Institution: University of Manchester

Unit of Assessment: UoA12a Chemical Engineering

Title of case study: Carbon Calculations over the Life Cycle of Industrial Activities (CCaLC)

1. Summary of the impact (indicative maximum 100 words)

Research in the UoA developed a methodology for Carbon Calculations over the Life Cycle of Industrial Activities (CCaLC), providing ‘cradle to grave’ carbon footprint estimates for commercial products. The methodology was embedded in a set of software tools designed to be used by non-experts, allowing companies to perform carbon footprinting in-house. The software is free to download, currently with 3300 users in more than 70 countries. The methodology and software tools have been endorsed by BERR (now BIS), DEFRA and the World Bank, and used widely by industry, across a range of sectors, to reduce carbon footprints of their products. This has resulted in significant environmental and socio-economic benefits, including estimated climate change mitigation gains in excess of £450m.

2. Underpinning research (indicative maximum 500 words)

The research underpinning this case study emerged from the project funded by EPSRC, NERC and the Carbon Trust from 1 Feb 2007–31 July 2010. Key researchers were:

- Professor Adisa Azapagic (2006-present; Principal Investigator);
- Dr Heinz Stichnothe (2007-2010; PDRA);
- Dr Haruna Gujba (2008-2010; PDRA);
- Dr Namy Espinoza Orias (2008-2011; PDRA);
- Dr Harish Jeswani (2008-present; PDRA); and
- Dr David Amienyo (2009-present; PhD student & PDRA).

The main aim of the research was to deliver a methodology (CCaLC) and decision-support software tools for industry to help companies reduce their life cycle environmental impacts, and particularly carbon footprints (greenhouse gas emissions), at minimum cost. A ‘whole systems’ approach was applied to consider complete life cycles of products, technologies and services from ‘cradle to grave’. This encompasses extraction of primary resources, production, use/reuse of products and end-of-life waste management. Whist the focus was on the estimation of carbon footprints, other environmental impacts, such as water footprint, ozone layer depletion, acidification and eutrophication, were also included to ensure that carbon emissions are not reduced at the expense of other impacts. As part of the research, over 50 case studies were developed in collaboration with 30+ partners from different industries, including the chemical, food & drink and bio-sectors.

The key generic findings of the research were that:

- CCaLC is a powerful tool for providing new insights on carbon hot spots, often overturning previous assumptions and helping to focus carbon reduction efforts in areas where greatest improvements can be achieved [e.g. 1-3,5,6].
- Significant carbon reductions can be achieved across different sectors using information obtained from CCaLC [e.g. 1-4].
- Mitigation of carbon emissions can often lead to an increase in other environmental impacts and/or costs –these trade-offs can be identified easily through CCaLC, helping to make more sustainable decisions [e.g. 2,3,4].
- CCaLC can be used successfully for engagement along supply chains, raising awareness and disseminating best practice for carbon reductions [e.g. 1,2,3,5].

3. References to the research (indicative maximum of six references)

CCaLC won several prizes, including: the IChemE top Award for Outstanding Achievements in Chemical and Process Engineering (2010); the GSK Innovation Award, awarded by the Chemical Industries Association (2011); and the Chemistry Innovation Award for the Best Collaborative Project (2011). The research was published in leading international research journals in the field of sustainability, including the International Journal of Life Cycle Assessment; Journal of Cleaner Production; and Resources, Conservation & Recycling.

Key publications

1. Stichnothe H. & Azapagic, A. (2009). Bioethanol from Waste: Life Cycle Estimation of the Greenhouse Gas Saving Potential. Resources, Conservation & Recycling 53(11) 624-630; doi:10.1016/j.resconrec.2009.04.012.
2. Stichnothe, H. & Azapagic A. (2013). Life Cycle Assessment of Recycling PVC Window Frames. Resources, Conservation & Recycling 71(1) 40-47; doi:10.1016/j.resconrec. 2012.12.005.
3. Amienyo, D., Gujba, H. Stichnothe, H. & Azapagic, A. (2013). Life Cycle Environmental Impacts of Soft Carbonated Drinks. Int. J. of Life Cycle Assessment 18(1) 77-92; doi:10.1007/s11367-012-0459-y.

Further relevant publications

4. Azapagic, A., H. Jeswani and H. Gujba (2011). Assessing Biomass Options for Electricity Generation on a Life Cycle Basis. Waste and Biomass Valorisation 2(1) 33-43; 10.1007/s12649-010-9057-z.
5. Espinoza-Orias, N., Stichnothe, H. & Azapagic A. (2011). The Carbon Footprint of Bread. The Int. J. of Life Cycle Assessment 16(4) 351-365; doi:10.1007/s11367-011-0271-0.
6. Jeswani, K.H., Smith, R. W. & Azapagic, A. (2013). Energy from Waste: Carbon Footprint of Incineration and Landfill Biogas in the UK. Int. J. of Life Cycle Assessment 18(1) 218-229; doi:10.1007/s11367-012-0441-8.

4. Details of the impact (indicative maximum 750 words)

Context

Existing carbon footprinting methodologies and software tools are either too simplistic or too complex and thus not suited for use in-house by industry. As a result, most companies have to rely on external consultants, which often inhibits them from estimating carbon footprints because of associated costs and confidentiality. Furthermore, most previous approaches have only considered estimation of carbon emitted directly by organisations rather than the emissions along the whole supply chain – a key requirement in mitigating climate change. CCaLC overcomes these barriers by enabling them to estimate the carbon footprint and identify optimal reduction strategies in-house. The research laid the foundations for addressing these issues by taking a life cycle approach with the aim of helping companies to identify carbon reduction opportunities from ‘cradle to grave’, in-house.

Pathways to Impact

We recognised that the key to achieving practical impact from the work was to embed the rigorous CCaLC methodology in software tools simple enough to be used by non-experts. Working with the 18 industry partners in the research (joined subsequently by 15+ others), we developed a suite of software tools incorporating a database with 6000+ data entries: *CCaLC* for estimation of carbon footprints applicable to all sectors; *CCaLC Optimiser* for optimisation of carbon footprints applicable to all sectors; *CCaLC PVC* applicable to the PVC sector; and *CCaLC BIOCHEM* applicable to the industrial biotechnology (IB) sector. To encourage uptake, CCaLC is provided free of charge. The first version was launched in July 2010 and up to 31 July 2013 had around 3300 users from more than 70 countries. Several updates have been released since the launch (currently v.3.1). To aid dissemination, we worked closely with the Chemistry Innovation

Knowledge Transfer Network (CIKTN), who helped disseminate CCaLC widely across industry. Examples of dissemination routes pursued by CIKTN included promotion to 250 SMEs across Europe to stimulate innovation in bio-based products, presentations to over 150 UK businesses, a series of industry events, and the CIKTN website. CCaLC is also included in CIKTN's Sustainable Design Guide to help drive innovation [A]. Amongst new partners was the World Bank who, as a result, recommend CCaLC as part of their Platform for Climate-Smart Planning [B].

Reach and Significance

CCaLC's international user base is made up of companies (~65%), government bodies (~10%) and others (~25%), including universities and individuals. CCaLC has significant geographical reach: 50% of users are UK-based, 25% are based in rest of Europe and 25% span countries as diverse as Australia, Brazil, Canada, China, India, Indonesia and USA. Examples of specific impacts are given below for four key industrial sectors.

PVC Industry: PVC is one of the most extensively used plastics in the world with current global demand of 37 Mt and a forecast annual growth of ~5% from 2011-2020. The European PVC sector is committed to carbon reductions through VinylPlus, an ongoing 10-year voluntary initiative to improve its sustainability. The CCaLC-PVC software has been used for the reduction and management of the carbon footprints of PVC products, processes and supply chains. It has been endorsed by DEFRA [C], and across the PVC sector, including by the British Plastics Federation and INEOS ChlorVinyls – a leading VinylPlus partner and Europe's largest PVC producer, employing 3000 people. Using CCaLC has provided INEOS with the insight that the use of recycled PVC offers a 20-fold reduction in greenhouse gas (GHG) emissions compared to virgin product, leading directly to a focus on recycling as a pathway to reducing the industry's emissions [D]. Currently Europe recycles 100 kt pa of waste PVC window frames, equivalent to a saving of around 200 kt CO_2 eq. pa [2] – a £42m pa saving through mitigation of climate change based on the findings of the Stern Report. Use of CCaLC showed that achieving the VinylPlus target of 800 kt pa recycled PVC by 2020 would result in a 1.6 Mt pa reduction in CO_2 eq. emissions, equivalent to 2.4% of the emissions from the sector. CCaLC also showed that a saving of 6.7 Mt CO_2 eq. pa could be achieved by using a new non-aqueous polymerisation route, instead of the current aqueous process [D]. This would represent a 10% saving of annual GHG emissions for the whole PVC sector, half of the emission reduction target of 20% set by VinylPlus for 2020 and, based on Stern's findings, equivalent to a saving of £360m in mitigation of climate change. Summarising the impact, INEOS ChlorVinyl state that "*CCaLC is increasingly being used across the PVC sector, and is viewed as a central plank in the European PVC industry's carbon commitment*. ...*It has proved valuable because it continues to provide a simple yet effective tool to illustrate how various players in the vinyl value chain can make a difference to carbon and other environmental savings.*" [D].

Industrial Biotechnology: In recognising that the industrial biotechnology (IB) sector will be "one of the strongest driving forces behind the world's low-carbon revolution", the BERR (now BIS) IB Innovation and Growth Team for UK Government recommended adoption of CCaLC as the preferred toolkit for the calculation of carbon footprint [E]. Subsequently, CCaLC is now used across the IB sector to identify carbon hot spots and improvement opportunities. An example is the UK-based speciality-chemicals company Croda International, who have 3400 employees in 34 countries, and boast revenues in excess of £1bn. Croda manufactures 70% of its chemicals using renewable materials and use CCaLC to calculate the carbon footprint of their products. As a result, they found out that, contrary to their expectations, the GHG emissions from cultivating raw materials are typically twice those from the manufacturing process [F]. In 2011 Croda rolled-out CCaLC across the whole company, training 18 key staff internationally in its application; CCaLC is now used routinely to monitor opportunities for carbon reduction [G]. Commenting on the usefulness of CCaLC not only for identifying improvement opportunities but also for responding to increasing requests by their customers for information on the carbon footprint of their products, Croda state that "*Without CCaLC, Croda would not be able to provide useful and meaningful information to our customers without significantly more work and cost, ...which could potentially result in lost business.*" [F]

Healthcare Industry: GSK, one of the world's largest health-care companies, used CCaLC, in collaboration with the UoA, to estimate the carbon footprint of 20 key products, including asthma inhalers and Horlicks. CCaLC showed that, contrary to company's expectations, the use and end-of-life of these products add significantly to the company's carbon footprint. For example, Ventolin, used by ~300 million asthma sufferers worldwide, is one of the main contributors to the total carbon footprint of the company owing to the use of HFA-134a propellant. To reduce the carbon footprint, GSK have started to collect and recycle waste inhalers which still contain a significant amount of unused HFA – in the UK alone, 90,000 inhalers have been collected to date, saving 682 t CO_2 [H]. CCaLC has also shown that large carbon reductions can be achieved by replacing Ventolin with a dry powder inhaler also produced by GSK, saving 630 kt CO_2 eq. per year, or 10% of GSK's total GHG gas emissions. GSK are also working with suppliers to reduce the carbon emissions in their supply chain, for example in the production of milk used in Horlicks, which contributes more than half of the 800 kt CO_2 from this product. GSK state that *"Having a tool like CCaLC is very powerful as we can quickly get into very detailed discussions on how to work with suppliers to reduce supply chain carbon footprint as well as reduce overall cost."* [I]

Food Industry: Kellogg's, one of the world's leading producers of cereals and convenience foods, with sales of ~$13 billion, are committed to reducing energy use, GHG emissions and water use by 15-20% by 2015 (on 2005). The company has been using CCaLC since 2010 to estimate the carbon footprint of their entire product range (ca. 2000 products), allowing them to track the cradle-to-grave impact for the first time [J]. They were surprised to find that transport had a low contribution to their carbon footprint, enabling them to refocus on areas of product life cycle that have a higher contribution, such as raw materials, packaging and energy efficiency. CCaLC estimates have shown clearly that Kellogg's carbon footprint can be reduced by up to 20% by focusing on these life cycle stages, helping the Company meet their 2015 targets [J]. Kellogg's have also found CCaLC to be useful in product design, helping them choose low-impact ingredients and recipes. An example is *Special K*, for which both carbon and water footprints were reduced by up to 20% as a result of using CCaLC [J]. The company state that "*CCaLC has helped Kellogg's to identify business-wide hot spots and provide focus in terms of future priorities for carbon reductions along the entire value chain … We habitually use CCaLC in all new food and packaging innovation and design... We've also found CCaLC is useful to inform how to design more sustainable future products and as a vehicle for engagement with suppliers"* [J].

5. Sources to corroborate the impact (indicative maximum of 10 references)

A. Letter from Lead Specialist - Sustainability, TSB [Previously Sustainability Manager, CIKTN]. Corroborates dissemination routes for CCaLC followed by CIKTN.

B. World Bank, Platform for Climate-Smart Planning. Shows CCaLC as a partner and a carbon footprinting tool on the World Bank's Platform for Climate Change.

C. DEFRA (2010). Windows Sustainability Action Plan. DEFRA, London (p24). Recommends CCaLC for use in the PVC sector.

D. Letter from Sustainability & Compliance Manager, INEOS ChlorVinyls. Corroborates the impacts from using CCaLC in the PVC sector.

E. IB 2025: Maximising UK Opportunities from Industrial Biotechnology in a Low Carbon Economy. BERR (p33). Recommends CCaLC as a preferred tool in the industrial biotechnology sector.

F. Letter from Research & Technology Director, Croda Europe. Corroborates impacts from using CCaLC by Croda.

G. Croda (2011). Sustainability Report. (pg 27). Corroborates evidence that CCaLC is used by Croda across the company, globally.

H. GSK (2012). Do More, Feel Better, Live Longer: CR Report (pg 65 & 67). Corroborates the evidence on recycling Ventolin and impacts of Horlicks, the products assessed by CCaLC.

I. Letter from Head of Environmental Sustainability, GSK. Corroborates the impacts from using CCaLC by GSK.

J. Letter from European Environmental Strategy Manager, Kellogg Europe. Corroborates the impacts from using CCaLC by Kellogg.