REPRESENTING THE UK TECHNOLOGY INDUSTRY

Evaluating the carbon impact of ICT
or
The answer to life, the universe and everything

Understanding the limitations of LCA-based carbon footprinting methodologies

Preliminary note: policy context

Back in 2009 the European Commission published a Recommendation on ICT which promoted the adoption of ICT and ICT-enabled technologies to deliver emissions reductions.[1] In return, the sector agreed to a number of undertakings, one of which was the development of a common framework to measure the carbon impact of ICT. The Commission is determined that the ICT sector will meet its obligations, and Commissioner Neelie Kroes made this clear in the Digital Agenda for Europe:[2]

"Assess whether the ICT sector has complied with the timeline to adopt common measurement methodologies for the sector's own energy performance and greenhouse gas emissions and propose legal measures if appropriate". She also underlined this intention in a recent blog.[3]

Over the last two years a number of standards bodies and industry consortia have been working on developing methodologies to evaluate the carbon impact of ICT products and services, and in most cases the work is nearing completion. Each approach has its own strengths and weaknesses. All are to some extent based on life cycle assessment (LCA) and build on global ISO standards (14040 and 14044).

The Commission has recently issued a tender[4] for a study of these different approaches with a view to establishing whether they provide a suitable basis for legislation. The tender states

"With a coherent methodological framework for measuring the GHG and energy footprints of ICT in place, it needs to be assessed how suitable these methodologies are for integration into concrete policy measures that contribute to the "greening" of ICT."

The intention to legislate seems clear, and from previous indications it is likely that the Commission will want to use these methodologies a) as a basis for taxation, b) to inform eco-labelling, c) to allow consumers to compare products on the basis of carbon characteristics and d) to establish a baseline footprint for the entire sector and use this to set reduction targets. Current LCA based approaches (i.e. the methodologies being developed) are unsuitable for these purposes. This paper explains why.

In the following pages we describe a number of methodologies or initiatives and explain what they can and cannot be used for. We demonstrate that LCA has a very important role in helping us identify, evaluate, understand and address the environmental impacts of the products and services we manufacture and use. LCA and other reporting processes also have a number of other benefits, such as their tendency to help create frameworks for better communication down the supply chain. But LCA is not designed or intended to be used to compare similar products or to provide organisational or sector level footprints. So we need to manage our expectations and ensure that the very significant value of these approaches is not overlooked.

One useful analogy for this message is food. Many of us are a bit too fat. If we want to lose weight, there is little point in spending years calculating whether a strawberry or a raspberry has fewer calories. What we really need to do is to stop eating pies[5]. And with carbon, as with calories, it is the pies – or rather their carbon equivalents - that are important. LCA is a poor tool for differentiating between strawberries and raspberries, but it is a wonderful tool for identifying where the pies are, and who is eating them.

We have chosen a slightly different analogy for this document, for which we have to thank Douglas Adams.

1 Recommendation C(2009) 7604: http://ec.europa.eu/information_society/activities/sustainable_growth/docs/recommendation_d_vista.pdf
2 http://www.europarl.europa.eu/meetdocs/2009_2014/documents/deea/dv/1011_10_/1011_10_en.pdf
3 http://blogs.ec.europa.eu/neelie-kroes/ict-footprint/
4 http://ec.europa.eu/information_society/newsroom/cf/itemdetail.cfm?item_id=7910
5 Chris Chant, then UK Government CIO, used this rather elegant analogy back in 2008 when encouraging government departments to take action on big impacts rather than trying to establish which marginal approaches were best.

Executive summary

We urgently need to understand more about the carbon impact of ICT. ICT is a key weapon in our fight against climate change, but it does not come absolutely free: ICT products and services themselves use energy so there is a carbon cost to set against each enabling solution and we need to know that cost, as a proportion of the reductions delivered, to evaluate the solution objectively. We also need to know more because ICT is complex, pervasive, disruptive, and growing.

In response to this need, numerous standards bodies and industry consortia are working on standardised methodologies to evaluate the carbon impact of ICT products, networks and services. These include ITU, ETSI, IEC, and GHG Protocol. Their approaches are based on life cycle assessment (LCA). LCA examines the environmental impacts of a product or service over its life – from the extraction of raw materials to disposal, including manufacture, distribution and use. Consortia including PAIA and iNEMI are working on associated initiatives. Some methodologies have been published and others are in final draft stages.

Each methodology sets out clear objectives, but LCA is a relatively new and complex tool. The result is that there is considerable confusion regarding what these approaches can and cannot do. There is also confusion over what we are measuring –the carbon impact of ICT products and services or the ICT sector as a whole. Then there is confusion around what we can do with the results. There is also confusion as to how these methodologies work in practice. And there is confusion about how they fit together.

The result, predictably, is that expectations may exceed the capabilities and stated objectives of these methodologies. In particular, there seems to be a worrying expectation that LCA can deliver all the answers, when in fact it is designed to do something much more specific. This paper looks briefly at the methodologies on offer or in development and then compares their capabilities and objectives with the expectations of the various stakeholders: government, industry and academia.

The paper concludes that LCA is an important tool in helping us understand the carbon impact of ICT, but it is not a cure-all. Just like any other tool, LCA should be used for the purpose for which it is designed: for identifying the most carbon intensive points in the lifecycle and directing reduction efforts accordingly. LCA is also appropriate for comparing the carbon impact of different supply chains (sourcing copper in Australia as opposed to Brazil) or comparing different technologies (reading a newspaper compared to an e-reader).

LCA cannot provide a reliable means of comparing similar products (eg one smart phone with another). This is primarily because of the degree of uncertainty associated with LCA outcomes. Many choices and assumptions have to be made for complex products, and the use stage emissions are highly variable for many products. This is particularly problematic if LCA is to be used at the point of purchase for consumer information on environmental performance or ecolabelling because LCA includes the use phase which has not yet occurred and is in many cases dictated by the user. LCA is also an unsuitable tool for assessing the carbon impact of the ICT sector as a whole because it relies on setting boundaries that do not actually exist.

Therefore, attempts to use LCA based methodologies as a basis for setting energy benchmarks at sector level, for taxation or for ecolabelling as a means of product comparison are misguided. LCA is simply the wrong tool. Moreover, placing unrealistic expectations on LCA based approaches distracts attention from the very significant value they can bring in helping us to identify, estimate and manage the carbon impacts of ICT products and services.

The fact that we want – or need- to do something does not automatically mean that it is possible. LCA-based methodologies are not designed to provide all the answers. The good news is that LCA based methodologies are providing vital insights in certain areas and if allowed to evolve and develop, will play an increasingly important role in strengthening our understanding of the energy performance of our industry.

That should lead us to re-examine the original question. Do we really want to calculate the total carbon impact of the ICT sector, bearing in mind that it is a sector that is notoriously difficult to define in a meaningful way and that also presents a rapidly moving target to analysts? Or would it be more productive to identify the most carbon intensive activities associated with that sector's products and processes so we can direct attention accordingly? LCA cannot satisfactorily address the first question but it is perfectly suited to provide the answers we need to the second.

Contents

1. Introduction

Anyone familiar with The Hitch-Hiker's Guide to the Galaxy will know that the answer to the Question of Life, the Universe and Everything is 42. It took an extraordinary amount of effort, and millions of years of computing, to achieve this figure. Sadly, the answer was something of a disappointment to those who had posed the original question, partly because they were all dead long before the calculations were complete.

How we evaluate the carbon impact of ICT is another Very Big Question. It may take a very long time to calculate the answer and when we do succeed, the result may not tell us what we want – or more importantly, what we need - to know. So it seems sensible to articulate very clearly exactly what we do want to know, and in the light of this, examine whether the approaches we are taking are likely to meet this requirement.

Currently, numerous standards bodies and industry consortia are working on methodologies to evaluate the carbon impact of ICT products, networks and services. Some also aim to address indirect effects (see Box 1) and some aim to estimate the footprint of ICT at an organisational level or a project level. Some even provide methodologies that aggregate the results to reflect the impact at city, country or sector level.

This paper looks at the various methodologies on offer or in development and then compares their capabilities and objectives with the expectations of the various stakeholders: government, industry and academia. Are our expectations realistic? Will existing approaches tell us what we want to know? Do we even need to know what we think we want to know? Are we using the right tools for the job or are we knitting with teaspoons?

Box 1: Indirect Effects

ICT is unusual as a sector because it has the capacity to deliver energy reductions across the wider economy. Emissions resulting directly from the use of ICT (eg from electricity consumption) are usually called direct effects. However, the use of ICT may have indirect effects in other sectors, for instance a logistics software application may enable a freight operator (transport sector) to reduce fuel consumption, or a teleconferencing facility may reduce transport emissions for a business (industry sector). Indirect effects are caused by using ICT and may be positive (intended) or negative (unintended). Enabling effects tend to describe positive effects only – i.e. the carbon savings that are enabled by ICT. Negative effects, those that increase carbon emissions, tend to be described as rebound effects. Some people use the terms "primary and secondary" as another way of describing (respectively) direct and indirect effects.

2. Why should we care about the carbon impact of ICT?

We do need to know more about the carbon impact of ICT for the following reasons.

2.1 Because the sector is large, so the impact is significant, and it is growing. Although the sector is improving energy efficiency very quickly, it is also growing quickly, and if this growth is very rapid then the net impact of ICT could increase. We need to be able to identify not just the main impacts but how they are changing over time so we can focus attention in the right places.

2.2 Because ICT is rather unusual. ICT is one of only a handful of underlying infrastructures that will fundamentally shape our carbon consumption for decades to come. ICT uses energy at all stages of its life-cycle. So ICT has its own carbon footprint, which must be minimised, but it also has the capacity to deliver emissions reductions across the wider economy, (see box 1) by improving efficiency in existing processes (eg logistics or energy management in buildings) or by enabling dematerialisation (eg electronic commerce and travel substitution). So what we really need to know is the net impact of ICT, that is, the emissions associated with ICT minus the emissions reduced or avoided by the deployment of ICT. But to estimate the net impact of an ICT product or service we first need to know more about the direct impact of ICT.

2.3 Because ICT is horizontal and pervasive (i.e. the sector is hard to delimit). ICT is as integrated across other industry sectors as engineering, so it is incredibly difficult to identify and then evaluate emissions associated with ICT as opposed to those attributable to other sectors. So the software that helps to operate a car or programme a washing machine has to be attributed to one sector or another. Methodologies for carbon footprinting ICT help to identify where boundaries should be set and provide consistency in terms of defining scope[6]. Moreover, within ICT itself, the systems that applications or devices rely on may have multiple functions so it is often unclear where the energy impact of one entity ends and another begins.

2.4 Because ICT enabled technologies tend to be disruptive technologies – they change behaviour. That means that whatever impact they have – for good or ill – can be magnified by this behaviour change, so it is important to understand whether an intensification of a particular activity will have a significant or negligible effect on overall emissions so we can target attention accordingly.

2.5 Because ICT is to some extent an energy iceberg. For many ICT devices some of the energy demand in the use stage is invisible to the user. When powering a fridge or a car, the user sees the energy cost at the petrol pump or on the electricity bill, but many ICT devices depend on a network or networks that themselves use energy. A Kindle, a phone or a computer with email all depend on communications networks and data centres to move, manage, process and store the information that is accessed or exchanged by these devices. Systematic footprinting studies help us understand the total impact of a device, as opposed to its visible impact.

2.6 Because ICT tends to be rather emotive – stimulating responses from evangelical to fear and distrust – and we need to obtain a more objective view, backed up by facts rather than conjecture. Far too much rubbish is talked about the carbon impact of ICT and we need to set the record straight. Better data would provide the evidence needed to inform the policy making process, helping to ensure that policy tools are appropriately designed and implemented.

6 Even the OECD definition of ICT includes a whole range of consumer electronic (CE) products that many would not expect to see classed as ICT.

3. How do we measure it? Bottom-up or top-down?

3.1 Alternate approaches

Simplistically speaking, there are two approaches for measuring the carbon impact of ICT at a macro level: bottom-up and top-down. But what do these terms really mean? They tend to be used rather loosely and the boundaries between them are rather blurred since in reality it is often necessary to use hybrid approaches which to some extent combine the two. For our purposes, however, we can categorise them very approximately as follows.

3.1.1 Bottom-up

Aggregating, or synthesizing, data from many individual results to produce a general result is called a bottom up approach. The bottom-up approach tends to work at a granular level, examining individual characteristics of a product or service in detail, often using life cycle assessment (LCA - see box 2 and diagram 3.1). When applied to ICT there is an assumption that the results of these individual LCAs can in theory be multiplied or aggregated to give a meaningful idea of the cumulative impact of lots of devices, networks or services, and that this in turn can provide an estimate of the impact of the ICT sector as a whole.

At the data collection level, the bottom-up approach would probably use a combination of primary and secondary data. Primary data is data that you have collected at source yourself. Secondary data, in the form of secondary emissions factors (see Box 3) can be obtained from a range of sources such as PE international[7], EcoInvent[8], or JRC[9]. Practitioners then apply software tools such as SimaPro[10] or GABI to help them calculate LCAs. In practice, bottom up approaches might also take a representative approach in which the different equipment types are identified and their energy characteristics modelled.

Box 2: What is LCA?

LCA, or Life Cycle Assessment, (sometimes called life cycle analysis) looks at the environmental impacts made by, say, a product over its whole life, usually broken into different stages, such as raw material extraction, manufacture, distribution, use and end-of-life. Life cycle assessment can cover a range of environmental impacts such as use of resources or raw materials, waste or biodiversity. Many focus on selected impacts such as water or carbon. This paper focuses on LCAs that evaluate carbon or GHG impacts. LCA can be applied to products or services. LCA has been used for at least 30 years and was developed in academia to analyse the environmental impacts of products - eg roses or tomatoes flown in to the UK compared to those grown in heated greenhouses. The ISO has produced general standards for conducting LCAs; ISO 14040 and ISO 14044. The ICT sector and other stakeholders are using the ISO standards as a basis for more specific LCA methodologies for assessing the carbon (and other) impacts of ICT products and services.

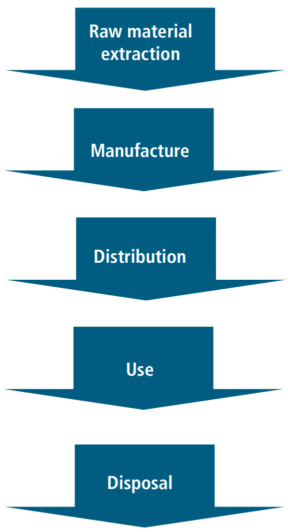
Box 3: Secondary Emissions Factors, LCI databases and LCA software tools.

Secondary emissions factors are available from life cycle inventory (LCI) databases and are essentially data on the emissions associated with a whole range of materials such as steel or plastic. LCI databases supply the basic data used by LCA practitioners.
A number of organisations such as EcoInvent, JRC and PE International provide LCI databases of emissions factors for thousands of products and materials. JRC provides the ELCD database which is available freely. The others are proprietary.
Secondary emissions factors are widely used but provide secondary data, which may not reflect the exact characteristics of the material when used in your product or your supply chain. If you want primary data then you have to get it yourself, which is extremely time consuming.

LCA Software tools

Practitioners use LCA software tools to do the modelling and computing of products and systems from a life cycle perspective. For example PE licences software called GABI and PreConsulting licences software called SimaPro, though there are many other alternatives.

Diagram 3.1 Typical stages in LCA



7 www.peinternational.com provide GaBi software for product LCA which provides an LCA tool and access to two databases – PE's own database and the Ecoinvent database, plus optional additional data
8 www.ecoinvent.org publish Ecoinvent database of LCA data
9 http://lct.jrc.ec.europa.eu/ Joint Research Council of the European Commission provide the ILCD handbook and the ELCD (European Life Cycle Database) ELCD: http://lca.jrc.ec.europa.eu/lcainfohub/datasetArea.vm
10 http://www.simapro.co.uk/ SimaPro is LCA software provided by PRé Consultants

3.1.2 Top-down

A top-down approach starts with data collected at a corporate, industry or network level and then applies assumptions and modelling techniques to extrapolate total energy use and estimate the embodied carbon (See Box 4). The top down approach tends to be used by consultancies. Some have attempted to footprint the whole ICT sector – among the most widely referenced are the 2007 Gartner study[11] and GeSI's 2008 Smart 2020 report[12].

3.2 Practical applications

For example if we wished to measure the carbon impact of all our telecoms networks, the bottom-up approach would examine all the components of the network – which could involve identifying every router, its model number, date of manufacture, its power consumption and its embodied energy - and add them all up for each network operator and then aggregate all those figures to reach a total. The top down approach might start by estimating the total energy used by network operators (who are likely to know their energy consumption). Then energy patterns of the phone users would also have to be modelled and added to give a total figure for use stage. Some assumptions might then be applied to calculate a proxy for the embodied carbon. The top down approach tends to combine high level data and modelling.

3.3 Disadvantages

The disadvantages of the bottom-up approach are fairly obvious – it is intensely time consuming and costly and for studies relying on primary data it may be impractical, if not impossible, to identify and evaluate every single component in a complex network. Double counting[13] is also a particular risk when aggregating individual studies. While it is conducted at a more granular level, a bottom-up approach is not necessarily more accurate than a top-down approach because assumptions still have to be made when aggregating the number of components in a larger network or across a number of networks. Moreover, if the carbon impact of those components is inaccurate, that inaccuracy will be magnified by the aggregation. In such cases a top-down approach may well be more accurate.

However, top-down approaches also have their disadvantages. The validity of the assumptions may depend on the sample size used. The models used are not always robust and the approach may not be transparent, particularly if it involves a proprietary methodology. While assumptions are usually published, any lack of transparency means that it would be very difficult for a third party to duplicate or test the approach. If an update or a comparison of carbon impact over time were needed, then one could say that this study could only be conducted by the same organisation that conducted the previous one and even then, technological changes would make the original models and assumptions obsolete, so new assumptions would have to be used and the models would have to be adapted[14].

Box 4: Embodied carbon

The definition of embodied carbon varies depending on who you ask. For the purposes of this document, we use the definition applied by the WRI GHG Protocol ICT sector guidance. In this case embodied carbon is all the carbon emissions associated with a product or service over its full life cycle EXCEPT those associated with the use phase. The reasoning behind this is to be able to separate out the use stage from the other stages as the use stage firstly can dominate the other stages; secondly is out of the direct control of the manufacturer; and thirdly is subject to greater variability.

Some definitions of embodied carbon exclude the disposal stage, taking the view that the embodied carbon represents the carbon associated with the product at the point of purchase or first use. Others exclude the transport stage too. Although embodied carbon is not actually physically bound into that product, it is the carbon emitted as a result of making that product. It is invisible to the user but nevertheless a real consequence of producing the product.

For many, embodied carbon provides the most rational basis for comparing products because use phase consumption is affected not just by usage patterns but also by the carbon intensity of electricity generation in the country of use. The problem is that the use phase is often the most significant.

11 http://www.gartner.com/it/page.jsp?id=503867
12 http://www.smart2020.org/publications/
13 Double counting happens when the carbon impact is counted twice. Software in a car could be counted as part of the car's carbon impact or part of the IT supplier's carbon impact. If it is counted as both then it has been double counted. The three GHG scopes essentially organise emissions into levels according to their exposure to double counting.
14 One other major issue with the top down approach for, say, a telecom network application, is allocating the service under analysis over the portion of the network responsible for delivering that service (either by a single service provider or over multiple networks and/or service providers).

3.4 Choosing an approach

The important message from this is that both approaches have advantages and drawbacks, but that it is wrong to assume that a less detailed approach is necessarily less accurate. The approach needs to match the objective of the study. So if you are trying to assess the carbon impact of a specific product or individual component, then a detailed LCA based approach would seem appropriate. If you are trying to assess the aggregate impact of a number of different products in a market, then a top down approach using estimation techniques, or a combination of top-down and bottom-up, may well be more valid than a bottom up approach that aggregates a lot of detailed studies.

In reality, most studies, whether product LCAs or attempts to estimate a sector level carbon footprint (see box 5), use a combination of approaches. Sector level studies that combine both approaches include Malmodin et al 2010[15]. And even in a product LCA where data is gathered bottom-up, some data will be allocated top down from company level: e.g. amortising the energy consumption of a factory across the products it manufactures.

Box 5: Carbon footprinting vs. LCA

Carbon footprinting – strictly speaking – relates only to carbon emissions associated with a product or entity. Carbon footprint is sometimes expressed as GHG emissions, usually in the form of CO_2e[16] and sometimes as CO_2 emissions. Unlike an LCA, a carbon footprint can be expressed as a single number: eg your personal carbon footprint is likely to be between 3 and 15 tonnes CO_2 per year. GHG protocol scopes 1, 2, and 3 help provide a framework for calculating carbon footprints.

In general, you can calculate or estimate the carbon footprint of an organisation but you do not tend to use LCA for organisations, because an organisation does not usually have a "cradle to grave" lifespan in the way that a product does, so you are missing a critical set of boundaries. The same applies to calculations at sector level. Generally it is agreed that neither company LCAs nor sector level LCAs can be derived by simply adding up product LCAs.

15 Malmodin J, Moberg Å, Lundén D, Finnveden G, Lövehagen N. (2010) Greenhouse gas emissions and operational electricity use in the ICT and Entertainment & media sectors, Journal of Industrial Ecology, vol 14, issue 5, pp.770-790, October 2010

16 CO_2 is not the only GHG. GHGs vary in their global warming potential. A tonne of methane is equivalent to around 70 tonnes of CO_2. CO_2e (carbon dioxide equivalent) is a common notation used to indicate the cumulative impact of different greenhouse gas emissions.

4. A quick overview of current approaches

4.1 LCA Family Hierarchy

It is possible to view current approaches to LCA as a family hierarchy (see figure 4.1, below). At the top are the generic ISO standards 14040 and 14044. These deal with all environmental impacts and provide a framework for examining the lifecycle[17]. These standards are generally not prescriptive in terms of what LCA can and cannot be used for, although they place clear restrictions on the use of LCA for comparative purposes. While they mandate the need to consider complete lifecycles, defining the goal of the study is part of the process itself, so to some extent LCA can theoretically be used for different purposes depending on how the objectives are defined.

Below these generic standards are more prescriptive standards such as PAS 2050 or the GHG Protocol product standard which have narrowed the scope from environmental effects to one specific impact – climate change (technically greenhouse gas emissions (GHG) generally expressed as CO_2e, colloquially expressed as carbon). Then there are sector specific standards and methodologies which set out supplementary requirements for ICT related goods, networks and services.

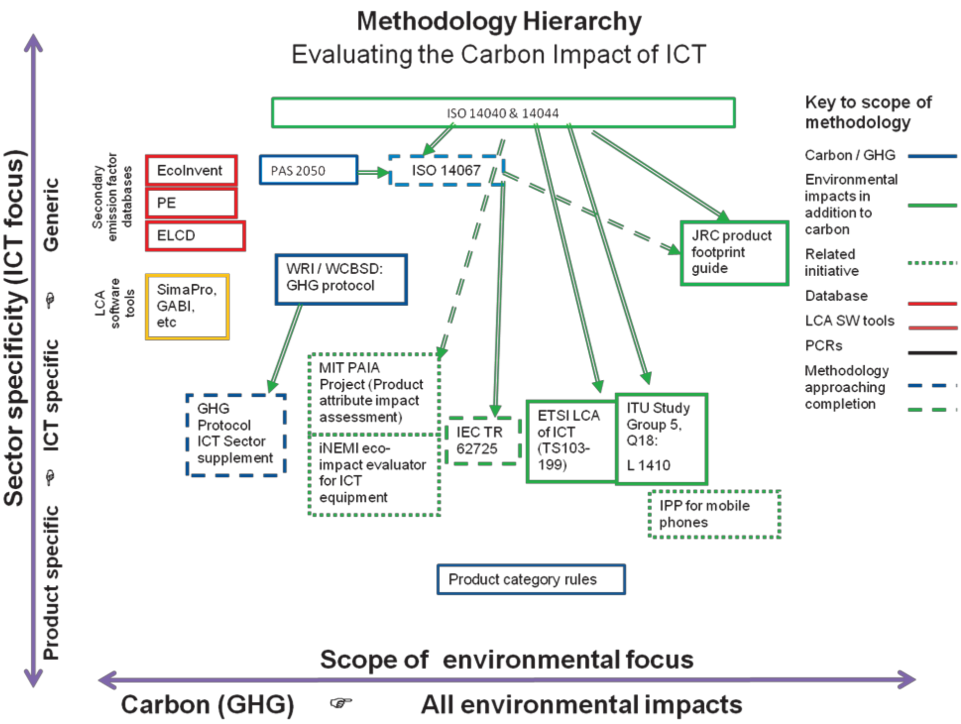
Some of these are specific to carbon and others are not. Then below these are product category rules which tend to be very specific and set clear boundaries both in terms of what is measured and how a given product is defined. (See Box 6 and diagram 4.1)

Box 6: What are Product Category Rules?

Product Category Rules (PCR) provide guidance for collecting data and other information relating to products. They include information on how the calculations should be conducted in order to translate the data into impact on climate and how the resulting information should be presented. They explain how to set boundaries, what should be included and what should be left out of the study and help with product definitions. PCRs tend to be developed collaboratively by industry. PCRs exist for some ICT products but not others.

Each unique product could in theory have its own product category rules but this would lead to a plethora of different documents, so a more simplified approach is adopted – i.e. by category. This is because PCR can be significantly simplified if product groups share raw materials and components and in such cases more general rules can apply to a larger number of products. Even though PCRs are intended to help make studies more comparable, the extent to which they can do this is limited.

Diagram 4.1



[17] This framework tends to follow a similar pattern which includes most or all of the following steps: set goals and define scope, inventory analysis, impact assessment, interpretation, reporting and critical review.

Diagram 4.1 maps some of the different methodologies and related initiatives. The vertical placement indicates how specific they are to ICT, with the more generic approaches at the top and increasing specificity as one goes down. The x-axis gives an idea of environmental focus with the methodologies arranged very roughly according to their level of environmental specificity. Those specialising in climate change (for which carbon is used as the colloquial proxy) are on the left and those that cover a wider range of environmental impacts further along the x-axis. This diagram is only indicative and does not attempt to be comprehensive or exact.

As the map shows, organisations that have recently published, or are currently developing, standards, methodologies or approaches to measure the carbon impact of ICT include the ITU, ETSI, the IEC, and consortia led by MIT (PAIA), iNEMI and the Greenhouse Gas Protocol, all of which are explained (along with their acronyms) in more detail below.

4.2 How methodologies for measuring ICT fit together

The current approaches considered in this document have common characteristics. All are based on, or to some extent build on, existing LCA approaches such as ISO 14040 and IS0 14044 or the GHG Protocol Product Standard (which itself is based on the ISO standards). These are then tailored or adapted to clarify ambiguities or resolve specific problem areas related to ICT which could otherwise introduce too much uncertainty into the calculations and results. It is probably fair to say that the less prescriptive the approach, the wider scope there is for variability in results. That is why specialised versions are needed if we want to look in detail at a particular sector. The GHG Protocol has already published sector specific guidance for other sectors such as forestry.

4.3 Overview of current and emerging methodologies to evaluate the carbon impact of ICT

4.3.1 ITU-T L.1410 and L.1420

ITU-T is the Telecommunications Standardisation Sector of the International Telecommunications Union, an agency of the UN and responsible for coordinating global telecommunications standards. These two standards are part of an emerging suite of standards all relating to the carbon footprint of ICT. L1400 provides an introduction, L1410 covers goods, networks and services, L1420 covers ICT in organisations, L1430, L1440 and L1450 will cover ICT in projects, cities and countries respectively. This is an LCA-based approach, focusing on GHG, that is compatible with globally recognised LCA standards ISO 14040 and 14044, among others. Essentially the ITU is tailoring existing approaches to ICT by making the process more prescribed and reducing ambiguity and the potential for variance in results.

4.3.2 ETSI TS103-199 LCA of ICT equipment

ETSI is the European Telecommunication Standards Institute, a non-profit standardisation body with 700 members spread across 62 countries and five continents. As with other approaches, the objective of this standard is to address the lack of consistency in LCA results for ICT using globally recognised approaches like ISO 14040 and 14044 and the ILCD handbook, while remaining compatible with them. Again, the idea is to reduce ambiguity and encourage consistency and transparency through a more prescribed approach. Work started in 2008 and was completed in 2011 and the resulting ETSI standard is more specific to ICT than generic standards but less specific than product category rules (see Box 4) for devices.

4.3.3 IEC (TR 62725 and TR 62726)

The International Electrotechnical Commission (IEC) is a leading standards body for electrical and electronic technologies. The IEC's Technical Committee 111 is developing environmental standards and this approach (termed a technical report) is intended to provide users with guidance to understand current standards and special electro-technical considerations related to carbon footprinting, when quantifying the GHG emissions on a lifecycle basis for any type of electronic or electrical product. The approach follows nine basic steps and is based on the results of a comparative study on existing methodologies such as ISO/DIS 14067, ISO 14040/44, ITU-T L.1400, GHG Protocol. TR62725 provides guidance for calculating GHG emissions and 62726 deals with reductions of GHG emissions from a baseline[18].

4.3.4 GHG Protocol Product Standard ICT Sector Guidance

The Greenhouse Gas Protocol is the most widely recognised international accounting tool for quantifying greenhouse gas emissions and is the product of a partnership between the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD). The ICT sector guidance is an industry -wide initiative launched in March 2011 involving WRI, WBCSD, the Global e-Sustainability Initiative (GeSI) and the Carbon Trust.

18 TR 62725 Quantification methodology of greenhouse gas emissions for electrical and electronic products and systems. TR 62726 Quantification Methodology of greenhouse gas emission reductions for electrical and electronic products and systems from the project baseline.

The initiative is developing practical sector guidance for the GHG assessment of ICT goods and services, to support the GHG Protocol Product Accounting and Reporting Standard. The Sector Guidance focuses on ICT services, with chapters on Telecoms Network Services, Desktop Managed Services, Transport Substitution, and Cloud Services. There are supporting chapters covering hardware, software and data centres. The draft methodology was published for review in March 2012.

4.4 Related Initiatives

Some initiatives are not intending to develop methodologies but are nevertheless playing an important role in this area. Current approaches include the PAIA and iNEMI initiatives and it also worth mentioning the IPP project, an earlier initiative that focused on mobile phones.

4.4.1 MIT PAIA Project (Massachusetts Institute of Technology Product Attribute Impact Assessment)

This is an industry-led research initiative that simplifies the difficult task of conducting an LCA without sacrificing rigour. The approach matches the level of accuracy to the required outcome. PAIA primarily looks at, but is not restricted to, GHG. Broadly speaking the objective is to develop information on the carbon impact of products based on their component parts. The ultimate objective is to relate ICT product characteristics to environmental performance and help industry identify priority areas for improvement.

The PAIA project differs from other approaches in that it is not aiming to produce a standard and it is not a methodology, although it uses existing methodologies. The project uses data from participating companies and secondary emission factors from third party sources. Statistical analysis generates an estimate of the carbon impact at a component level together with the standard deviation (effectively the error margin). So far, work has focused on laptops. Essentially, for a laptop with known components the PAIA project enables the footprint to be estimated without the need to calculate it from scratch. The results are therefore based on hardware characteristics but may not capture the specifics of the production process.

In addition to the specific data that has been generated for individual components, common findings have emerged that are providing valuable insight into the carbon impact of ICT. PAIA results confirm what LCA practitioners have known for some time; that the most significant impacts of a laptop are consistently the number and size of processors, the size and type of circuit boards and the size and type of screen display. The casing, hard drive, power supply and other optical drives emerge consistently as secondary impacts.

4.4.2 iNEMI Eco-Impact Evaluator for ICT Equipment project

Led by the International Electronics Manufacturing Initiative (iNEMI), an industry consortium, this project aims to provide a simplified means of determining the main environmental impacts of ICT products through their lifecycles (and therefore identify the best opportunities for improvement). The focus is on embedded carbon, plus data collection and modelling of components. The objective is to define the most significant components or processes and develop a framework and calculator to estimate carbon footprints. This project aligns with the Eco-Sustainability Summit's Life Cycle Analysis Team and their desire to develop simplified tools for deriving information on the key environmental impacts of ICT. The project will provide an estimator tool to categorise products or assets and establish a standard format for requesting LCA information from suppliers. The objective is to demonstrate measureable improvements within the supply chain.

To put the PAIA and iNEMI projects into perspective, think of two differently branded laptops as an example. They may comprise many identical components, right down to the factory where the parts are produced. It makes little sense to compare the two through a full LCA if all the most carbon intensive components within them are exactly the same. The PAIA and iNEMI approaches remove the need for the full LCA without compromising the accuracy of the results.

4.4.3 IPP (Integrated Product Policy) Pilot Project on Mobile phones

This European Commission project involved a cross section of the mobile phone industry (phone and component manufacturers, telecom/network operators, academics, recyclers, NGOs and policy makers) and was led by Nokia. The objective was to use life cycle thinking to drive environmental improvements in products. The first phase involved a life cycle assessment of the environmental impact of mobile phones and this was followed by successive phases which included both policy approaches and industry initiatives to improve environmental performance. The LCA stage demonstrated that the main energy impacts of a mobile phone are consistently the printed wiring board (PWB), the integrated circuit (IC) and the liquid crystal display (LCD). In the use phase the standby power consumption of the charger accounted for the greatest environmental impact. The project report concluded that KEPIs (key environmental performance indicators), validated as the most important environmental impacts of an electronic product's life cycle, provide a good and simple assessment tool, but need revalidating at intervals[19].

19 See: http://ec.europa.eu/environment/ipp/mobile.htm

5. What can - and can't - LCA be used for?

5.1 What can LCA be used for?

In general, LCA based methodologies can be used to:

1) identify points or stages in the lifecycle of a product or process that are carbon intensive (or have other environmental impacts) and by so doing, identify where reduction efforts should be focused;
2) estimate changes in the environmental impact of a product or process over time;
3) compare broad impacts in different industries (eg how much carbon is involved in the production of a radio compared to producing a pint of milk);
4) compare different supply chains for the same products (eg imported vs. home grown tomatoes, imported vs. home reared lamb);
5) compare products that perform the same function using different technologies (eg hybrid or electric vehicle compared to conventional petrol vehicle, book compared to e-reader);
6) set the record straight on some of the misconceptions regarding the energy impact of ICT by providing more objective figures;
7) inform ecolabel development (eg LCA might reveal a hotspot in the lifecycle of a product which would in turn indicate a priority area for the application of performance standards) See also point 11;

5.2 What can't LCA be used for?

A worrying trend seems to be emerging in terms of the expectations that stakeholders are placing on the various methodologies currently being developed, expectations that these approaches were not designed for, and which practical experience suggests they are not suitable for. For instance, some stakeholders anticipate that the approaches considered in this paper will enable us to:

8) aggregate individual LCA studies to derive a figure for the total carbon impact of ICT and use this figure as a benchmark for reduction targets;
9) aggregate individual LCA studies to derive a figure for the total carbon impact of ICT and compare this to the indirect impacts of ICT to derive a net figure;
10) use LCA study results to compare ICT and CE products head to head (i.e. laptop A against laptop B, smartphone X against smartphone Y) in terms of their carbon impact;
11) use LCA study results as a basis for ecolabelling products or for setting environmental taxes.[20]

5.3 Why and why not?

It is clear from points 8-11 that expectations are very high regarding the kind of information these methodologies can deliver. But are these expectations realistic? The answer is no. In fact, currently, LCA based approaches can do none of these things reliably enough for the results to be used as the basis for decision making – and that is the key point, which we will address later. The following table lists some of the expectations and indicates whether they are feasible or not, with short explanations.

20 There is an important differentiation to make between the use of LCA **to inform** ecolabel development and the use of LCA results **as a basis** for ecolabelling. See also table 1.

Table 1: Traffic light Spectrum of what LCA can and cannot be used for

Objective/goal	Feasible?	Conditions/issues/remarks/examples
Identify the environmental impact of points or stages in the lifecycle of a product or process to identify where reduction efforts should be focused.	Yes	
Estimate changes in the environmental impact of a process or product over time.	Yes	There is a tendency for those having conducted LCAs to publish figures without stating clearly the assumptions/conditions, and for those interpreting LCA results not to examine those assumptions or apply the necessary conditions. The danger is that once a number is published, only that number, and not its context, is publicised. (see below under "the way we use numbers").
Compare broad impacts in different industries and supply chains (eg how much carbon is involved in the production of a car compared to producing a pint of milk.)	Yes	
Compare the environmental impact of different supply chains for the same product.	Yes	This is where much LCA work has previously been focused.
Compare products that perform the same function but rely on different technologies.	Yes	Differences may not be clear cut.
Set the record straight on some of the rubbish talked about ICT by providing more objective figures.	Yes	LCAs are systematic rather than emotive and demonstrate that we can't necessarily rely on instinct. eg an LCA-based approach could kill off the erroneous media perception that a Google search uses the same energy as boiling a kettle (in fact it uses around 0.2%)[21].
Estimate the net impact of a given ICT service, taking into account the direct effects (the carbon emitted as a result of using ICT) and the enabling effects (the benefits of applying ICT-enabled carbon reduction strategies).	Yes, under certain conditions.	This could really only be done on a case by case basis, but it can be very effective in assisting decision making in organisations. Eg. a multinational company replacing internal face to face meetings with virtual presence technologies.
Identify and prioritise larger scale (eg corporate, industry or policy) initiatives to identify environmental impacts and prioritise action.	Yes, under certain conditions.	A large CE manufacturer did a limited LCA of all their products (manufacturing, logistics and use) and established that 4% of the carbon impact was in manufacturing, 1% in logistics and 95% in the use stage of their products[22]. This focused their R&D on making their products more energy efficient, as they knew that improvement here would be most effective in reducing overall emissions[23].

21 A 2KW kettle takes about 4.5 minutes to boil when full which equates to about 150Wh (you can test with your own kettle, a watch and a portable appliance tester). Average Google query, including building the search index, uses 0.3Wh. 150Wh/0.3Wh = 500, or 0.2% (See http://googleblog.blogspot.co.uk/2009/01/powering-google-search.html#!/2009/01/powering-google-search.html)

22 A full LCA was conducted on a small number of products and the raw material extraction and disposal stages did not significantly alter these results.

23 This suggests that the European Commission's legislative focus on the in-use energy demand of CE and ICT products is the right approach, from an LCA perspective.

Objective/goal	Feasible?	Conditions/issues/remarks/examples
Extrapolate individual results to sector level in order to focus activity/policy.	Not reliably.	It is useful to know where the main impacts lie in order to direct policy but in sectors where technology is developing fast, data is soon obsolete. Policy making is not known for its ability to keep pace with technology.
Use individual results to derive a figure for the total net impact of ICT - i.e. direct impacts minus enabling effects.	Not really.	This can only be done on a case by case basis and aggregating both sets of results would be impossibly complex, most probably generating error margins well in excess of the estimated impact.
As a basis for eco-labelling products for consumers.	No, but LCA can inform ecolabel develop-ment.	LCA results are too variable to be used as a basis for ecolabelling or product comparison, particularly because the use phase has not started at point of purchase. However, LCA can inform ecolabels (and other standards such as ecodesign) without necessarily linking the actual standards to LCA calculations. For instance, technical staff responsible for developing standards take into account available LCA studies in their preparatory work (which for example might show that a certain component or life cycle stage represents an impact hot spot which in turn would indicate that the standards should cover that component or stage in some way).
Compare products between manufacturers	No	A decision making process has to rely on robust evidence. LCA results may be accurate enough to compare milk with peanuts but are not robust enough to reliably compare one kind of laptop or smart phone with another, for instance because of differing assumptions, the use of secondary data and uncertainty in data. Some say that a very limited degree of comparison could possibly be made for products with strict PCRs but even then the margin of error is likely to be too great to enable decision making between similar products and there are issues with data, tools etc.
Calculate the total sector footprint of ICT	No	LCA provides a value for a clearly defined product, process or service over its life. LCA is an unsuitable tool to use at sector level because a sector, just like a business, does not have a physically or temporally defined life-cycle in the way that a product does. Aggregating products and service LCAs to try and estimate a value for the sector is unrealistic in a sector that is horizontal and pervasive (ICT is similar to engineering in this sense). Even if it were possible, such an approach would have to include a huge array of assumptions with a high error margin. There is also the very problematic issue of allocation in a horizontal sector (eg how you decide whether car software is an IT emission or a transport emission).
Derive a sector footprint to use as a benchmark to set sectoral reduction targets.	No	See above. Moreover, setting absolute reduction targets for a rapidly growing sector is problematic. Carbon productivity[24] would be a far better measure. Also, ICT is a derived demand and should therefore be evaluated in terms of what it delivers (i.e. its net impact).

24 Carbon productivity is the amount of GDP (or occasionally, other output) produced per unit of CO_2 emitted.

6. Why isn't LCA the answer to life, the universe and everything?

The reasons that LCA can never be the answer to Life, the Universe and Everything boil down to two things: uncertainty (variability and opportunity for error) and the way we use numbers. It might seem logical if you can use an LCA to identify the carbon impacts of a product at a detailed level, that you should then be able to use that information to compare different products or compare similar products produced by different companies or aggregate the results to get a better idea of the impact of a large number of products. But actually, it is all far more complicated than that.

6.1 Uncertainty

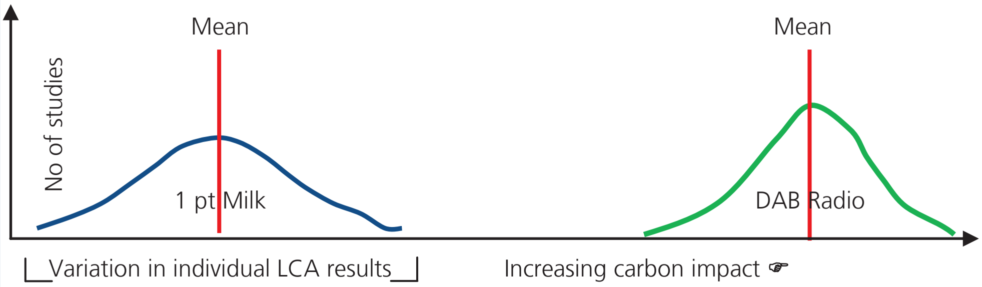
Uncertainty is related to variability and/or error. Variability means that results are different despite being correctly derived. Error means that the results are wrong or inaccurate. In practice, we cannot compare similar products on the basis of LCA because of the uncertainty, and therefore the lack of consistency, of LCA results (see box 7).

6.1.1 Variability

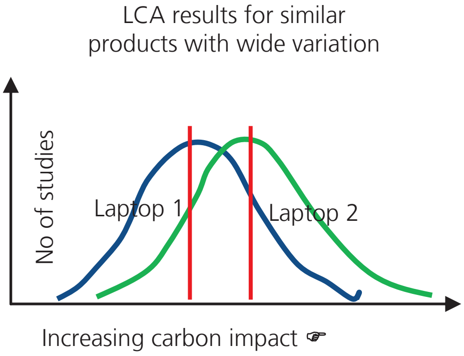
Although, as explained earlier, more prescriptive approaches to LCA help to improve consistency in results (by reducing uncertainties, setting boundaries and scope, and resolving ambiguities), they can't eliminate variability. This means that while LCA can be reliable in identifying the most carbon intensive part of the lifecycle, there are limitations to the way that results can be used or interpreted.

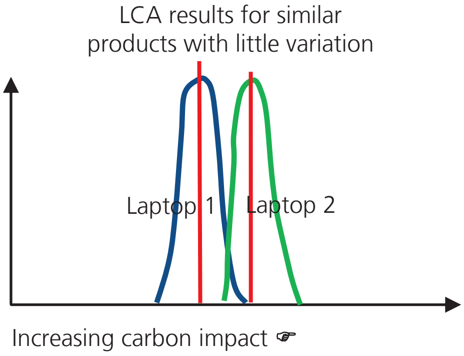
Box 7: Variability

Take a look at some imaginary distribution curves for LCA results, which illustrate this point. The first shows LCA results for milk and DAB radios. On the basis of these results one could confidently say that a DAB radio has a greater life cycle carbon impact than a pint of milk. This is because there is no overlap between the distribution curves – in fact there is a significant gap between them - so even the most carbon-intensive pint of milk has a lower carbon impact than the most efficiently produced radio.



The next two diagrams (below) show the kind of results you might get for more similar study subjects, for example laptop computers, where there is much less difference between the mean values for the LCAs. In the first of these two the variability of results is quite large and the overlap between the two results sets is very significant. Even when the variation is minimal (as depicted in the right hand diagram below) there is still some scope for misleading results if decision making is based on the mean values. Such a small variation, however, is not very likely for complex devices, as we will see later.



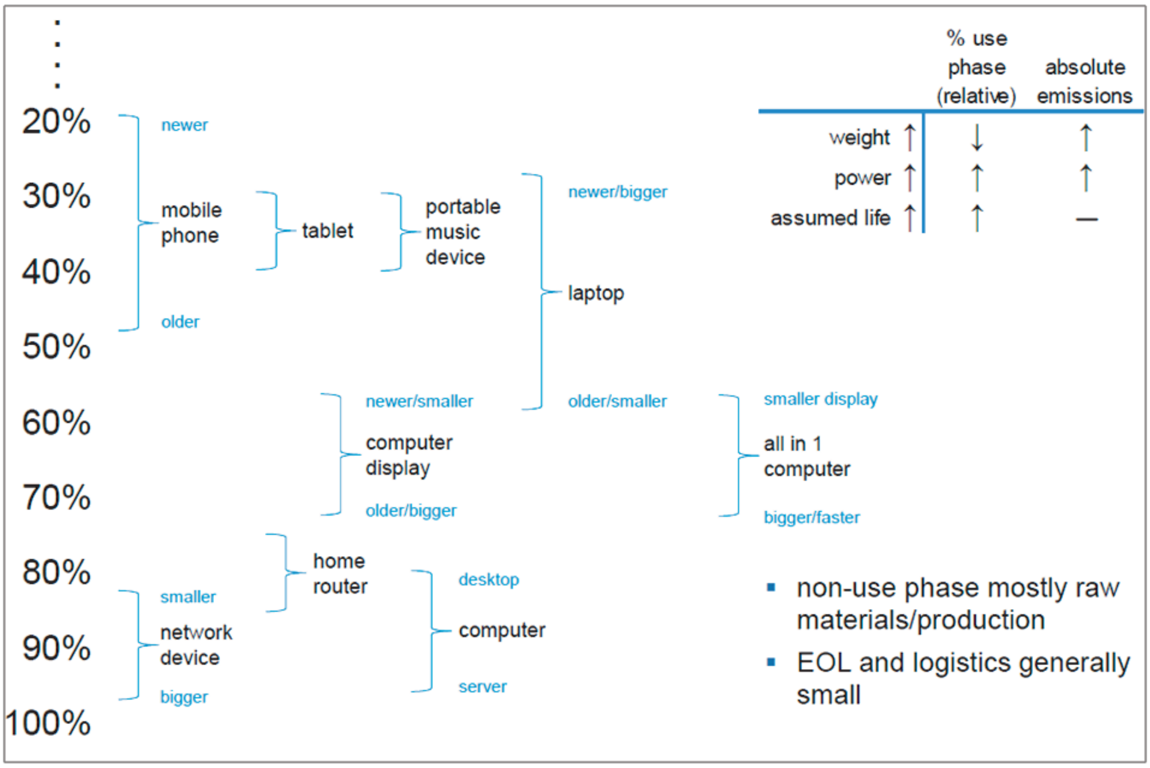


(Red line indicates the mean value, green and blue curves represent different products)

One of the strengths of LCA is its tendency to throw up unexpected results – results that demonstrate the benefits of systematic analysis over assumption. The downside to this is that it is harder than one might expect to make generalisations on the basis of LCA results because it can be rare for clear cut differences in results between products and processes to be consistent enough to allow generalisations to be made. For example, it is possible to say with confidence, as a result of LCA, that meat production for food is significantly more carbon intensive than vegetable production, but other LCA results are often less clear cut. Orange juice would be a good example. One might expect juice made from concentrate to be less carbon intensive than fresh orange juice but the outcome actually depends on the exact combination of factors applicable in each case, including the carbon intensity of the electricity used to concentrate the juice. In this case, as in many others, it all depends on the unique characteristics of the individual supply chain. Applying a generic rule of thumb on the basis of an isolated LCA study would be misleading, and, if decisions are made on this basis, unhelpful at best and counterproductive at worst.

Diagram 6.1 shows the variability between different published LCAs for a range of ICT devices and components. The data for this chart was taken randomly from a web search of LCA results and is not comprehensive – it merely demonstrates that if you search for LCA outcomes for specific products you get lots of different results. The y-axis indicates the percentage of total lifecycle carbon emitted in the use stage. So for a laptop, the percentage of carbon attributable to the use phase appears to vary from about 25% to around 60% and mobile phones from about 20% to 45%[25]. Even for devices like routers where use patterns are consistent, there is 10% variation in LCA results just for this one stage, and this is before you add variation in each of the other life stages.

Diagram 6.1



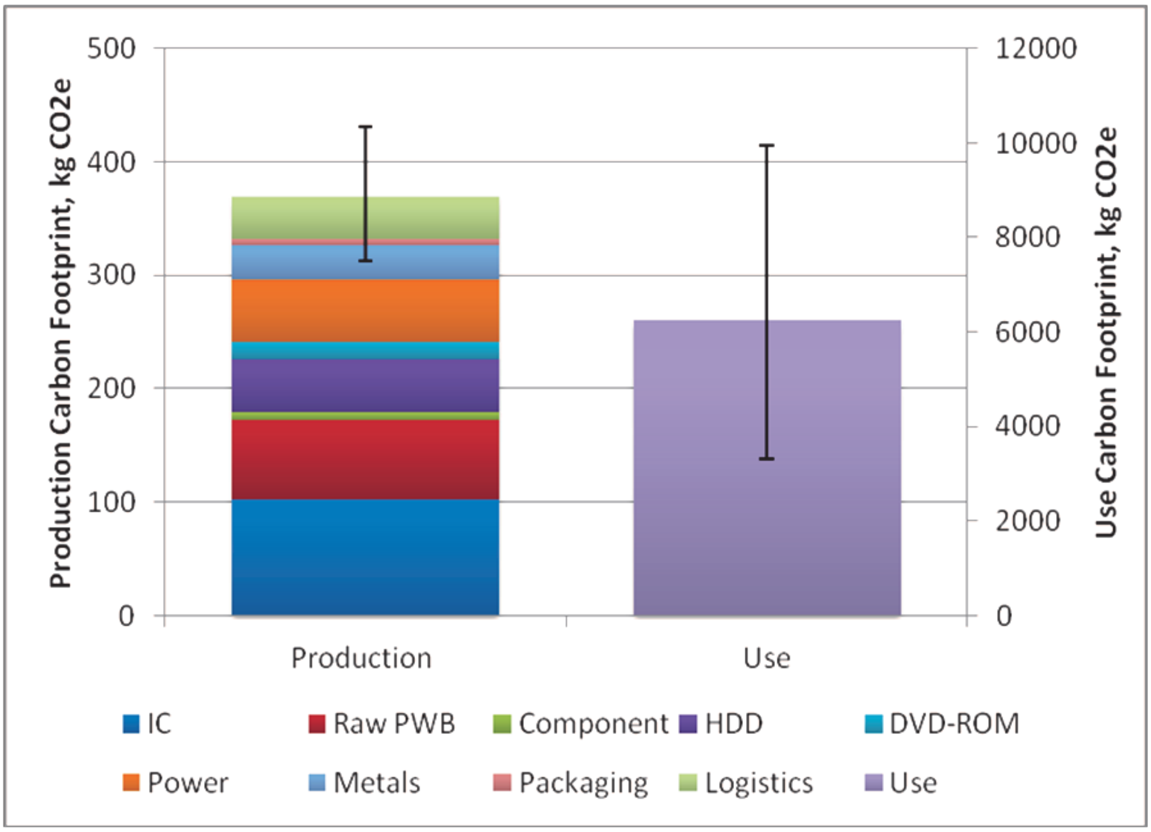
Analysis of a web-search of published LCA study results for ICT devices showing percentage use-stage carbon. Source: Darrel Stickler, Cisco

25 On this chart, mobile phones appear to vary from around 20% to 45% but this suggests that some of the study results must be for older phones because current average use stage carbon is only about 20% (Source: Nokia, 2012). In fact the variation is greater depending on the lifestyle of the phone user. A mobile phone just used for emergencies will have a very low use stage carbon impact – probably well below 5% (provided the charger is not left plugged in!) - but as mobile phones take on more applications (like Pandora that stream music to the end user), the use stage could rise to nearly 50%. And of course the carbon impact will differ depending on the energy mix of the country of use.

6.1.2 Opportunity for error

LCA presents many opportunities for error. Even a detailed LCA study of a single device demonstrates how significant this can be. In the diagram below (6.2) the left hand column represents the emissions associated with the production and supply of a server (around 370kg CO_2e) compared to the emissions associated with its use (a little over 6000kg CO_2e). The error margin in the use phase is not only significant but at nearly 4000kg CO_2e, the error margin alone is around ten times the total emissions associated with production. The big problem with error is that we often don't know how big the error is when comparing a model based system to real life. So we could get a set of results that are very variable but for which the average value is roughly correct, or a set of results with very little variation that are all completely wrong.

Diagram 6.2



Product Carbon Footprint of IBM Server by Component and Phase. The production stage is presented on the left axis, use stage on the right axis. Note that the left hand axis uses a different scale to the right hand axis.
Key: IC = integrated circuits, PWB = printed wiring board, HDD = high density disk drive
Source: IBM/Carnegie Mellon University Carbon Footprint Research Study[26]

6.2 Why all this uncertainty? What causes variability and error?

Uncertainty, either in the form of variability or error, is driven by several factors. These are complexity, time, and the limitations of a modelling approach.

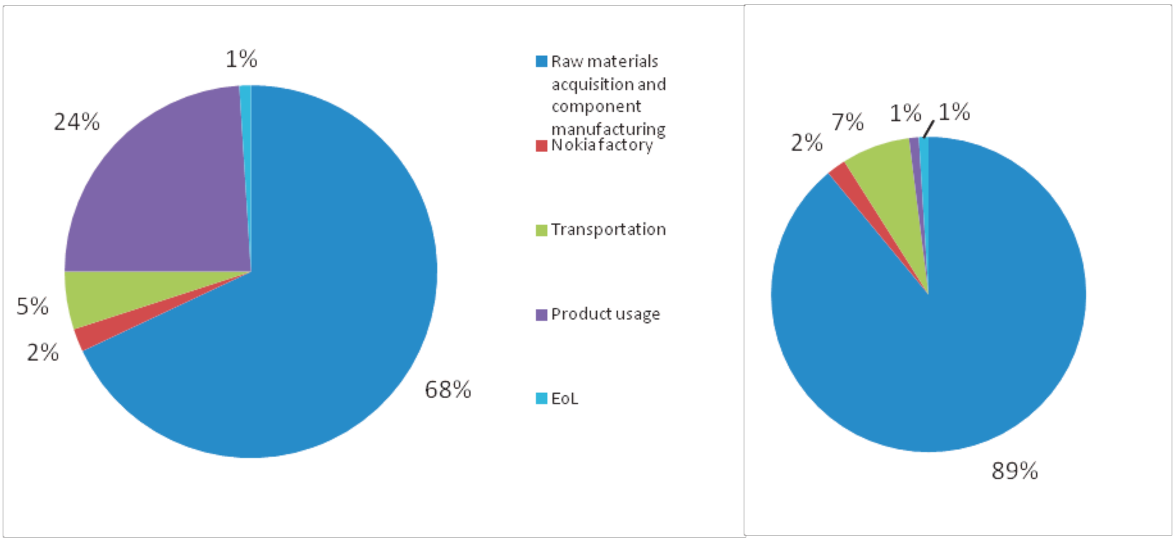
6.2.1 Complexity

ICT products are spectacularly complex. Even everyday mobile phones are made out of hundreds of different parts and materials and products like teleconferencing systems may contain several thousand components and materials. Both involve a huge and dynamic supply chain. With so many variables, even an exhaustive approach covering each component will include many assumptions and much secondary data. While the result will provide an indicative figure that is very useful at the individual product level, the margin for error is too great to enable comparisons to be made between similar products and any attempt to aggregate the figures would most likely compound the inevitable errors.

26 Strictly speaking this graph could be regarded as a graph of variability rather than error. This exact terminology does not really matter. The important point is that both error and variability contribute to uncertainty.

As diagrams 6.1 and 6.2 demonstrate, the use profile is one of the most complex parts of the LCA to model because it is significant but very variable. It is hard to predict use patterns, for instance how often phones are charged and whether or not the chargers are unplugged after charging. Geographic location adds further to this complexity. A mobile phone used in Norway, where most electricity comes from hydropower, will have different results to one used in China even when the use profile is identical – see diagram 6.3.

Diagram 6.3 Climate change impact of a Smart Phone[27]



33Kg CO2e
China energy mix in use phase

25Kg CO2e
Norway energy mix in use phase

Source: Nokia

6.2.2 Time

The technology associated with ICT and consumer electronics changes rapidly over time. This can have a significant impact on LCA results. During the use stage, the energy consumption of a device or component may change dramatically – just look at the effect of Moore's Law on basic processor efficiency. In addition, manufacturers are developing chips that reduce power demand during low use periods.

In terms of embodied energy, many studies are based on secondary emissions factors that were calculated some time ago. The older the data, the more likely it is that technological changes, (eg in the manufacturing process) will not be reflected. Moreover, these will have been calculated from specific processes within a particular factory that are unlikely to be representative of all production.

These changes are not necessarily a problem provided other parts of the life cycle are evolving in similar ways. However, this is not always the case. Where analysis has shown that the main energy burden of a product is in use, then manufacturers and policy makers have focused (quite correctly) on improvements on this stage.

27 The energy use and greenhouse gas emissions figures are based on a Life Cycle Assessment in accordance with ISO 14040 and ISO 14044. These calculations take into account the raw materials acquisition, component manufacturing, Nokia's own factory processes, inbound & outbound logistics, usage (3 years) and recycling of the mobile devices. The source data is measured at Nokia's own factories and operations and collected from suppliers and from internationally available LCI databases. The environmental impacts of different accessories, packaging, user guides, and Nokia corporate overhead including travel are not included. More information www.nokia.com/lca

For instance, significant progress has been made in improving the energy efficiency of phones in the use stage, and if we were comparing phones like for like (see box 8) then the last ten years would show a very significant reduction in life stage carbon impact (probably an order of magnitude). It is unlikely that the same degree of improvements will have been achieved in all the other life stages. As a result, the ratio between the energy impacts of the different life stages can change significantly even over relatively short timescales. Using out of date figures could therefore be very misleading. Time, therefore, significantly increases uncertainty.

Box 8: Like for like

If mobile phones had stayed the same over the last ten years, then the proportion of emissions attributable to the use stage would have declined very significantly. However, functionality (the number of things we expect a mobile phone to do), and the amount of data it handles, have increased dramatically, which increases energy demand. So to compare a 1990's mobile phone, essentially used just to make calls, with one now which is used as a video camera and viewer, a GPS, an email service, among other things, is meaningless. If you bought a chair in 1996 and a chair in 2012, the functionality would not have changed: it would still be a chair. That is not true of mobile phones. The problem with rapidly evolving areas of technology is that you cannot compare like for like over time because the original product has ceased to exist.

6.2.3 The limitations of a model-based approach

While an LCA provides insight into the environmental footprint of a product or service, it is still the result of a model-based approach. Moreover, the result cannot be verified by measurement. Returning to the example of the pint of milk, it might in theory be possible to create a micro-environment in which milk is produced while the input and output of all materials and all energy is controlled and measured, so that a carbon balance (or even a full material balance) can be made. For a complex electronic product, or an ICT service, such model environments cannot be created realistically, so auditing is the only means of verifying the outcome. Auditing will ensure that the principles of LCA are consistently and correctly applied but auditing cannot ensure that the starting points or the assumptions of the LCA correctly represent the real world. This means that there is always the risk that the LCA outcome of a complex product is erroneous, and that the error margin cannot be quantified.

6.3 The way we use numbers

We are very data hungry and one of the consequences of our thirst for numbers is that the moment anyone produces a figure publicly it is circulated, quoted and re-quoted, and as this happens the context and assumptions under which it was produced all mysteriously disappear. Just look at the two classic LCA studies for desktop computers. One, based on a device used about 4 hours a day and replaced after 2-3 years, found that 81% of its carbon impact was in manufacture and 19% in use[28]. Another, with a device used 9 hours a day and replaced after 6-7 years, found almost the exact opposite – over 80% of the energy consumed during the use phase and less than 20% in manufacture[29]. So the parameters are absolutely key. Because one of the studies is better known than the other, the general perception is that computers use more energy in manufacture than in use. It is easy to see that without their context, using these figures is misleading – imagine how this perception could misinform the decision point for replacing old, inefficient servers with new models (servers are likely to consume at least 90% of their energy in the use stage)[30]. A recent report by ANEC on the limitations of LCA includes a series of case studies which demonstrate that the results almost inevitably depend on the way the parameters are set[31].

This lack of context is particularly problematic when it comes to making comparisons. If company A publishes LCA data about its smart phone, and company B does the same about its competing device, the immediate temptation is to compare those results. But comparing those results without knowing all the assumptions made, the data sources, databases and tools used is meaningless. And even if the two studies used the same methodology and even tried to match the assumptions, the margin for error would almost certainly make the comparison pointless.

Unfortunately, many business and even policy decisions are made on the basis of such information.

28 Williams, E., "Energy Intensity of Computer manufacturing: hybrid assessment combining process and economic input-output methods", 2005, United Nations University, Tokyo

29 Source: Preparatory studies for eco-design requirements of EuPs, Lot 3, Personal Computers (desktops and laptops) and computer monitors. IVF Industrial Research and Development Corporation, prepared for DG TREN.

30 So single value based carbon footprints could be counterproductive if they encourage consumers to make a purchasing decision that are not relevant for their own usage profile. Eg someone buying a mobile phone for emergency use only need not worry too much about how energy efficient it is in use.

31 ANEC, 2012, Environmental Assessment goes Astray: a critique of Environmental Footprint Methodology and its ingredients

6.4 Catch-22: Primary and Secondary data

We mentioned several times above that you cannot compare LCA results for ICT devices unless the LCAs use the same assumptions and the data comes from a common database (see box 9). This raises a problem. If you are using databases then you are using secondary data, not primary data (see box 3). If you use primary data (i.e. data that you have gathered yourself independently) then the LCA results will reflect the exact characteristics of your product over its life but it will also include a whole range of specific assumptions and uncertainties. So when two separate studies present different results, part of that difference is caused by actual differences in the products but part is caused by methodological choices that are unconnected to the products. Although in theory, these differences could perhaps be eliminated if all companies reported a full set of primary data for all their processes and if allocation methods were very clearly defined, in practice even primary data is always sample data, not the full set. As a result, LCA results based on primary data are not comparable. So to be comparable we need to rely on secondary data. But the Catch-22 is that the more you rely on secondary data the less it relates to the exact characteristics of your specific product, and therefore the less meaningful the results will be. So an LCA of two laptops based on primary data will give different results and not be comparable and the LCA results based on secondary data will essentially be the same – so the outcome will be meaningless. In other words, if you want to create a situation where the variations caused by methodological choices are sufficiently reduced to enable some kind of comparison between products, you need to sacrifice the specifics that characterise your particular product: Catch-22![32]

6.5 Future evolution

This all suggests that using LCA approaches to make comparisons between similar products is not feasible at the moment and will continue to be very challenging for the foreseeable future. Many more studies will be needed, together with common databases (see box 9) where everyone shares the same data (although they will not solve the Catch-22 problem regarding primary and secondary data). Data capture is currently manual and extremely time consuming and it needs to become automatic. One of the biggest variables in LCA results for most ICT equipment is the usage pattern. So the lack of data on usage patterns is a big issue for the sector, but automatic data capture of usage patterns – user profile monitoring - whilst feasible, could only be rolled out with the next iteration of devices and even then the resulting data would somehow have to be collated and managed. Monitoring of mobile products is particularly challenging and any monitoring has its own energy impact. The good news is that steps are already being taken to incorporate internal power measurement in devices, where data is collected and forwarded to a central point.

6.6 The silver lining

Despite the fact that LCA results for similar products are unlikely to be clear cut enough to allow broad generalisations, multiple LCAs do tend to produce results that are consistent in certain restricted areas. So, although the total carbon impact of a laptop may vary dramatically depending on the usage pattern, common findings do emerge about individual components or aspects of that lifecycle. End of life is usually insignificant, transport rarely if ever exceeds 5%, while the integrated circuit boards tend to account for nearly 50% of embodied carbon.[33] Over time, a consistent picture starts to emerge. So, while LCA might fail to distinguish one circuit board from another reliably, it can demonstrate that the circuit board is likely to be a major contributor to the embedded carbon in a device.

Box 9: Common Database

Some suggest that everyone should use a common database, in which industry constantly files and updates information. So instead of companies using their own databases or choosing between ELCD and proprietary databases such as PE or EcoInvent, everyone would use the same source. This seems sensible but there are practical issues. Someone has to own and manage this resource. For this common database to be truly comprehensive it will require all supply chain participants to provide full disclosure on inputs, outputs, energy mix etc. for every product. This is truly very ambitious* and the experiences of organisations operating databases suggest that this objective may be elusive.

32 Interestingly, the iNEMI LCA estimation tool uses secondary data and states explicitly that it cannot be used for company product comparisons.

33 Although it should be noted that current studies are limited and any end of life profile estimated today is likely to have changed by the time products currently in use reach their end of life.

* (nearly as ambitious as the ultimate supercomputer (Earth) operated by Douglas Adams' white mice, but hopefully less vulnerable to a Vogon hyperspace bypass).

7. Conclusion

Why are LCA-based methodologies important? Why do we need to continue to work on these approaches? Will there be an evolution in LCAs in conjunction with Product Category Rules so that we can eventually use LCAs to compare competitors' products or validate claims? Will Arthur Dent ever recover from drinking three pan-galactic gargleblasters?

7.1 Why do we need LCA?

LCA is an extremely useful tool which will play an increasingly important role in improving our understanding of the carbon[34] impact of ICT at a product or service level. LCA is especially helpful in providing consumers and users with robust information on the environmental impacts of ICT particularly when some of these impacts are hidden or when they are very complex.

7.2 What is LCA intended for?

LCA based methodologies are designed to identify the part of the lifecycle of a product or service with the most significant carbon impact so that in turn, organisations can direct their efforts to the point where they can deliver the greatest improvements. LCA can also be used by companies to evaluate changes in their products over time, for instance to monitor the effects of a change in the supply chain or the adoption of a new process. LCA is also very useful in making broad comparisons between different activities – for instance, evaluating the carbon impact of manufacturing a computer compared to producing a car, or using a virtual presence conference service instead of travelling to meetings. In turn, such approaches can help inform organisations of the carbon impact of applying or adopting ICT-enabled technologies by comparing "with" and "without" scenarios. By so doing LCA approaches can confer much greater objectivity on the net carbon impact of ICT.

7.3 What are the limitations of LCA?

LCA based approaches, however, have a number of limitations. As mentioned above, LCA results cannot be verified by measurement and this makes LCA an economic rather than a scientific tool where accuracy and certainty will both continue to be elusive. LCA results for complex products should always take the form of a range, so a single figure, such as 42, can never be the answer as far as LCA is concerned. And because of the importance of the parameters, the answer provided by an LCA should always be prefaced by "it depends".

As discussed above, without strict PCRs and the obligation to use exactly the same assumptions, the error ranges are likely to be too great to use LCA to compare products – particularly quite similar products – in a meaningful way. So, given similar assumptions and common data, it could be possible to compare some products - such as a laptop with a large screen with a laptop with a smaller screen but it would not be feasible to compare similar laptops. And of course the problem with similar assumptions and common data is that they don't reflect the individual characteristics of the products, so the comparison lacks meaning. Moreover, as the PAIA project results suggest, there isn't much point in comparing similar devices - because they are similar.

7.4 Can LCA tell us what we need to know about sector level emissions?

While LCA is helpful on a case by case basis, extreme caution must be applied when extrapolating or aggregating results to estimate impacts at a sector level. It is essential, therefore, to differentiate the role of LCA based methodologies in helping us understand and evaluate the carbon impact of ICT products and services from their role in evaluating the footprint of the ICT sector. Adding up the aggregated carbon impacts of ICT products cannot and will not provide a sector level footprint. LCA is the wrong tool to evaluate the carbon impact of the ICT sector. Top-down analyses are likely to be much more useful, but LCA can have a role in informing these exercises.

34 Or other environmental impact: although this paper focuses on carbon, LCA applies to a wide range of environmental impacts.

7.5 So what was it we wanted to know?

At the beginning of this paper we stressed that we need to be sure about what we want to know. If we want a figure for the carbon footprint of the ICT sector then LCA is not the right tool. If we want to compare the carbon credentials of similar products then again LCA is the wrong tool. But if we want to identify, understand and address the big carbon impacts of those devices then LCA is a marvellous tool.

7.6 Where next?

Industry must continue to support this valuable work and ensure that it continues to evolve. The more we apply these methodologies, the better we will understand them and the more useful the information they provide will be. Policy makers need to ensure they fully understand these methodologies and the kind of information that they can deliver before they design, develop or implement policy instruments around them. So for instance, if we understand that the vast majority of the carbon impact of a server is in its use phase, then policy focused on the energy performance of that device is likely to be much more effective than policy instruments focused on its manufacture or distribution. But that policy tool might be less appropriate for PCs and laptops where usage patterns are far more variable. So it is not just the LCA results that help inform policy making. To make best use of LCA, policy makers need to understand the capabilities and limitations of the LCA process.

At the moment, attempts to use existing approaches as a basis for comparing similar products, for eco-labelling or for taxation are misguided. Moreover, placing unrealistic expectations on LCA based approaches distracts attention from the very significant value they can bring in improving our understanding of the carbon impact of ICT. It also undermines their increasingly important role in enabling us to add a carbon as well as a monetary value to investing in an ICT or ICT enabled product or service. Just because we want – or need – to do something does not necessarily mean that it is possible – yet. So we have to overcome the almost irresistible temptation to view LCA as the solution for the whole problem when in fact it is only the solution for part of it.

7.7 Is LCA the answer to Life, the Universe and Everything?

LCA is a tool. Tools are designed for specific purposes. You would not use your hairbrush to hammer nails into the wall and you are equally unlikely to use a hammer to brush your hair. Unlike LCA, hammers and hairbrushes are simple, familiar tools whose purpose is obvious. LCA is a relatively new and complex tool that hardly anybody seems to understand and the inevitable result is confusion over its purpose.

LCA-based methodologies are not designed to provide all the answers on the carbon impact of ICT, but they are providing vital insights in certain areas and if allowed to evolve and develop, will play an increasingly important role in strengthening our understanding of the energy performance of our industry.

We will finish by revisiting Chris Chant's analogy, which we quoted at the start of this paper. Reducing carbon, he said, was a bit like dieting. And while there is little point obsessively trying to differentiate between a strawberry and a raspberry in terms of calorific value, we do need to stop eating all those pies. As we said at the beginning, LCA is a poor tool for telling us the difference between a strawberry and a raspberry but it is a wonderful tool for showing us where all the pies are, and who is eating them. We just have to remember that, where LCA is concerned, 42 is not the right answer.

8. Further reading

ANEC, 2012, Environmental Assessment Goes Astray: a Critique of Environmental Footprint Methodology and its Ingredients
http://www.anec.eu/attachments/ANEC-ENV-2012-G-008final%20(3).pdf

Ericsson, March 2010: Measuring Emissions Right; Assessing the Climate Positive effects of ICT
http://www.ericsson.com/res/docs/whitepapers/methodology_high3.pdf

Ernst & Young / EC, Oct 2010: Product Carbon Footprinting: A Study on Methodologies and Initiatives
http://circa.europa.eu/Public/irc/env/carbon_footprint/library?l=/ernstyoung_report/version_22112010pdf/_EN_1.0_&a=d

Gartner, April 2007: Gartner Symposium / IT Expo, 26th April 2007
http://www.gartner.com/it/page.jsp?id=503867

GeSI, 2008: SMART 2020 – Enabling the low carbon economy in the information age
http://www.theclimategroup.org/assets/resources/publications/Smart2020Report.pdf

Intellect, Feb 2008: High tech: low carbon: The role of technology in tackling climate change
http://www.intellectuk.org/hightechlowcarbon

Koomey, Feb 2007: Estimating total power consumption of servers in the US and the world, Koomey, J G.
https://files.me.com/jgkoomey/98ygy0
http://www.koomey.com/research.html

Malmodin, Moberg et al, "Greenhouse Gas Emissions and Operational Electricity Use in ICT and Entertainment & Media Sectors"
http://onlinelibrary.wiley.com/doi/10.1111/j.1530-9290.2010.00278.x/abstract

Author: Emma Fryer

Acknowledgements

Intellect would like to thank the following for their help in preparing this document:

Tom Okrasinski, Alcatel-Lucent
Peter Shearman, BSG
Gabrielle Giner, BT
Andie Stephens, Carbon Trust
Darrel Stickler, Cisco
Ian Barham, DEFRA
Sylvie Feindt, DigitalEurope
Pernilla Bergmark, Ericsson
Susanne Lundberg, Ericsson
Tracey Rawling-Church, Kyocera
Tony Rooke, Logica
Salla Ahonen, Nokia
Noora Paronen, Nokia
Jos Beekwilder, Océ
Thomas Geruschkat, Sony
Lay reader: Diane Barningham

For further information please contact:

Emma Fryer
T 01609 772 137 | 020 7331 2000
E emma.fryer@intellectuk.org

intellect
REPRESENTING THE UK TECHNOLOGY INDUSTRY

About Intellect

Intellect, the trade association for the UK technology industry, provides a collective voice to over 850 member companies ranging from SMEs to multinationals.

Intellect works with this community to:

- develop the UK's capability to support a globally competitive, innovative and sustainable economy led by a strong technology sector
- help member companies improve their business performance by
  - engaging with government and regulators to create the most favourable environment for growth and employment
  - providing insights into markets and supply chains
  - constructively influencing market development
  - maintaining the industry's reputation, championing its strategic importance
  - promoting best practice through the Business Professional Certificate

For more information visit www.intellectuk.org

Intellect Russell Square House 10-12 Russell Square London WC1B 5EE
T 020 7331 2000 F 020 7331 2040 E communications@intellectuk.org W www.intellectuk.org