Review of Green House Gas (GHG) accounting tools in use in Scotland

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Executive Summary

This report provides evidence and comment on a database of sectoral carbon accounting tools relevant to Scotland, compiled for ClimateXChange by the Initiative for Carbon Accounting (ICARB), which is led by Heriot-Watt University, Glasgow Caledonian University, and the Crichton Carbon Centre.

The report is split into two parts:

Part 1 provides a summary further evidence on the tools listed under each sector Part 2 provides further discussion and commentary on the cross-sectoral issues discovered, and draws on the initial results of work by the ICARB team due for publication in 2014

Carbon accounting is a relatively new and rapidly evolving field, and the number and variety of tools available has expanded alongside new and enhanced methods, guidance and reporting requirements. However questions remain over how the evidence carbon accounting provides can best be used to meet policy objectives, which will itself shape the future of the field.

Such objectives may be better met through increased standardisation of tools and practices, however progress in defining and agreeing common 'rules' has been stronger in some sectors than others, and the cross-sectoral links between sectors mean that care needs to be taken to carefully align any future steps towards standardisation. This progress should also benefit from greater transparency, and this needs consideration with regard to the development of future reporting requirements. A final issue here is the need to better align top down and bottom up accounting practices to better serve Scotland's emissions reduction efforts.

This review of the available carbon accounting tools in Scotland has enabled us to lightly characterise the characteristics of a range of Scottish sectors in Part 1 and in Part 2 briefly review some of the strengths and weaknesses of the range of tools outline in Part 1 and charted in part 3.

In completing the following study it became apparent that three further research endeavours can be recommended:

1. To scope out a clear specification of the required attributes of 'Fit for Purpose' basic tools for carbon accounting methods in Scotland, sector by sector: what functions they must have and how they need to relate to accounting methods for other sectors of the economy.
2. To undertake a complete and detailed attribute analysis of the existing methods outlined below
3. To map the required functions of sectoral accounting systems against the capabilities of the currently available tools and maps the gaps between them and the overlaps to inform the next stage in developing a comprehensive carbon accounting capability for the Scottish Economy.

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Part 1

1.0 Introduction

Legislation relating to energy use, conservation, design and regulation is changing rapidly in response to UK and Scottish Government targets for emissions reduction. In the last ten years a large number of guides, directives, incentives and policies have been generated including:

EU Policy Legislation: Energy Performance of Buildings Directive,

UK Policy and Regulations: Energy White Paper, the introduction of Energy Performance Certificates and Display Energy Certificates, the Carbon Reduction Commitment Energy Efficiency Scheme, Carbon Trading, Climate Change Levies, and more.

Scottish Policy and Regulations: Scottish Building Standards Section 6: (Energy) Reducing CO_2 Emission and Energy Demand,

Specific tools and initiatives for the built environment: Building Research Establishment Environmental Assessment Method (BREEAM), the Standard Assessment Procedure (SAP), the BRE Green Guide, and the Code for Sustainable Homes (CfSH).

Specific tools and initiatives for transport: Traffic Scotland's basic CO2 emissions calculator for various transport types and distances,; Transport Scotland's Carbon Management System including maintenance, lighting, buildings and personnel.

Specific tool for spatial planning: The Spatial Planning Assessment of Climate Emissions (SPACE) tool provides a bespoke application for local authority planners to consider the climate emissions from decisions made on development plans.

Specific tools and initiatives for waste: The Carbon Metric developed by Zero Waste Scotland, and the Scottish Pollutant Release Inventory (SPRI) which contains emissions returns from operators which are then collated by SEPA and published to provide information about the scale of emissions, energy use and climate change to make data available for policy makers, academics and the public.

Greenhouse Gas accounting relies on Life Cycle Assessment (LCA) style tools to:

- Scope and set boundaries for inclusion
- Derive inventories for products, processes and activities and
- Collect reliable impact data on materials, processes and logistics.

LCA can be used for various purposes and applications across sectors that generate products, uses processes, or performs activities. It can be used to investigate various environmental impacts including toxicity, ozone depletion, and eutrophication, or can be limited to GHG emissions. This report focuses on GHG emissions only, across a number of sectors in Scotland. A Life Cycle Inventory (LCI) is a database developed to provide appropriate and accurate data for LCAs.

Inter-connectivity between GHG tools across these sectors aids comparability, transparency, boundary and scope setting, availability of data, data quality and policy setting. Achieving an integrated approach to GHG accounting relies on understanding the status quo, the difficulties associated with data quality and availability, and the nature of tools which are currently available. Sector specific barriers also exist as well as common issues relating to time and cost, application and skills, and adoption of standards prevail across all sectors.

There is a wide consensus that if GHG accounting is to be systematically adopted then it must not be a punitive exercise but one that promotes and enables the better management of emissions to the benefit also of those applying the tools. Hence the development of mandatory reporting frameworks that are flexible enough to discourage the disincentives developing in the market around issues of competitive advantage.

1.1 Methodologies

There have been numerous methodologies and tools developed across a range of disciplines for LCA studies and their LCI databases. These methodologies refine on issues of data and the underlying calculations within inventory analysis. A lack of transparency in the structure of how such methods work can render their results incomparable to the individual outputs of other methods and unrepresentative of the averaged outputs of a range of methods applied to a particular sector; LCA results will differ significantly when different system boundaries, functional units, assumptions made, data quality and availability, and impacts ratings are applied [Menzies & Turan, 2007]. In addition a lack of understanding throughout the impact assessment phase can lead to complex allocation problems (partitioning of environmental burdens). LCAs can be extremely time and cost intensive, both in terms of consultancy time, and investment in measuring equipment for data acquisition.

Attempts to create publicly available databases and to foster data exchange have been made. A generic database may lack the detail and data quality required to perform an accurate and specific LCA analysis, while in-depth studies for specific applications may be of little use to a wider audience of practitioners. For instance, many databases are not suitable for a number of construction projects as they consist mainly of basic materials, for which data quality/uncertainty estimates are rarely available. Where more detailed and accurate databases do exist they are often expensive to access and can again be unavailable because of issues of competitive advantage. Deterministic approaches such as process analysis, input-output analysis, and hybrid analysis, have sought to overcome these problems.

1.1.1 Process analysis

The Process analysis method (also called conventional or traditional method) is the oldest and still most commonly used method, and involves evaluation of direct and indirect energy inputs to each product process, such as extraction, transportation, manufacturing, use, recycling and disposal. It usually begins with the final product and works backwards to the point of raw material extraction (required by ISO 14040). However, difficulties in obtaining data, not understanding the full process thoroughly, and extreme time and labour intensity are its main disadvantages. These result in compromises to system boundary selection (which is generally drawn around the inputs where data is available). Furthermore it is likely to ignore some of the processes such as services (banking and insurance, finance), inputs of small items, and ancillary activities (administration, storage). The magnitude of the incompleteness varies with the type of product or process, and depth of the study, but can be 50% or more. For these reasons Process analysis results are found to be consistently lower than the findings of other methodologies [Menzies & Turan, 2007].

1.1.2 Input Output analysis

Originally developed by Wassily Leontief [1936] in the 1930s as a technique to represent financial interactions between the industries of a nation, this method can be used in inventory analysis to overcome the limitations of process analysis. Used by various academics and practitioners the method is based on Input-Output tables, which represent monetary flows between sectors, and which can be transformed to physical flows to capture environmental fluxes between economic sectors. The number of sectors, and their definitions vary within each country: an important development has been the launch in 2012 of several global datasets that now enable imported goods and services to be modelled with greater ease and accuracy (see for instance: World Input-Output Database: www.wiod.org/; EORA: http://worldmrio.com/). The major advantage of Environmental Input-Output analysis (EIO) is that, in theory, the impacts of complete supply chains are captured, thus overcoming the boundary cut-off problems of Process analysis (P-LCA). However despite the comprehensive framework and complete data analysis, EIO analysis is subject to many uncertainties. A major source of uncertainty is due to high levels of aggregation in datasets: dissimilar commodities, or sectors containing dissimilarities, are often put into the same category and assumed to be identical. Additionally, a fundamental assumption of EIO is that of constant returns to scale. Unsurprisingly, LCAs based on Process analysis (P-LCA) and EIO analysis yield considerably different results. EIO-LCA is suitable for strategic policy making decisions (comparing sectors) as well as providing complementary data on sectors not easily covered by Process analysis. P-LCA is best used to assess or compare specific options within one particular sector.

1.1.3 Hybrid analyses

First developed by Bullard et al [1978] in the late 1970s, the disadvantages of previous methods can be reduced if a hybrid method, combining both P-LCA and EIO-LCA methodologies, is employed. In this model some of the requirements (often higher in contribution, direct and first order requirements), are assessed by process analysis, while the remaining requirements (generally upstream such as material extraction and manufacturing, which are smaller in contribution) are covered by input–output analysis. The advantages of both methods; completeness of input output method and the process specificity of Process analysis are brought together. However, the main disadvantages of these techniques are the risk of double counting, possible subjectivity, and the time consumed to generate results.

1.1.4 Restricted studies

Due to the complexities of LCAs, and the complications in LCI databases a number of simplistic methods were developed for industrial use, mainly aiming to develop quick decision making tools. Christiansen et al. [1997] introduced a “hot spot” approach which selects essential issues in the inventory and applies generic data to quickly analyse products, while around the same time, The Chalmers Institute [Svensson & Ekvall, 1995] developed a method of 'screening' and 'streamlining' to restrict LCA scope; data is obtained from a number of sources to identify environmental 'hotspots'. These hotspots are subject to further and fuller analysis, but can be time efficient due to the elimination of some processes. Other practices involve restricting LCA boundaries e.g. for complex products containing materials which are poorly represented in LCA databases.

1.2 Sector Specific Discussions

An analysis of LCA tools which adopt a variety of methodologies and are available specifically in a Scottish context, including those which are more generic but still applicable in Scotland, is presented below. Some sectors have experienced more focused LCA activity than others. The sector specific narratives below should be read in conjunction with the searchable *Tool Database* which accompanies this report.

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1.2.1 Planning

Planning has been slow to introduce carbon accounting tools at a regional or national level in support of policy development on land use issues. This may well be because the regulatory planning system has traditionally focussed on statutory processes of decision making rather than defined outcomes. It may also be because of the complexity of the multi-sectoral issues involved and/or be a result of the shortage of the required skills base within the planning profession. Appeal against a planning decision is normally by judicial review i.e. the correct procedures have not been complied with, and has never to date involved issues around carbon accounting.

Carbon emission tools are a recent innovation within the planning field involving Environmental Impact Assessment (EIA) for a project, or the Strategic Environmental Assessment of a plan or strategy. The EIA guidance has always had a component entitled 'climatic impacts'. There is, however, now a new requirement for windfarm proposals of over 50Mw located on peatlands to carry out a carbon assessment as part of the EIA. Local authorities embarking on new development plans are now encouraged to use newly available tools to assess the carbon impacts of proposed spatial strategies as part of SEA. These tools are described below.

These carbon planning tools are also being used by planners and other local government officials as a means to raise awareness of CO_2 emissions, and to test out different future development scenarios with regional stakeholders to influence their corporate policies.

Section 36 Planning consents

These consents are given by the Scottish Government (SG) for larger energy developments, with the

Local Authority affected being one of the statutory consultees in the process. Technical consultations cover, noise, aviation safeguarding, landscape and biodiversity impacts. Since June 2011, Scottish Ministers have required that such proposed development on peatland should assess the potential carbon losses and savings and this is now a 'material consideration' in the consent process, implying it is a potentially 'deal breaking' issue. This policy was developed, in part, to avoid catastrophic losses of carbon from peat landslides, but also to understand the carbon 'cost' of constructing wind developments and hence the overall carbon saving benefits. On behalf of Scottish Government SEPA reviews the carbon assessment submitted with the application.
The **carbon calculator tool** is a 'full' life cycle methodology for calculating how long a proposed development will take to 'pay back' the carbon created during its construction and to calculate the direct carbon savings from the wind development during its lifetime. It is based on the original research by Nayak et al (2008) and is a concerted attempt to understand impacts on the carbon cycle. The technical guidance explains the scope of the assessment:

*The **total** C emission savings from a wind farm are estimated with respect to emissions from different power generating sources, loss of C due to production, transportation, erection, operation and dismantling of the wind farm, loss of C from backup power generation, loss of C-fixing potential of peat land, loss of C stored in peat land (by peat removal and by drainage of the site), C saving due to restoration of habitat and loss of C-fixing potential as a result of forest felling. Different components of this can be estimated to compare with other sources of energy where a complete life cycle analysis is not applicable.*

This type of analysis on a site-by-site basis will be prohibitively expensive, so generic data from UK and Scottish datasets are provided as an alternative. The input data is collected through 12 worksheets covering the wind farm characteristics; characteristics of the peatland before windfarm development (air temperature, weight and depth of peat, drainage, etc); characteristics of bog plants, forestry, borrow pits; wind turbine foundations; access tracks; cables; peat landslide hazard; improvement of C sequestration on site; restoration after decommissioning; counterfactual emission factors. It is not known how often the tool has been used since June 2011.

Strategic Environmental Assessment

The Spatial Planning Assessment of Climate Emissions (SPACE) has been devised by consultants for the Scottish Government to allow spatial planners and stakeholders to compare the GHG emissions of different policy scenarios. It is not mandatory to carry out this assessment as part of the SEA. It is a new tool, which the SG states will be tested first on the draft National Planning Framework 3. There are four main policy components or types to the tool: housing development; commercial development; other buildings such as schools, hospitals, leisure centres that are not included in the first two categories, and other emissions development. Outputs, or emissions, for each of these types are calculated for each scenario tested. The emissions are presented by tonnes of carbon dioxide equivalent for the following categories: building energy use; transport energy use; waste; and land use change.
The tool requires baseline data to be input for each policy component such as area of land, the number and type of buildings for the Baseline Scenario. There are datasheets to help build other Policy Scenarios which can be compared against the baseline or each other. The tool calculates emissions for different years. Results are displayed in tabular and graphic format. They include emissions in use in the development. They do not include embodied emissions.

The tool is designed to be easy to understand ('allow one hour to play around with the tool'). There is an easy to use guide in which Appendix 3 acknowledges the data sources used by the tool developers with an assessment on how often the data will need to be updated.

Scenario testing: awareness and engagement

There are several carbon tools used by Local Authorities and regional groupings of public sector bodies to look at the consequences of policy decisions/ different development decisions on emissions /CO2 impacts. The Resources and Energy Analysis Programme (REAP) and The Greenhouse Gas Regional Inventory (GRIP) are the tools most used to understand the dynamics and impacts of land use and transport behaviour. Both tools allow regional/ local stakeholders to develop scenarios in an iterative way and provide a consistent reporting structure/ user interface which is easy to understand. The weaknesses are that these are both bespoke tools, so it's difficult for the user to modify the assumptions without knowing the technical details of the tool.

REAP

This tool has been developed by Stockholm Environment Institute to help policy makers to understand and measure the environmental pressures associated with human consumption. It's been used by several authorities in Scotland through a series of pilot projects encouraged by the Sustainable Scotland Network and supported by WWF Scotland at the start of the Millennium. There have been good links with the Scottish Government who have funded some follow on Local Footprints Projects. REAP can be used at several spatial scales (local, regional, national) and has three main components:

- Carbon dioxide emissions and GHG emissions measured in tonnes per capita
- The Ecological Footprint to sustain an area in global hectares per capita
- The material flows of products and services through an area measured in thousands of tonnes.

Stakeholders can use the tool and baseline data for their area, test out different future scenarios and compare these with policy targets or to alternative futures based on different trends and assumptions.

GRIP

This tool is the outcome of Sebastian Carney's PhD in 2006 and is designed to encourage a stakeholder led approach to understanding the potential of GHG reduction at the national and regional scales. Stakeholders first build the inventory of GHG and energy use as the baseline, then develop and test future policies/ scenarios, and finally agree the future strategy. It has been tested in a dozen countries as part of an EU funded project on the role of spatial planning in mitigating climate change. SEPA paid for the consultancy team to run 6 events (£25k) in Stirling, Edinburgh, and Inverness.

If all key actors can participate, the tool can facilitate shared ownership of any solutions. The Glasgow and Clyde Valley Strategic Development Plan Authority found the missing actors ('hard to reach') included private sector companies, environmental lobbies, and the public.

The first stage of GRIP - building the inventory is important to the engagement due to the need to standardise data across the different spatial scales (local, region, and nation). The tool spans three levels of data intensity, each with its own prescribed level of uncertainty, and is programmed to accommodate differing levels of base data accuracy so that it can be applied in areas which have different levels of data availability.

The GRIP tool methodology is available on-line at www.getagriponemissions.com and comes complete with clear instructions, tips on how best to access data sources and a common reporting format for ease of cross comparison. The tool has the following sectors: Economy and demographics, Domestic sector, Electricity, Transportation, Services, Energy and Industry. The tool presents GHG emissions in terms of CO2 equivalent using the Global Warming Potential (GWP)100 standard, which demonstrates the impact of greenhouse gases in terms of CO2. All emissions associated with the consumption and combustion of fuel within the region are accounted for as emissions from the Energy sector. This includes energy consumed in the home, by industry and commerce, as well as from transportation, agriculture and offshore and onshore fuel extraction.

See following sites for the applications in Aberdeen and Inverness:

- http://www.aberdeencityandshire-sdpa.gov.uk/nmsruntime/saveasdialog.asp?lID=873&sID=460
- http://www.google.co.uk/url?sa=t&rct=j&q=grip+carbon+tool+in+inverness&source=web&cd=3&ved=0CEUQFjAC&url=http%3A%2F%2Fwww.sepa.org.uk%2Fscience_and_research%2Fconferences_and_events%2Fidoc.ashx%3Fdocid%3D74b62012-d92b-46ae-8d0c-e2ff6b9e99a3%26version%3D-1&ei=mFe2UIuLOqia1AXJtYCQBg&usg=AFQjCNFQ77knzCZVggpFTbSgwKognGcnng

1.2.2 Electric generation and supply

Assessing the carbon emissions associated with the generation and supply of electricity to buildings, transport and industry, may not really require a tool in the conventional sense. Rather, estimates for the carbon intensity of electricity are used by tools within other sectors (such as the building tools used above), to account for this form of energy use. While such estimates can differ depending on the source of information used and the boundaries, assumptions and data used by that source (and, indeed, in the past different government departments have used different grid carbon intensities for a kWh of electricity), there is a degree of standardisation for the carbon intensity of the grid.

The below table provides an indication of life cycle carbon intensities using the standard methodologies from the electricity industry.

Table 1 – LCA of GHG emissions from electricity generation (gCO2e/kWh) [Eurelectric, 2011]

Values	Bio-power	Solar		Geo-thermal	Hydropower	Ocean	Wind	Nuclear	Natural Gas	Oil	Coal
		PV	CSP								
Minimum	-633	5	7	6	0	2	2	1	290	510	675
25th percentile	360	29	14	20	3	6	8	8	422	722	877
50th percentile	18	46	22	45	4	8	12	16	469	840	1001
75th percentile	37	80	32	57	7	9	20	45	548	907	1130
Maximum	75	217	89	79	43	23	81	220	930	1170	1689
CCS min	-1368								65		98
CCS max	-594								245		396

There can, however, be a discrepancy in units of carbon used. This impacts, for instance on the building sectors where in many building models, such as SAP and SBEM, the carbon emissions of energy consumption (at point of use) are given in $kgCO_2/kWh$. Other sources use "kilograms of carbon dioxide equivalent" ($kgCO_2e/kWh$), which can be numerically different if this is being used to account for other greenhouse gas emissions. CO_2 equivalent is often used in DECC publications [2002], where it can provide the equivalent warming potential of other gases beyond just carbon dioxide. It is questionable whether such discrepancy in core units is helpful, and the different basic carbon metrics used inevitably result in widespread and generally misleading comparisons.

A further discrepancy can result from whether indirect emissions are accounted for not, as well as losses in transmission and distribution. A further discussion of such boundaries to carbon emission factors can be found in a Defra publication.

1.2.3 Heat generation and supply

Heat is increasingly, and rightly, being seen as a resource in itself, however this means that it is generally included in other sectoral and energy modelling tools, or modelled using bespoke ones.

From an organisational perspective, a useful and commonly used tool is Natural Resources Canada's RETScreen Suite for energy modelling and management. These are essentially free, open source and transparent, and have the advantage of being in use internationally, allowing for meaningful comparisons to be drawn between organisations / projects / etc. An example of how RETScreen has been used in Scotland is the modelling of a cost effective strategy for installing low carbon generation technologies at Denny Primary School, Falkirk, carried out by Glasgow Caledonian University.

However in Scotland the renewed focus on low carbon and low cost heating is driving the development of community and district heating programmes that may benefit from a standardised toolkit for modelling and mapping energy and heat. This is one clear gap in the Scottish carbon accounting capabilities that requires rectifying.

1.2.4 Public sector and local government

The Resource and Energy Analysis Programme (REAP), developed by the Stockholm Environment Institute at the University of York, is the most authoritative, sophisticated and widely-used accounting tool in the public sector and local government, and as such is the closest the UK has to a standard for this sector. The other options for organisations in this sector are bespoke tools developed in-house and / or by specialist consultants, either completely from the bottom up or by using other software such as SimaPro and other more sector-specific tools included in the database.

This raises the question of how much standardisation these end users would like to see at present, and further research is needed to determine whether these end users would favour either standardisation of tools at a sectoral or sub-sectoral level. Usability and affordability of tools and processes are both key issues in the advancement of correct carbon accounting for activities in all sectors. However, whilst these organisations provide a wide range of services, the vast majority (97%) of their CO_2 emissions come from buildings (67%), waste (17%), and transport (13%)[SG 2012]. Standardised tools exist for buildings, and possible standards exist for waste and transport, and so any future decision-making on carbon accounting requirements from these organisations should now go back to gather and seriously consider the opinions of these particular end users and evaluate the strengths of the currently available and their core functions.

1.2.5 Non-domestic and domestic buildings

In the non-domestic and domestic building sectors, carbon accounting tools have both a range of calculation methodologies and also a wide range of applications. It can therefore be a somewhat unfair assessment to compare a tool designed for a very broad overview of, for example, household energy consumption with a detailed building simulation model. To provide suitable boundaries to this review exercise, building tools are chosen that are commonly used for standardised carbon assessments, particularly relating to Energy Performance Certificates (EPC) and the Energy Performance in Buildings Directive (EPBD). Even with these tools, it should be borne in mind that they will usually only form part of a Life Cycle Assessment, being primarily concerned with operational energy consumption; specifically the “regulated” part of operational energy consumption that includes lighting, heating, cooling and ventilation (but not appliance and Information Technology (IT) energy consumption).

In the non-domestic sector, EPCs (providing a modelled estimation of the regulated energy consumption of a building) can be produced using the Building Research Establishment’s (BRE) Simplified Building Energy Model (SBEM) calculation methodology, which is a steady-state calculation, or a more detailed “dynamic” calculation. Buildings that are deemed relatively simple are categorised as either “level 3” or “level 4”. These definitions are further explained elsewhere, but level 3 comprises the majority of the non-domestic stock and, therefore, most buildings are modelled using the very simple approach of SBEM. For buildings deemed to reach “level 5” complexity, often due to more complex ventilation strategies or level of services rather than actual size of building, then dynamic simulation must be used to generate the EPC.

In the domestic sector, the only standardised and approved methods are based around the BRE Standard Assessment Procedure (SAP) calculation. This, like SBEM, is a simple, steady-state calculation that does not always have a strong correlation with real operational data from energy bills. It does, however, provide an industry standard for calculating carbon emissions for regulated operational energy for dwellings. For new dwellings, a full version of SAP (version 9.90, currently based on a 2009 iteration of SAP) is required whereas existing dwellings use a reduced data version of SAP (RdSAP, currently version 9.91).

Although not specific to Scotland, the UK is dominated by two LCI datasets; the BRE Green Guide to Specification which provides information to Impact, BREEAM and the Code for Sustainable Homes; and the Inventory of Carbon and Energy (ICE) from Bath University. The Green Guide is a construction specific LCA based tool which is defined by the Environmental Profiles methodology. Its strengths lie in the breadth of construction components covered by the tool, but it is limited in use to expert LCA practitioners because of its cost and used with caution because h its lack of transparency, repeatability and data reliability. The Inventory of Carbon and Energy (ICE) database, initially from Bath University, and now managed by BSRIA, is the most comprehensive, open access LCI dataset available in the UK. It is widely used in LCA studies with good coverage of basic industry and construction materials. Care needs to be taken when using any data, as different, non-explicit, boundary conditions apply to datasets from different sources. For example some sources include transport effects while other omit them and some report cradle to gate data, while others report cradle to grave or cradle to site data.

Specific LCA tools for buildings have not been developed for Scotland, but there are a range of national and international tools which are applicable in Scotland. These include: the new Impact tool from Integrated Environmental Solutions (IES) which incorporates BRE Green Guide data in its analysis; SimaPro, one of the world leading LCA tools, and based on a comprehensive and international database, the Swiss Ecoinvent tool and inventory; Athena, a Canadian software tool capable of incorporating various LCI data sources including Ecoinvent; GaBi is a powerful LCA engine and database developed in Stuttgart, Germany, that supports Life Cycle Assessments, Life Cycle Reporting, Life Cycle Working Environment studies to develop manufacturing processes that address social responsibilities across a range of environmental fields and BEES (Building for Environmental and Economic Sustainability), a US building specific software tool developed by the National Institute of Standards and Technology, which provides a powerful technique for selecting cost-effective, environmentally-preferable building products. All of these tools are for use by expert LCA practitioners and come at some or considerable cost.

1.2.6 Small and Medium-sized Enterprise, SMEs

As defined in EU law, the main factors determining whether a company is an SME are the number of employees and either the turnover or balance sheet total (EU recommendation 2003/361):

Table 2: Definition of SME

Company category	**Employees**	**Turnover**	or	**Balance sheet total**
Medium-sized	< 250	≤ € 50 m		≤ € 43 m
Small	< 50	≤ € 10 m		≤ € 10 m

Micro	< 10	≤ € 2 m	≤ € 2 m

Small and Medium-sized Enterprises (SMEs) are defined here as enterprises with less than 250 employees and a turn-over not exceeding €50 million.

In the UK, SMEs comprise 99.8% of all enterprises and provide 48.5% of employment (Office of National Statistics, 2010). Despite a lack of data on the environmental impact of SMEs at a national or regional level (Hillary, 2004) their environmental impact (intensity) is likely to be higher than that of larger firms, as the latter experience resource efficiencies resulting from economies of scale (Rutherfoord et al., 2000). It has been estimated that cumulatively the UK's SMEs consume 45% of total energy used by businesses (BERR/ONS, 2008 in Vickers et al., 2009) and contribute up to 60% of business-related greenhouse gas emissions (Marshall, 1998).

While the focus for policy instruments and mandatory emission reporting schemes are at present (and should be) enterprises with sufficiently high emissions such that the costs of participating are compensated by savings realised, smaller organisations will (of necessity) have to contribute to statutory emissions reductions in the future. Indeed, if the UK and Scotland are to achieve their challenging GHG reduction targets, then it is highly likely that demands will be placed SMEs to reduce their emissions.

To date the UK and Scottish Government's approach to improving the environmental performance of SMEs has been to promote the financial and business arguments for voluntary action (Rutherfoord et al., 2000; Revell and Blackburn, 2007). While there is at present little or no direct governmental pressure, indirect pressure from large companies, such as Marks and Spencer's 'Plan A' commitments to improve their environmental performance (Marks and Spencer Group Plc, 2010), will place increasing demands on smaller enterprises within their supply chain to become aware of their climate impact.

Sectors and the need for SME specific tools

SMEs operate across all sectors of the economy, and as such all sector specific tools and guidance can be considered applicable to SMEs. Likewise, should an SME wish to assess the carbon footprint of their product or the carbon footprint of their buildings, they would follow the same process as a larger business. However, SMEs experience a series of entrenched barriers to taking action to improve their environmental performance, of which some of the most commonly cited are resource constraints, both time and money, and a lack of internal knowledge or expertise (Gibson and Dunk, submitted). As such, proprietary, paid for, carbon accounting tools and services designed for larger businesses to manage their operational emissions may be somewhat lacking in appeal for SMEs, particularly micro and small businesses, due to their cost and/or their complexity and requirement for existing knowledge of the subject. There is therefore a clear need for robust SME specific carbon accounting tools and guidance that strike an appropriate balance between ease of use for the end user and completeness of the assessment. Furthermore, tools that provide only carbon accounting information, and do not also track financial data such as costs and savings, and may fail to result in emissions reductions as there is a clear need to make a strong business case to SMEs in order to promote environmental performance improvement.

Benchmarking and policy perspectives

We do not as yet have a good measure of the contribution of SMEs to Scottish emissions. Making a realistic assessment of the potential contribution of SMEs to national ghg emissions reduction targets very difficult, if not virtually impossible. Nor are robust benchmark carbon, absolute or intensity based, footprints available. Thus it is also difficult for businesses and/or their customers to assess how well they are doing in terms of carbon performance relative to the sector as a whole. To gain a measure of overall SME emissions and generate robust benchmarks will require a centralized data set where all users enter their data following the same methodology and for the same time period, preferably with the additional functionality of ongoing performance management. Very few currently available tools provide this, with a few exceptions. The IGJane's Bicycle IG tool is a tool developed for the creative sector activities(http://www.juliesbicycle.com/resources/ig-tools) and CloudApps developed by the Crichton Carbon Centre and funded by the ERDF under the Sustainable Process Improvement programme (http://www.cloudapps.com/2011/09/) providing rare examples.

Carbon Trust Tools

In addition to a range of guidance and reports, the Carbon Trust provides a set of eight free to access carbon management tools, three of which are specific to or particularly relevant to SMEs: Carbon Trust SME Network; Carbon Trust Empower (a staff engagement tool) and the Empower Savings Calculator.

These tools are carbon management tools (designed to promote and support engagement with carbon management) rather than carbon accounting tools; i.e. the tools are not intended to be used to measure an operational carbon footprint, although the Empower tools could be used to estimate CO2 savings from energy efficiency actions undertaken by an organisation. The Empower Savings Calculator is based on the same set of potential actions as the Empower staff engagement tool, scaling up to potential whole business savings based on either total energy bill or number of employees. It assumes for this up-scaling that 1 employee is approximately equal to an assumed annual energy bill of £132.9, and that all savings are assumed to scale up directly with directly related increases in employee numbers and energy bills.

There is no publicly available methodology paper for the Empower tools and no information is provided on the assumptions underlying the tool. As such the tools are not transparent.

The Carbon Trust Scotland SME Carbon Management Programme

The SME Carbon Management Programme launched in 2010 has assisted over 20 SMEs in the pilot phase (free to participants), with a further 55 places in the second phase of the programme (£500 contribution required from participants) being filled, bringing the total to 75 SMEs assisted by the programme up until March 2013. This is a 5-month support programme offered through the Carbon Trust Scotland and delivered by sub-contracted consultants.

SME participants are provided with carbon accounting and reporting tools, specifically the Carbon Trust Baseline Tool and the Carbon Trust Carbon Management Plan Template, both of which have been simplified for SME use. Use of these tools is not prescribed, with programme participants being free to use other available tools or develop their own tools.

The Carbon Trust Baseline Tool is a simple carbon accounting tool provided in excel format. The tool utilises Defra/DECC emission factors (latest available at the time of release) and largely follows Defra/DECC (2012) guidance to small businesses regarding the emission sources that should be included in an operational carbon footprint assessment – including electricity use (Scope 2), fuel use (Scope 1), company owned vehicles (Scope 1), business travel (Scope 3), waste to landfill (Scope 3) and water (Scope 3). Keeping emission factors up to date is the responsibility of the user, where updated versions are not released to past programme participants. Mindful of time and knowledge barriers to SME participation in carbon management, the baseline tool has been kept as simple as possible. Users enter available usage data.

The tools are currently only available through participation in the SME Carbon Management Programme. Future availability and use will depend on funding and/or commercialisation of and by the Carbon Trust itself.

A key issue with SME carbon accounting tools is their cost. Providers understandably keep the core method hidden to protect its value, but in so doing transparency, and its educational value, is sacrificed. For instance in many methods such as this tool emission factors are not visible (hidden in spreadsheet) and beyond user data entry the excel spreadsheet cannot be edited (password protected with locked cells, hidden formulas and hidden data), therefore users cannot readily update emission factors or make them locally appropriate to their own on site generation etc.

Simplicity is possibly both the greatest strength and greatest weakness of methods such as that of the Carbon Trust toolkit. The Baseline Tool has one data entry line for a particular reporting period against electricity and usage of each fuel type. As the tool is locked, additional data entry lines cannot be user added. The result is that either (a) the SME user has to pre-calculate their annual consumption and costs prior to data entry into the Baseline Tool, which complicates rather than simplifies the process, or (b) the SME user enters data for less than 1 year. If data is entered for less than 1 year, then a simple annualisation is performed by the tool to estimate annual consumption, emissions and costs. This has the potential to introduce a significant error as energy consumption is assumed to be constant throughout the year and no consideration is made of seasonal trends in energy consumption.

CloudApps – available to SMEs via the Crichton Carbon Centre ERDF funded project – Environmentally Sustainable Process Improvement

CloudApps is built on the SalesForce platform, where the current CloudApps license cost (single seat) is around £80/yr. The initial configuration of CloudApps is both complex and time consuming and as such is likely to have low appeal to SMEs (due to time, knowledge and potentially cost barriers). However CloudApps and SalesForce have both provided 100 licenses through their charitable foundations to the Crichton Carbon Centre for use in *Environmentally Sustainable Process Improvement (SPI)*, an ERDF funded project, – which aims to work directly with 90-100 SMEs over a 3 year period to enable them to complete their own carbon management audit and plan for2012-2015. There are currently 27 registered SME users for this programme. Configuration for SPI SME users has been conducted by the Crichton Carbon Centre, and participants are provided with free access to CloudApps (thus removing the time, knowledge and cost barriers). The SPI programme follows the Greenhouse Gas Protocol Corporate Accounting and Reporting Standard and the Value Chain (Scope 3) Accounting and Reporting Standard in line with Defra/DECC emission factors, requiring SME users to monitor all significant emission sources.

Perhaps one of the most significant benefits of the use of CloudApps in the SPI programme is the potential development of a database containing the anonymised carbon accounting data for 90-100 SMEs, which can be interrogated by business size, sector and geographic location, enabling baseline studies to be carried out cost efficiently.

1.2.7 Industry

Uses of LCA in industry are varied. Internally, they tend to be used to drive radical changes in product lifecycles and innovations, to anticipate legislation, to screen supply chain providers, to provide better product stewardship, to allocate costs, to compare products, and to benchmark products against eco-labels. Externally, they can be used to negotiate long-term legislation, to define marketing and advertising strategies, and to participate in eco-labelling schemes. The main application of LCA has historically centred on identifying product bottle-necks, providing information and education to customers and stakeholders, and to compare existing products with planned alternatives. Research and Development in product design has also been a key driver for LCA studies. Most benefits are generally recognised to be long-term in nature, perhaps describing why larger companies are more able to support R&D work, and the costs of bespoke LCA studies.

In the main, industry LCA studies tend to be bespoke and limited to individual product LCAs, using recognised Life Cycle Inventory (LCI) datasets like the Inventory of Carbon and Energy (ICE, 2011), the EcoInvent database, GaBi and Athena. Alternatively, process analysis datasets can be generated to improve representativeness and remove the need to use generic data.

Industry specific activity

Specific industry tools are very limited. TEAM software developed by Ecobilan at PricewaterhouseCoopers is a tool which allows the user to build and manage large databases, and to manage operations relating to products, processes and activities. TEAM allows the user to describe industrial systems and to calculate the life cycle inventories and associated potential environmental impacts in accordance with ISO 14040 & ISO 14044. A set of baseline data covering the current major utilities such as energy and transport is included in the TEAM license, but the software is also capable of importing data from external sources like EcoInvent.

The Plastics Profile provides an ISO 14040 compliant LCA methodology to describe the LCA and LCI of various plastic products and families. It is an online tool to group these LCAs into process and production flows, products and product families, and an alphabetical directory of polymers and precursors. The Plastics Profile allows access to PlasticsEurope's Eco-profiles and Environmental Product Declarations (EPDs). This kind of grouping activity is becoming more commonplace. Wood First aims to increase the demand for timber in construction, and with it the demand for sustainably managed forestry, (plus the associated economic, social and environmental benefits). In September 2012 Wood First announced the Wood First Plus initiative, aimed to provide clarity on the carbon credentials of timber, EPDs for various timber and timber-based products, and engineering data for effective design and specification of timber in construction projects. While these are not LCA tools *per se* they describe a growing trend in industry activity; to group and present LCA and LCI data collectively in like-industry groupings.

International perspective

Industry LCA activity is largely dominated by EU companies, groups and tools. Activity in the Netherlands, Germany, France and Switzerland is leading in longevity, application and market saturation. Switzerland is home to the Ecoinvent database, used by many software tool developers and providers, including; SimaPro from Pre Consulting, an international environmental consulting organisation; GaBi software from PE International, LCA Calculator, a web based calculator which uses Ecoinvent LCI data to perform quick LCA calculations for products, processes and activities.
The Netherlands are home to IVAM from the University of Amsterdam; bespoke Excel based LCA tools, SimaPro from Pre Consulting, and Radboud University in Nijmegen who specialise in LCA development and methods. France boasts a number of specialist software tool developers, including EcoMundo, a chemical regulations specialist company with their REACH factory suite of software applications. Germany has a wide number of environmental specialist consultant organisations and software tool developers, including LEGEP, a modular software for the design of sustainable buildings and GaBi software from PE International developed originally in Stuttgart.

The ELCD II database brings together LCI data from EU businesses and other sources for key materials, energy providers, transport, and waste with a focus on data quality, consistency, and applicability. The data sets are provided and approved by named industry associations. Data is accessible without charge or use restrictions for all LCA practitioners. The target user is intended to be an LCA expert/practitioner. The main purpose of the ELCD core database is the integration into LCA tools and databases. The ELCD database contributes to the ILCD Handbook, the International Reference Life Cycle Data Handbook.

Developed further afield but widely used in the UK is the Athena tool from the Athena Sustainable Materials Institute, Canada. The US is home to Boustead Consulting Ltd, the National Institute of Standards and Technology (NIST), and The Right Environment Ltd Co.

Spanning international boundaries are LCA tools which can be focused on a particular location or country using specific LCI data. These include SimaPro, Athena, GaBi and tools based on the Ecoinvent database.

UK Perspective

No publically available industry tools, which are specific to Scotland, were found. As discussed above under domestic and non-domestic building sectors, there are number of LCI databases which are used by expert LCA practitioners to perform bespoke, and industry specific carbon accounting studies, and Environmental Product Declarations (EPDs). These LCIs include the BRE Green Guide to Specification, the Inventory of Carbon and Energy, and Ecoinvent.
In general, and internationally, as data sets improve in quality and coverage, broad-based LCAs are becoming less popular, while environmental sustainability indicators, such as total water use and greenhouse gas emissions are growing in number. LCAs are complex systems that can ease, or

complicate decision-making by specifiers and consumers. Of growing importance is not just the environmental sustainability of products, but social and economic sustainability also. Various tools for social and economic LCAs are gaining research attention.

1.2.8 Transport

Transport can be treated as a sector in itself and / or a component of other sectors. Emissions accounting tools specifically for transport cover freight and / or passenger travel. Of the freight-specific tools, EcoTransit provides a useful example of good practice in an online tool by having a robust and transparent methodology published alongside the easy to use calculator. However alternatives exist, such as the Carbon Intervention Modelling Calculator which is available from Heriot Watt University and is being developed further.

Passenger travel is, of course, included in tools for other sectors, and because of the standardised Defra factors anyone able to use a spreadsheet can easily calculate the emissions from all but the more specialist forms of transport, and then have this verified. This does mean that some simple and free tools exist for calculating transport emission with the only caveat when using them is to first check they are still using the latest Defra / IPCC figures. At a higher level, accounting for emissions from transport is prone to organisational and geographical transboundary issues, particularly when projects to reduce emissions within or across boundaries drive up those elsewhere. Therefore there may be an argument that any future standardisation should take into account the clear need for better alignment of transport with energy, as noted by the IPCC. Decision-makers may wish to see the scope of emissions reporting required for transport widened to include other emissions and particulates.

1.2.9 Waste

Waste can be treated either as a sector in itself (e.g. IPCC, REAP), or as a component of other sectors (as in Scotland), and there are also differing needs across sectors for reporting emissions from waste. At present the most relevant waste-specific tool is the Scottish Carbon Metric, available from Zero Waste Scotland. This is a free and open source spreadsheet-based tool aimed primarily at organisational accounting. We are aware of work being done on a successor to this but have no further information at present, however at a Scottish level it would seem sensible to see some standardisation of waste tools could enable greater standardisation in other sectors.

Furthermore, there also the need to consider those sectors and industries that are waste intensive and / or deal with specialist waste. An example of this is the construction sector, for which WRAP has produced Net Waste, a similar tool aimed specifically at site managers. Other sectors for which decision-makers may wish to see more specific waste tools include energy and water, agriculture, forestry and fishing, and mining.

1.2.10 Agriculture

Agriculture was omitted from the original brief and we make no claim to a comprehensive coverage. However through our work we have become aware of the Cool Farm tool, developed by Unilever, which is a useful example of best practice in open-source carbon accounting.

ICARB's work so far has found agriculture to be a particularly difficult area for carbon accounting, however many Scottish institutions are working to help overcome the problems, much of which stem from the difficulties and costs of accurately measuring emissions over large areas of land. This is further hampered by the need to calculate the full Kyoto basket because of the higher proportions of non-CO_2 emissions from land and livestock.

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Part 2

2.0 Introduction

This section of the report provides an assessment of how well the tools fit together to provide a complete picture of Scotland's emissions, and explores some key opportunities and barriers for improving sectoral carbon accounting. This is based on both the survey work and initial results from ICARB's first two years of Scottish Government funded activity undertaken to develop carbon accounting 'rules and tools' in conjunction with others in the Scottish carbon accounting community. The first academic outputs of this work will be published in a special edition of the Journal of Greenhouse Gas Measurement and Management in 2014. ICARB has adopted the GHG Protocols Group's '5 Principles of Carbon Accounting', and these used in the ICARB database which forms Part 3 of this report to assess the tools. However more detailed assessments of the attributes, outputs and relative merits of individual tools will be needed to fully inform choices on availability, suitability and applicability of different tools in Scotland. Although there is more work to be done on how the Scottish sectors may be better aligned (with each other, with the IPCC, etc), and some sectors are currently omitted from this report (see Omissions), we have been able to capture a snapshot of cross-sectoral progress against these principles.

Relevance - Tools exist for all the sectors covered, however there is a need for a clearer understanding of what 'relevance' means to Scottish policy, which would enable better alignment of sectors, and subsequently tools. Clear specifications for the optimal requirements for carbon accounting tools are needed against which the attributes of different tools can be match to understand where 'best fits' exist by sector.

Completeness - It is difficult to assess completeness of accounting tools by sector at a national level, in part because not all are covered here, but also because some sectors use bespoke tools that were not available to us. A further problem here is that while most tools are complete within their defined scopes, there is disagreement over how scopes (should) apply to sectors.

Consistency - The overall consistency of the tools covered is generally good, which would seem to reflect the widespread adoption of the GHG Protocols guidelines and standards for carbon accounting, as well as the Carbon Trust's PAS2050, ISO standards, etc.

Transparency - There remains a need for greater agreement on what level of transparency is acceptable for reporting sectoral emissions, and there is a huge variation in the transparency of the tools available. This is explored in more depth later. For many commercial organisations the issue of transparency is critical for both providers and clients of carbon accounting because of issues of commercial advantage and the Intellectual Property rights on accounting methods.

Accuracy - Carbon accounting tools are ultimately as accurate as the factors used in them, providing of course they are used correctly. However there remain questions over how accurately they can be used to determine Scottish emissions, for example whether (as many argue) emissions inventories are more accurately reflected by consumption-based accounting systems. The accuracy of a toll is affected by the factors used in it and the calculations and assumptions used to link them in the toll. It is impossible to evaluate the accuracy of a tool where its workings are not transparent.

The following sections provide further discussion of key issues raised by this work.

2.1 Key issues and Discussion

Carbon emissions are usually expressed in one of three ways:

1. **Carbon (C)**: This is the amount of carbon atoms only and is increasingly rare. To convert to CO_2 multiply this by $\frac{44}{12}$ (or 3.67).
2. **Carbon dioxide (CO_2):** This is the amount of carbon dioxide only, and is useful for accounting exercises in which the contribution of other GHG emissions is known to be negligible, and is still widely in use.
3. **Carbon dioxide equivalent (CO_2e):** This is the amount of carbon dioxide plus the relative amounts of the other gases in the Kyoto basket, which are weighted by their global warming potential. This is the gold standard for carbon accounting and is now the most common figure for expressing GHG emissions.

Some accounting tools extend this beyond the Kyoto basket, for example to the full IPCC list and / or pollutants such as PM10s. As the wider reporting needs here can be highly sector-specific there may be benefits to exploring how carbon accounting tools can be better aligned to support these, for example reporting pollution impacts from transport.

Most sectoral tools now calculate emissions using the metric of CO_2e. However it is also useful to understand how the relevant contributions from the additional gases varies between sectors, and that in some cases there are significant uncertainties around measuring and calculating these emissions. An example of this lies in the gricultural sector, where methane and nitrous oxide emissions are proportionally high but with a high level of uncertainty due to the higher costs involved in measurement.

2.2 Tool Boundaries, Transboundary Problems, and Overlaps

Most tools covered in the database account for all or most of Scope 1 and 2 emissions, however not all categories under each scope are equally appropriate to every sector. These variations reflect various underlying factors, such as different sectoral and organisational reporting needs, and can contribute to transboundary problems.

Transboundary problems can occur in various ways, such as:

- Uncertainties in determining sectoral and organisational reporting boundaries
- Uncertainties in determining lifecycle / scope / temporal boundaries
- Uncertainties in determining boundaries for resource flows between sectors
- Uncertainties in determining geographical boundaries

One example of the problems caused by these uncertainties is measuring and attributing emissions from waste, which can be treated as a sector in itself, or a component of all other sectors, and as the end of life component of a life cycle assessment (which may itself form part of an organisational / sectoral footprint). Another sector prone to transboundary problems is transport, where changes to infrastructure to reduce emissions within one geographical and organisational boundary risk opposition if they result in an increase in emissions elsewhere.

A potentially confusing overlap between sectors relates to accounting for waste. Waste can be accounted for as a standalone sector (as in REAP), a component of other sectors (e.g. energy and waste and wastewater) and as the end of life component of the carbon embodied in a resource / product / capital asset / etc.

Geographical Issues

Many of the tools covered have been designed specifically for Scotland or the UK or can be easily changed to use national conversion factors, therefore there are no obvious geographical compatibility conflicts between tools across the different sectors. However, one well-documented minor exception is the error induced by the climate data in SAP and SBEM-based tools for housing and non-domestic buildings in more northern and exposed areas (Baker et al., 2012).

Omissions

At present the database is limited to those tools that are available and in use in Scotland / the UK and calculate carbon / greenhouse gas emissions (usually expressed in CO_2 / CO_2e). This means that we have not included water and wastewater in the sectors covered as Scottish Water uses a bespoke tool; and similarly bespoke tools in use by local authorities, community groups, and others are currently omitted.
Although agriculture was also missed out in the original brief we have included the one tool that we are aware of as it represents an important example of good practice, but other sectors missing from the brief are currently omitted, including forestry, tourism and the retail / service sector. We apologise for these and any further omissions and hope to update this work in future.

Top down and bottom up accounting

As shown in Figure 1, the sectoral definitions used by the IPCC do not map directly to the sector categories used in the Scottish Carbon Budget, however it is important to note that the sectoral tools in the database cover all these overlaps and potential overlaps, or that they map directly onto these sectors or one another.
These figures are included to illustrate the difficulties of meshing bottom up and top down carbon accounting approaches and tools, which reflect the differing needs of users and stakeholders. The degree to which the number and complexity of these pathways could be feasibly reduced is a difficult question that ICARB's on-going work is attempting to address. A more detailed attribute analysis of the tools would enable us to identify exactly where the inconsistencies exist and their scale and potential impacts.

Transparency

The tools in use in Scotland offer different levels of transparency, from being 'black boxes' that display few, if any, factors such as the Green Freight Europe tool, through to truly open-source spreadsheets provided with all cells unlocked or unlockable such as the Scottish Carbon Metric tool. In between these are the more sophisticated tools where the factors in use may not be obviously discernible to non-specialist users, for example by being listed separately, sourced from online databases, or simply hidden in menus.

Transparency is essential to good practice in carbon accounting, however there may be some acceptable tradeoffs to be made when selecting more complex tools and / or those aimed at non-specialist users.

Similarly, there are many benefits to using open-source tools that can be modified by users, although obviously care must be taken in recording all modification; and where these are used full copies of the calculations would need to be published in order to ensure transparency.

Finally, it should noted that we have not been able to include coverage of any bespoke tools designed and used in-house, although these are in widespread use. However providing these are published for inspection this is a standardisation issue rather than one of transparency.

Skills Requirements

Although the tools covered are limited to those that calculate carbon emissions they generally reflect the wider trend of more sophisticated tools needing more experienced users. The clear bias in these being building and energy-related tools may be partly a reflection of the authors' backgrounds, however on-going research by ICARB suggests this is a fair reflection of the overall landscape.

Nevertheless, there is an increasing range of tools that can be used to produce sufficiently robust results with minimal support or training, although of course many such results will still require external verification. Such tools, which tend to be those implemented as spreadsheets like . Unilever's Cool Farm tool, have the advantage of engaging with and educating a much wider audience and thereby potentially generating spillover effects.

Standardisation

The database demonstrates the variety of publicly available carbon accounting tools that already exist within and across sectors, however this variety means there is relatively little standardisation of methods and tools in Scotland. The main exception to this is the water industry due to Scottish Water's effective monopoly, and there is no single standard tool for England and Wales.

Waste could be standardised using the Scottish Carbon Metric (or what we understand may update or replace it), however implementing a standard tool for waste would require ensuring that it integrates well with other widely-used tools and methods such as REAP and PAS2060.

Another sector with potential for greater standardisation is agriculture, and specifically farming. At present, and within the scope of this work, we are aware of only one tool for this sector. Cool Farm is published by Unilever as a free and open source tool for its suppliers, but appears sufficiently fit for purpose for wider adoption. Specifically targetted Landuse Workshops run by ICARB (See : www.icarb.org and www.icarbconference.org) were designed to explore the extent to which forestry and agricultural accounting tools can be integrated to give landowners and policy makers effective means for deciding which landuse options to adopt based on their carbon impacts on the atmosphere. The results of these workshops will be posted on the ICARB websites.

The Building sector is one in which there has been much standardisation but also much disagreement. Although SAP and SBEM are used as standards for buildings there are widely documented concerns over their 'Fitness for Purpose', particularly for Scotland. A wide variety of tools are currently used for modelling building systems and components but the outputs of different models can vary widely, no least from the reality as built and occupied.

The difference between accounting for whole buildings versus building systems is mirrored in other sectors where an organisation / company needs to account for individual components of its operations as well as reporting and overall footprint. This poses problems for greater standardisation where purpose-specific tools need to be integrated into wider organisational accounting processes and tools.

To date, ICARB's work has found practitioners tend to support efforts towards greater standardisation, appreciating a level playing field, with some strong caveats, particularly in regard to ensuring any standard tools are appropriate and robust prior to any standardisation. Therefore we could not recommend any existing tool without further research and stakeholder consultation.

Cost of Accounting Tools

The growing market for carbon accounting tools, products and services is naturally being developed as viable business opportunity. However the cost of actually purchasing or leasing some of the high end tools and databases is relatively prohibitive for most businesses. The Part 3 spreadsheet does not list costs of tools not least because of the complexity of their costing mechanisms for example for different license costs for individuals, organisations, time limited leases of software etc. However a deeper analysis of the fitness for purpose of the available tool range should look at this issue of cost in relation to the best-fit users for the tool.

2.2 Conclusions

Carbon accounting is a relatively new and rapidly evolving field, and the number and variety of tools available has expanded alongside new and enhanced methods, guidance and reporting requirements. However questions remain over how the evidence carbon accounting provides can best be used to meet policy objectives, which will itself shape the future of the field.

Such objectives may be better met through increased standardisation of tools and practices, however progress in defining and agreeing common 'rules' has been stronger in some sectors than others, and the cross-sectoral links between sectors mean that care needs to be taken to carefully align any future steps towards standardisation.

This progress should also benefit from greater transparency, and this needs consideration with regard to the development of future reporting requirements. A final issue here is the need to better align top down and bottom up accounting practices to better serve Scotland's emissions reduction efforts.

In completing the following study it became apparent that three next steps can be recommended:

1 To scope out a clear specification of the required attributes of 'Fit for Purpose' basic tools for carbon accounting methods in Scotland, sector by sector including what minimal functions they should fulfil and how they should relate them to adjacent sectoral methods.
2 To undertake a complete and detailed attribute analysis of the existing accounting tools outlined on the chart in Part 3.
3 To map the required functions of sectoral accounting systems against the capabilities of the currently available tools and maps the gaps between them and the overlaps to inform the next stage in developing a comprehensive carbon accounting capability for the Scottish Economy.

This review of the available carbon accounting tools in Scotland has enabled us to lightly characterise the characteristics, strengths and weaknesses of the range of tools that it covers and highlight the need for further work, as outlined above.

2.3 Part 2 Further References

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