construction	Data Download / Duplication	0.1
	4	5	Check if annual statements have been received	Internal Communication	0.1
	4	5	Follow up if not.	Internal Communication	0.2
			April total CRC effort:		**5.1**
May	1	1	Download HH electricity data and populate into CRC tool	Data Download / Duplication	0.25
	1	2	Compare available annual statements with available HH data	Internal Audit	0.9
	1	2	If more than 5% different, contact the supplier	External Communication	0.1
	2	2	Download and populate external hauliers fuel for Quarries	Data Download / Duplication	0.1
	2	2	Request Quarries production data and populate into CRC tool	Internal Communication	0.4
	2	2	Download and populate turnover information for Quarries	Data Download / Duplication	0.1

	2	5	Check if annual statements have been received	Internal Communication	0.1
	2	5	Follow up if not.	Internal Communication	0.2
	3	1	Compare available annual statements with available HH data	Internal Audit	0.5
	3	1	If more than 5% different, contact the supplier	External Communication	0.1
	3	2	Check for installed / terminated supplies	Internal Communication	0.5
	3	2	Request for first / last bill	Internal Communication	0.1
	4	1	Populate CRC tool with fuels data	Data Download / Duplication	0.4
	4	1	Follow up on above bills	Internal Communication	0.2
	4	2	Populate CRC Evidence pack with statements	Evidence Pack Update	0.5
	4	3	Populate data in to CRC Footprint Tool	Data Download / Duplication	1
	4	4	Populate data in to CRC Footprint Tool	Data Download / Duplication	1
			May total CRC effort:		**6.45**
June	1	1	Download HH electricity data and populate into CRC tool	Data Download / Duplication	0.25
	1	3	CRC Footprint Tool final update	Data Download / Duplication	1
	1	4	Request information required for evidence pack update	Evidence Pack Update	0.5
	1	4	Discuss and calculate number of allowances to buy	Data Analysis & Reporting	0.5
	2	2	Download and populate external hauliers fuel for Quarries	Data Download / Duplication	0.1
	2	2	Request Quarries production data and populate into CRC tool	Internal Communication	0.4
	2	2	Download and populate turnover information for Quarries	Data Download / Duplication	0.1
	2	3	Copy NHH elec and gas sites data into CRC tool	Data Download / Duplication	1
	2	4	Audit elec & gas bills: Ind, Man, Env	Internal Audit	0.8
	2	4	Request if missing / unavailable / incorrect bills	Internal Communication	0.1
	3	1	Audit fuels invoices: Ind, Man, Env	Internal Audit	0.7
	3	1	Get audits certificate signed by BW	Internal Communication	0.1
	3	1	Request if missing / unavailable / incorrect invoices	Internal Communication	0.1
	3	2	Update Special events/change database	Evidence Pack Update	1
	3	3	Update new sites / bills in evidence pack	Evidence Pack Update	0.1
	3	3	Update contacts/responsibilities list	Evidence Pack Update	0.1
	3	3	Update list of external records	Evidence Pack Update	0.1
	3	4	Update & record CRC policies / procedures	Evidence Pack Update	0.5
	3	4	Update records of exclusions	Evidence Pack Update	0.25
	4	1	Populate CRC tool with fuels data	Data Download / Duplication	0.4
	4	1	Confirm availability of complete / correct bills for next audit	Internal Communication	0.1
	4	1	Confirm availability of complete / correct invoices for next audit	Internal Communication	0.1
			June total CRC effort:		**8.3**
July	1	1	Download HH electricity data and populate into CRC tool	Data Download / Duplication	0.25
	1	2	Request turnover information for group	Internal Communication	0.05
	1	2	Request Gas oil data for Construction	Internal Communication	0.05
	2	1	Download and populate external hauliers fuel for Quarries	Data Download / Duplication	0.1
	2	1	Request Quarries production data and populate into CRC tool	Internal Communication	0.4
	2	1	Download and populate turnover information for Quarries	Data Download / Duplication	0.1
	2	2	Audit elec & gas bills: Const.	Internal Audit	0.8
	2	2	Request if missing / unavailable / incorrect bills	Internal Communication	0.1
	2	2	Follow up on turnover information for group	Internal Communication	0.1
	2	3	Audit fuels invoices: Construction	Internal Audit	0.7
	2	3	Get audit certificate signed from BC	Internal Communication	0.1
	2	3	Request if missing / unavailable / incorrect invoices	Internal Communication	0.1
	2	4	Populate turnover information for group into CRC tool	Data Download / Duplication	0.1
	2	4	Request external hauliers fuel for Manufacturing	Internal Communication	0.05
	2	4	Request Derv card purchases and petrol data	Internal Communication	0.05
	2	5	Compile data for footprint report	Data Analysis & Reporting	0.5
	2	5	Compile data for annual report	Data Analysis & Reporting	0.5
	3	3	Discuss and Calculate number of allowances to surrender	Data Analysis & Reporting	0.5
	3	4	Follow up on external hauliers fuel for Manufacturing	Internal Communication	0.05
	3	4	Populate Derv card purchases and petrol data into CRC tool	Data Download / Duplication	0.1
	3	4	Follow up on Gas oil data for Construction	Internal Communication	0.05
	4	1	Populate CRC tool with fuels data	Data Download / Duplication	0.4
	4	1	Confirm availability of complete / correct bills for next audit	Internal Communication	0.1
	4	1	Confirm availability of complete / correct invoices for next audit	Internal Communication	0.1
	4	4	Download and populate external hauliers fuel for Manufacturing	Data Download / Duplication	0.1
	4	4	Download and populate Gas oil data for Construction	Data Download / Duplication	0.1
			July total CRC effort:		**5.55**
August	1	1	Download HH electricity data and populate into CRC tool	Data Download / Duplication	0.25
	2	2	Download and populate external hauliers fuel for Quarries	Data Download / Duplication	0.1
	2	2	Request Quarries production data and populate into CRC tool	Internal Communication	0.4
	2	2	Download and populate turnover information for Quarries	Data Download / Duplication	0.1
	4	1	Populate CRC tool with fuels data	Data Download / Duplication	0.4
			August total CRC effort:		**1.25**
September	1	1	Download HH electricity data and populate into CRC tool	Data Download / Duplication	0.25
	2	1	Copy NHH elec and gas sites data into CRC tool	Data Download / Duplication	1
	2	2	Download and populate external hauliers fuel for Quarries	Data Download / Duplication	0.1
	2	2	Request Quarries production data and populate into CRC tool	Internal Communication	0.4
	2	2	Download and populate turnover information for Quarries	Data Download / Duplication	0.1
	2	3	Audit elec & gas bills: Ind, Man, Env	Internal Audit	0.8
	2	3	Request if missing / unavailable / incorrect bills	Internal Communication	0.1
	2	4	Audit fuels invoices: Ind, Man, Env	Internal Audit	0.7
	2	4	Get audits certificate signed by BW	Internal Communication	0.1
	2	4	Request if missing / unavailable / incorrect invoices	Internal Communication	0.1
	2	5	Discuss and calculate number of allowances to buy	Data Analysis & Reporting	0.5
	3	1	Update Special events/change database	Evidence Pack Update	1
	3	2	Update new sites / bills in evidence pack	Evidence Pack Update	0.1
	3	2	Update contacts/responsibilities list	Evidence Pack Update	0.1

	3	2	Update list of external records	Evidence Pack Update	0.1
	3	3	Update & record CRC policies / procedures	Evidence Pack Update	0.5
	3	3	Update records of exclusions	Evidence Pack Update	0.25
	4	1	Populate CRC tool with fuels data	Data Download / Duplication	0.4
	4	1	Confirm availability of complete / correct bills for next audit	Internal Communication	0.1
	4	1	Confirm availability of complete / correct invoices for next audit	Internal Communication	0.1
			September total CRC effort:		**6.8**
October	1	1	Download HH electricity data and populate into CRC tool	Data Download / Duplication	0.25
	2	1	Request Gas oil data for Construction	Internal Communication	0.05
	2	2	Download and populate external hauliers fuel for Quarries	Data Download / Duplication	0.1
	2	2	Request Quarries production data and populate into CRC tool	Internal Communication	0.4
	2	2	Download and populate turnover information for Quarries	Data Download / Duplication	0.1
	2	3	Audit elec & gas bills: Const.	Internal Audit	0.8
	2	3	Request if missing / unavailable / incorrect bills	Internal Communication	0.1
	2	4	Audit fuels invoices: Construction	Internal Audit	0.7
	2	4	Get audit certificate signed from BC	Internal Communication	0.1
	2	4	Request if missing / unavailable / incorrect invoices	Internal Communication	0.1
	2	5	Request external hauliers fuel for Manufacturing	Internal Communication	0.05
	2	5	Request Derv card purchases and petrol data	Internal Communication	0.05
	3	4	Follow up on external hauliers fuel for Manufacturing	Internal Communication	0.05
	3	4	Populate Derv card purchases and petrol data into CRC tool	Data Download / Duplication	0.1
	3	4	Follow up on Gas oil data for Construction	Internal Communication	0.05
	4	1	Populate CRC tool with fuels data	Data Download / Duplication	0.4
	4	1	Confirm availability of complete / correct bills for next audit	Internal Communication	0.1
	4	1	Confirm availability of complete / correct invoices for next audit	Internal Communication	0.1
	4	4	Download and populate external hauliers fuel for Manufacturing	Data Download / Duplication	0.1
	4	4	Download and populate Gas oil data for Construction	Data Download / Duplication	0.1
			October total CRC effort:		**3.8**
November	1	1	Download HH electricity data and populate into CRC tool	Data Download / Duplication	0.25
	2	2	Download and populate external hauliers fuel for Quarries	Data Download / Duplication	0.1
	2	2	Request Quarries production data and populate into CRC tool	Internal Communication	0.4
	2	2	Download and populate turnover information for Quarries	Data Download / Duplication	0.1
	3	1	Check for league table publication	External Communication	0.1
	4	1	Populate CRC tool with fuels data	Data Download / Duplication	0.4
			November total CRC effort:		**1.35**
December	1	1	Download HH electricity data and populate into CRC tool	Data Download / Duplication	0.25
	2	1	Download and populate external hauliers fuel for Quarries	Data Download / Duplication	0.1
	2	1	Request Quarries production data and populate into CRC tool	Internal Communication	0.4
	2	1	Download and populate turnover information for Quarries	Data Download / Duplication	0.1
	2	2	Copy NHH elec and gas sites data into CRC tool	Data Download / Duplication	1
	2	3	Audit elec & gas bills: Ind, Man, Env	Internal Audit	0.8
	2	3	Request if missing / unavailable / incorrect bills	Internal Communication	0.1
	2	4	Audit fuels invoices: Ind, Man, Env	Internal Audit	0.7
	2	4	Get audits certificate signed by BW	Internal Communication	0.1
	2	4	Request if missing / unavailable / incorrect invoices	Internal Communication	0.1
	3	1	Update Special events/change database	Evidence Pack Update	1
	3	2	Update new sites / bills in evidence pack	Evidence Pack Update	0.1
	3	2	Update contacts/responsibilities list	Evidence Pack Update	0.1
	3	2	Update list of external records	Evidence Pack Update	0.1
	3	3	Update & record CRC policies / procedures	Evidence Pack Update	0.5
	3	3	Update records of exclusions	Evidence Pack Update	0.25
	4	1	Populate CRC tool with fuels data	Data Download / Duplication	0.4
	4	1	Confirm availability of complete / correct bills for next audit	Internal Communication	0.1
	4	1	Confirm availability of complete / correct invoices for next audit	Internal Communication	0.1
			December total CRC effort:		**6.3**
			Total CRC Efforts in days per year		**56.55**

APPENDIX 28: CRC Conversion Factors

CRC Energy Efficiency Scheme Order: Table of Conversion Factors
Version 1: Published 22 January 2010

Under the CRC Energy Efficiency Scheme, participants will be obliged to measure the emissions from energy supplies for which they are responsible according to the relevant conversion factors. These relevant conversion factors are specified in the list below. These amounts will then be converted by the Registry into tonnes of carbon dioxide by the application of standard emissions factors.

Converting fuel types to CO2	Gross CV Basis	
Fuel Type	Measurement Unit	Emissions Factor kgCO2 / per measurement unit
Aviation Spirit	tonnes	3128
Aviation Turbine Fuel	tonnes	3150
Basic Oxygen Steel (BOS) gas	kWh	0.996
Blast furnace gas	kWh	0.996
Burning Oil/Kerosene/Paraffin	litres	2.532
Cement industry coal	tonnes	2373
Coke Oven Gas	kWh	0.146
Commercial/Public Sector Coal	tonnes	2577
Coking Coal	tonnes	2932
Colliery Methane	kWh	0.184
Diesel	litres	2.639
Electricity	kWh	0.541
Fuel Oil	tonnes	3216
Gas Oil	litres	2.762
Industrial Coal	tonnes	2314
Lignite	tonnes	1203
Liquid Petroleum Gas (LPG)	litres	1.495
Peat	tonnes	1357
Naphtha	tonnes	3131
Natural Gas*	kWh	0.1836
Other Petroleum Gas	kWh	0.2057
Petrol	litres	2.3035
Petroleum coke	tonnes	2981
Scrap tyres	tonnes	1669
Solid smokeless fuel	tonnes	2810
Sour gas	kWh	0.2397
Waste (other than waste oil or waste solvents)	tonnes	275.0
Waste oils	tonnes	3026
Waste solvents	tonnes	1613

* This conversion factor should be used for any gas supplied through the national grid network

(Source: Environment Agency, 2010)

APPENDIX 29: Carbon reduction in IT Office

IT Office Improvements

The server AC units system is comprised of two independent 12 kVA heating / cooling inverted systems with a combined capacity of 23 kVA. These systems are linked using a shared duty automatic switching system which allows system to swap between the two independent systems sharing the cooling requirements and load. However, it was observed that these AC units are now running in excess of 60% of their duty, generally cooling, in order to maintain the required temperature. Due to increased load on servers, the current system now requires that both the 11.5 kVA units are now operating at all times.

A system has been proposed with these features:

- Partial passive cooling of the server
- Heat recovery from the server room

It has been proposed to bring cold fresh air directly below the server from the adjoining corridor. The fresh air supply must be filtered to remove the possible incoming coal dust. Hot air will be removed from the top end of the servers' cabinets at the same time. The recovered heat will be directed to an IT store to reduce humidity and avoid damage to the IT equipment. The proposed system would provide ducted hoods set on the top of the existing cabinets, with individual balanced dampers, to ensure that all cabinets have equal volumes of air removed. Likewise the replacement air would be forced through a double filter system which would have the ability to have additional cooling connected at a later stage, should it be required. It has been estimated that the existing cooling systems would run on average 25% of their duty, resulting in a 58% reduction their load.

APPENDIX 30: Induction lighting business case

Lighting - Energy Saver and Cost Calculator

Project - Car Park

Energy Unit Cost - (Pence per kWh) 6 p
Annual Inflation Estimate - (%) 3.70 %

Make changes in "pink" cells

Existing Lighting Usage			Replaced Lighting Usage		
Hours per day	12	hrs	Hours per day	12	hrs
Days per week	7	days	Days per week	7	days
Weeks per year	25	weeks	Weeks per year	25	weeks

Existing Lighting Plan

Number of fittings	Type of Fitting	Fitting Cost	Total Cost	Fitting Wattage	Annual kWh	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
					Rate (Pence)	6	6.222	6.452	6.691	6.939	7.195	7.461	7.738	8.024	8.321
22	250W SON Streetlight			300	13,860	£832	£862	£894	£927	£962	£997	£1,034	£1,072	£1,112	£1,153
	Sub Total:		£0		13,860	£832	£862	£894	£927	£962	£997	£1,034	£1,072	£1,112	£1,153
	Climate Change Levy:					£65	£68	£70	£73	£75	£78	£81	£84	£87	£90
	Total Energy Cost:					£897	£930	£964	£1,000	£1,037	£1,075	£1,115	£1,156	£1,199	£1,244

Replacement Lighting Plan

Number of fittings	Type of Fitting	Fitting Cost	Total Cost	Fitting Wattage	Annual kWh	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
					Rate (Pence)	6	6.222	6.452	6.691	6.939	7.195	7.461	7.738	8.024	8.321
22	70W HQI EQV	£264	£5,807	85	3,927	£236	£244	£253	£263	£272	£283	£293	£304	£315	£327
	Sub Total:		£5,807		3,927	£236	£244	£253	£263	£272	£283	£293	£304	£315	£327
	Climate Change Levy:					£18	£19	£20	£21	£21	£22	£23	£24	£25	£26
	Total Energy Cost:					£254	£263	£273	£283	£294	£305	£316	£328	£340	£352
	ENERGY SAVINGS TOTAL				9,933	£643	£666	£691	£717	£743	£771	£799	£829	£859	£891

Additional Savings

Maintenance Savings

Labour Hourly Rate £20.00

Lamp Costs	Lamp Type	Number of Lamps	Lamp Life (Years)	Lamp Cost	Labour mins/lamp	Annual Cost
Lamp Type 1	250W SON	22	4	£15.00	30	£165
Lamp Type 2						
Lamp Type 3						
Lamp Type 4						
Specialist Equipment Hire						£0

Total maintainence saving (Per Year)	£165
CRC Saving (Per Year)	£66
Total Additional savings (Per Year)	£230

Overall Savings	
Grand Total Year 1:	£873
Grand Total Year 2:	£896
Grand Total Year 3:	£921
Grand Total Year 4:	£947
Grand Total Year 5:	£973
Grand Total Year 6:	£1,001
Grand Total Year 7:	£1,029
Grand Total Year 8:	£1,059
Grand Total Year 9:	£1,089
Grand Total Year 10:	£1,121
Total Saving over 10yrs:	£9,909

Costs	
Equipment Cost	£5,807
Project Cost	£5,807
ECA Saving	-£1,626
Effective Cost	£4,181

Annual Carbon Saving 5 Tonnes

Lighting - Energy Saver and Cost Calculator

Project - Paintshop

Energy Unit Cost - (Pence per kWh): 8 p
Annual Inflation Estimate - (%): 3.70 %

Make changes in "pink" cells

Existing Lighting Usage		Replaced Lighting Usage	
Hours per day	12 hrs	Hours per day	12 hrs
Days per week	5 days	Days per week	5 days
Weeks per year	50 weeks	Weeks per year	50 weeks

Existing Lighting Plan

Number of fittings	Type of Fitting	Fitting Cost	Total Cost	Fitting Wattage	Annual kWh	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
					Rate (Pence)	8	8.296	8.603	8.921	9.251	9.594	9.949	10.317	10.698	11.094
6	400W SON			450	8,100	£648	£672	£697	£723	£749	£777	£806	£836	£867	£899
	Sub Total:		£0		8,100	£648	£672	£697	£723	£749	£777	£806	£836	£867	£899
	Climate Change Levy:					£38	£39	£41	£42	£44	£46	£47	£49	£51	£53
	Total Energy Cost:					£686	£711	£738	£765	£793	£823	£853	£885	£917	£951

Replacement Lighting Plan

Number of fittings	Type of Fitting	Fitting Cost	Total Cost	Fitting Wattage	Annual kWh	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
					Rate (Pence)	8	8.296	8.603	8.921	9.251	9.594	9.949	10.317	10.698	11.094
6	200W Induction HiBay	£329	£1,977	220	3,960	£317	£329	£341	£353	£366	£380	£394	£409	£424	£439
	Sub Total:		£1,977		3,960	£317	£329	£341	£353	£366	£380	£394	£409	£424	£439
	Climate Change Levy:					£19	£19	£20	£21	£22	£22	£23	£24	£25	£26
	Total Energy Cost:					£335	£348	£361	£374	£388	£402	£417	£433	£449	£465
	ENERGY SAVINGS TOTAL				4,140	£351	£364	£377	£391	£406	£421	£436	£452	£469	£486

Additional Savings

Maintenance Savings

Labour Hourly Rate: £30.00

Lamp Costs	Lamp Type	Number of Lamps	Lamp Life (Years)	Lamp Cost	Labour mins/lamp	Annual Cost
Lamp Type 1	250W SON	6	4	£15.00	30	£45
Lamp Type 2						
Lamp Type 3						
Lamp Type 4						
Specialist Equipment Hire						£0

Total maintainence saving (Per Year): £45
CRC Saving (Per Year): £28

Total Additional savings (Per Year): £73

Overall Savings	
Grand Total Year 1:	£424
Grand Total Year 2:	£437
Grand Total Year 3:	£450
Grand Total Year 4:	£464
Grand Total Year 5:	£479
Grand Total Year 6:	£494
Grand Total Year 7:	£509
Grand Total Year 8:	£525
Grand Total Year 9:	£542
Grand Total Year 10:	£559
Total Saving over 10yrs:	£4,882

Costs	
Equipment Cost	£1,977
Project Cost	£1,977
ECA Saving	-£554
Effective Cost	£1,423

Annual Carbon Saving: 2 Tonnes

Lighting - Energy Saver and Cost Calculator

Project - Workshop

Energy Unit Cost - (Pence per KWh) 8 p
Annual Inflation Estimate - (%) 3.70 %

Make changes in "pink" cells

Existing Lighting Usage

Hours per day 12 hrs
Days per week 5 days
Weeks per year 50 weeks

Replaced Lighting Usage

Hours per day 12 hrs
Days per week 5 days
Weeks per year 50 weeks

Existing Lighting Plan

Number of fittings	Type of Fitting	Fitting Cost	Total Cost	Fitting Wattage	Annual kWh	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
					Rate (Pence)	8	8.296	8.603	8.921	9.251	9.594	9.949	10.317	10.698	11.094
22	400W SON			450	29,700	£2,376	£2,464	£2,555	£2,650	£2,748	£2,849	£2,955	£3,064	£3,177	£3,295
	Sub Total:		£0		29,700	£2,376	£2,464	£2,555	£2,650	£2,748	£2,849	£2,955	£3,064	£3,177	£3,295
	Climate Change Levy:					£140	£145	£150	£156	£161	£167	£174	£180	£187	£194
	Total Energy Cost:					£2,516	£2,609	£2,705	£2,806	£2,909	£3,017	£3,128	£3,244	£3,364	£3,489

Replacement Lighting Plan

Number of fittings	Type of Fitting	Fitting Cost	Total Cost	Fitting Wattage	Annual kWh	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
					Rate (Pence)	8	8.296	8.603	8.921	9.251	9.594	9.949	10.317	10.698	11.094
22	200W Induction HiBay	£329	£7,249	220	14,520	£1,162	£1,205	£1,249	£1,296	£1,343	£1,393	£1,445	£1,498	£1,553	£1,611
	Sub Total:		£7,249		14,520	£1,162	£1,205	£1,249	£1,296	£1,343	£1,393	£1,445	£1,498	£1,553	£1,611
	Climate Change Levy:					£68	£71	£73	£76	£79	£82	£85	£88	£91	£95
	Total Energy Cost:					£1,230	£1,275	£1,323	£1,371	£1,422	£1,475	£1,529	£1,586	£1,645	£1,706
	ENERGY SAVINGS TOTAL				15,180	£1,286	£1,333	£1,383	£1,434	£1,487	£1,542	£1,599	£1,658	£1,719	£1,783

Additional Savings

Maintenance Savings

Labour Hourly Rate £30.00

Lamp Costs	Lamp Type	Number of Lamps	Lamp Life (Years)	Lamp Cost	Labour mins/lamp	Annual Cost
Lamp Type 1	250W SON	22	4	£15.00	30	£165
Lamp Type 2						
Lamp Type 3						
Lamp Type 4						
Specialist Equipment Hire						£0

Total maintenance saving (Per Year) £165
CRC Saving (Per Year) £100

Total Additional savings (Per Year) £265

Overall Savings	
Grand Total Year 1:	£1,551
Grand Total Year 2:	£1,598
Grand Total Year 3:	£1,648
Grand Total Year 4:	£1,699
Grand Total Year 5:	£1,752
Grand Total Year 6:	£1,807
Grand Total Year 7:	£1,864
Grand Total Year 8:	£1,923
Grand Total Year 9:	£1,984
Grand Total Year 10:	£2,048
Total Saving over 10yrs:	£17,874

	Costs
Equipment Cost	£7,249
Project Cost	£7,249
ECA Saving	-£2,030
Effective Cost	£5,219

Annual Carbon Saving 8 Tonnes

APPENDIX 31: Burner replacement revised business case

Coating plant burner

Capital Cost	£30,000		
Annual O&M Cost	£500		
Annual coated production	20,000	tonnes	(estimated)
Fuel Price	£0.50	£/litre	
Fuel consumption (before)	12	litre/ton	
Fuel consumption (after)	10.5	litre/ton	
Annual fuel saving	30,000	litres	
CO2 reduction per litre	2.78165	kgCO2/litre	(assuming 50%Gasoil/50%Kerosene)
Annual cost saving	£15,000		
Annual CO2 reduction	83.45	tonne-CO2	

APPENDIX 32: Interviews on Decision Support Tool

INTERVIEWS ON USEFULNESS OF DECISION SUPPORT TOOLS

The following questions were raised in the Focus Group meetings, and the responses were summarised as answers.

Part 1: MACC as Decision support tool for Carbon Reduction opportunities

<u>1. Do you consider MACC as a simple tool to compare carbon reduction opportunities? Please give reasons for your answer.</u>
- Yes. MACC is a simple model, easy to compare the carbon reduction opportunities. Though, as it shows, an opportunity in negative is a good opportunity is a strange concept.

<u>2. Do you consider MACC as a reliable tool to decide which carbon reduction opportunities should be implemented? Please give reasons for your answer.</u>
- It is a good tool, but it does not take into account the impacts of inflation on running costs and benefits related to a project, which can impact a project. The tool does not help in identifying if the project makes a good investment case.

<u>3. Do you believe if use of MACC can be helpful to the company in CRC?</u>
- Yes, it can be used to discount an opportunity where the carbon abatement cost is higher than the CRC allowance price.

<u>4. Do you believe if use of MACC should be continued for the company?</u>
- Yes. We intend to use MACC not just as a comparison tool, but to identify our key objectives (projects) to meet our carbon reduction targets.

Part 2: ERIC as Decision support tool for Carbon Reduction opportunities

1. Do you consider ERIC as a simple tool to compare carbon reduction opportunities? Please give reasons for your answer.
- ERIC is difficult to understand as it uses the logarithmic scale. Apart from that, it is a good tool to compare the investment case of various carbon reduction opportunities.

2. Do you consider ERIC as a reliable tool to decide which carbon reduction opportunities should be implemented? Please give reasons for your answer.
- It is a good tool to decide which carbon reduction opportunities should be implemented for maximum financial return. There is a danger that opportunities with high carbon reduction potential may be neglected as the emphasis is on financial return.

3. Do you believe if use of ERIC can be helpful to the company in CRC?
- No, as it does not give any indication of the carbon abatement costs. But, it can be helpful to identify which opportunities should be implemented to save money and balance the costs that are paid in CRC tax.

4. Do you believe if use of ERIC should be continued for the company?
- Yes. For the comparison of financial value of carbon reduction projects.

Part 3: CALoRIC as Decision support tool for Carbon Reduction opportunities

1. Do you consider CALoRIC as a simple tool to compare carbon reduction opportunities? Please give reasons for your answer.
- The flexibility in CALoRIC to adjust the required IRR and carbon abatement cost is very useful. Though like ERIC, it is difficult due to the logarithmic scale, but since you adjust the required IRR yourself, there is less chance of ignoring the fact that it is a logarithmic scale. The main purpose of these tools is to reduce the risks and uncertainties when making decisions, and highlighting opportunities with possible ‘partial implementation’ is a very good idea to pick opportunities with less risk / uncertainty. The ‘must do’ opportunities are highlighted which also saves time. This tool could be even more helpful when there is very large number of available opportunities.

2. Do you consider CALoRIC as a reliable tool to decide which carbon reduction opportunities should be implemented? Please give reasons for your answer.
- Yes. We can quickly pick the ‘must do’ and ‘partially implementable’ opportunities. We may even pick an opportunity with a poorer IRR or marginal abatement cost if it is ‘partially implementable’. Though it is based on MACC and ERIC, but CALoRIC is more reliable as it reduces the risk by identifying partially implementable opportunities.

3. Do you believe if use of CALoRIC can be helpful to the company in CRC?
- Yes, we can adjust the vertical line to see how many opportunities give a better marginal abatement cost than CRC allowance price.

4. Do you believe if use of CALoRIC should be continued for the company?
- Yes, definitely. The chart may be used to highlight even more, such as highlighting the opportunities which exceed available capital funds, the opportunities which do not run until a certain number of years, etc.

APPENDIX 33: Sensitivity analysis

1. Transport Energy Reporting System

Case	Development cost	Running cost	Reduction	Fuel price	Annual usage	Capital cost	Annual benefit/cost	CO2 reduction
1	£25,000	£15,000	2%	Standard	Standard	£25,000	£41,000	105
2	'+20%'					£30,000	£41,000	105
3	'-20%'					£20,000	£41,000	105
4		'+20%'				£25,000	£38,000	105
5		'-20%'				£25,000	£44,000	105
6			'+25%'			£25,000	£55,000	132
7			'-25%'			£25,000	£27,000	79
8				'+10%'		£25,000	£46,600	105
9				'-10%'		£25,000	£35,400	105
10					'+20%'	£25,000	£52,200	126
11					'-20%'	£25,000	£29,800	84
worst case	'+20%'	'+20%'	'-25%'	'-10%'	'-20%'	£30,000	£12,240	63
best case	'-20%'	'-20%'	'+25%'	'+10%'	'+20%'	£20,000	£80,400	158

2. Plug-in Timers

Case	capital cost	Day-hours saved	Electricity Price	winter weeks	Capital cost	Annual benefit/cost	CO2 reduction
1	£250	6.5	Standard	25	£250	£4,910	27
2	'+10%'				£275	£4,910	27
3	'-10%'				£225	£4,910	27
4		'+1 hour'			£250	£5,210	28
5		'-1 hour'			£250	£4,610	25
6			'+10%'		£250	£5,405	27
7			'-10%'		£250	£4,415	27
8				'+20%'	£250	£5,900	32
9				'-20%'	£250	£3,920	21
worst case	'+10%'	'-1 hour'	'-10%'	'-20%'	£275	£3,308	20
best case	'-10%'	'+1 hour'	'+10%'	'+20%'	£225	£6,890	34

3. Coating Plant Burner Replacement

Case	capital cost	Fuel price	Production	Exp. lit/ton	Capital cost	Annual benefit/cost	CO2 reduction
1	£30,000	Standard	20,000	Standard	£30,000	£22,000	83
2	'+20%'				£36,000	£22,000	83
3	'-20%'				£24,000	£22,000	83
4		'+10%'			£30,000	£24,400	83

5		'-10%'			£30,000	£19,900	83
6			'+50%'		£30,000	£33,250	125
7			'-50%'		£30,000	£10,750	42
8				'+10%'	£30,000	£6,250	25
9				'-10%'	£30,000	£37,750	142
worst case	'+20%'	'-10%'	'-50%'	'+10%'	£36,000	£2,560	13
best case	'-20%'	'+10%'	'+50%'	'-10%'	£24,000	£62,995	213

4. Drying Room Improvements

Case	capital cost	Electricity Price	Saving Measurement error	Capital cost	Annual benefit/cost	CO2 reduction
1	£575	Standard		£575	£6,762	37
2	'+20%'			£690	£6,762	37
3	'-20%'			£460	£6,762	37
4		'+10%'		£575	£7,453	37
5		'-10%'		£575	£6,071	37
6			'+10%'	£575	£7,453	41
7			'-10%'	£575	£6,071	34
worst case	'+20%'	'-10%'	'-10%'	£690	£5,449	34
best case	'-20%'	'+10%'	'+10%'	£460	£8,213	41

5. Solar PV

Case	Yield	capital cost	Electricity Price	Incentive	capital cost	Annual benefit/cost	CO2 reduction
1	Standard	£135,000	Standard	Standard	£135,000	£16,210	21
2	'+10%'				£135,000	£17,883	23
3	'-10%'				£135,000	£14,536	19
4		'+20%'			£162,000	£16,210	21
5		'-20%'			£108,000	£16,210	21
6			'+10%'		£135,000	£16,599	21
7			'-10%'		£135,000	£15,820	21
8				'+20%'	£135,000	£18,780	21
9				'-20%'	£135,000	£13,639	21
worst case	'-10%'	'+20%'	'-10%'	'-20%'	£162,000	£11,873	19
best case	'+10%'	'-20%'	'+10%'	'+20%'	£108,000	£21,139	23

6. Storage Sheds

Case	capital cost	Fuel price	Production	Exp. lit/ton	Capital cost	Annual benefit/cost	CO2 reduction
1	£25,000	Standard	Standard	Standard	£25,000	£19,770	110
2	'+20%'				£30,000	£19,770	110
3	'-20%'				£20,000	£19,770	110
4		'+10%'			£25,000	£21,748	110
5		'-10%'			£25,000	£17,793	110
6			'+50%'		£25,000	£29,656	165
7			'-50%'		£25,000	£9,885	55
8				'+10%'	£25,000	£11,460	64
9				'-10%'	£25,000	£28,081	156
worst case	'+20%'	'-10%'	'-50%'	'+10%'	£30,000	£5,157	32
best case	'-20%'	'+10%'	'+50%'	'-10%'	£20,000	£46,334	234

7. Vertical Bitumen Tanks

Case	weather	capital cost	Electricity Price	Heat Loss	Capital cost	Annual benefit/cost	CO2 reduction
1	Standard	£161,387	Standard	6.6	£161,387	£35,533	222
2	-2DegC				£161,387	£36,047	225
3	+2DegC				£161,387	£35,020	219
4		'+20%'			£193,664	£35,533	222
5		'-20%'			£129,110	£35,533	222
6			'+10%'		£161,387	£39,148	222
7			'-10%'		£161,387	£31,919	222
8				'+20%'	£161,387	£34,879	218
9				'-20%'	£161,387	£36,216	226
worst case	+2DegC	'+20%'	'-10%'	'+20%'	£193,664	£30,862	215
best case	-2DegC	'-20%'	'+10%'	'-20%'	£129,110	£40,473	230

8. IT Server Room Improvements

Case	capital cost	Est cooling load	Electricity Price	Capital cost	Annual benefit/cost	CO2 reduction
1	£15,000	25.00%	Standard	£15,000	£4,627	44
2	'+20%'			£18,000	£4,627	44
3	'-20%'			£12,000	£4,627	44
4		'+10%'		£15,000	£3,448	33
5		'-10%'		£15,000	£6,207	54
6			'+10%'	£15,000	£5,310	44
7			'-10%'	£15,000	£4,345	44
worst case	'+20%'	'+10%'	'-10%'	£18,000	£3,103	33

best case	'-20%'	'-10%'	'+10%'	£12,000	£6,828	54

9. LED Lighting

Case	capital cost	Electricity Price	Existing lighting load	Capital cost	Annual benefit/cost	CO2 reduction
1	£22,010	Standard	Standard	£22,010	£2,890	20
2	'+10%'			£24,211	£2,890	20
3	'-10%'			£19,809	£2,890	20
4		'+10%'		£22,010	£3,164	20
5		'-10%'		£22,010	£2,616	20
6			'+10%'	£22,010	£3,253	23
7			'-10%'	£22,010	£2,527	18
worst case	'+10%'	'-10%'	'-10%'	£24,211	£2,288	18
best case	'-10%'	'+10%'	'+10%'	£19,809	£3,561	23

10. Wind Turbine

Case	capital cost	Wind speed	Electricity Price	Turbine uptime	Incentive	Export	Capital cost	Annual benefit/cost	CO2 red.
1	£320,000	6.1	Standard			0%	£320,000	£28,113	57
2	'+20%'						£384,000	£28,113	57
3	'-20%'						£256,000	£28,113	57
4		'+15%'					£320,000	£46,163	86
5		'-15%'					£320,000	£14,675	35
6			'+10%'				£320,000	£28,959	57
7			'-10%'				£320,000	£27,267	57
8				'+5%'			£320,000	£30,075	60
9				'-5%'			£320,000	£26,151	54
10					'+20%'		£320,000	£33,505	57
11					'-20%'		£320,000	£22,721	57
12						50%	£320,000	£25,470	57
13						25%	£320,000	£26,791	57
worst case	'+20%'	'-15%'	'-10%'	'-5%'	'-20%'	50%	£384,000	£7,072	33
best case	'-20%'	'+15%'	'+10%'	'+5%'	'+20%'	0%	£256,000	£60,518	91

APPENDIX 34: Energy Newsletter

barr

is greener!

Issue 3 January 2013

Energy Newsletter

Energy Management at Barr - 01290 700 763 / 3063

Special Interest Articles

- Barr Limited drives towards BSI Kitemark for Energy Reduction
- At Barr Environmental, Energy Management takes a gear up
- CRC Year 2 update
- Energy Database is on-line
- Sheds saving money at Tongland Quarry

Did you know?

- For every two minutes a car is idling, it uses about the same amount of fuel it takes to go about one mile.
- 1 hour idling of a 50 kW motor costs £1,255 in energy bill and £81 in CRC tax every year
- 1 hour idling of Komatsu 470 costs £15.37 and emits 55.24 kg of CO_2
- Idling compressors consume 20-70% of their full load power and one small leak costs over £500 a year

Conversions:

- 1 tonne of CO_2 is emitted when producing:
  - 32 tonnes of coated products
  - 100 metre-cubes of concrete
  - 200 tonnes of aggregate
- Boiling more water than you need in an electric kettle emits an extra 20 grams of CO_2 per cup. Fill it only with as much water as you need.

More news..

- Installation of energy saving timer controls on heaters at Garlaff and Auchencarroch
- Energy use by bitumen tanks is being monitored in all quarries to identify energy saving opportunities
- In addition to the Guidance notes available in the Energy Database for lights and heating controllers, more guidance notes will be available for 'Drying rooms' and 'Meter reading' from February 2013

Please contact:
ali.sheikh@barr.co.uk
01290 700 763 or ext 3063

Barr Holdings drives towards 'BSI Kitemark for Energy Reduction Verification'

There are on-going external audits from BSI to verify reduction in company's energy use over the last three years. The audits also include site visits to verify the data collection processes and best practice, where applicable. Upon positive outcome of the audits, the Group will be awarded with the 'BSI Kitemark for Energy Reduction Verification'.

This BSI Kitemark will not only replace our previous certifications with the Carbon Trust Standard, but also help us in achieving the ISO 50001 International Energy Management Standard in the coming years.

The criteria to achieve 'BSI kitemark for Energy Reduction Verification' is more challenging than the Carbon Trust Standard. It requires us to reduce our specific energy consumption by 2.5% every year.

The BSI Kitemark will cover the operations of Barr Holdings, comprising the Industrial, Environmental and Construction divisions.

So, what's next? Sky Is The Limit!! Please keep contributing towards your company's and your country's energy efficient future, so even tougher challenges could be faced as easily.

Carbon Footprint Update

According to the latest calculation, Barr's carbon footprint for calendar year 2012 was 15,328 tonnes of CO_2. In addition to our consistent implementation of a number of energy saving initiatives, the slowing market was the major factor in reduction in our energy use & carbon emissions. Due to expected increase in our energy intensive business, the overall carbon footprint will be rising again in 2013.

<u>Barr's carbon footprint</u>

2006: 24,312 tonnes of CO_2
2007: 33,834 tonnes of CO_2
2008: 28,780 tonnes of CO_2
2009: 19,698 tonnes of CO_2
2010: 23,485 tonnes of CO_2
2011: 22,035 tonnes of CO_2
2012: 15,328 tonnes of CO_2

More Energy savings at Sorn and Tormitchell Quarries

After Barlockhart quarry, PSX timer switches have now been installed at Sorn quarry and Tormitchell Quarry. 2 units have been installed on each of these quarries.

A monitoring & verification exercise was carried out at Sorn Quarry before and after the implementation, which showed a saving of £86 per month on each quarry. The implementation will reduce 2,729 kg of CO_2 every winter on each of these quarries.

CRC - Year Two

In the CRC year-2 (i.e. Apr-11-Mar-12), our CRC related carbon emissions were 15,452 tonnes of CO_2, and after applying all possible exclusions, we paid a sum of £152,220 in CRC tax for the year.

Due to recent changes in CRC announced in Dec'12, some fuels have been excluded which will reduce our CRC bill, but, we must continually reduce our carbon emissions, as the excluded fuels will soon be covered under a proposed new climate change levy.

The CRC League Table has been abolished; therefore, we will not have the pleasure any more to see ourselves ahead of our competitors in the carbon emission reduction.

As per our energy policy, **each individual employee is responsible** for the delivery of our energy efficiency objectives. **Saving energy saves jobs** by ensuring that our organisation remains competitive, and it is also necessary to provide a fair living atmosphere to our coming generations.

Myths:

- It is a myth that 'Leaving air conditioning on overnight reduces energy costs as the system stays at the required temperature'. ***Switch air-con off overnight at your workplace!***
- It is a myth that 'It is better to leave fluorescent lights on as starting them up wastes more energy than if they remain permanently switched on'. ***Switch the lights off if when they are not required!***

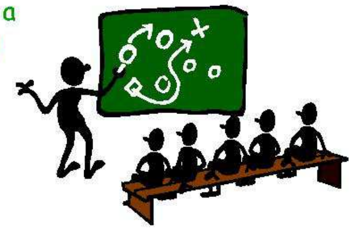
What will be happening in the next few months?

- Circulation of certificate of achievement of 'BSI Kitemark for Energy Reduction Verification'.
- Internal energy audits
- Deployment of energy saving timer controls in more sites

Please ask for:

- Available posters:
  - Switch it off
  - Handle with care (for Asphalt burners)
  - It's in your hands

Energy Management takes a gear up at Barr Environmental



Barr Environmental, which emits 21% of company's overall carbon emissions, is now taking a gear up in carbon reduction initiatives.

The latest initiatives at Barr Environmental include Energy Toolbox talks, Energy awareness in monthly site based meetings, and feasibility studies for voltage optimisation system and PSX timer switches.

Energy benchmarking is also being introduced at Barr Environmental. Initially, the benchmarking will include the on-site plant and Leachate treatment systems only, but later it will include the operations such as baling, landfill, etc.

Energy Audits

Going forward, all QEMS Internal audits will also include elements in line with 'BSI Kitemark for Energy Reduction Verification' requirements. Supporting information on Energy is available on the Industrial QEMS and Barr Environmental workspace on Lotus Notes. Please contact IT Helpdesk if you face any difficulty accessing these databases.

Energy Saving Ideas

'Energy saving ideas' were requested from the Quarries staff in the last quarter of 2012. Sorn Quarry took the lead by coming up with 2 quick ideas, which were 'Operational improvements in shovel use' and 'installation of innovative PSX timer switches'. Both the ideas were implemented resulting in at least a monthly reduction of over 3.5 tonnes of CO_2 and a saving of £850 a month.

Sheds at Tongland Quarry

Installation of Material storage sheds was completed at Tongland Quarry in Sep'12. A saving of 6,400 litres of fuel in the months of October and November was calculated on the basis of production levels, at 1.5 litres per tonne reduction.

The sheds have been designed to face South West to benefit from the sun, and the floor is inclined to allow natural removal of moisture. There are 3 partitions under the shed, storing 4mm down dust, 6mm down dust and asphalt sand.

Savings were also verified on basis of existing research, which shows that every 1% moisture reduction can save 0.7 litres per tonne. David Jaszewski, Quarry Manager at Tongland, measured the moisture in fines both under the shed and lying outside, finding a difference of 8.3% between the two.

Toolbox-talks introduced at Construction Division

Barr Construction have introduced a mandatory requirement for each site to carry out a minimum of one environmental toolbox talk per month, Energy Management talks feature on the list. These talks will also be a requirement site wide thus encouraging all our sub contractors to engage in implementing best practice.

Top 6 words since the last newsletter:

#CRC Update

#BSI Energy Kitemark

#Sheds at Tongland

#Shovels at Sorn

#New Energy Toolbox Talks

#New Innovative plug-in timers on heaters

Search the newsletter to find why these words are at the top!

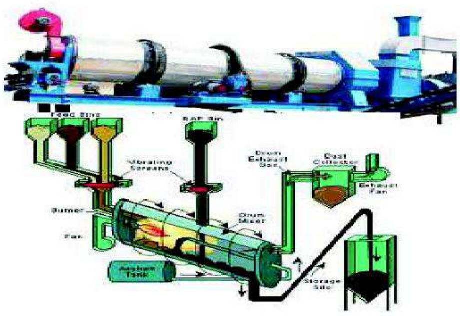
APPENDIX 35: Toolbox Talk

barr

Toolbox Talk

Energy

THEME:
COATING PLANT



DON'T BURN MONEY!

How often should a coating plant burner be serviced?
It depends on how much we use the plant, but usually, a coating plant burner must be serviced at least twice a year. At every service, a service report is generated by the servicing company.

What should I see about Carbon mono-oxide in the coating plant service report?
The service report provides the value of Carbon Mono-oxide (CO) in parts per million (ppm). If CO levels are above 250 ppm, this means fuel is not being burned fully. A good service of the plant should give a value of 250 ppm or less.

What should I see about Oxygen (O2) levels in the coating plant service report?
The service report provides the value of Oxygen (O2) levels as O2 percentage. If O2 is above 16%, this means fuel is being wasted by heating too much cold air. A good service of the plant should give a value of 16% or lesser.

What should I see about Flue gas temperature in the coating plant service report?
The service report provides the value of flue gas temperature. If Flue gas temperature is above 130°C, this means not enough heat is being transferred to the aggregate in the dryer. A good service of the plant should give a value of 100 °C or near.

How can I reduce the amount of energy we use in coating plant?
Brainstorm for site specific answer. General opportunities include servicing keeping aggregate dry, drum insulation, minimum number of starts, reducing any idling of motors / belts, etc.

How much could uninsulated flanges and valves on a bitumen tank cost over a year?
As much as £1,400

How much impact does it make on energy consumption if we can reduce the moisture in aggregate?
A 2% reduction in aggregate moisture content can reduce energy consumption by 15%. When taking aggregate from the stockpile, you must avoid taking it from the floor / very bottom of the pile.

Where the stockpiles should be positioned / located to make the process most energy efficient?
The storage stockpiles should be positioned to ensure that the distance between crushers and storage stockpiles of their products is minimum for the shovels. Aggregate for the coating plant must be stored in a location where its distance from both the crusher and the coating plant is minimum.

APPENDIX 36: KPI / Benchmarking sheet

Energy Use Calculator	**Quarry:**			
Month / Year	/			
Product:	Dry			
	Consumption	**Multiply By**	**Energy Used (kWh)**	
Electricity consumption for Dry only (kWh)		1.0		(A)
Fuels consumption for Dry only:	-	-	-	-
- Gas Oil		10.6		(B)
- Kerosene		10.3		(C)
- Other fuel		___		(D)
Total Energy Used (A+B+C+D)				(E)
Tonnes of Dry produced			Tonnes	(F)
Energy per unit of product (E / F)			kWh/tonne	(G)
Industry Benchmark	18		kWh/tonne	(H)
Difference (G - H)				(I)
Note: If 'I' is positive, you need to take serious action to reduce your energy consumption.				
Product:	Coated			
	Consumption	**Multiply By**	**Energy Used (kWh)**	
Electricity consumption for coated only (kWh)		1.0		(A)
Fuels consumption for coated only:	-	-	-	-
- Gas Oil		10.6		(B)
- Kerosene		10.3		(C)
- Other fuel		___		(D)
Total Energy Used (A+B+C+D)				(E)
Tonnes of coated produced:			Tonnes	(F)
Energy per unit of product (E / F)			kWh/tonne	(G)
Industry Benchmark	130		kWh/tonne	(H)
Difference (G - H)				(I)
Note: If 'I' is positive, you need to take serious action to reduce your energy consumption.				
Product:	Concrete			
	Consumption	**Multiply By**	**Energy Used (kWh)**	
Electricity consumption for Concrete only (kWh)		1.0		(A)
Fuels consumption for concrete only:	-	-	-	-
- Gas Oil		10.6		(B)
- Kerosene		10.3		(C)
- Other fuel		___		(D)
Total Energy Used (A+B+C+D)				(E)
Metre-cubes of concrete produced:			m3	(F)
Energy per unit of product (E / F)			kWh/m3	(G)
Industry Benchmark	5		kWh/m3	(H)
Difference (G - H)				(I)
Note: If 'I' is positive, you need to take serious action to reduce your energy consumption.				
CRC Costs:	**Consumption**	**Multiply By**	**tonnes-CO2**	
Electricity (total kWh)		0.000541		(J)
Gas Oil (total litres)		0.002762		(K)
Kerosene (total litres)		0.002532		(L)
Total tonnes of CO2 (J+K+L)				(M)
Total CRC Cost (M x £15)			£___________	
Name:	**Sign./Date:**		/	