Government
Institute for
Economic Research

Research Reports 143:2

Towards certified carbon footprints of products – a road map for data production

Climate Bonus project report (WP3)

Kirsi Usva
Mikko Hongisto
Merja Saarinen
Ari Nissinen
Juha-Matti Katajajuuri
Adriaan Perrels
Pauliina Nurmi
Sirpa Kurppa
Sirkka Koskela

Research Reports 143:2 October 2009

VATT RESEARCH REPORTS

143:2

Towards certified carbon footprints of products – a road map for data production

Climate Bonus project report (WP3)

Kirsi Usva
Mikko Hongisto
Merja Saarinen
Ari Nissinen
Juha-Matti Katajajuuri
Adriaan Perrels
Pauliina Nurmi
Sirpa Kurppa
Sirkka Koskela

Valtion taloudellinen tutkimuskeskus
Government Institute for Economic Research
Helsinki 2009

Climate Bonus – a carbon bonus/credit system for households

Kulutuksen ilmastovaikutus – ostosten ilmastopäästöjen hallintaa kuluttajan valinnoin

http://extranet.vatt.fi/climatebonus/

ISBN 978-951-561-890-0 (nid.)
ISBN 978-951-561-891-7 (PDF)

ISSN 0788-5008 (nid.)
ISSN 1795-3340 (PDF)

Valtion taloudellinen tutkimuskeskus

Government Institute for Economic Research

Arkadiankatu 7, 00100 Helsinki, Finland

Email: etunimi.sukunimi@vatt.fi

Oy Nord Print Ab

Helsinki, October 2009

Towards certified carbon footprints of products – a road map for data production

Climate Bonus project report (WP3)

August 2009

Kirsi Usva
Mikko Hongisto
Merja Saarinen
Ari Nissinen
Juha-Matti Katajajuuri
Adriaan Perrels
Pauliina Nurmi
Sirpa Kurppa
Sirkka Koskela

Funded by

Tekes, the Finnish Funding Agency for Technology and Innovation

Elisa Oyj

HK Ruokatalo Oy

Nokia Oyj tytäryhtiöineen

Ruokakesko Oy

Stora Enso Oyj Consumer Board

Tuulia International Oy

The Climate Bonus Research Consortium

Government Institute for Economic Research (VATT), coordinator

Perrels Adriaan (project leader), Heikkilä Tuomo (project manager), Sahari Anna, Tuovinen Tarja

Technical Research Centre of Finland (VTT)

Hongisto Mikko, Järvinen Timo, Kallio Arto, Lehtinen Juha-Matti, Melin Magnus, Södergård Caj

Agrifood Research Finland (MTT)

Katajajuuri Juha-Matti, Kurppa Sirpa, Nurmi Pauliina, Saarinen Merja, Usva Kirsi

Finnish Environment Institute (SYKE)

Koskela Sirkka, Nissinen Ari, Pakarinen Suvi, Seppälä Jyri, Tenhunen Jyrki

National Consumer Research Centre (KTK)

Hyvönen Kaarina, Saastamoinen Mika, Timonen Päivi

The project produced the following project reports:

Perrels A. – Hongisto M. – Hyvönen K. – Katajajuuri J.M. – Nissinen A. (2009): *A quick scan of climate policy services and of underlying data system approaches – Climate Bonus project report (WP1)*, VATT Research Reports 143:1

Usva K. – Hongisto M. – Saarinen M. – Katajajuuri J. M. – Nissinen A. – Perrels A. – Nurmi P. – Kurppa S. – Koskela S. (2009): *Towards certified carbon footprints of products – a road map for data production – Climate Bonus project report (WP3)*, VATT Research Reports 143:2

Perrels A. – Nissinen A. – Sahari A. (2009): *Reviewing key building blocks of an integrated carbon footprinting and consumer purchases' monitoring & reward system – interaction with the consumer – Climate Bonus project report (WP4)*, VATT Research Reports 143:3

Hyvönen K. – Saastamoinen M. – Timonen P. – Kallio A. – Hongisto M. – Melin M. – Södergård C. – Perrels A. (2009): *Kuluttajien näkemyksiä kotitalouden ilmastovaikutusten seuranta- ja palautejärjestelmästä – Climate Bonus hankeraportti (WP5)*, VATT Tutkimukset 143:4.

Perrels A. – Nissinen A. – Sahari A. (2009): *The overall economic and environmental effectiveness of a combined carbon foot-printing and feedback system – Climate Bonus project report (WP6)*, VATT Research Reports 143:5.

Perrels A. – Heikkilä T. – Hongisto M. – Hyvönen K. – Katajajuuri J.M. – Nissinen A. – Usva K. (2009): *Sustainable Consumption and Production Exposed – Synthesis report of the CLIMATE BONUS study concerning combined use of carbon footprinting, monitoring, feedback, and rewards*, VATT Research Reports 143:6.

Towards certified carbon footprints of products – a road map for data production

Government Institute for Economic Research VATT Research Reports 143:2/2009

Kirsi Usva – Mikko Hongisto – Merja Saarinen – Ari Nissinen – Juha-Matti Katajajuuri – Adriaan Perrels – Pauliina Nurmi – Sirpa Kurppa – Sirkka Koskela

Abstract

This report is a part of a series of reports from the Climate Bonus project. The report illustrates the basic structure of a system that could produce strict and reliable data needed for generating product-oriented carbon footprints in Finland. It also represents a road map for developing the system for the energy and food sectors. Steering mechanisms, standards and possible data sources central to the system are also reviewed. Accuracy and a scope of the outlined system should be developed step by step, starting from the major emission sources, processes and products. Account has also been taken of linkages between the proposed system and existing environmental management systems, annual reporting practices and the European emission-trading scheme (EU-ETS).

Key words: greenhouse gases (GHG), carbon footprint, indirect emissions, life cycle assessment (LCA), input-output modelling, monitoring of emissions, verification, guarantee of origin, environmental product declaration (EPD), product certification, supply chain management

JEL classes: O13, O31, O33, Q01, Q19, Q27, Q49, Q54, Q55, Q56

Tiivistelmä

Tämä raportti on osa Climate Bonus -hankkeen raporttisarjaa. Raportissa esitetään perusrakenne järjestelmälle, jolla Suomessa voitaisiin laajamittaisesti tuottaa tuotekohtaisiin hiilijalanjälkiin tarvittavia tarkkoja ja luotettavia tietoja, ja ”tiekartta”-järjestelmän luomiseksi erityisesti energia- ja elintarvikesektoreilla. Raportissa tarkastellaan myös tämän järjestelmän kannalta keskeisiä ohjausmekanismeja, standardeja ja mahdollisia tietolähteitä. Hahmotellun järjestelmän tarkkuuden ja kattavuuden ajatellaan kehittyvän vaiheittain alkaen keskeisimmistä päästölähteistä ja prosesseista. Ehdotetun järjestelmän kytkeytyminen olemassa oleviin ympäristöhallinnan menettelyihin, vuotuisiin raportointitarpeisiin ja päästökauppajärjestelmään on otettu huomioon.

Asiasanat: kasvihuonekaasupäästöt, hiilijalanjälki, välilliset päästöt, elinkaariarviointi, LCA, panos-tuotosmallinnus, päästöjen monitorointi, verifiointi, alkuperäjärjestelmä, ympäristöseloste, tuotesertifiointi, tuotantoketjun hallinta

JEL-luokat: O13, O31, O33, Q01, Q19, Q27, Q49, Q54, Q55, Q56

Foreword

Carbon footprints for consumer products have become an integral part of the climate change discussion. The project Climate Bonus – a carbon bonus/credit system for households rises to the challenge of climate change mitigation by assessing the possibilities for and effectiveness of an innovative bonus system for households that provides the knowledge, means and motivation to promote products and solutions with low greenhouse gas emissions. In order to enable a practicable and credible bonus system for households, development of the underlying product-related information system is critical.

This research report addresses the challenges of providing reliable, cost-effective and up-to-date data to formulate a realistic, systematic information structure that represents the basis of a bonus system for households. One of the key questions relates to resolution of the data that allows households to compare different products and services in terms of carbon footprints. The report introduces a vision of a voluntary data production system for Certified Carbon Footprint of Product (CFP) and considers its essential components. To realise this vision, the report presents a roadmap that incorporates the Finnish energy and food sectors as examples. The report also takes a look at the essential standards, steering mechanisms and sources of information required by the system. Critical challenges for further implementation of the system will evidently be represented by management of a range of data derived through tracing or use of default values that reflect the detailed nature of the supply chain.

The Climate Bonus project was carried out by a consortium comprising the Government Institute for Economic Research VATT (the coordinator), the Finnish Environmental Institute, MTT Agrifood Research Finland, the National Consumer Research Centre and VTT Technical Research Centre of Finland. A multidisciplinary research group provided a fruitful forum for an integrated approach. Funding partners included Funding Agency for Technology and Innovation, Kesko, Elisa, StoraEnso, Nokia, HK Ruokatalo, and Tuulia International. The present research report and underlying working package was coordinated by MTT Agrifood Research Finland. The report provides elements and materials to continue the discussion related to further research and development needs, and applications of the CFP system both at the national and international level. It is of vital importance that there are forums for participatory dialogue on the system and its applications that involve researchers, policy makers, businesses and consumers.

Helsinki, September 2009

Sari Forsman-Hugg

Research manager of Responsible Food Economy programme

MTT

Summary

This report based on work package 3 of the Climate Bonus project, illustrates the basic structure of a system that could produce strict and reliable data needed for generating product-oriented carbon footprints in Finland. It also represents a road map for developing the system for the energy and food sectors. Steering mechanisms, standards and possible data sources central to the system are also reviewed. Accuracy and a scope of the outlined system should be developed step by step, starting from the major emission sources, processes and products. Account has also been taken of linkages between the proposed system and existing environmental management systems, annual reporting practices and the European emission-trading scheme (EU-ETS).

The report proposes a system for so-called Certified Carbon Footprints of Products (CFP system), which needs further development prior to full-scale introduction. Central parts of the system are a generic national CFP programme, product category rules (PCRs) produced according the guidelines of the CFP-programme and a chain monitoring or actor-wise monitoring plan, validation of the monitoring plan and reporting and verification of data, and an ICT system to support data management, sharing and quality assurance. The system is designed around activity-based monitoring data. The envisaged operational CFP system would produce data according to modules (i.e. production or process stage), such that carbon footprints of final products can be consistently and reliably calculated. Data would be produced step by step along the supply chain, and every actor would be responsible for production and reporting using data generated through its own activities.

Further development and introduction of the CFP system requires a structured process of national deliberation. The first set of steps for introduction of the CFP system includes establishment of the CFP programme and allocation of roles for different actors, definition of generic calculation principles and instructions for setting up PCRs, establishment of a verification and validation scheme, and development of the ICT system. One of the most central calculation principles relates to use of defaults because these have to be used to some extent, although the system is primarily based on monitored activity-based data. Default values should be conservative enough to encourage actors to produce more accurate and traceable data. The concepts of guarantee value and ceiling level are proposed to account for the time-related variation of emissions. The guarantees of emission levels would be documented thoroughly in monitoring plans and attached to product specifications.

As regards the energy sector, the development of CFP system could be facilitated by joining acquisition and handling of data sources and reporting with the commensurate processes in EU-ETS, the systems for declaration of origin of

electricity, life cycle assessments of fuels, and environmental management systems. For the food sector, the development of the CFP system requires establishment of new architecture for data acquisition and quality assurance, development of existing mechanisms (e.g. environmental support of agriculture) and consolidation of these activities in the CFP system. Moreover, additional research will be needed, particularly regarding emissions from agricultural production as well as consolidation in existing environmental management systems. Phased development of carbon data for energy and food products in the near future is outlined in the report. Broad cost-effective realisation of the CFP system requires development of internet-based tools for data acquisition, sharing and calculation.

The proposed CFP system has been created in conjunction with the development and testing of a GHG emission monitoring and feedback system for consumers in the Climate Bonus project. This internet-based service enables consumers to get an overview of the carbon footprints of their purchases and to keep track of them over time. Carbon footprints of products generated by the proposed CFP system are meant to be comparable at product level and therefore can be used for product specific carbon or climate labels. The CFP system information could also be used for eco-design and process development.

Yhteenveto

Tämä raportti on osa Climate Bonus -hankkeen raporttisarjaa. Raportissa esitetään perusrakenne järjestelmälle, jolla Suomessa voitaisiin laajamittaisesti tuottaa tuotekohtaisiin hiilijalanjälkiin tarvittavia tarkkoja ja luotettavia tietoja, ja ”tiekartta”-järjestelmän luomiseksi erityisesti energia- ja elintarvikesektoreilla. Raportissa tarkastellaan myös tämän järjestelmän kannalta keskeisiä ohjausmekanismeja, standardeja ja mahdollisia tietolähteitä. Hahmotellun järjestelmän tarkkuuden ja kattavuuden ajatellaan kehittyvän vaiheittain alkaen keskeisimmistä päästölähteistä ja prosesseista. Ehdotetun järjestelmän kytkeytyminen olemassa oleviin ympäristöhallinnan menettelyihin, vuotuisiin raportointitarpeisiin ja päästökauppajärjestelmään on otettu huomioon.

Jatkokehittämiseen ja käytäntöön sovellettavaksi ehdotetun tuotekohtaisten sertifioitujen hiilijalanjälkien tuottamisen järjestelmän (Certified Carbon Footprint of Products system, CFP system) keskeiset osat ovat yleinen, kansallisen tason CFP-ohjelma, sen alla ja ohjauksessa sektoreittain tuotettavat tuoteryhmäkohtaiset laskentasäännöt (PCR, product category rules), koko tuotantoketjun tai toimijan/toimijoiden tarkkailusuunnitelma (MP, monitoring plan), tarkkailusuunnitelman ohjeiden mukaisuuden varmistaminen (validation of MP) ja tuotettujen tietojen suunnitelman mukaisuuden vahvistaminen (verification of data) ja tietojen hallintaa, jakamista ja laadunvarmistusta tukeva tietojärjestelmä (ICT system). Järjestelmä perustuu toimintokohtaisen tiedon (activity based data) tuottamiseen. Toiminnassa ollessaan tuotekohtaisten sertifioitujen hiilijalanjälkien tuottamisen järjestelmä (CFP system, CFP-järjestelmä) tuottaisi lopputuotteiden hiilijalanjälkiin tarvittavat tiedot moduuleittain, tuotantoketjun osa kerrallaan, niin että kukin tuotantoketjun toimija vastaisi itse omaa toimintaansa koskevien hiilijalanjälkitietojen tuottamisesta ja raportoinnista.

Järjestelmän edelleen kehittäminen ja käyttöönotto edellyttää kansallista keskustelua. Keskeisiä asioita järjestelmän käyttöön soveltamiselle ovat CFP-ohjelman perustaminen ja eri osapuolten rooleista sopiminen, yleisistä kaikille sektoreille yhteisistä laskentaperiaatteista ja tuoteryhmäkohtaisten laskentasääntöjen laadinnan ohjeista sopiminen, tarkkailusuunnitelman varmistamis- ja tietojen vahvistamisjärjestelmän luominen ja tietojärjestelmän kehittäminen. Yksi keskeinen sovittava laskentaperiaate koskee oletusarvojen (defaults) käyttöä, sillä käytännössä niitäkin joudutaan käyttämään, vaikka järjestelmä perustuukin toimintokohtaiseen mitattuun tietoon. Taulukkoarvojen pitäisi olla riittävän konservatiivisia, jotta ne kannustaisivat todellisten tuotantopaikkakohtaisten tietojen mittaamiseen tai tarkennettuihin malleihin. Raportissa ehdotetaan tarkkailusuunnitelmassa ”luvattavien” päästötakuun ja kattoarvojen käyttöönottamista päästöjen ajallisen vaihtelun huomioon ottamiseksi.

Energiasektorilla CFP-järjestelmän kehittäminen voisi edetä siten, että siinä tarvittavia tiedonhankinnan ja raportoinnin rakenteita sovitettaisiin yhteen päästökauppajärjestelmän, sähkön alkuperäjärjestelmän, polttoaineketjujen elinkaaritutkimusten ja ympäristöjärjestelmien tiedonhankintaan ja raportointeihin. Elintarvikesektorilla CFP-järjestelmän edelleenkehittäminen tarvitsee uusien rakenteiden luomista, olemassa olevien rakenteiden kehittämistä ja yhteensovittamista CFP-järjestelmän kanssa (esim. maatalouden ympäristötuki, yritysten ympäristöjärjestelmät) ja tutkimusta varsinkin alkutuotannon osalta. Raportissa esitetään ehdotuksia energiatuotteiden ja elintarvikkeiden hiilijalanjälkitietojen vaiheittaiseksi kehittämiseksi lähitulevaisuudessa. CFP-järjestelmän laaja-alainen ja kustannustehokas toteuttaminen edellyttää internetpohjaisten laskennan, tiedonhankinnan ja tietojen jakamisen työkalujen kehittämistä.

Ehdotettu järjestelmä on luotu vuorovaikutuksessa Climate Bonus -hankkeessa kehitetyn ja kuluttajien kanssa kokeillun kuluttajapalautejärjestelmän kanssa, jossa kuluttajat voivat saada tietoa kulutuksensa hiilijalanjäljestä. Ehdotetun järjestelmän avulla tuotettavat tuotekohtaiset hiilijalanjäljet olisivat vertailukelpoisia ja voisivat toimia myös tuotteiden hiili- tai ilmastomerkkien pohjana. Tuotettavaa tietoa voitaisiin käyttää myös eko-designissa ja tuotantoprosessien kehittämisessä.

Ehdotettu järjestelmä on luotu vuorovaikutuksessa Climate Bonus -hankkeessa kehitetyn ja kuluttajien kanssa kokeillun kuluttajapalautejärjestelmän kanssa, jossa kuluttajat voivat saada tietoa kulutuksensa hiilijalanjäljestä. Ehdotetun järjestelmän avulla tuotettavat tuotekohtaiset hiilijalanjäljet olisivat vertailukelpoisia ja voisivat toimia myös tuotteiden hiili- tai ilmastomerkkien pohjana. Tuotettavaa tietoa voitaisiin käyttää myös eko-designissa ja tuotantoprosessien kehittämisessä.

Contents

1 Introduction

An important underlying philosophy of the Climate Bonus project is that credible and structured information provision regarding external environmental impacts of production processes and systematic feedback for consumers, constitute essential elements for the correction of market failures. This is particularly topical when it concerns consumer product chains. The key purpose of the Climate Bonus project has been to assess the possibilities for and effectiveness of a bonus system for households that encourages them to consume in such a way that greenhouse gas (GHG) emissions are reduced. It also persuades retailers to offer a product portfolio that advances the choice for low GHG solutions by households. In order to enable a workable and credible bonus system development of the underlying information system is indispensable. In this work package 3 (WP3) report, the system and its elements for producing product specific emission data on the production side (supply chain) is illustrated, outlined and discussed.

In the other work packages additional aspects of the monitoring and feedback system are studied. In the report of WP4 the consumer side will be discussed, with particular reference to options and effectiveness of product information provision, monitoring of consumer activities and feedback to consumers. A tested consumer pilot is discussed in the report of WP5. The report of WP6 concerns the review of the information service package from a policy point of view.

This WP3 report concerns feasibility of data and information system for product related data. In addition to the standard functions of the envisaged supply chain emission information system of the Climate Bonus system, it could yield information about carbon footprints of products and processes. For example, information could be made available on the carbon footprint label of a product, or for audits aimed at identifying emission reduction potential in modelled supply chains. Labelling and auditing are not part of the envisaged Climate Bonus system, but expected to be important elements of the company or supply chain climate strategy in which the Climate Bonus system is to be embedded (see also the WP4 and WP6 reports). The multi-purpose character of the supply chain information system simultaneously underscores its importance and its complexity. The availability of product specific emission data is considered to be the most challenging issue in the pathway towards reliable commercial carbon footprint services and creation of effective consumer driven greenhouse gas mitigation policies and measures.

This report introduces the elements that are considered to be essential for the production of comparable, reliable and up-to-date carbon footprint data. Carbon footprint data that fulfill these requirements are termed Certified Carbon

Footprints of Products (CFP) in this report. We consider international standards, Product Category Rules (PCR), real chain data (activity-data), monitoring plan, transparent documentation, reporting and verification by 3rd party approach as essential building blocks for the creation of a reliable data management system for CFP.

The cost-efficiency of data production and sharing is critical. It needs to be radically improved in relation to that which currently pertains on a case-by-case and product-by-product carbon footprint basis. We therefore focus on the need to formulate a logical and harmonised data management system that can be developed using a stepwise modular logic to cover entire production systems producing multiple products. The essential points are: 1) each actor/organisation is responsible for its own activity data so that data collection can be integrated into every-day management processes, and 2) it should be possible to integrate reliable data collected for other purposes into the CFP system. In addition the data collected for the CFP system should be as useful as possible also for other purposes of organisation. On the other hand, calculation rules applied in the system should be based on international, widely accepted standards and directives. Until there is an extensive international system for calculation rules, national regulations and systems have to be developed and introduced in Finland These will facilitate practical experience, as has taken place in many other countries. A vision of these is introduced in this report, as well as a roadmap to achieve the aims, especially in the energy and food sector.

2 Sources and applicability of information concerning product level greenhouse gas emissions

2.1 The rationale behind product specific carbon footprints for consumer products

The envisaged Climate Bonus system is meant for promoting a sustainable transition (e.g. Fischer-Kowalski et al. 2009, Bergman et al. 2008, Rotmans 2006, see also the report of WP6). Specifically it is meant to bring about substantial changes in product selection and consumption habits of consumers such that it results in reduction of attributed greenhouse gas emissions[1]. The guidance that consumers need in order to make changes goes well beyond the generic communication about the need for changing life styles and changing consumption patterns, which can be read and heard in the media.

The provision of generic information, assisted by carbon calculations that provide households with an initial idea of their own impact on climate change (e.g. https://www.carbontrust.co.uk/publicsites/CFCalculator), is essentially about eliciting interest and understanding of the role of consumption in generation of greenhouse gas emissions. Consequently carbon footprint values do not need to be extremely exact and can cover broadly defined consumption categories (see also the report of WP4, notably chapter 4.2). In fact, for two of the most emission-intensive consumption categories, i.e. residential energy use and (fossil[2]) motor fuels for private vehicles, the amount of attributable household greenhouse gas emissions can be assessed fairly accurately, provided information about the quantities of purchased fuels, heat and electricity is available. However, the need for more sophisticated data assessment increases rapidly when people wish to consider the greenhouse gas emission impacts of all their purchases. Foodstuffs belong to that group of purchases.

In general, there are market developments that indicate that consumers are seen as drivers of sustainable development. Carbon compensation (offset) and green bank/credit cards are already in quite common use, and carbon footprint labels came to the fore most visibly in Great Britain (e.g. the communication of TESCO in 2007). French retailers and German consortia however are getting ever more active (see also the report of WP1).

---

[1] The system also aims at precipitating market introduction of low emission innovations, but that is not important for the discussion here about product specific information.

[2] Carbon footprints of bio fuels turn out to be much more complicated for roughly the same reasons as why carbon footprint of foodstuffs is complicated.

Inaccurate carbon footprints may constitute a serious risk for the effectiveness of these change-promoting instruments (Hertwich et al, 2008; Gunnarsson et al, 2009) because it may lead to wrong conclusions and advice for households. They can also lead to loss of credibility in this kind of information and feedback. This was a finding of the consumer pilot study (see report of WP5). Similarly, widely varying results of carbon calculators used in connection with carbon offset services, e.g. for compensating air travel emissions, created confusion and suspicion among consumers (Helsingin Sanomat 22.3.2009). Gunnarsson et al (2009) systematically tested 9 internet calculators for selected Swedish families and they found unexpectedly large variations in projected household's carbon footprints. Four calculators produced results outside the plausible (calibrated) range of the selected household carbon footprints. Interestingly, user friendliness and transparency of data sources did not necessarily coincide with accuracy of the calculators.

The carbon footprint of a product represents the cumulated amount of greenhouse gas emissions embodied in that product as a result of the greenhouse gases emitted during the subsequent stages of production (incl. transportation and storage) of that product[3]. The subsequent stages of production, often referred to as the *supply chain*, usually imply complex informational representations of the flows of natural and man made substances, materials, energy and waste (including recycling, side-products, etc.). What adds to the informational complexity of a supply chain is the existence of several alternatives regarding technologies, materials and energy sources, locations, and logistic solutions. Choices made in the system can have had marked impacts on the carbon footprint of the final product. Static "off-line" calculations and use of "literature data or averages", without any empirical coupling to activities and resource use of the operators, will often fail to promote (meaningful) reductions of greenhouse gas emissions in the production system (which is one of the central targets). If producers improve the actual GHG performance in some processes in the production chain, it is important that they are able to channel this information downstream and inform consumers in a reliable way about improved environmental quality of the product. This induces a competitive advantage and stimulates environmentally sound financial investments. To initiate this performance improvement mechanism on the production side, accurate, up-to-date, real monitored activity data are needed. In the long run, changes, especially improvements, in production systems must have an impact on end-product specific results realisable in the marketplace.

[3] In a complete closed system approach also the use phase as well as reuse/recycling should be considered. In this report carbon footprints refer to GHG emissions at the production side (incl. retail) only, unless stated otherwise.

It should be stressed that product-specific emission information may be used in various – not mutually exclusive – ways. It can be used to feed into Climate Bonus-like monitoring and feedback systems, as well as form the basis for product labelling and/or marketing campaigns. In addition, it can be used for internal purposes like development of production processes, auditing and environmental reporting and management system. *It is important to understand that the creation of a systematic dynamics to promote emission reduction through changes in consumer choices and through (a subsequently boosted) market introduction of low emission alternatives requires the detailed and reliable assessment of the emissions throughout the supply chains (i.e. carbon footprint) for consumer products and services.* This leads to the challenge taken up in this work package report, namely to outline a carbon footprint data generation system capable of covering many products from many different consumption categories.

2.2 Different data for different use

Greenhouse gas emissions and global warming potential of different products and services have already been broadly assessed, and new assessments are produced continually. Assessments are based on various approaches, ranging from input-output analysis (IO-analysis) of national economies to life cycle assessments (LCA) for single products. The results from using different methods are usually not comparable. It is evident that the quality requirements for the climate impact estimates (e.g. carbon footprints), and the methods on which they are based, are related to the purpose for estimating the impacts and of the means of delivering the climate information about products and services (Nissinen & Seppälä 2008, p. 13, 30).

The information sources can be roughly divided into 4 categories, ordered by rigour specificity: 1) expert judgements and partial estimates, 2) input-output (IO) data, 3) impact category results of global warming potential (GWP) from a life cycle assessment (LCA) of a product/service (unverified), 4) reliable life cycle assessment or carbon footprint analysis of the specific product/service (i.e., well-specified system boundaries and allocation rules). In addition, under category 4, additional classes can be distinguished: 4a) carbon footprint analysis of a specific product/service made in an EPD programme (complying with Product Category Rules, see sections 3.1 and 3.2), and 4b) carbon footprint analysis covering the specific product batch, including aspects such as product category rules for making the analyses, chain monitoring, and verification of results. There can be overlap of classes 4a and 4b, i.e. carbon footprint analysis can simultaneously be a member of both groups.

Table 1. Sources and applicability of greenhouse emission data. Letters A–H are explained in the table at first mention, but see also text below.

	Sources	Remarks	Feasibility of data
1	Expert judgements and partial estimates	partial estimates can be exact for a life cycle stage	A = General communication; B = labels about impacts in use-phase (cars, electrical appliances)
2	Input-output data	very aggregated product group data, indicative or secondary data for LCAs	A; C = Compensating; D&E = Climate calculators
3	GWP data from LCA's	reliability and accuracy depending on procedures	A–E; F = Eco-design; G = criteria development for eco-labels
4	Verified and comparable GWP data from LCAs and Carbon Footprint analyses	Product-chain specific, reliable data	A–G; H = Carbon Footprint labels

The applicability of the information is divided into 8 somewhat crudely defined application areas:

A) General communication about the need for changing lifestyles and changing general shopping patterns,

B) Labels about impacts in use-phase (cars, electrical appliances),

C) Compensating services (including green visa cards),

D) 'Personal calculators', i.e. calculators for personal climate balance sheets,

E) 'Bonus calculators', i.e. calculators by retailers or government, introducing some positive feedbacks based on reductions in greenhouse gas emissions,

F) Eco-design in companies,

G) Type I environmental labels (voluntary positive environmental labels, requiring the fulfilling of product-group specific criteria),

H) Carbon footprint labels showing the 'exact' value of climate impacts of the product/service life cycle.

2.2.1 Expert judgements and partial estimates

The first category includes estimates based on some stages of the life cycle (partial estimates), as well as other estimates that do not follow any well-defined methodology based on life cycles. In some cases, such as for CO_2 emission values, e.g. fuel use of passenger cars, these can be relatively accurate figures and can provide valid comparisons between different makes and models. Partial estimates produced using LCA methodology also play a crucial role in business-to-business relations, as elements of the whole life cycle assessment or carbon footprint assessment.

Judgements and estimates can, however, often confuse making choices rather than ease them, e.g. when focusing only on transport stage but not the whole life cycle (Nissinen & Seppälä 2008, p. 46). The values are of some value in general discussion (way of use A), if the constraints of the knowledge base are well described and are reflected in the conclusions. Evidently they should not be used as such in any systems that calculate emissions, i.e. ways of use B, C, D and G ('as such' refers to the case of products like cars, for which the climate impacts from fuel burning can be estimated quite accurately, but also car and fuel production should be included in the estimate).

EU Emissions Trading Scheme as source of a partial estimate of climate impact of products

The EU Emissions Trading Scheme (EU-ETS) currently produces verified data on CO_2 emissions of thousands of European installations, covering almost half of Europe's CO_2 emissions. These data are very accurate, as they are produced according to certain rules (EC 2007) and are verified annually. However, the data are for installations and not for entire production chains. A single permitted installation might include several processes and emission sources. More than 600 installations were permitted by the Competent Authority (CA, Energy Market Authority, EMV) in Finland for the second ETS-period (2008–2009) (EMV 2009d). The CO_2 emissions of installations are monitored according to the permit and approved monitoring plan, and reported by the operators and verified by the verification bodies annually. All the information regarding Finnish ETS-installations is published on EMV's internet-based data-system (EMV 2009b). ETS sector cover around 50% of the total greenhouse gas emissions reported in the National inventory in Finland. In Finland combustion based power and heat production is included to the ETS. The EU-ETS sector includes also oil-refineries, steel production, pulp, paper and board production, cement, glass, limestone burning plants and brick works – representing the major share of energy intensive industry.

Emission data ($t,CO_2/a$) and energy inputs (TJ/a) for these units are made public, but production data for individual installations or companies is not usually published, even if used in initial allocation. However, all electricity vendors are obliged to inform their customers about their primary energy sources (categories) and to publish their average CO_2 emissions per kWh based on fuel mix of their own production and electricity purchases during the previous year, according based to the Act on Verification and Notification of Origin of Electricity (1129/2003). Possibilities to take advantage of these systems are discussed further in section 3.5.

2.2.2 Input-output (IO) data

The second category, data from input-output analysis, is based on input-output (IO) tables of the national economy. The IO tables are components of national accounts. Input-output tables describe the relationships among the various sectors in an economy. In monetary terms they quantify how the outputs (goods or services) produced by one sector either go other sectors, where they serve as inputs (intermediate use), or go for end use as exports, investments, and private and public consumption. The primary matrix of intermediate deliveries can be extended with secondary matrices on attributed embodied emissions per value unit (i.e. mln euro) of delivery. The easiest way to generate such secondary matrices (one for each type of emission) is by assuming that the quantity of emissions per delivery to another sector is proportional to the fraction of the value of the delivery to the total output of the delivering sector (see e.g. Tukker et al. 2006, Minx et al. 2007). If the used IO tables contain numerous sub-sectors[4], which coincide well with particular production processes and their specific emissions, the overall level of accuracy of such systems might already suffice for some types of manufactured products. However, for product chains with significant natural (incl. seasonal) variations and/or substantial parallel but technically different sub-chains, IO systems alone cannot produce the level of accuracy in emission data required for systems such of Climate Bonus. Foodstuffs typically fall into this category.

A weakness of the IO models is that although they include information on the use phase in households, and waste management and recycling stages, they do not link these to products/services. Thus they perform cradle-to-gate and cradle-to-shopping-bag analyses, but treat the use and waste phases as undivided blocks. For a cradle-to-grave analysis, as needed for carbon footprint assessment, specific solutions need to be found to cover the use, waste management and recycling stages.

Obviously inaccuracy is a weak point of emission attribution systems when they are purely based on input-output data. Apart from the above mentioned reasons for inaccuracy, that one way or another relate to limitation in achievable disaggregation in an IO system, the monetary basis of the IO table implies also that all kinds of price fluctuations, including variations in exchange rates, can affect the attribution of emissions, even though nothing has changed physically.

Nevertheless, the IO model has the benefit of giving a *total* picture of the economy, i.e. including all the emissions generated in the depicted economy. This is why Minx et al. (2007), who made an analysis of the methods available

[4] For example, in many OECD countries – including Finland – statistical agencies produce input-output base tables which usually distinguish hundreds of (sub-)sectors.

for carbon footprint measurements, suggested hybrid LCA, i.e. combining process LCA and IO data, to be the preferred method to reach high levels of robustness and comparability, while remaining cost-effective. According to Minx et al (2007) hybrid life cycle methods can overcome system boundary problems of process LCA by using sectoral data from environmental input-output analysis as a source of secondary data, where no primary or secondary process level data are available. They state that collection of process data in LCA is typically begun without knowing the complete system, whereas in hybrid LCA the analysis starts from the complete system and adds process specific data where available. The problem of system boundary setting should disappear as the study system is inherently complete.

There is a steady flow of research efforts at national and international levels (e.g. EU) to elaborate on input-output methods in conjunction with the modelling of environmental impacts of production and consumption. Several of the studies and methodological elaborations also attempt to link input-output systems with LCA methods, so-called hybrid systems, which aim to combine rigour with completeness. In a study made on products in 25 European countries, estimates of climate impacts were calculated for 478 product groups (Tukker et al. 2006). Similar analyses have been made for the USA economy, distinguishing 491 product groups (Carnegie Mellon University Green Design Institute 2008).

Input-output data for environmental impacts of consumption commodity groups in Finland

Input-output data and environmental impacts related to them have been studied since early 2000's in Finland. Mäenpää published environmental impacts for 15 consumption commodity groups in 2005 (Mäenpää 2005). This model was updated and a more detailed version was published in a project named 'Envimat'. This environmentally extended IO model distinguishes 151 product groups and 52 consumption commodity groups (Seppälä et al. 2006, Seppälä et al. 2009).

The 'Envimat'-model can be used to identify the economic actors in the product manufacturing chain that have most important for greenhouse gas emissions and should be targeted as primary activities, using primary data sources. For the secondary data sources, the results of the 'Envimat' IO model can be used. Seppälä et al (2009) describe in a more specifically how the Finnish environmentally extended IO can be used.

The Ketjuvastuu-project is completing the 'Envimat'-model for the food sector. This project produces detailed data for the food sector, summarising environmental impacts of different industrial sub-branches (such as impacts of meat production. In this approach the IO-hybrid LCA method for studying food stuffs is being piloted and the results will be published in 2009.

The estimates of cumulated embodied greenhouse gas emissions for product groups (including services) produced by IO models have many applications. They can be used for application areas A, B and C (see table 1), as long as the limitations imposed by the inaccuracy of the data are taken into account. For application area C (carbon offset services), more accurate information must be used when easily available, such as for car fuel use. For E and F, the estimates provide an overview of the importance of different products in society, and secondary data for carbon footprint analyses and life cycle analyses, are needed to identify the most important environmental aspects and criteria. For G they can provide a valuable method for identification of life cycle stages and actors that need to be treated as primary activities, and act as a source of secondary data, as described earlier.

2.2.3 LCA, Life cycle assessment of a product/service representing the product group

Standard 'life cycle assessment' or 'LCA', defined in the ISO 14040 series (see Chapter 3.1 for a detailed discussion) represents the basic methodology for carbon footprint measurements (Minx et al. 2007, BSI 2008, SETAC Europe LCA Steering Committee 2008). However, published LCA studies have added only fragmented information to the carbon footprint implementation discussion to date.

Although the results from numerous LCA studies are available for various products and services, their number is small compared with the large numbers of different products and services available in the European market. In addition to low coverage of markets, other problems are the focus on business-to-business products, which cannot be compared, and the results of which are outdated (i.e. the results do not correspond to new products on the market, but a situations of some years earlier).

For example, 104 publications were found for 2004 from a literature database 'Recent References Related to Natural Sciences', using search words 'life cycle assessment', 'life cycle inventory', 'life cycle analysis', 'lca' and 'lci'. Of these, 46 dealt with actual LCA studies, and only 10 dealt with consumer products. For 2006–2008, the numbers of LCA studies were around 250.

Why do we not find LCAs suitable for consumption studies? One reason could be that scientific LCAs are conducted for comparing certain product systems or services. Often the motivation is eco-design or business-to-business information delivery. LCAs are also made to serve the needs of policy makers, not consumers. The aim of such studies is not always a full LCA. For example, in comparative analysis, the stages which are equal in both product systems can be omitted.

There is a range of methodological variations even within the LCA approach, although there is an international standard for LCA. For example, data from common databases and literature are widely used while only a few studies are primarily based on real chain data acquired from real production chain activities. Good examples of that kind of LCA are the Finnish food LCA case studies

(Foodchain LCA projects) made by MTT Agrifood Research Finland and the Finnish agro-food industry and trade companies since the late 1990s.

Regardless of the approach to data acquisition, the methodology of supply-web LCA modelling used in these studies (and related data collection and generation, especially in agriculture), has developed significantly over time (Usva et al. 2009). The results are not strictly comparable, but the studies still provide an indication of the magnitude of the carbon footprint for various products. The same conclusion can be drawn from other LCA studies made by different researchers at different times and under different conditions. Common methodological bases for comparing LCA studies do not exist, and accordingly comparable LCA results do not exist for food products with respect to global warming or other environmental impacts.

The challenge of using published LCA studies is well illustrated by the study of Nissinen et al. (2006). In order to develop consumer information about environmental impacts of products/services and consumption, they collected and assessed tens of published LCAs. They reduced these to five LCA studies that they could modify and update, to demonstrate environmental impacts of various products to the public.

Due to the lack of comparability, using results of 'ordinary' life cycle assessments is restricted. In the standard it states that they are not to be used for comparisons of two products (brands and models) unless they have undergone a critical review. Applications are much broader however than those for 'partial estimates', and provide a more exact and complete picture of the environmental aspects of specific product systems. Motivation and funding for the work often comes from companies and such LCAs are of value in eco-design.

LCAs of food stuffs in Finland

In the late 1990s the Finnish agro-food industry and trade companies, in co-operation with MTT Agrifood Research Finland, initiated a process to generate comprehensive environmental performance data on Finnish food production and supply systems. Before this only some energy comparisons for foodstuffs were published.

A number of LCAs has been published in recent years. These include LCAs for cheese, potato flour, oat flakes and potato gratine (Katajajuuri et al. 2004), beer (Virtanen et al. 2007), cucumber (Katajajuuri et al. 2007) and broiler chicken (Katajajuuri 2007). These Foodchain LCA projects were carried out for individual Finnish brand products. The data collection and generation were based on actual production chains, i.e. the chains from retail products to farms was traced back and relevant data were collected. Correspondingly, results were product specific as primary data were collected from the field and suppliers. Environmental impacts of beer were also analysed using the same approach (Virtanen et al, 2007).

However, there remain large differences among these studies due to development of supply web based LCA modelling and related data collection and generation, especially for agricultural products (Usva et al. 2009). Some of the studies are already out of date, and e.g. sample sizes for farm production were quite limited for the first Foodchain studies. However, although the older studies describe the situation at that time, it is important to note that the situations and processes have changed over the last eight years. This means that the studies with more comprehensive data collection and with larger sample sizes cannot easily be compared as brands differ for the same product group. The older studies are still useful, however, to estimate the size of the carbon footprint for various products. There remain challenges for traditional LCA, e.g. uniform allocation procedures, system boundary settings, crediting principles of side flows and data quality indicators have not been done between case studies.

Rainbow trout and Baltic herring (Grönroos et al. 2006), and milk and rye bread (Grönroos and Seppälä, 2000) have also been assessed in Finland. The studies were based more on expert knowledge models. Companies were not as deeply involved in the studies as in the Foodchain studies led by MTT. The ConsEnv-project, a large project in its final phase, produces general level LCA data for different foodstuffs and the results will be presented as comparisons of the environmental impacts attributable to different lunch plates (Kurppa et al 2009, Saarinen et al. 2009).

However, there does not currently exist comparable data for different food and brand products because there are no uniform methodologies to allow comparisons to be made among studies carried out at different times.

3 Exploitable standards and steering systems

Carbon footprint determination and development of a system that produces carbon footprint values for products can be based on several standards, specifications and steering systems. The most important of these are international the standards for life cycle assessment and eco-labels, PAS 2050, and standards for validation and verification. Also the principles, rules and guidance related to the EU-ETS and National GHG inventories must be taken into account. The overlap of various legal and voluntary management systems reduces costs.

3.1 Standards on life cycle assessment (LCA) and eco-labels

The basis for producing accurate, reliable and comparable information on carbon footprints for products and services is provided by the LCA (ISO 14040 series) and environmental labeling (ISO 14020 series) standards published by the International Organization for Standardization (ISO). The standards for these series are listed in Annex 1. Standards 14040 and 14044 are especially important as they define the principles and general requirements for LCA studies. Of the 14020 series standard 14025 is the most significant in this respect as it builds on the LCA standards and emphasises the use of LCA as the method for producing environmental information that enables comparisons to be made between products. In addition to these standards, the standard series 14060 on greenhouse gas accounting (see chapters 3.3 and 3.4) and the standard "ISO 14050:2009 Environmental management – Vocabulary", which defines the fundamental terms used in the ISO 14000 standard series, are connected to carbon footprints.

GHG emissions originating from products and services, and their potential impact on climate change, are covered by the ISO LCA standards because global warming potential (GWP) is an impact category indicator. GWP is a key indicator in LCA but it should be used in combination with other important environmental indicators. However, as the ISO standards specify general requirements and give guidance for compiling and evaluating information on the environmental effects of product systems, they do not address the practical issues of how to gather and use information for any specific impact category, e.g. climate change.

It is stated in the ISO 14040 standard that comparing the results of different LCA studies is possible only if the assumptions and contexts of each study are equivalent. This precondition is further elaborated in several additional requirements and recommendations given in ISO 14044. The requirements are even stricter for LCA studies used in comparative assertions intended for public disclosure. These requirements and recommendations address data quality, impact category indicators, analysis of the results, reporting, and a critical review that should be conducted by a panel of external interested parties. It is also stated that the studies compared should be of comparable scope, have the same functional units, and there should be equivalent methodological considerations regarding performance, system boundary, allocation procedures, decision rules on evaluating inputs and outputs and impact assessment. The differences between systems should be reported. However, all the requirements and recommendations stated in the standards are of a general nature and thus provide only the framework for performing comparable life cycle assessments (SFS-EN ISO 14040 and 14044.) According to the definition of the standard, these comparisons are primarily made only between competing products that perform the same function (SFS-EN ISO 14040, p. 15).

The ISO LCA standards do not directly address the issue of who should produce the life cycle information of a product or whether this task could be divided among those involved in the value chain of a product. However, in the ISO 14025 standard dealing with environmental declarations, the idea of *modularity* is mentioned (SFS ISO 14025, p. 15), i.e. that the LCA-based data for products that are used in the manufacture of other products can be used to produce environmental declarations for those other products. The issues of responsibility limits (concerning when someone involved in the value chain of a product should gather the information), or practical implementation of such an information management system, are not addressed in the ISO standards.

The ISO 14020 series identifies three ways of communicating the environmental aspects of a product: 1) self-declared environmental claims, 2) a label indicating that the product meets a set of predetermined criteria defined by a third party, and 3) environmental product declarations (EPDs). The development of all these labels and declarations should be based on life cycle thinking (ISO 14020), but only the EPD (defined in ISO 14025) requires use of life cycle assessment (as defined in ISO 14040 and 14044). In practice, an environmental label or declaration may take the form of a statement, symbol or graphic for a product or package, in product literature, in technical bulletins, or in advertising, among other things (ISO 14020). A label may contain e.g. a number (e.g. kg CO_2 equivalents per kg or per product), a symbol (e.g. recyclable) or another graphical sign indicating the performance of the product in relation to other products (e.g. traffic lights).

3.2 Product Category Rules within Environmental Product Declaration programmes

ISO 14025 defines the procedures for developing Type III environmental declaration programmes and Type III environmental declarations (Environmental Product Declarations, EPDs). These programmes are defined as voluntary and have a set of rules, managed by a programme operator who guides their administration and operation. The programme operator can be a company or a group of companies, an industrial sector or a trade association, a public authority or agency, or an independent scientific body or other organisation. Type III environmental declarations provide information on the environmental aspects of products and services based on LCA studies performed according to the ISO 14040 and 14044 standards. The declarations provide quantified environmental data using predetermined parameters and are intended to allow a purchaser or user to compare the environmental performance of products on a life cycle basis. EPDs are primarily intended to be used in business-to-business communication, but their use in business-to-consumer communication is not excluded. Additional requirements are defined in the standard for developing environmental declarations for business-to-consumer communication (SFS ISO 14025).

The development of product category rules (PCR) is essential in the EPD programmes. They are a set of rules, requirements and guidelines for developing EPDs for one or more product categories (group of products that fulfill equivalent functions). They define among other things the product category in question, the functional unit, system boundary and parameters to be used in the LCA, the data collection, calculation and allocation procedures and the way of reporting. PCRs are developed in order to facilitate the production of environmental declarations and to ensure the comparability of the declarations (SFS ISO 14025).

Verification of the data in an EPD is also essential in an EPD programme. For the verification of PCRs, LCA information and EPDs, EPD programme operators have to develop transparent procedures (SFS ISO 14025).

The carbon footprint of a product produced by LCA is a limited EPD, so called single-issue EPD, which is not defined or even considered in the ISO 14025 standard, but the general principles outlined in ISO 14025 can be used as a basis to develop carbon footprint programmes.

The ISO 14025 standard provides general requirements and guidelines for developing EPD programmes and EPDs, but the details of the procedures are left for the programme operators to decide. Harmonisation of general programme instructions, and particularly PCRs between programmes, is encouraged in the standard to meet the principle of comparability. Programme operators are encouraged to work cooperatively to achieve harmonisation of the programmes and to develop mutual recognition agreements. The consideration of the adoption of readily available PCR documents in the same product category and in the appropriate market area is also recommended when developing PCRs. The standard does, however, recognise that there may be valid reasons for developing PCR documents that have different contents (SFS ISO 14025).

EPDs strive for the comparability of results that are often lacking in LCAs not linked to an EPD programme. As the International EPD® system describes it (EDP 2009), collecting LCA data to be included in the declaration is a core activity in the process of creating an EPD with the following basic prerequisites: 1) to comply with internationally accepted principles for LCA, according to the ISO standards 14040–43, 2) to follow the general purpose of EPDs, the collection of data, methods and assumptions used as advocated in the ISO standard 14025 and described in the General Programme Instructions, and 3) to be in line with the PCRs, for the product category of interest. In addition to EPDs, which cover several environmental impact classes, the International EPD® system has also issued so-called "Climate Declarations" as the first example of *single-issue EPDs.*

3.3 Standards and specifications for carbon footprints

<u>Ongoing ISO standardisation work</u>

The following product level carbon footprint standards are currently being developed by ISO (ISO TC 207/ Subcommittee 7, Greenhouse gas management and related activities):

- ISO 14067 Carbon footprint of products – Part 1: Quantification
  - Quantifying the carbon footprint
  - Builds on ISO 14040 and 14044 standards
- ISO 14067 Carbon footprint of products – Part 2: Communication
  - Harmonising the methodologies for communicating the carbon footprint information.
  - Builds on ISO 14025 standard

The new development projects were approved in November 2009. Parties involved with the development of PAS 2050 (see the following section) are contributing to the development of ISO 14067. However, the proposal to base the new ISO standard on PAS 2050 as a “seed document for the quantification and monitoring module” was rejected at the August 2008 meeting of ISO TC 207/SC 7 in Bogota. The ISO 14067 standard is to be completed in March 2011; parts 1 and 2 will be developed in parallel and completed at the same time (ISO 2009, TC207 2009, University of Bath 2009).

Also the work of the “ISO/TC 207 Subcommittee 3 – Environmental Labelling” is related to the topic. A task group has been established to examine the options for alignment and adaptation of the ISO 14020 series standards (review of the ISO 14020 series in light of market developments such as carbon footprint claims). In addition, the "ISO/TC 207 Subcommittee 5 – Environmental Life Cycle Assessment" has established a new working group to develop ISO 14045 on eco-efficiency assessment and possibly a new environmental life cycle costing standard (TC207 2009).

<u>The European Commission (EC)</u> is also working towards harmonising ISO-based LCA practices and developing (through the Institute for Environmental and Sustainability of the Joint Research Centre working under the EC) an International Reference Life Cycle Data System (ILCD) Handbook for this purpose. The ILCD Handbook consists of a series of technical guidance documents that build on the ISO 14040 and 14044 standards. The purpose of the handbook is to give more detailed guidance on how to perform an ISO-compliant LCA in practice, and to provide a basis for ensuring consistency and quality across LCA data, methods, and assessments for different applications. Most of the ILCD Handbook documents are now under public consultation and the planned launch of the documents is at the end of 2009 (European Platform on LCA 2009).

<u>Publicly Available Specification (PAS) 2050</u>

The Publicly Available Specification (PAS) 2050, not intended as an official standard, was prepared by the BSI British Standards, and the development was co-sponsored by the Carbon Trust, an independent company set up by the UK government in 2001, and the British Department for Environment, Food and Rural Affairs (Defra). During the preparation of the PAS 2050:2008, and now during its development and adoption, a large number of companies and other organisations worldwide have been consulted and pilot projects conducted. PAS 2050, with a 60-page guide, was officially launched in October 2008. *PAS 2050 is intended to provide a clear and consistent method for the assessment of the life cycle GHG emissions associated with goods and services.* PAS 2050 specifies requirements for identifying the system boundary, the sources of GHG emissions associated with products that fall inside the system boundary, the data requirements for carrying out the analysis, and calculation of the results. It is stated in the PAS 2050 that it builds on standards ISO 14040 and ISO 14044 by specifying requirements for the assessment of GHG emissions. It does, however, include certain contradictory requirements (BSI 2008a and b). The guide to PAS 2050 includes also practical examples for calculation. PAS 2050 is an important cornerstone in the development pathway for carbon footprinting methodologies and is expected to be referred to for most practical carbon footprints in the near future. The issues already covered by PAS are considered in the document if some contradictory aspects emerge. Acquaintance with the original PAS documents is recommended.

According to PAS 2050, allocation should be avoided, preferably by dividing the unit processes to be allocated into sub-processes, or by expanding the product system if division is not possible. With system expansion the avoided average GHG emissions associated with the possible avoided products should be considered. If allocation cannot be avoided, economic allocation should be used. In addition to these general rules, special allocation rules are given for certain processes, e.g. combined heat and power generation, transport and wastes (BSI 2008a, p. 22).

One of the targets of PAS 2050 is to enable the comparison of GHG emissions between products and the communication of this information (BSI 2008a, p. 1). However, PAS 2050 does not specify requirements for communication. PAS 2050 does not directly take a stand in relation to the question of which products could or should be compared with each other (e.g. products from the same product group or products which perform the same function). Indirectly the PAS 2050 standard implies that the comparisons could or should be made between competing products.

PAS 2050 does not require but recommends verification of GHG emission calculations. It does not include specific guidance for verification. However, three certification or verification alternatives are given:

1) independent third party certification,

2) other party verification, and

3) self verification (based on ISO 14021),

to be selected according to the goal of the calculation project.

Independent third party certification refers to an assessment performed by a certification body accredited by an internationally recognised accreditation body (e.g. United Kingdom Accreditation Service, UKAS or respectively FINAS in Finland), and it is stated that this type of certification is most likely to gain consumers' confidence when communicating the results to third parties (BSI 2008a and b). The same procedural architecture is applied when EU-ETS verifiers are accredited. Accreditation services co-operate within EA (European co-operation for Accreditation), develop guidance documents and have official status in the EU. When the EU-wide certification scheme based on accredited verifiers for carbon footprinting activities is designed, the full use of capacity and networks operating under the EA should be considered.

Regarding PCRs, the PAS2050 standard refers to the International EPD® system (see Section 3.2. and www.environdec.com) and PCRs published in it. PAS2050 does not, however, require the use of PCRs – published PCRs should be used e.g.

for determining system boundaries *if available* for the product in question (BSI 2008b, pp. 12–13).

In the future, it is intended to review PAS 2050 at a minimum every two years and any amendments will be published as amended Publicly Available Specifications. In the future PAS 2050 will be withdrawn if it becomes the basis of an official national, European or international standard (BSI 2008a). It is highly probable that the EU will consider the overall situation regarding various standards and approaches in the near future.

3.4 Standards on validation and verification

ISO 14064 standards for greenhouse gas accounting and verification published in 2006 provide government and industry with an integrated set of tools for programmes aimed at reducing greenhouse gas emissions, as well as for emission trading. ISO 14064 greenhouse gases objectives are to:

- enhance environmental integrity by promoting consistency, transparency and credibility in GHG quantification, monitoring, reporting and verification;
- enable organisations to identify and manage GHG-related liabilities, assets and risks;
- facilitate the trade of GHG allowance or credits; and
- support the design, development and implementation of comparable and consistent GHG schemes or programmes (Weng & Boehmer 2006).

ISO 14064 Part 1: Specification with guidance at the organisation level for quantification and reporting of greenhouse gas emissions and removals, focuses on principles and requirements for designing, developing, managing and reporting organisation or company level GHG inventories. It includes requirements for determining GHG emission boundaries, quantifying an organisation's GHG emissions and removals and identifying specific company actions or activities aimed at improving GHG management. It also includes requirements and guidance on inventory quality management, reporting, internal auditing and the organisation's responsibilities in verification activities.

ISO 14064 Part 2: Specification with guidance at the project level for the quantification, monitoring and reporting of greenhouse gas emission reductions and removal enhancements, focuses on GHG projects or project-based activities specifically designed to reduce GHG emissions or increase GHG removals. It includes principles and requirements for determining project baseline scenarios and for monitoring, quantifying and reporting project performance relative to the baseline scenario and provides the basis for GHG projects to be validated and verified (Weng & Boehmer 2006).

ISO 14064 Part 3: Specification with guidance for the validation and verification of greenhouse gas assertions, details principles and requirements for verifying GHG inventories and validating or verifying GHG projects. It describes the process for GHG-related validation or verification and specifies components such as validation or verification planning, assessment procedures and the evaluation of organisation or project GHG assertion. Part 3 can be used by organisations or independent parties to validate or verify GHG assertions and establishes new international best practices for the GHG validation or verification process (Weng & Boehmer 2006).

ISO 14064:2006 is complemented with ISO 14065:2007, Greenhouse gases – Requirements for greenhouse gas validation and verification bodies for use in accreditation or other forms of recognition. It details requirements for GHG validation or verification bodies for use in accreditation or other forms of recognition. While ISO 14064 provides requirements for organisations or persons to quantify and verify GHG emissions, ISO 14065 specifies accreditation requirements for organisations that validate or verify resulting GHG emission assertions or claims (ISO 2007).

ISO 14065 provides requirements for bodies that undertake GHG validation or verification using ISO 14064 or other relevant standards or specifications. The objectives of the ISO 14064 and 14065 standards are to:

- promote and harmonise best practices;
- support the environmental integrity of GHG assertions;
- assist organisations to manage GHG-related opportunities and risks; and
- support the development of GHG programmes and markets (ISO 2007).

Standard ISO/CD 14066 Greenhouse gases – Competency requirements for conducting greenhouse gas validation and verification engagements with guidance for evaluation, is under development. ISO TC 207/ Subcommittee 7 comprises working group 1 (WG1), Competency requirements for greenhouse gas validators and verifiers document, and working group 2 (WG2), GHG management in the value or supply chain (ISO 2009).

In practice, almost all production systems include input material streams from installations already covered by the obligatory EU-ETS system. The emission reports of these “modules” are verified annually. In the entire EU-ETS, the verification must be in compliance with the commission decision (2007/589/EC) establishing guidelines for the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council (called “MRG2”, EC 2007) and in most European countries it is executed according to the legislation and guidance given by member states (e.g. in Finland EMV 2009c and EA 2008). In this situation the “re-verification” of these “modules” attached to larger production systems is not necessary. The interactions of various systems must be designed carefully.

3.5 EU Emissions Trading Scheme (EU-ETS)

The EU Emissions Trading Scheme (EU-ETS) is currently the cornerstone of the EU’s strategy for fighting climate change. It is the world’s first large-scale international trading system for CO_2 emissions. In 2008, it covered 12,357 installations (EC 2009a) collectively responsible for close to half of Europe’s CO_2 emissions (2,060 million tonnes). An extensive survey and figures about "the state of the EU-ETS" is in the reference (EEA 2008). In addition, a substantial share of the rest of the GHG-emissions (outside EU-ETS boundary) originates from oil-fuels produced in the ETS-installations (oil refineries). The carbon content of refinery products (gasoline, diesel, heating oils) and used in housing or transportation is not regulated in the EU-ETS. On the contrary, taxing instruments are applied.

Guidelines for the monitoring and reporting of greenhouse gas emissions (MRG2) establish the rules for EU-ETS monitoring and reporting practices in the EU[5] (EC 2007). They aim to harmonise emission monitoring practices in different types of installation in all member states. Member states have implemented these “MRG2 rules” into their own legislation and operators of ETS-installations are generally aware of these. Some countries, including Finland, have some additional and detailed guidance for monitoring (EMV 2007) and web-based reporting[6].

The guidance includes 1) generic sections, 2) rules for the calculation of combustion-based emissions, and 3) sector-specific appendices. The need to specify calculation principles for sector-specific activities (processes) has been obvious. The same issue is recognised in EPD systems and is addressed using product category rules (PCR).

The central concepts and tools for emission monitoring and reporting for installations set in the MRG2 concern

---

[5] MRG2 is available at http://ec.europa.eu/environment/climat/emission/mrg_en.htm

[6] In Finland FINETS system: www.paastolupa.fi

- boundaries (scope, emission sources to the atmosphere),
- calculation and measurement-based methodologies,
- tier of approach (accuracy levels and default/specific emission factors, calorific values etc.),
- public monitoring plan attached to the emission permit by competent authority,
- continuous monitoring of activity data (mainly carbon containing input streams),
- annual reporting of emissions,
- retention of information, and
- quality control and annual verification.

These issues are briefly discussed from the point of view of utilisation in construction of a CFP system (described in chapter 4) in Chapter 3.5.2.

Central outcomes from monitoring and reporting activities according EU-ETS are

- validated emission permit including all emission determination methods (detailed monitoring plan) applied in the installation,
- the annual emission report of the permitted ETS-installation,
- verification statement by the accredited verification body (quality assurance), and
- emission balance (allowances/emissions) of the installation issued by competent authority (CA).

The usefulness of EU-ETS for generation of the Certified Carbon Footprint of Product system (the CFP system) proposed in this report is based on the above-mentioned systemic structure of EU-ETS (i.e. central elements), scope of data produced within EU-ETS and calculation logic of EU-ETS, which can be adapted to support production of integrated figures covering larger production systems consisting of several "ETS and non-ETS modules". The emission monitoring activities and guidance of EU-ETS and increasing competence of ETS monitoring and verification experts can also be utilised to determine emissions of external units. Emission figures alone can serve several policy measures other than cap and trade systems. Verified CO_2 emission data on several ETS installations can be used as a data source in creating carbon footprints to avoid multiple reporting and verification, and improve cost efficiency.

3.5.1 Scope of CO_2 emission data produced within EU-ETS in Finland

More than 600 installations were permitted for the second compliance cycle by the Competent Authority (CA, Energy Market Authority, EMV) in Finland. The CO_2 emissions of installations are monitored according to the permit and approved monitoring plan and are reported by the operators and verified by the verification bodies annually. All this information is published via EMV's internet-based data-system (www.paastolupa.fi) and on EMV's internet pages (www.energiamarkkinavirasto.fi). The ETS sector in Finland covers around 50% of the total greenhouse gas emissions reported in the national inventory and the share fluctuates annually for several reasons. In 2008 the total CO_2 emissions of EU-ETS installations in Finland was 36.2 million tonnes (EMV 2009), which is 15% less than emissions in 2007.

In 2007, Finland's greenhouse gas emissions totalled 78.3 million tonnes of CO_2 equivalent. The total emissions in 2007 were 11% above the level of those for 1990. As part of the burden sharing of the EU Member States, Finland has made a commitment to keep its average emissions over the 2008 to 2012 period at the level they were in 1990 (Statistics Finland 2009).

Electricity, district heating and fossil fuels are important input-streams in most supply chains. In Finland combustion-based power and heat production is extensively included in the ETS, except for waste incineration plants and small district heating plants connected to heat distribution networks, where all units are smaller that 20 MW. In Finland, CO_2 emissions from fossil fuel combustion (61.8 million tonnes) accounted for 97% of the energy sector's total emissions and 79% of total greenhouse gas emissions in 2007 (Statistics Finland 2009). Thus, almost all production systems usually include marked input streams from activities included in the EU-ETS.

EU-ETS covers several industries (see Figure 1). Both Finnish **oil-refineries** belong to the EU-ETS. These complex and highly integrated refineries produce almost all liquid fossil fuels delivered for final consumption in Finland. ETS boundaries of these sites differ regarding inclusion of power and steam production. However, as an example, direct emission factors for oil-fuels (based on carbon content) could be supplemented with the indirect emission factor generated from the EU-ETS emissions for refineries, and combining these with production statistics and an allocation rule (e.g. energy content based /economic allocation, or utilising more specific technical process descriptions).

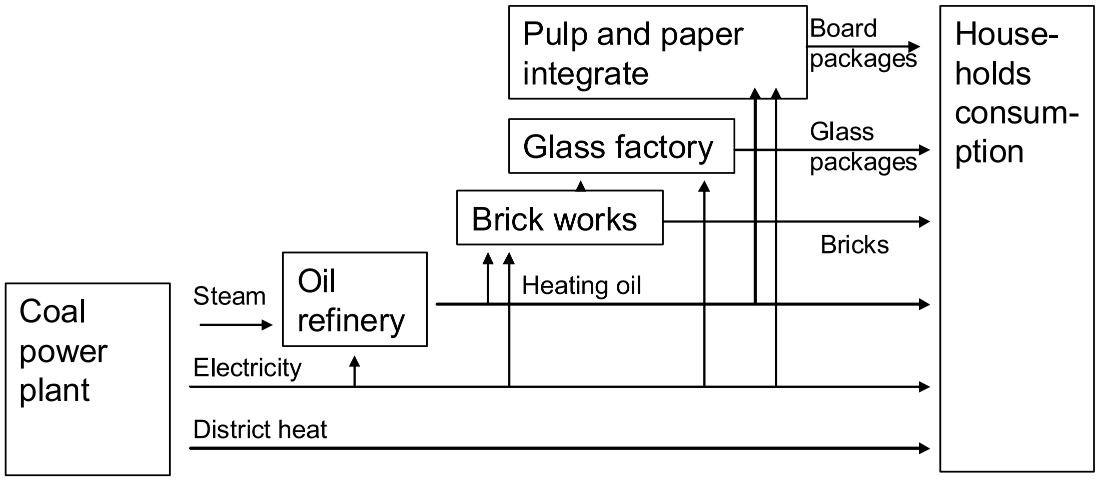
Most important emission sources for the **steel industry** (4 integrates) are included in the ETS and monitored using a mass balance approach (EC 2007). In these cases, using the ETS data, it is in principle possible to generate product specific emission estimates. Even if these estimates are "partial" and should be supplemented with upstream data, they capture the major share of total CO_2 emissions of the production system based on real activity data. In practice other production statistics (e.g. from company annual reports) must be combined to obtain "rough" estimates. However, these integrates are so complex and their impact on the carbon footprint of final products is often so significant, that the use of monitored and verified ETS emission data as a part of the supply chain calculations of end-products is worth considering.

More than 40 **pulp, paper and board** units are included in the ETS. These sites are typically monitored using the "one boundary principle" i.e. balance area containing several emission sources to the atmosphere and monitoring only the carbon containing streams crossing the system boundary. The utilisation of ETS emission estimates (and fossil inputs data) requires additional allocation methodologies due to the multiple product categories.

In addition to the previously mentioned industrial activities, the Finnish ETS includes two **cement mills**, six **glass plants** (glass wool, packages, plates and fibres), several **limestone burning** units, relatively small **brick works**, one expanded **clay factory**, combustion processes of two **mineral wool factories** and the combustion processes of one **petrochemical** integrate. Data for these units can be used when calculating direct and indirect emissions for products.

ETS installations produce CO_2-intensive final and intermediate products like electricity, heat, fuels, and construction materials (cement, bricks, steel, glass, insulation materials) and packaging materials (glass, plastic, paper and board) to downstream manufacturers and for final consumption. EU-ETS emission data are useful for the generation of product specific carbon footprints for several semi-products and a few consumer products, but real production statistics must be added to generate specific emissions. On the other hand, the availability of production output data is also a prerequisite for implementation of benchmarking-based initial allocation principles in the Post-Kyoto period. Currently production data are seldom published by the authorities responsible for initial allocation, making development of installation-specific benchmarks difficult. ETS data and defaults of CO_2 emission factors alone are not sufficient for the generation of product specific GHG emission estimates for food products, for example, where N_2O and CH_4 emissions are significant.

Figure 1. Overview of utilisation of installation-specific CO_2 emission estimates produced in EU-ETS for product-specific CO_2 emission estimates



3.5.2 Monitoring practices and calculation logic of EU-ETS

Boundaries

According to the MRG2, all relevant greenhouse gas emissions from all emission sources and/or source streams belonging to activities[7] carried out at the installation should be included in the monitoring and reporting process for an installation. The monitoring of emissions includes emissions from regular operations and abnormal events including start-up and shutdown, and emergency situations over the reporting period. However, emissions from mobile internal combustion engines for transportation purposes are excluded from the emission estimates. (EC 2007, p. 11)

Only the source streams containing carbon (releasing or binding carbon in the process) are monitored. ETS data do not include indirect emissions of source streams. However, these indirect emissions (e.g. electricity input of the installation) might be outputs of upstream installations, belonging to the ETS or not. The modular calculation strategy allows integrating new monitored installations into the production system or network.

[7] ‘Activities’ means the activities listed in Annex I to Directive 2003/87/EC ((EC 2007, p. 7). In practice, ‘activities’ means main processes containing emission sources of the site.

Greenhouse gas emission permits contain a description of the activities and emissions from the installation, i.e. all emission sources and source streams that are to be monitored and reported are listed in the permit. Greenhouse gas emission permits include monitoring requirements, specifying monitoring methodology and frequency (EC 2007, p. 11).

Calculation and measurement-based methodologies

According to MRG2[8] permits, emissions are determined using either:

- a calculation-based methodology, determining emissions from source streams based on activity data[9] obtained by means of measurement systems and additional parameters from laboratory analyses or standard factors;
- a measurement-based methodology, determining emissions from an emission source by means of continuous measurement of the concentration of the relevant greenhouse gas in the flue gas and of the flue gas flow.

Calculation-based methodology is the principal methodology, but in some cases continuous emission measurement-based (CEMS) methodology may be allowed, as well as a combination of both.

Basic formula for calculation of CO_2 emissions is (EC 2007, p. 13):

CO_2 emissions = activity data * emission factor * oxidation factor[10]

An alternative approach is applied if it is defined in the activity-specific guidelines. This formula is also specified for process emissions. The basic formula is (EC 2007, p. 14):

CO_2 emissions = activity data * emission factor * conversion factor[11]

---

[8] And Annex IV to Directive 2003/87/EC.

[9] Activity data represent information on material flow, consumption of fuel, input material or production output expressed as energy [TJ] (in exceptional cases also mass or volume [t or Nm3], see Section 5.5) in the case of fuels and mass or volume in the case of raw materials or products [t or Nm3] (EC 2007, p. 19).

[10] Oxidation factor expresses an un-oxidised or partially oxidised carbon content of fuel (EC 2007 p. 13).

[11] Conversion factor expresses carbon contained in input materials, which is converted to CO_2 during the process. This factor is used if emissions factors do not take into account the conversion factor (EC 2007, p. 14).

In EU-ETS 'process emissions'[12] has a slightly different meaning than in the LCA approach, especially when applied to agricultural production. In the LCA approach applied to agricultural production, process emissions originate mainly from biological processes, and include gases other than CO_2, such as N_2O and CH_4. In addition, emissions of N_2O and CH_4 depend more on "process conditions" than on material flows. Implication of biological processes makes a significant contribution to the calculation of indirect emission from food products.

For carbon footprints, the calculation methods of MRG2 (EC 2007) should be simplified as much as possible. The use of (functional) units that are used for everyday commercial purposes and emission factors directly applicable to these units (kgCO_2/ litre diesel) are recommended (factors are listed in the Annex 3 of this report). The usage of, for example, oxidationfactors is not necessary (separately) because it can be taken into account when direct emission factors are formulated, and the impact is negligible in any case.

In addition to this, there are situations where the end-product also contains carbon, and in a way it might have to be considered and monitored as a carbon sink. Then emissions are determined based on a carbon balance approach.

In terms of the **measurement methodology** applied in EU-ETS, greenhouse gas emissions can be determined by using continuous emission measurement systems (CEMS) from all or selected emission sources using standardised or accepted methods once the operator has received approval from the competent authority. The MRG2 contains further requirements regarding sampling rates, missing data and corroborating emission calculations (EC 2007, p. 21).

Tier of approach, accuracy levels and default emission factors

Regarding data quality requirements, MRG2 uses the **tier of approach**[13] concept. The operator may apply different approved tier levels to the variables in a single calculation. The choice of tiers is subject to approval by the competent authority. The increasing numbering of tiers from one upwards reflects increasing levels of accuracy, with the highest numbered tier being preferred (EC 2007, p. 14).

The requirement for using a certain tier depends on the amount of emission from a particular emission source (i.e. minor vs. major sources), technical feasibility

[12] In EU-ETS language it means "greenhouse gas emissions other than combustion emissions occurring as a result of intentional and unintentional reactions between substances or their transformation, including the chemical or electrolytic reduction of metal ores, the thermal decomposition of substances, and the formation of substances for use as product or feedstock" (EC 2007, p. 7).

[13] 'Tier' means a specific element of a methodology for determining an activity data, emission factors and oxidation or conversion factors (EC 2007, p. 7).

and fairness of costs. Use and changes of tiers is fully documented (EC 2007, p. 14).

The concept of tier can be adapted during development of the system for product carbon footprint, especially during the early stages when data on upstream processes are not used. In such a case predetermined values can be used. If the scope of ETS monitoring is widened to include non ETS activities or product-service systems, it is probable that the low tier levels for input streams would be used together with default emission factors because of low annual “modules” emissions. A significant amount of “rethinking” is necessary to adapt installation-specific optimisation logic to the supply chain perspective.

As with PCRs in the EPD system, annexes in the EU-ETS MRG2 are designed to optimise (and limit) monitoring costs and harmonise requirements for emission determination in various industrial processes (activities). These requirements include rules for **accuracy levels** (in terms of 95% confidence intervals) and applied functional units for the monitored material streams (amount/a) and corresponding requirements to select **default emission factors** (emissions/amount) or specific methodologies to analyse them (EC 2007).

<u>Monitoring plan</u>

The monitoring plan is prepared by the operator of an installation and is approved by the competent authority (CA) in accordance with the criteria set out in MRG2. The main purpose of the monitoring plan is to provide specification of the monitoring methodology to be applied by an installation (EC 2007, p. 12). The CA ensures the compatibility of the specific monitoring plan against background rules and guidance in the “validation” phase of the process.

The monitoring plan contains, among other things, the following:

- the description of the installation and activities carried out by the installation to be monitored;
- information on responsibilities for monitoring and reporting in the installation;
- a list of emission sources and source streams to be monitored for each activity carried out in the installation;
- a description of the calculation-based methodology or measurement-based methodology to be used; and
- a list and description of the tiers for activity data, emission factors, oxidation and conversion factors for each of the source streams to be monitored (EC 2007, p. 12).

The monitoring plan can be adapted for producing data on production chain emissions from products. Some member states (including the UK and Finland) have additional guidance and ICT tools to develop these plans.

Reporting and retention of information

The EU-ETS emission report on installation covers annual emissions over a calendar year for a single reporting period. The content of the report is determined in the MRG2. The report is verified in accordance with the detailed requirements established by the Member State[14]. Emission reports are made available to the public by that authority (EC 2007, p. 25).

The MRG2 requires that an operator of an installation retain information described in the MRG2 for at least ten years after submission of the report to allow reproduction of the determination of emissions by the verifier or a third party (EC 2007, p. 27).

Control and verification

The MRG2 emphasises control of data acquisition and handling for the monitoring and reporting of greenhouse gas emissions in accordance with the approved monitoring plan, the permit and the MRG2. According to the MRG2, the operator establishes, documents, implements and maintains an effective control system to ensure that the annual emissions report, resulting from the data flow activities, does not contain misstatements and conforms with the approved monitoring plan, the permit and the MRG2. The operator identifies and implements control activities for the purposes of controlling and mitigating the inherent and control risks (EC 2007, pp. 28–29).

The operator designs and implements reviews and validation of data, in accordance with the risks, for managing the data flow. The design is such that boundaries for rejecting the data are made clear in advance, where possible. Simple and effective data reviews may be performed at the operational level by comparison of monitored values using vertical and horizontal approaches. A vertical approach compares emission data monitored for the same installation during different years (EC 2007, p. 29).

The objective of **verification** is to ensure that emissions have been monitored in accordance with the guidelines and that reliable and correct emission data are reported. A verification opinion that states with reasonable assurance whether the data in the emissions report are free from material misstatements and whether there are no material non-conformities (EC 2007, p. 30).

---

[14] Requirements are pursuant to Annex V of Directive 2003/87/EC.

The accredited verifier presents the verification methodology, the findings and verification opinion in a **verification report (often "verification statement")**, addressed to the operator, to be submitted by the operator with the annual emission report to the competent authority. An annual emission report is verified as satisfactory if the total emissions are not materially misstated, and if, in the opinion of the verifier, there are no material non-conformities. In the case of non-material non-conformities or non-material misstatements, the verifier may include these in the verification report (verified as satisfactory with non-material non-conformities or non-material misstatements). The verifier may also report these in a separate management letter. The verifier may conclude an annual emissions report is not verified as satisfactory if the verifier finds material non-conformities or material misstatements (with or without material non-conformities). The verifier may conclude an annual emissions report is not verified when there it is of limitation scope (when circumstances prevent, or a restriction prevents the verifier from obtaining evidence required to reduce the verification risk to a reasonable level) and/or material uncertainties exist (EC 2007, p. 32).

These principles for control and verification can be adapted for the system of certified carbon footprint of products and verification can be carried out on a "modular basis", installation by installation, through strategic sampling. The verification strategy of an entire production chain is an issue that requires further research and development work. The competence and services of ETS verifiers could be developed and employed widely for this emerging purpose.

3.5.3 Conclusions of utilisation of EU-ETS for certified carbon footprint of products

The boundary setting of an installation is in most cases clear and reasonable for the EU-ETS, but from the point of view of production chain monitoring it has to be expanded in two ways. Firstly, only CO_2 emissions are currently included in the monitoring and reporting of EU-ETS, but other emissions, such as for N_2O and CH_4, are relevant in food production, for instance. This also has implications for calculation methodologies. Secondly, the EU-ETS concentrates on direct emissions of an individual installation while production chain monitoring has to comprise the entire chain, including, for example, indirect emissions from production of the final product.

In the EU-ETS only direct CO_2 emissions to the atmosphere inside the system boundary are calculated on the basis of "monitored activity-data" and "analysed emission factors". Indirect emissions originating from fossil fuel use in upstream processes outside the ETS (e.g. oil extraction, coal mining and transportation etc.), are not taken into account in ETS emission reports.

> *However, in principle, indirect CO_2 emissions of the production site (or of the final product) are direct emissions of upstream sites (modules in the complex network) and most often originate from fossil fuels.*

In the case where there are direct CO_2 emissions from several sites (upstream), and the quantitative coupling (the amount of inputs and outputs at the sites is known from linked streams), indirect emissions for the final product (emissions from the entire chain in relation to the product unit) can be calculated. *Impact of upstream emissions on downstream processes depends on the amount of inputs (from upstream process) required to produce outputs at issue (final product).* This means that ETS concepts can be adapted and used to determine CO_2 emissions of "modules" if the streams are linked with each other to generate product-specific emission data. Direct emission factors for outputs of a module can be estimated from the emissions and production data of the module itself, but the indirect "additional" part of the emission factor depends on the operations of upstream modules.

In addition to other restrictions, only the input (and in some cases output) source streams containing fossil carbon are monitored to determine direct emissions. The amount of non-carbon input streams (producing indirect emissions) are not monitored and reported. <u>Determination of indirect emissions associated with non-carbon inputs is not currently possible by application of ETS data.</u>

However, the ETS emission monitoring concepts can be developed and used for CFP purposes. Input and output streams can be linked to external processes constituting entire production systems. **The concept of "indirect emission factor" can be introduced to supplement the concept of "direct emission factors".** Stepwise development is recommended: first use defaults (e.g. results from other databases or LCA studies) and then create "living process systems". In addition, at least the amount of all "essential" streams with marked "indirect emission factors" should be monitored (outside the scope of EU-ETS). However, to assess whether a particular stream is significant or not, modelling exercises or previous LCA studies should be analysed (danger of circular reasoning exists).

Vehicle emissions (and vehicles in installations) have to be included in supplementary modules. Their monitoring is usually possible on an annual basis and the "overheads" can be added to product-specific estimates.

Rules, calculation methods and competences currently applied in ETS monitoring and verification provide some logical structure (but not sufficient), calculation principles, categorisations and background data, which can be used and adapted to produce certified carbon footprints of products originating from future complex production systems. <u>It is concluded that ETS results represent an important source of verified installation-specific CO_2 emission data for</u>

calculating carbon footprints, but must be supplemented with large amounts of additional data, concepts and methods.

The enlargement of application highlights at least two new challenges. Firstly, the basic unit of the EU-ETS emission monitoring is currently a production site, which might include several emission sources. With a change in approach to the product perspective, including impacts of a production chain, there is a need for **allocation**. Total site emissions must somehow be allocated to the products. An option for allocation is a dividing process so that emissions per product can be measured from actual production processes for the product. However, process-based measuring for end products is not yet very common. Secondly, the production outputs of the monitored system must be known for determination of product-specific GHG emissions. The lack of production data (in terms of functional units) is the first obstacle that has to be overcome by means of complementary data if verified annual emission reports (AERs) are to be used to calculate carbon footprints.

Annual emission data (t CO_2/a) and carbon-containing source stream information (amounts) of permitted units are made public, but the production output data per installation or company is not published in most cases. However, the data are used in initial allocation procedures based on benchmarks. To overcome this problem (in the case of the energy sector) the origin of the electricity can be used. All electricity marketing companies are obliged to inform their customers of their primary energy sources (categories) and to publish their average CO_2 emissions per kWh based on the fuel mix for their own production and electricity purchases during the previous year. This is based on the Act on Verification and Notification of Origin of Electricity (1129/2003).

Modular structures (with flexible boundaries), real monitoring of input and output streams (with focus on categorisations and multi-tier accuracy requirements) seem to be compatible principles for product orientated “chain or network calculations”. Decisions regarding carbon neutral fuels (e.g. wood, straw) should be done according to EU-ETS monitoring and reporting guidelines (EC 2007) and IPCC guidelines for National GHG inventories. Categorisation is detailed in the annex 3 of this report. The integration of the impacts of land use changes for real carbon balances associated with use of biomaterials is a challenging issue and is discussed elsewhere (VTT 2009). The consequence of precise investigations might be that some streams currently categorised as “carbon neutral” are not carbon neutral if indirect emissions in production chains and changes in carbon storage are taken into account.

Product based emissions can also be calculated based on data from various time windows, including time allocation principles. To integrate a consumption perspective (and product specific GHG estimates) into the climate policy perspective and corporate reporting practices an annual time window should be used as a framework for all calculations, original data production (monitoring) and reporting. Execution of full-scale verification to assure quality of the footprints can be risk-based and is not necessary on an annual basis.

The monitoring concept of EU-ETS (EC 2007) produces absolute annual emissions to the atmosphere originating from the monitored emission sources. The method is not currently strongly production oriented, although some member states use (specific) production data in their initial allocation processes (benchmarking). However, in Finland, for example, the source data used in initial allocation processes are not published such that they could be used to determine production statistics for the installation. Monitoring functions do not include any allocation principles that would be necessary to add, if the total emissions from the site were to be allocated to different product-streams produced from the permitted unit. It is supposed that new benchmarking principles will be introduced in the EU-ETS in the post-Kyoto period, based on production benchmarks. The more “system boundaries” are used, the more allocation is needed in multi-production instances and vice versa. Economic principles for allocation can be applied when products are used for different purposes or applications and functional units of various output streams differ, making it impossible to use them in allocation.

Due to its huge scope and the accuracy of emission data, use of ETS emission results and other capacity must be considered and tested carefully when a certified carbon footprinting scheme is introduced. All production chains include inputs from emission intensive processes that are already part of the EU-ETS. In these cases, the effective use of verified ETS CO_2 emission data is important. The integration of ETS and CFP systems is an issue that requires further thought.

At the EU level it is necessary to consider how ETS data in general, and emission data, together with ICT-based control systems and registries, could be developed to serve generation of product specific CO_2 emissions for a wide range of products. How can ETS experiences on monitoring, reporting and verification, but also web-based ICT tools, be used to produce carbon footprints for end products? The experiences of costly European efforts to monitor and verify CO_2 emissions of ETS installations should be used with other public data systems when the next generation of ICT-based consumer oriented climate-policy instruments are designed. Research and development could usefully be directed at current EU-ETS data systems to expand them into modular, web-based ICT systems. These would be able to produce product-specific GHG estimates for business-to-business users and consumers, in addition to providing an “emissions to the atmosphere perspective”.

There are some lessons to be learned from EU-ETS experiences. The first four years of EU-ETS have shown that the challenges of practical emission monitoring have been underestimated. Trust and confidence in the system depends on the compliance of procedures, accuracy of data, transparency of reports and interplay of various actors (communication served by means of ICT tools). The distribution of responsibilities to “the field” and integration of emission monitoring activities with conventional reporting, auditing and management practices, takes time, but is necessary to achieve real emission mitigation. The learning process of operators, verifiers and authorities and other supporting personnel represents a considerable investment by the EU. The use of generated know-how, division of tasks, competence of personnel and guidance might strengthen estimation of carbon footprints. However, there is considerable potential to simplify EU-ETS monitoring rules and practices when the target group comprises small and medium sized concerns. On the other hand, product-orientated emission estimation in complex production systems requires that new concepts, ICT tools and skills are developed.

4 Outline of the Certified Carbon Footprint of Products system (the CFP system)

The principles and key elements of the Certified Carbon Footprint of Products-system (CFP system) are described in this Chapter 4. The overall object of the CFP system is to produce comparable, reliable and real-time carbon footprint data for products. The development of the CFP system is strongly supported by experiences in EU-ETS and empirical LCA-studies. In addition, relevant standards and specifications are incorporated.

4.1 Starting points and key elements of the CFP system

Starting points for the development of the CFP system were:

1) It should provide representative, reliable and up-to-date information on carbon footprints of products (for different uses where comparable information is needed).

2) Provide information at product level.

3) Be cost-effective to society and producers.

4) Be acceptable, flexible and as easy as possible to use for producers.

5) Allow for gradual improvement of resolution, scope and accuracy.

Objectives 1) and 2) relate to data quality requirements and calculation rules. Data generation should be based on accepted international regulations and standards to the extent possible. However, this is not an established field and it is expected that it will be developed rapidly over the coming years. To achieve its objectives, the CFP system consists of **key elements**:

1) **utilisation of real monitored process-based activity data,**

2) **calculation rules** (guidelines, standards) at the generic and specific product group level,

3) **voluntary emission guarantees** and **a ceiling level** for total product emissions,

4) **validation of guarantee documents** against background rules and standards,

5) **attached chain monitoring plan** at the production chain level or covering single modules,

6) **the specific emission report** for output streams, and

7) **verification** of data and methods applicable to a 3rd party approach.

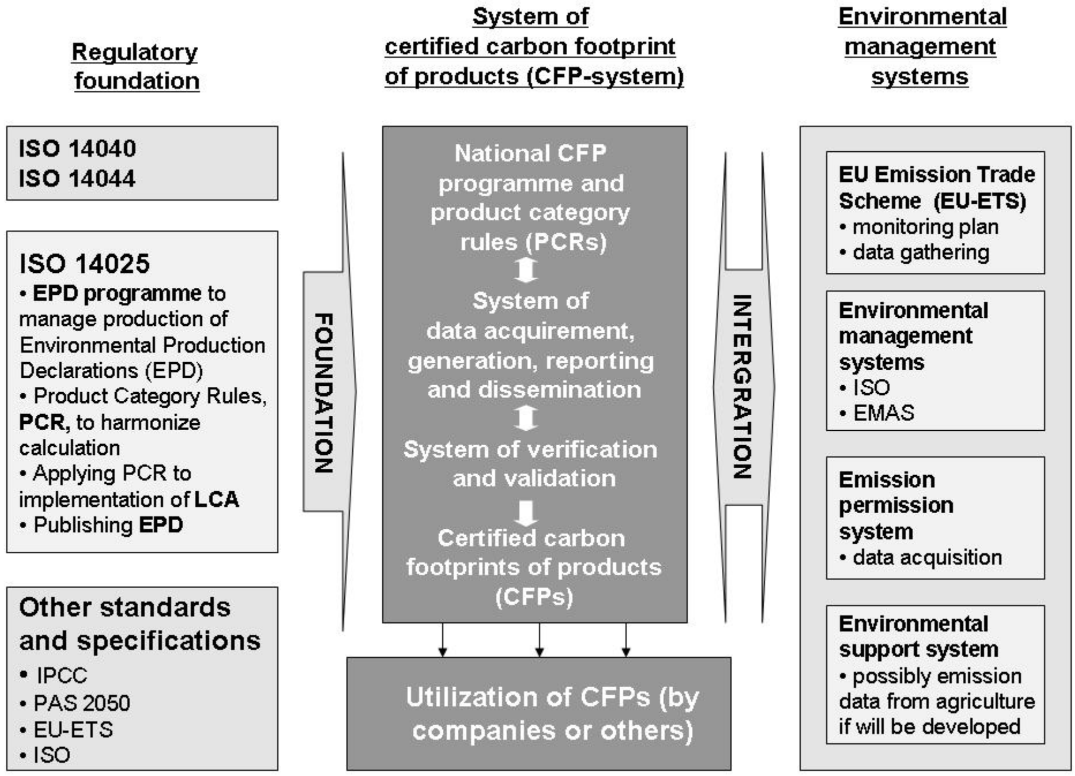
These issues are discussed in Chapters 4.2, 4.3 and 4.5. In addition, competence assessments are needed (conducted by member states' accreditation services) to give accreditation for services relating to carbon footprint data verification (for verification bodies). A new certification scheme could be developed in the EA (European co-operation of accreditation).

Objectives 3), 4) and 5) relate to operational acceptance of the system and could include links to existing environmental management systems. For achieving the operational acceptance of companies, the CFP system comprises a key element:

8) **the emission database** (and ICT system) representing the foundation of the emission report for the production system (modularity).

Operational acceptance is a basic feature of the CFP system, and it is particularly taken into account in the data dissemination system discussed in Chapter 4.4. Integrating the CFP system into existing environmental management systems and annual reporting practices is an important requirement for acceptance of the proposed system because it adds cost-effectiveness and saves resources. This issue is discussed in Chapter 5 (Roadmap). The CFP system linkages are illustrated in Figure 2.

Figure 2. *CFP system linkages to the international regulatory foundation and environmental management systems in Finland*



4.2 Provision of real process-based data by utilisation of activity-based data

The use of real process-based data means that data from every activity of (most) stages of the supply chain are based on emission monitoring. The overall production system of any product consists of numerous dynamic processes and streams. Consequently the resulting complexity and information volume make the collection of activity-based data challenging and expensive. Therefore, indirect emission factors (defaults) and not-so-accurate database values are widely used in LCA and carbon footprint calculations. However, PAS 2050, for example, suggests that in the longer run defaults should be substituted with process descriptions based on real monitoring, resulting in "real process dependent indirect emission factors". This is a task for the proposed CFP system, and accordingly represents a fundamental challenge for data management (database) in the CFP system.

Greenhouse gases originate from different sources. CO_2 emissions are mainly from fossil fuels, but CH_4 and N_2O emissions originate from biological processes. CO_2 emissions originate from the material streams (mostly fossil fuels) containing carbon released from "processes" into the atmosphere.

Biological process-based emissions are more significant than material stream-based emissions, unlike for products other than food, when total amount of emissions from the food chain are considered. Both emission sources can be reduced in production processes, but particularly CH_4 emissions, which mostly originate from animal production, and for which the most significant reduction potential depends on consumer choice between animal based and plant based products. Reduction potential for emissions from processes and consumer choices are substantial and can be supported with product-specific information provided by a CFP system.

Data calculation and management processes must be as clear and simple as possible to enable transparency and development of large ICT applications. In Figure 3, the simplified structure of a generic production process is illustrated with interlinks of inputs and outputs, and emissions linked to inputs and outputs. Data provision and management can be based on responsibility of individual (carbon) **balance areas** for emissions. Balance area can be an installation or farm for example.

The general (simplified) CO_2 calculation principle for activity-based emissions for a production chain can be formulated in the following way:

Emission of the stream = Activity data x (direct emission factor + emission estimate for the upstream chain producing the stream)

- **Activity data** presented in units compatible with invoicing (litre, kg, kWh). Activity data reflect, for example, amount of material flow.

- **Direct emission factors** Carbon content of input can be formulated from net calorific values and corresponding emission factors for fuels, for example, or directly from the carbon content of the material stream (releasing carbon to the atmosphere). Regarding renewable carbon-neutral material, a direct emission factor of zero is assumed because of the natural carbon cycle.

- **Emission estimate of the chain** reflects indirect emissions (from upstream chain). Nowadays, in many cases, it can only be estimated based on published data. However, the commensurability of various estimates depends on "judgements". In the case of fossil energy products this factor increases the direct CO_2 emissions for fossil fuels from roughly 5% to 15% or more and should be estimated case-by-case if possible. In the near future, it is expected that these factors will be made more accurate. In the longer run indirect emission factors (defaults) should be substituted with process descriptions with real monitoring actions resulting in "real process dependent indirect emission factors".

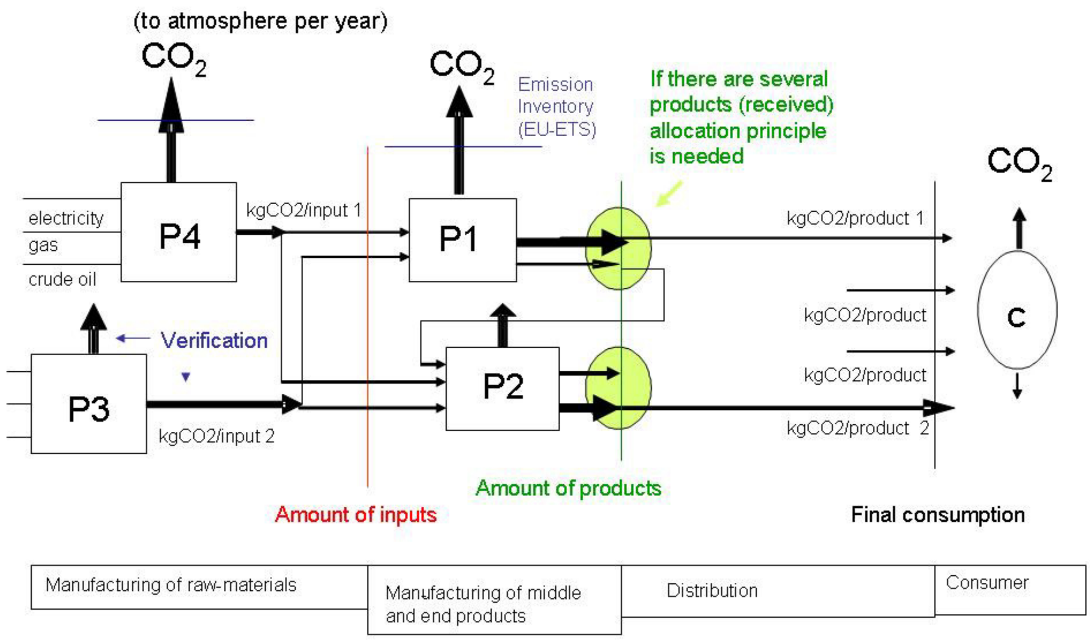
Splitting the emission factor into direct, indirect (and storage change) "module" components enables stepwise improvement of accuracy.

Emission of the module (system boundary/carbon balance area) is basically a sum of single activity-based emissions of streams. Regarding food products, calculation procedures behind emission estimates related to biological process (CH_4, N_2O) have to be further developed.

For the calculation of CO_2 emissions for specific output products, the following is needed:

- determination of the production system structure,
- decisions regarding stream categorisation,
- carbon contents of inputs (direct emission factors),
- emission factors reflecting upstream emissions (indirect emissions),
- the amount of annual input and output streams of "the processes or balance area", and
- allocation procedures.

Figure 3. Generic production process with interlinks between inputs and outputs for different balance areas (P) in relation to consumption (C), and EU-ETS verifications and emission inventories within a production process



4.3 Calculation Rules for data production

There needs to be harmonisation of calculation rules for data production at three levels to promote reliable Certified Carbon Footprints of Products that are comparable at product level. Such calculations cover all kinds of product (i.e. clothes, food and services) and should be sufficient for consumers to compare climate impacts of consumption of various products. However, calculations are equal at a very detailed level for the products in the same product group (e.g. fuels for the motor vehicles[15]). The tools for managing calculation rules at different levels are (see Figure 4):

1) CFP Programme,

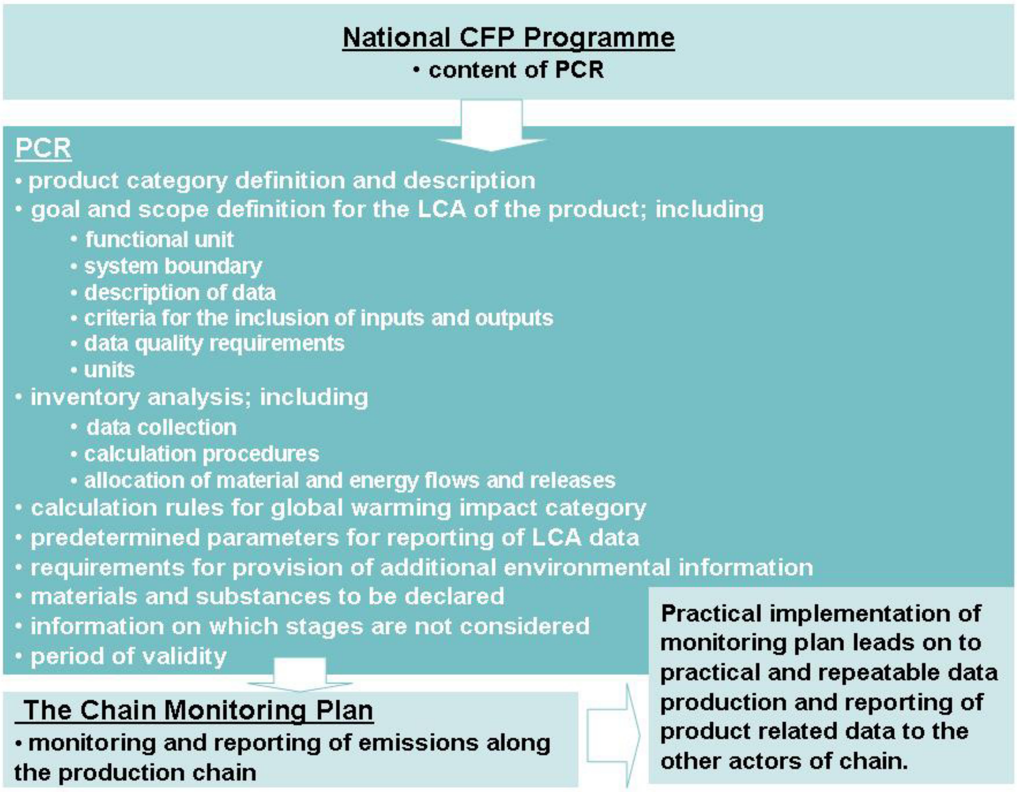
2) PCR, and

3) The Chain Monitoring Plan.

[15] Food products categories for this purpose have to be thought through very carefully.

The three levels form a hierarchy, the upper level determining the lower level. It is possible to distinguish two harmonisation pathways; procedural harmonisation and content harmonisation. Procedural harmonisation comprises the rules on what the next level rules have to address, and has increased emphasis at the upper levels. Content harmonisation comprises the methods that have to be applied in calculation and monitoring. Content harmonisation is accentuated towards the lower levels. Full content harmonisation at the lowest level is only possible if the calculation is procedurally harmonised (from the uppermost level).

Figure 4. *Outline of levels for calculation rules and rule content at different levels. Formulation of National CFP Programme and PCR based on ISO standard 14025 and formulation of The Chain Monitoring Plan is based on the EU-ETS structure.*



4.3.1 The National CFP Programme

The National CFP Programme represents the uppermost level of calculation rules for CFPs in the CFP system. In addition, the international standards, ISO 14025 and ISO 14040 series, provide a general basis for the CFP system, and PAS 2050 is important in adapting the ISO 14040 standard to the carbon footprint calculation. An ISO standard for carbon footprints is also being developed, but the time schedule for the work is not known. Until international standardisation and specification work on carbon footprints reaches a decision, national regulations are needed, and we suggest that it takes the form of The National CFP Programme[16].

The National CFP Programme should adopt the definition of the EPD programme that is described in the ISO 14025 standard. The EPD programme, and accordingly the National CFP Programme, has functions in addition to the calculation logic, including management of PCR preparation and the data confidentiality system (see also Chapter 5.1). Regarding calculation rules (i.e. calculation logic), the National CFP Programme should prepare, maintain and communicate **general content of PCRs,** i.e. the overall principles for development of PCRs.

Adapting the idea behind PAS 2050, the common rules for general content of PCR might include:

- identification of system boundaries;
    - which stages/activities have to be included and which stages/activities have to be excluded
- sources of GHG emissions associated with products that fall inside the system boundaries;
    - e.g. a list of included GHG emissions (gases)
    - activities within system boundaries that should be included
- the data requirements for carrying out the analysis, including definitions of
    - time-related coverage
    - geographical specificity
    - technology coverage
    - accuracy of the information
    - precision

[16] There are already five national EPD programmes covering several product categories. They are in Sweden (the first), Italy, Japan, Norway and South Korea. In addition, there is an emerging programme in Denmark. See more in www.environdec.com > Other activities > Other programs (see Annex 2).

    - completeness
    - consistence
    - reproducibility, and
    - data source with reference to the primary or secondary nature of the data
    - data sampling
    - variability in emissions over time
    - non-CO_2 emissions data for livestock and soils
    - emissions data for fuel, electricity and heat
    - validity of analysis over time
- the calculation of results
    - identification of assessment methods (e.g. the latest IPCC 100-year global warming potential, GWP)
    - inclusion and treatment of land use changes
    - treatment of soil carbon change in existing agricultural systems
    - offsetting
    - allocation principles.

The ultimate aim of harmonising calculation rules is to be able to compare products with each other in terms of their climate (or environmental) impacts. In terms of comparability of LCA product data as a basis for EPDs, the ISO 14025 standard suggests that comparable products are from the same product group i.e. they perform the same function. This is very important regarding consumer information & feedback systems, like Climate Bonus demo (described in WP5-report), in which climate impacts of consumer choices (i.e. purchases) are reported to households at various aggregation levels (products >> product groups >> all expenditures). This multi-level reporting requires comparability of products within the same product groups but also of products from different sectors and product groups. This could also be based on EEIO data or expert judgement (see Chapter 2), but eventually the more developed version of the reporting system needs a dynamic tool. This could in turn be based on recorded purchases, but the involved information details have to be assessed and elaborated to avoid supplying misleading information. However, this issue notably concerns consumer information & feedback systems rather than product specific data generation as such. Furthermore, there remains the question as to what extent the calculation rules should be harmonised at the CFP Programme level, including guidelines as to which products, and their climate impact, should be comparable.

Issues to be handled at the PCR level are listed in Figure 4, but it remains to be determined which issues are to be dealt with at the CFP programme level to promote broader spectrum of comparability than just between products of a particular product group. PAS 2050 is a generic specification[17] (i.e. not product group specific), and provides some suggestions. ISO 14040 and 14044 standards do similarly at a more generic level. The problem is that both sets of guidelines basically restrict comparability to products of the same product group. The principal difficulty remains comparability of LCA results for products from different product groups. This inter-product group comparability is important for two reasons, being (1) coherent aggregation of emissions at the product level to emissions at product group and household budget level, and (2) serving households that want to consider more comprehensive changes in their consumption pattern (e.g. with respect to commuting and shopping (location) patterns). Products from different product groups naturally meet different needs or function differently and therefore substitution is much less straightforward in technical, economic, and psychological terms (see also the report of WP4 for further discussion of this issue). Nevertheless, implicitly or explicitly consumers do make choices involving these more complicated substitutions[18]. For example, one might choose to buy a book or go to the cinema, or one could go shopping for clothes or go to the library to browse books. Many consumption decisions are made at this level and – in principle – connected to a certain lifestyle.[19,20] Despite these consumption side reasons in favour of harmonisation, demand for equal LCA calculation rules could be questioned because products from different product groups are produced in different contexts with different linkages, with different environmental consequences. This requires deep understanding of the

---

[17] Intending to provide a clear and consistent method for the assessment of the life cycle GHG emissions associated with goods and services (see also Chapter 3).

[18] I.e. "for the same function" is not always self-evident.

[19] However, also for the key categories in terms of emission impacts (food, transport, and home energy) lifestyle choices are important and interconnected, even though – obviously – as regards food consumer choices imply first and foremost substitution *within* the product group (but one can adapt food *quality* choices and thereby reallocate money to or from the household food budget, see also the report of WP6).

[20] The question of how environmental impacts of lifestyle and implementation should be assessed resembles assessment of overall consumption for which the database is very briefly discussed in the previous chapter. The report of WP4 contains a summarising discussion on household economics, choice making, habits and lifestyles. Complete assessment of alternative sets of consumption choices (i.e. comparing lifestyles) requires also abundant physical and behavioural information from the use phase as well as from the waste and recycling phase.

production chains and division of climate (or environmental) impacts related to them rather than application of common calculation rules (in relation to, for example, system boundaries, sources of emissions and allocation) for very different product groups. Harmonisation should be pragmatic and focused on sufficiently reliably aggregation and comparison options for emissions at the consumer side, instead of ensuring precision throughout the entire information chain.

The precision required for harmonisation of calculation rules at the CFP programme level (is it sensible to use generic rules and "the upper product group level" for calculation rules at the CFP programme level?[21]) has to be determined through a transparent development process in the national CFP programme. The National CFP Programme could be the forum where details of regulations could be discussed without sector boundaries. The CFP Programme would establish procedures and content for developing the Product Category Rules (PCRs) for different product groups.

4.3.2 Product Category Rules, PCR

Calculation rules have to be described and defined at the sector-specific level, i.e. in PCRs, within the limits of the CFP Programme. The main issues to be addressed at PCR level, according the ISO14025 standard, are listed in Figure 4. Content of some of these will be defined already at the CFP Programme level, but some of them are product group specific. They are logically dealt with at the PCR level, although some represent challenges for a new procedural tool for the upper level rules, like **the guaranteed level of emission** and **the ceiling level of a product** (see below). Examples of product specific issues to be addressed at the PCR level include:

- some data requirements related to time coverage; including
    - variability in emissions over time
    - timing of emissions
- some predetermined parameters for reporting LCA data, and
- allocation of material and energy flows and releases to some extent.

[21] That is, in turn, connected to the product categorisation – which represents the product groups for which rules are to be set.

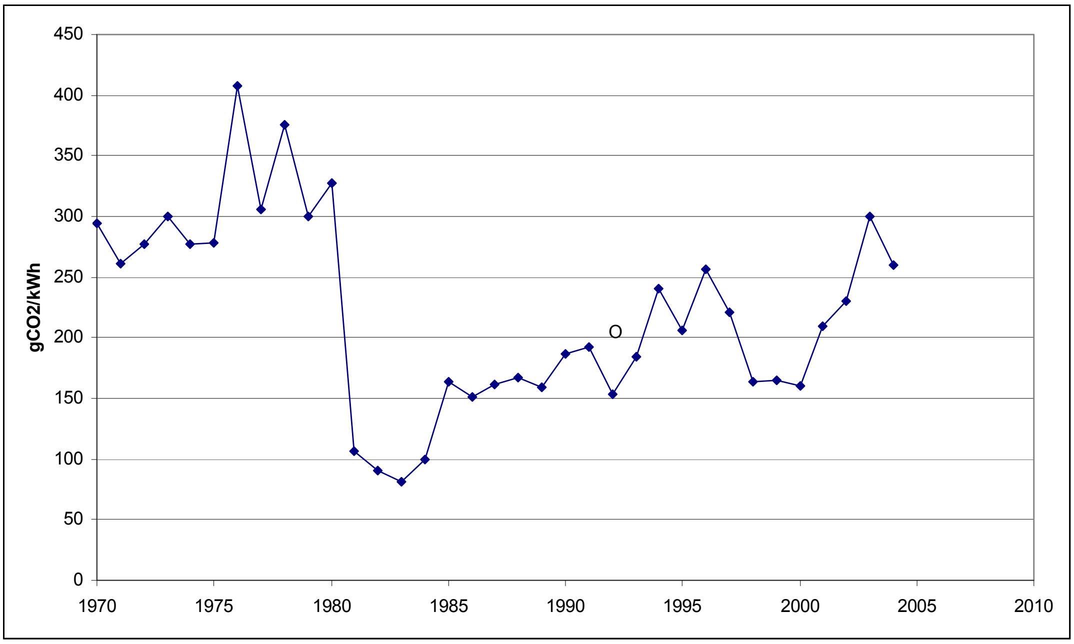
Variability in emissions over time

LCA calculation and reporting (of resource use and emissions) is often followed a year after initiation. Large-scale climate policies are also based on annual data. In some cases and for some product groups, a year is not optimal for getting reliable emission level data for certain products or to assess consumption patterns. For example, in agricultural production annual harvest represents a natural time span, but yields can differ considerably over the years. Therefore, greenhouse gas emissions for agricultural products (derived from yield) vary substantially among harvests. In Finland, using the same input level (fertilisers etc.), crop yield can vary considerably from one year to another. Input level is decided in advance (in relation to yield expectations), and product emission is mainly determined by conditions during the season. Consumer preference therefore cannot influence emissions. Regarding global warming, agricultural production is the most critical phase in food production and annual variation in production considerably influences life cycle results for final food production. Consumers are not able to appreciate many of the changes, including advantages from global warming that can occur in a production chain not linked to agriculture, because the global warming effects are confounded with yield level changes. Using a longer time span for monitoring can allow this problem to be obviated. For example, the mean value of three harvests fluctuates far less than annual values. Another option is to use **a voluntary guaranteed level** instead of a single average CO_2 equivalent value. This option applies to the CFP calculation and is discussed further in Chapter 4.3.3.

Another example of annual variations in emissions that affect consumption emissions associated with a product is electricity production of (see Figure 5). However, in this case consumption can affect release of emissions because electricity must be produced as it is consumed, i.e. demand control supply. Annual variation of emissions is due to the emission profile of complex "multi-source" production systems comprising several production technologies that use different energy sources with large variations in emissions.

The emission burden of the same "standardised" end-use product (e.g. bread, electricity) can vary considerably according to weather conditions, production systems, technologies and raw materials etc. On the other hand these factors can be attributes that should be taken into account when developing taxonomy for product groupings and when mitigation options are sought. Comparative analysis might not be fruitful if the range of uncertainty for average specific emissions for the products is wide. Determination of the average specific emission of a product is dependent on the character of that product and that is why the calculation rules have to apply at PCR level. The problem of annual variation could be addressed through **the voluntary guaranteed level of total emission** and **the ceiling level of final product**. Their use has to be set at the PCR level and the actual values are set by production-chain personnel in the chain monitoring plan. When used as tools, the guaranteed level of total emission and the ceiling level of final product have to be introduced already at the CFP Programme level.

Figure 5. The average specific CO_2 emission for electricity in Finland in 1970–2005.



Source: Energiateollisuus ry. Sähkötilasto (Finnish Energy Industries. Statistic of electricity).

Timing of emissions

The carbon footprint of a product should be in a line with actual emissions released during its production. This affects the emission calculation because it is not always clear when emissions occur. There can be considerable time differences for emissions for some types of product. This is a significant issue because in terms of global warming, release times and timing of sink formation during the carbon cycle influence the levels of greenhouse gases in the atmosphere.

For example, methane emissions from landfills occur after the product has been produced and consumed. In addition, methane is released over a long time period as the product, or the waste from the production chain, decomposes at the landfill. In contrast, durable goods such as buildings are long-lasting and can function as carbon sinks for years or decades before ending up to in a landfill.

In some cases the emissions occur before production has begun. In Finland the pH of the soil in agricultural fields must be kept optimal for production by liming. Lime application causes CO_2 emissions when $CaCO_3$ decomposes. Liming is normally carried out in every fourth or fifth year and the field produces four or five crops during that period. Thus emissions associated with liming should be divided evenly over all yields.

These issues are product specific and therefore calculation rules for emission timing have to be set at the PCR level.

Predetermined parameters for reporting LCA data

The aim is that primary data are preferred for calculating CFP. However, primary data are not always to hand or are not always even necessary. Some predetermined parameters for exiguous emissions need to be taken into account. However, the nature of exiguous emissions has to be defined at the PCR level in addition to the predetermined parameters.

Allocation

Allocation is needed when the production system generates more than one product, or is not based on linearity of raw material inputs and outputs. During allocation, inputs and outputs are channelled into products using described procedures. Allocation has stimulated scientific discussion and there is not consensus for the way it should be done. ISO 14040 standards and PAS2050 both emphasise avoidance of allocation by dividing a unit process into two or more sub-processes and collecting input-output data for the sub-processes, or expanding the product system to include the additional functions related to the co-products. When allocation cannot be avoided, ISO 14040 standard suggests the use of physical allocation[22] and PAS 2050 the use of economic allocation[23].

Traditionally LCA studies are geared towards production or administrative requirements, but product oriented carbon footprints are supposed to guide consumers, although the rationality of allocation can differ from the consumers' point of view. It has to be considered carefully what the effects of different allocation procedures have on consumers (supposing that carbon footprints affect consumer choices), and accordingly how consumer choice influences production. This needs further research and consideration, and it makes sense to define allocation principles for calculation rules even at the CFP Programme level. The decisions on allocation procedures represent one of the most important stages in a LCA study and can influence the results considerably. Results from different

---

[22] I.e. allocation should reflect the underlying physical relationship between products and by-products, that is, they should reflect the way in which the inputs and outputs are changed by quantitative changes in the products or functions delivered by system.

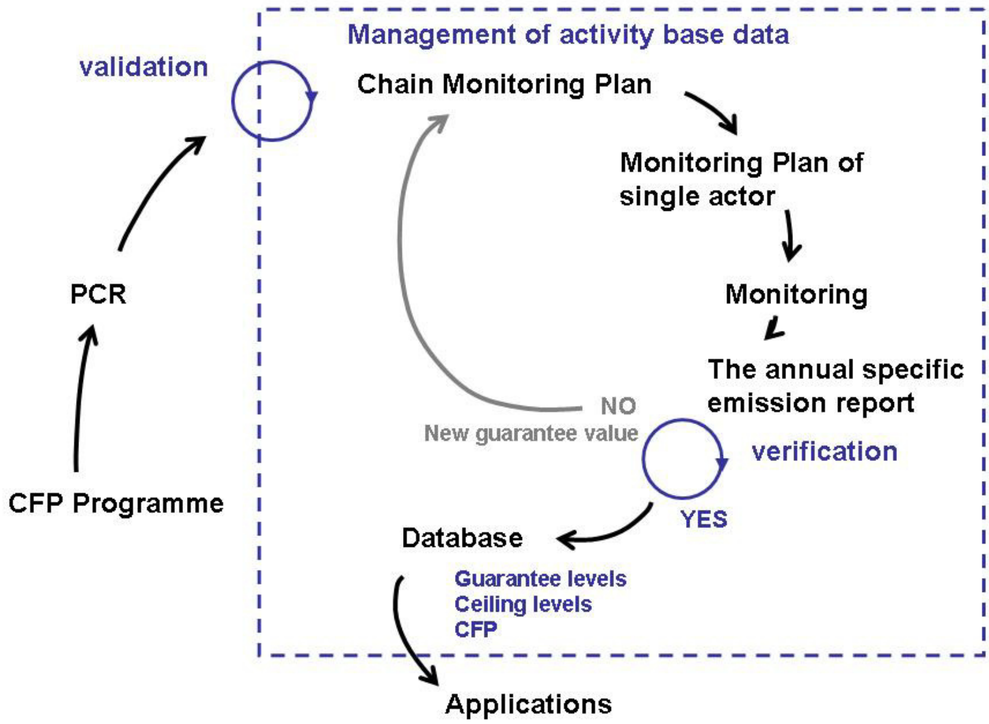
[23] I.e. input and output data might be allocated between co-products in proportion to the economic value of the products.

methods of calculation would be comparable and allocation principles can be specified in the Product Category Rules (PCR).

4.3.3 The Chain Monitoring Plan

In the proposal for a CFP system, the most detailed level of calculation rules is at the chain monitoring plan level. In an ideal situation the production chain represents the basis of the Chain Monitoring Plan, for which **the continual data collection** and **the (annual) emission calculation** is described in detail using balance area definition (see Figure 3 in Chapter 4.2). Alternatively, the monitoring plan can be made separately for particular organisations, modules, cells and production networks. The Chain Monitoring Plan (or monitoring plan of a single actor) should conform to the CFP validating system (see Chapter 4.5). In this case each company in the production chain produces data on its own activities (balance areas) according to the Chain Monitoring Plan (or the monitoring plan of single actor). This is the basis of **modularity** and the use of information modules as a source of LCA data of products is introduced in the ISO 14025 standard. The results of annual emission calculations, as well as methods for continual data collection and other relevant procedures, are described in **the annual specific emission report**, to document verification. After verification, the results of monitoring are entered into an emission database and then used in commercial consumer-oriented ICT applications. **The voluntary emission guarantee of balance area** and **the ceiling level of product** are the published results of the emission calculation if it falls under the voluntary emission guarantee value or ceiling level of product (see Chapter 4.5 and Hongisto et al. 2008). If calculation value for balance area is not under the voluntary emission guarantee value or ceiling level of product, a new increased guarantee value can/must be defined, e.g. based on findings in the verification procedure (See Figure 6). The decision regarding shifting the guaranteed level can be made after the verification statement is ready.

Figure 6. Outline of links in The Monitoring Plan and other key elements of CFP system



4.4 Infrastructure for data dissemination

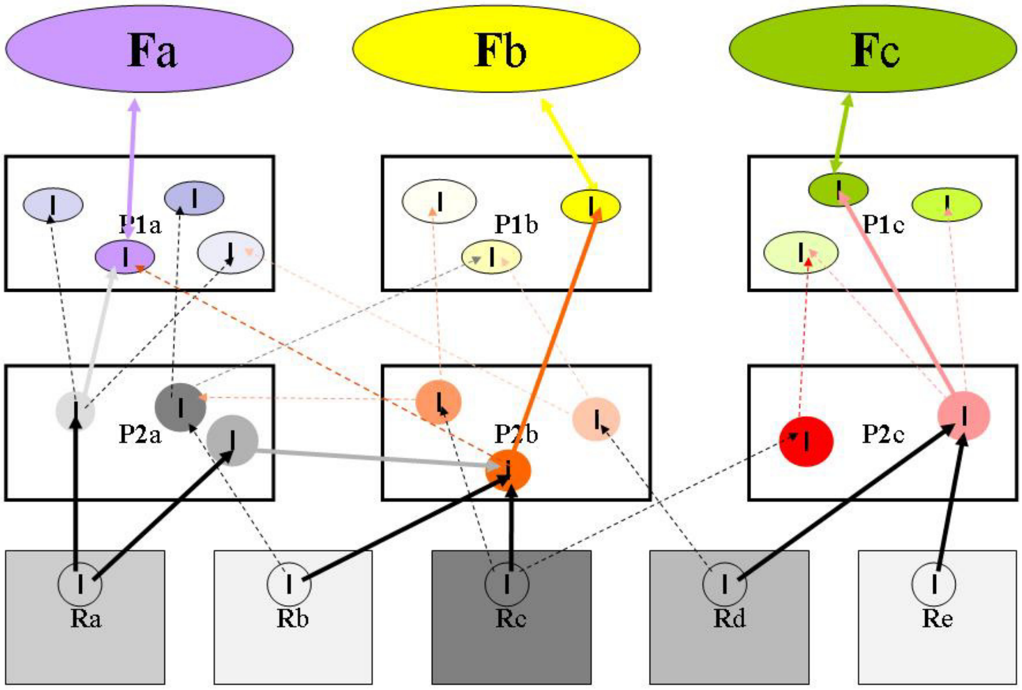
The CFP system for carbon data acquirement, calculation and verification requires a systematic approach and a highly sophisticated ICT-infrastructure to support its operations. In addition to managing and publishing PCRs and CFPs (i.e. the ceiling level), infrastructure is needed for dissemination of the voluntary guarantee levels from business-to-business and to support emission and climate impact calculation. This dissemination could be based on modularity and the information modules described in a previous chapter. The idea behind modularity and information modules is illustrated in Figure 7. Development of ICT solutions for supporting the CFP system should be begun in co-operation with chain actors, the CFP operator and research institutes.

Dissemination of the voluntary guarantee levels from business-to-business needs an emission database, in which they could be published as the Public Voluntary Guarantees and the Ceiling Level of Products. These documents should include at least definitions of:

- scope of monitoring; including
    - system boundaries of balance area,
    - links to other balance areas upstream that are included in calculations, and
    - time coverage.
- actors responsible for monitoring,
- data management,
- data quality management,
- applied specific calculation rules, and
- product-specific emission value as The Voluntary Guarantee Level or The Ceiling Level.

Linkage of one balance area to another for calculation of emissions is made according to procedures described in Chapter 4.1.

Figure 7. Simplified outline for formulation of chain data by linking information modules (I). Carbon footprint data on product (F) can be constructed using modular information of end product production phase (P1), semi production phase(s) (P2) and raw material extraction phase(s) (R). Information modules should include separated data on impacts of balance area emissions per product and former chain in relation to each input flow (direct impacts and indirect impacts). Arrows illustrate material flows of products Fa, Fb and Fc as well as possible module information flows. Broken line arrows illustrate other material flows within these production chains (or production web).



4.5 Validation of methods and verification of data

Validation refers to the comparative process that revises the consistency between background guidance and a more specific monitoring plan. The monitoring plan contains all the methods used for generating quantitative product-specific emission estimates based on various transparently identified data sources. Verification is a compliance checking process that addresses correctness of numbers used and validity of applied monitoring and calculation methods in relation to the monitoring plan. Areas of validation of methods and verification of data in the CFP system are illustrated in Figure 6.

The validation process should be conducted by experts who are fully aware of applied PCR and other upper level guidance and rules.

It is notable that the CO_2 emissions of more than 12,000 ETS installations (EC 2009a) in the EU are currently verified annually and almost half of the EU's CO_2 emissions are covered by these processes. This could represent a solid baseline for verification of CFP figures in Finland, but the approach would have to be extended to other emission sources for food products, for example. Direct CO_2 emissions to the atmosphere originate from the carbon content of material streams used in various production processes (inside the boundary), and accordingly the EU-ETS system is primarily designed for CO_2 control based on the "source stream logic", the use of commercial documents from transactions. Various emission sources together can represent boundary areas reported as a single entity (see also Chapter 4.1). Direct CO_2 emissions from a particular process can be verified based on input and output streams[24] as well as modules in a complex system including several processes (see Figure 7). In terms of CO_2 control, direct CO_2 emissions are very rarely measured using CEMS. If emission determination is based on continuous emission measurement systems, the stream information is not available from the ETS reports of that installation.

The emissions of N_2O and CH_4 depend more on "process conditions" than do CO_2 emissions, thus the calculation principles (and mitigation strategy) for them differ from source-based CO_2 emissions (and the corresponding mitigation strategy). The source-stream orientated calculation cannot be applied to the verification of N_2O and CH_4 because it would produce unreliable emission estimates. These emissions have to be measured and/or modelled. For food production and products, until now the predetermined parameters (defaults), based on emission models, have been the only means to estimate N_2O and CH_4 emissions. Calculation of N_2O and CH_4 values is unreliable and they are based on various models. Reporting values for these emissions and calculation models must therefore to be transparent. Until activity-based data production with measurement is possible, in addition to calculation, the verification of N_2O and CH_4 values relies on expertise in modelling the emissions. The use of default emission factors for CH_4 and N_2O should be detailed in the monitoring plans to guide the PCRs.

Regardless of verification logic, the figures for emissions should be verified against the ceiling level set up in the guarantee document and chain monitoring plan or the monitoring plan for a single chain actor applying a 3rd party approach. The verifier (verification/certification body) should be competent and accredited.

[24] Or from the carbon balance of them.

Members of the European Accreditation organisations (accreditation services like FINAS in Finland) use common criteria to develop their accreditation practices. It is not yet clear whether the ISO/IEC Guide 65:1996 "General requirements for bodies operating product certification systems" (corresponding to the SFS EN 45011) and/or the ISO 17024 "Conformity assessment – general requirements for bodies operating of certification of persons" could be directly applied for verification of carbon footprints.

The CFP data production can be verified for a process/module after verification principles are defined in the CFP Programme using current EU-ETS principles, EA 6/03 (EA 2008) Guidance and ISO 14065 and 14066 standards. The need for sophisticated ICT tools is inevitable using the installation orientated risk-based approach (of EU-ETS) after modification according to the value chain verification. Verification of modules should be carefully managed such that a single module is not verified several times, although several chains can use the same modules. However, in addition to the traditional ETS verification or other single-place verification, the quantitative couplings of individual processes, which constitute the process topology of a product, should be verified together against the Chain Monitoring Plan if it exists. In addition, traceability of the processes and streams is a prerequisite for calculating indirect emissions of the whole system.

The verification process concludes with the verification statement issued by an authorised verifier, whether the published voluntary guarantee emission level or ceiling levels of a product are not exceeded by actual emissions declared in the annual specific emission report. Verified ceiling level figures could then be published in the product-specific emissions database as CFP and can be used in any application based on CFPs.

In conclusion, verification of the supply chain should probably be made step-by-step on a modular basis to avoid overlapping of verification efforts and excessive costs. A specific strategy and tools are needed however to detect most critical modules and streams that should be verified. In addition, in further development of the CFP system, the need for accuracy in monitoring and verification may depend on the sector and intended application (steering method), and should be taken into account. For example, the use of financial incentives may require more exact rules and verification processes than the use of voluntary feedback-information systems.

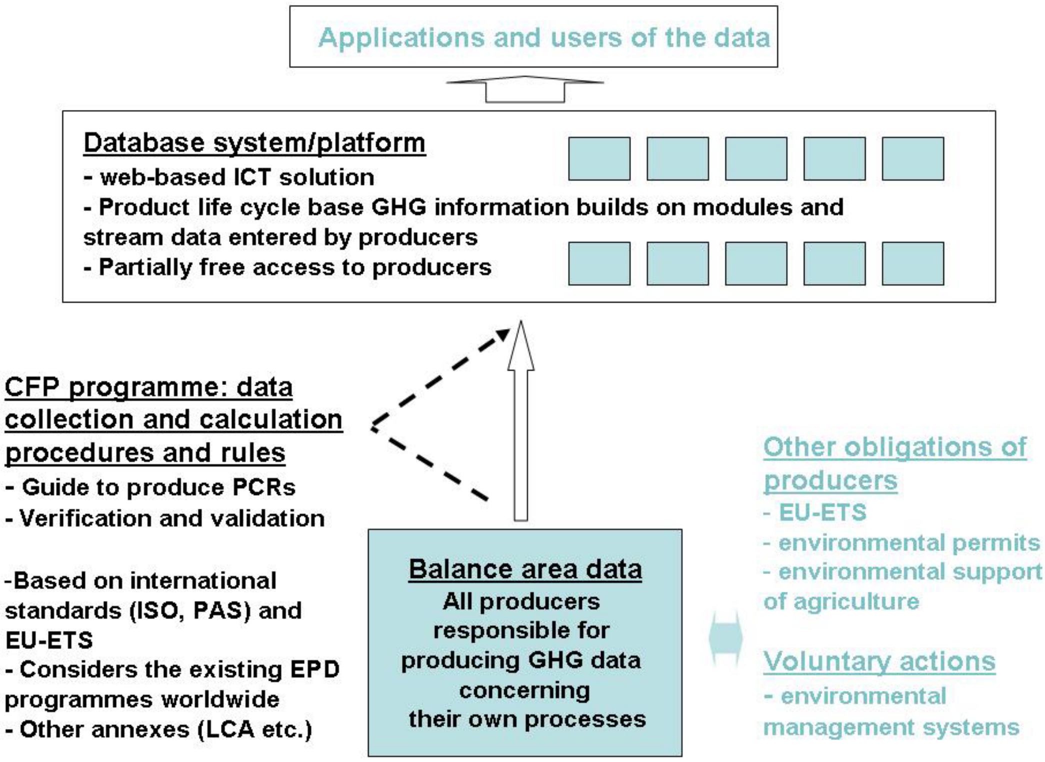
5 Roadmap

5.1 Vision

Vision is based on an idea that Finland aims in the near future to be able to produce reliable, credible and up-to-date data on carbon footprints of products that can be produced cost-effectively on a large scale. This will consequently ensure that consumers can be provided with reliable information on carbon footprints of products. That is one foundation for development of steering mechanisms of climate impacts of consumption. Consumers might not need the most accurate product-specific information at the outset in order to reduce their burden to climate, but the second step will require that all avenues are explored. At this stage resolution and coverage of the data should be sufficient to provide realistic incentives for R&D activities designed to improve environmental performance of products. The potential for R&D activities to reduce the climate burden, following increased consumer awareness of the effects of purchase choice, are as yet unexplored. There is a clear need for emission monitoring, data processing and reporting guidelines for various product groups in order to generate product-specific information on carbon footprints that can improve comparability and transparency among products with respect to their effects on the state of the environment.

The vision of the generic structure of CFP system is based on responsibility of producers for balance area data generation, CFP programme (including generic principles and calculation rules, PCRs and validation and verification system) and database system for disseminating the guarantee emission level data and the ceiling level of products (CFPs) (Figure 8).

Figure 8. Vision of data production and dissemination system for Certified Carbon Footprint of Product



5.2 Roadmap at the level of Finnish national economy

5.2.1 Strategic steps

The initial steps toward certified carbon footprints of products in Finland are

a) organisation and establishment of the national EPD programme for CFPs i.e. **CFP Programme** to organise establishment of generic principles and generic and sector specific calculation rules for greenhouse gas emission data production,

b) creation of **generic principles and calculation rules** for greenhouse gas emission data production,

c) creation and organisation the internet based emission **database** for the modular information, and

d) creation and organisation a transparent **validation and verification** system for the CFP system.

After these steps have been taken, actors in different sectors could begin to generate **the sector specific calculation rules (PCR)** in the generic context and generate certified carbon footprints for products (CFP). This work should take into account the various environmental management systems that operate (e.g. ISO, EMAS, Emission Permission System, Environmental Support System) and supply chain management systems and comprehensive logistic systems (e.g. SAP). In practice this presumes **broad participation** in formulation of CFP (or EPD) programmes and PCRs. Participation is also strengthened through the ISO 14025 standard on EPD.

To activate CFP generation in practice during its initial stages **default values** will be used for various situations and materials in full realisation that the final target is to use monitoring data within limits of the cut-off[25] criteria defined in the CFP programme and PCRs. It is crucial for progress in improving accuracy of CFP that defaults are *sufficiently conservative to represent activity-based monitoring data* and be of use in developing monitoring practices. The use of defaults should be detailed in PCRs. Definition of the shift from default to monitored data in the PCRs is an additional indication of progress. These principles should be defined in the CFP (or EPD) programme.

Development of the CFP programme, as well as generic principles, calculation rules and a verification system for the CFP Programme, should be mainly supported through public funding instruments so as to encourage comprehensive participation. The national CFP Programme should be built taking into consideration existing EPD programmes worldwide and ongoing standardization work. It also should interlink with the Global Type III Environmental Product Declarations Network (GEDnet, www.gednet.org) (see Annex 2).

It must be stressed that national EPD programmes (including the proposed CFP Programme) should represent an intermediate phase, the ultimate goal being able to compare carbon footprints of different products from the same category **globally**. This requires an international (or at least at EU level) EPD or CFP programme and internationally accepted PCRs.

Comparability of CFP data from different sectors is, to some extent, assured by comprehensive rules for sector-specific PCRs. These rules should at least cover questions concerning system boundaries, allocations, indirect emissions, time scales, and emissions included in the impact category. The second phase in developing calculation rules is formulation of sector-specific calculation rules, which can be PCRs.

---

[25] Cut-off criteria define the quantity of emissions that has to be taken into consideration, e.g. 95% of emissions.

Comparability of certified carbon footprints of products within a product group is assured by PCR. This is extremely important from the point of view of the consumer as in most cases the consumer wants to compare products of the same product group (i.e. different fuels for personal motor vehicles). The ISO 14025 standard requires that there is free participation in development of PCR. This is because development of PCRs is voluntary and open to everybody, but existing PCRs not are supposed to be restricted. In principle, participation empowers all the actors involved. PCRs might, in principle, be funded mostly from within the sector, which consequently benefits directly from the results. In practice, public funding is needed for the start-up phase. Broad-based PCR development also benefits generation of chain monitoring plans because there is experience of working together in production chains that require data management throughout the chain.

A database system is needed from the outset as it represents the key tool for data management in the production chains. Without a database system, as outlined in Chapter 4.4, the data would have to be managed on a case-by-case and chain-by-chain, basis that would inevitably be both laborious and costly.

Validation of PCRs and monitoring plans, and ultimately the carbon footprint data, guarantees the objective assessment of data reliability, and a validation system is therefore essential. A validation system should be transparent and cost efficient, and preferably harmonised with other environmental management systems, operating to cut costs and reduce duplication of efforts.

The generic structure of the CFP system is based on responsibility of producers for modular (activity based) information generation, a CFP programme (generic principles and calculation rules, PCRs and validation and verification system within it), a database system for dissemination of emission and modular information, and information on the most important strategic activities linked to them. However, different sectors have their own individual features and different starting points for generating carbon footprint data that must be taken into account when the CFP system is introduced. Such issues regarding the energy and food sectors are discussed further in Chapters 5.3 and 5.4 as examples of practical, sector-specific next steps. The major part of the climate impacts for an average Finnish consumer originates from housing (heating, electricity, building etc.), transport and consumption of food. To outline the overall situation and improve accuracy of household-specific figures these sectors should be prioritised.

5.2.2 Interplay of different actors in managing the CFP system

In addition to management of the CFP system (by some official body), the illustrated data generation and quality assurance system utilise competences and resources from several group of actors.

1) **Producers** in different stage of production chains are responsible for activity data generation and monitoring activities regarding their own processes.

2) Producers can utilise **external consultants** for example to formulate “chain monitoring plans” and system models for producing footprint for their end-products.

3) **Verifiers** can validate the monitoring plan against standards and guidelines as well as check the validity of actual monitored emission figures against established performance indicators.

4) **Research institutions** can support many other actors in numerous ways, for example by developing PCRs (optimise accuracy with costs) and by supporting producers (and maybe external consultants of producers) to develop system models for producing footprint for products as well as other tools related to carbon footprint. Research institutes also play an important role in supporting the development of national calculation principles and tools by utilising emerging generic global standards and experiences of other countries. Research institutions and research scientists should thus be aware of possible bias. The same personnel cannot be involved where distortion of the information might occur due to conflicts of interest and possible benefits linked to the roles.

5) **Software companies** can develop commercial applications that use databases that house verified product-specific data.

6) **Accreditation services** can provide accreditation for verification services.

5.3 Roadmap at the Finnish energy sector – steps for further consideration

In the energy sector, already existing and operative emission data generation and reporting systems like EU-ETS, “origin of the electricity” system, environmental reporting and other data from internal management systems can be utilised when CFP figures are formulated. This data can be supplemented with data on the fuel production chains applying stepwise processes. The integration of existing reporting systems to support CFP data generation is an important issue enabling development of cost efficient solutions. E.g. already verified ETS emission data can be utilised as such in the illustrated CFP system. To implement previously illustrated procedures on various energy products the following steps should be considered and developed further.

Fuels

Direct mass-based emission factors (defaults, without oxidation factors) for commonly used and marketed fuels in Finland are presented in Annex 3 according to fuel categorisation and definitions (Statistics Finland 2009a, 2009b). This fuel categorisation made by Statistics Finland, and used for Finnish EU-ETS installations, is a suitable foundation for energy product categorisation (i.e. identification of fuel streams). These fuel categories and default CO_2 emission factors are also applied in EU-ETS for small installations and minor source-streams (in Finland). To improve carbon content-based direct default emission estimates, the next step should be introduction of corporate specific figures based on monitored data covering also the most significant fuel production processes and transportation activities. Some forerunner companies are already able to produce brand specific figures for their customers. The hierarchical development model, with focusing boundaries and interlinks, can be developed step-by-step to improve accuracy of product specific emission factors.

Consumer products of oil-refineries

Both Finnish oil refineries belong to the ETS. These complex and highly integrated refineries produce almost all liquid fossil fuels delivered to Finnish consumers. As an example, the incremental impact of oil refineries for the carbon content based emission estimates for oil fuels can be added to “direct emission factors of fuels” using annual EU-ETS emission reports (EMV 2009b) from these installations together with the site-specific production statistics published in the annual reports of the refinery companies (Neste Oil 2009) and some allocation rules (e.g. tonne, energy content or economic value based allocation, and use of more specific technical process descriptions).

The ETS boundary settings of these sites in Finland differ regarding inclusion of power and steam production. The Porvoo refinery’s annual emission report (available from the FINETS system on the internet, EMV 2009b) includes emissions from integrated power production units. Using “crude production tonne-based allocation inside the ETS module/installation” the incremental impact of the refinery would be 0.24 t CO_2/t (all refinery products). This leads to a lower end estimate 3.39 t CO_2/t diesel fuel, which does not include indirect emissions related to crude oil extraction, processing, transportation, distribution and dispensing. As an example, to improve “monitored and traceable” specific emission estimates, some conservative defaults should be generated to cover these “non monitored” processes. However, according to recent and older studies (e.g. Concawe 2008, VTT 1999a, b), the carbon content of end products and the emissions from refinery processes cause a major share of the total emissions. When upstream emissions are included in the estimates, the carbon footprint is expected to increase, but not significantly.

It is possible to establish, update and develop the scope of monitored systems (covered processes) in the product specification documents when additional information is available. This development strategy starts from partial estimates, but it is expected that in a few years the accuracy of emission factors can be improved to the level (<±5-%), which makes possible the comparison of brand-specific fossil refinery products.

Based on Concawe's updated study (Concawe 2008), the best estimate for diesel would be 3.8 tCO_2eq/t diesel (-11 – +13 %). However, in EU-RES directive (EC 2009b) the fossil fuel comparator is a little lower 83.8 g CO_2eq/MJ (applied to petrol and diesel), which corresponds with the specific emission factor 3.6 tCO_2/t diesel if the typical calorific value of 42.8 GJ/t is used for diesel fuel. These figures represent background information for the default setting procedure for oil products.

By means of Concawe's datasheets, the incremental default 5.6 g CO_2eq/MJ fuel can be generated to cover emissions associated with crude oil extraction, processing, transportation, distribution and dispensing. This leads to a specific emission of 0.24 tCO_2/t diesel, which should be added to the direct emission factor of the fuel and indirect emission factor of the refinery. "Upper limits" for confidence intervals/uncertainty range could be used to ensure that the default is conservative and companies are thus encouraged to present activity-based monitored figures to cover missing information. For 2008 this example generates a specific emission estimate of 3.4+0.24x1.1=3.7 tCO_2/t diesel (3.1 $kgCO_2$/litre), which is probably sufficient, at least temporarily, for consumers and commercial carbon footprinting requirements. A similar approach for petrol results in 3.13+0.24+0.24*1.1=3.63 tCO_2/t petrol (2.7 $kgCO_2$/litre).

Based on the available information, the incremental impact of the fuel production chain on the direct emission factor is around +15% (±5%).

The detailed data sources and all methods can be further developed and presented in the product specification documents and/or attached emissions guarantee document (including detailed monitoring plan for specified system boundary).

Further steps that could be initiated include:

- development of ETS reporting to support determination of product-specific figures,
- improvement of emission data allocation for various (more specific) products, taking process routes and blends into account,

- allocation inside the core-refinery based e.g. on energy content of fuels (market prices for internal semi-products does not probably exist, net calorific value (NCV) reflects the value of energy products), and

- improvement of activity data monitoring and reporting of emissions originating from:

    1) crude oil production and other major input streams,

    2) transportation and distribution of feedstock and products, and

    3) dispensing activities.

Significant uncertainty remains because the purchaser does not always know anything of the origin of crude oil. Thus temporarily used defaults should be conservative enough to create incentives to improve transparency of the database and accuracy of real monitoring actions.

The traceability of feedstock material streams should be improved to reduce uncertainties regarding emissions of crude oil extraction and transportation. This challenge is known to be very difficult. However, in that the information is not based on traceable "monitored" source-streams covering the entire production system, the carbon footprint can be treated only as "a partial estimate". Subsequently, step-by-step conservative default factors can be used with data originating from real and monitored "living process cells". Higher tier levels can be introduced by means of stepwise processes.

Monitoring product distribution and dispensing activities should be done by various delivery companies, and their "modules/boundaries" could then be used to make these "refinery gate" figures more vendor company specific, to differentiate their products. Vendor-specific figures are needed to enhance competition, which provides incentives to develop all processes in the production networks.

Even if the emission information for fossil fuel oil chains can be significantly improved, the existing overall information base is accurate enough to allow use of emission data for commercial applications (especially carbon footprint services for transport and housing).

Limitations regarding the coverage of monitored processes could be explained and expressed in the emissions guarantee document, which establishes the applied monitoring methods. A Voluntary Emission Guarantee could be a part of the product specification documentation.

Monitored CO_2 emission data regarding liquid bio-component production are not yet available. However, this complex issue is investigated in several specific studies (VTT 2006, VTT 2008, VTT 2009, Concawe 2008). Preliminary ("official") default emission factors can be obtained from the EU RES-directive Annex V (EC 2009b), if needed, for various fuel categories. However, there exist methodological challenges regarding impacts of land use change and its GHG balance (IPCC 2003, IPCC 2006, UNFCCC 2006). Otherwise a modular, "module by module", calculation strategy is expected to be operative for renewable fuels and their blends. In the development work towards commercial ICT applications the trend towards differentiated and variable fuel mixtures should be taken into account.

As far as PCRs for the carbon footprints of fossil fuels do not exist, it is recommended that the refining company, transport service and delivery companies together design modules (system topology regarding consistent boundaries) and establish streams necessary for annual monitoring, which can be estimated using conservative defaults. Current monitoring actions required by EU-ETS can be supplemented to cover the main activities of the production chain. The next step would be creation of delivery company and product-specific estimates for commercial carbon footprint applications (company specific follow up and consumer feedback systems). In the longer run the defaults covering unspecified upstream activities should be replaced with monitored data.

Electricity

Publication of specific emission estimates (direct CO_2 emission / kWh) is mandatory in the Finnish electricity sector for the previous years' production, based on the Act on Verification and Notification of Origin of Electricity (MTI 2003a) and government decrees (MTI 2003b, MTI 2005). This can be treated as an example of "information delivery obligation" and "guarantee of origin" systems related to environmental goals. The origin of electricity is provided in electricity bills or their appendices directed to electricity users at least once a calendar year, and in sales promotion material directly distributed or sent to electricity users. These data represent a good basis for first vendor company-specific carbon footprint approaches.

The Act on Verification and Notification of Origin of Electricity (1129/2003) is an example or test-case for a product-specific emission "information delivery requirement". However, these data are made available after the purchase decision is made. This approach could be further developed and transformed into a forward-looking format by developing and applying a "guarantee of emissions system".

In practice all electricity production units that create direct CO_2 emissions belong to the EU-ETS (excepting Russian imports). The electricity production statistics of individual installations is not publicly available and due to the practices in the electricity market, linking this information to consumer contracts is very complex and cannot be done without access to companies' internal information. In this situation 3rd party verification can play an important role in creating confidence in the final figures.

The energy market authority is responsible for enforcing the origin of electricity. To improve effectiveness of energy markets the authority created a web-based price comparison system where the origin of the electricity is also shown (renewables, fossil, nuclear, EMV 2009a). It seems evident that the specific CO_2 emissions per kWh could be acquired from all electricity vendor companies and presented at least at the corporate level through this publicly accessible web-service. In addition to this "quick action", more development work should be initiated to link this information disclosure instrument to the verified EU-ETS emission reports and make the CO_2/kWh estimates more "electricity product/contract" specific.

To improve the accuracy of average CO_2/kWh estimates, a step from backward-looking estimates towards forward-looking "guaranteed emission levels" could be taken. In such a system the company "promises" the customer to keep specific emissions under a previously established level and reports of 3rd party verification are published via the ICT system.

The "origin of the electricity system" is temporarily not officially linked to the EU-ETS emission data. However, according to current official guidance (Finnish Energy Industries 2009), it is recommended that the previous year's ETS activity data are used as a basis for calculations. However, default values for emission factors (partial estimates, only combustion) are used. These factors differ from the activity-specific emission factors (based on laboratory analysis in accredited laboratories) used in large power plants during the Kyoto period. If interlinking the EU-ETS and "the origin of the electricity" systems could be improved, the vendor (and contract) specific emission factor (CO_2/kWh) could be formulated from installation-specific figures, and be reported and verified by means of competent accredited verifiers. Then the data are "quality assured" and can be provided to the public database accessed by commercial carbon footprint services.

For the time being indirect emissions originating from production chains of capital goods (buildings, machines and other equipment and apparatus) and upstream processes in fuel chains are not included in emission factors. For fossil fuel based electricity, these are expected to be less than 10% of combustion emissions (see. e.g. VTT 1999a, b). However, it is questionable whether calculation of the indirect emission of CO_2 is rational when the goal is to inform consumers about their carbon footprints and encourage upstream producers to mitigate their emissions.

Emission factors (for combustion) can be upgraded to reflect indirect emissions. During the first phase, monitored “actual” data do not usually exist for the emissions from these mostly international fuel chains (e.g. coal, natural gas and peat). In such cases the use of conservative estimates developed from independent studies is temporarily justified to improve direct emission data of origin for the electricity system. Emerging calculation methodology for regulatory purposes is published in the RES directive (Annex V, EC 2009b). If these estimates are not conservative enough there is no inducement to improve monitoring practices (accuracy of indirect data) and subsequently improve the performance of operators in the production chain. Therefore, emission mitigation investments cannot be initiated if consumers are not able to see and value “environmental quality of the product”. The information channel must be clear and accurate.

In case of nuclear energy and renewables (zero emission factor, non-combustion), monitoring indirect emissions originating from fuel and appliance manufacturing chains might create competitive advantages and other improved opportunities, e.g. product differentiation.

Product specifications (of all modules) can be developed to include information on specific emissions (direct) and additional information, which enables inclusion of the “product or service” for upstream processes in indirect emission calculations. The development of web-based ICT tools for this purpose is expected to enable further development of this in the near future.

The final goal is to substitute all partial estimates and defaults for indirect emissions from substantive source streams with actual and monitored activity data for “the modules in the production network” to create traceable and accurate emission figures for products. This development is expected to occur step-by-step and the scope of an “emission guarantee” can be broadened. Using this strategy, forerunner producers can move ahead and link their data for both upstream and downstream companies.

Heating

District heat is often a major factor in households’ annual carbon balances. Only rough regional estimates for direct emissions to generate district heat are currently available, based on statistics published by the district heating companies (Finnish Energy Industries 2008).

To allocate emissions of a combined power and heat plant for electricity and district heat, specific allocation rules must be applied. The economic allocation principle (recommended by PAS 2050) leads to relatively high emission estimates for district heat, especially if CHP units operate using fossil fuels (coal, HFO/LFO) or peat.

It is recommended that all producers of district heat consider the possibilities of introducing an "emission information delivery obligation system" (already applied as origin of the electricity) for district heat "products/contracts", even if such companies operate as regional monopolies. Consumers need more accurate public data on CO_2 emissions for district heat in order to be able to compare alternatives (e.g. electrical heating/district heat, heat pumps, oil heating etc.). General concepts and calculation principles, such as commercial boundaries, EU-ETS data integration with production data, origin of heat systems, self established ceiling levels/emission guarantees, and annual 3rd party verification can also be applied to district heat production.

Carbon footprint information on oil fuels (for heating) is expected to develop rapidly towards brand-specific figures in the wake of developments for transport fuels. The direct and indirect emission data on light fuel oil components were previously gauged to be sufficiently accurate (despite oil extraction data) to enable development of commercial carbon footprinting services.

It is recommended that also CO_2 emissions from transport be monitored, based on consumed and registered volumes of fuels (tank fillings + kilometre data). It is important to pay attention to annual cumulative emissions and economical driving skills – not only theoretical specific emission of vehicles (g CO_2/km).

Emission data from the production chain of heating appliances (boilers, piping etc.) are not yet available, but the data generation can be done in principle using similar modular principles as for other capital goods and appliances. Development of generic PCRs suitable for heating systems might be necessary.

The preliminary carbon footprint of households heating options can be characterised partially based on monitored emission data from previous years. The sector should consider recommending steps to produce company and product specific emission data for their customers. It is recommended that monitoring of activity data and CO_2 emissions, also for units outside EU-ETS, should be expanded. Some new data for emissions from minor units and district heating networks existing outside EU-ETS registries should be acquired.

In conclusion, efforts made in the energy sector during the two decades, together with some new developments and data, enable commercial step-by-step introduction of consumer-oriented carbon footprint services in the energy sector.

It is considered realistic to develop the accuracy improvement pathway in the energy sector stepwise through:

1) conservative defaults (based on direct emissions),

2) company/regional data (based on monitored company level data), and

3) product/contract specific data (covering essential processes).

Even if the current databases do not cover entire life cycles of energy products, and estimates are more or less partial, the major share of the GHG-emissions can be captured using actual and monitored systems.

Decisions regarding which additional processes should be monitored, or which can be estimated using defaults, can be made when PCRs for energy products are established.

The integration of annual reporting principles and existing data systems is key to enabling cost-efficient generation of specific emissions data for a wide range of energy products that represent an increasingly important part of developing product specifications.

5.4 Roadmap for the Finnish food sector

Food consumption contributes a significant portion, about 20–30%, to the carbon footprint of an average consumer (Seppälä et al. 2009). According the questionnaire used in the Climate Bonus project (WP5), consumers regard food consumption as a significant area where they could decrease their climate impact, and they would like to have information on carbon footprints for foods and food consumption.

While the main focus of the energy sector should be on integrating the EU-ETS into the CFP system, for the food sector the entire data production and sharing system has to be created from scratch. Fortunately the Finnish food sector has a tradition of studying environmental impacts using the life cycle approach. Extensive extended data production may possibly be initiated sooner and faster in the food sector than in other sectors that produce goods for final consumption – excluding energy and other EU-ETS sectors.

Both the energy and food sectors are faced with the common challenge of trying to get carbon data for production chains of imported raw materials and products. The main imported flows in the food sector relate to soy and other vegetable oil seeds and raw fodder materials, but minor material flows from abroad are various. The use of conservative defaults represents an important solution (see 5.1). In practice all those involved have to put significant effort into extending data acquisition to cover imported material flows.

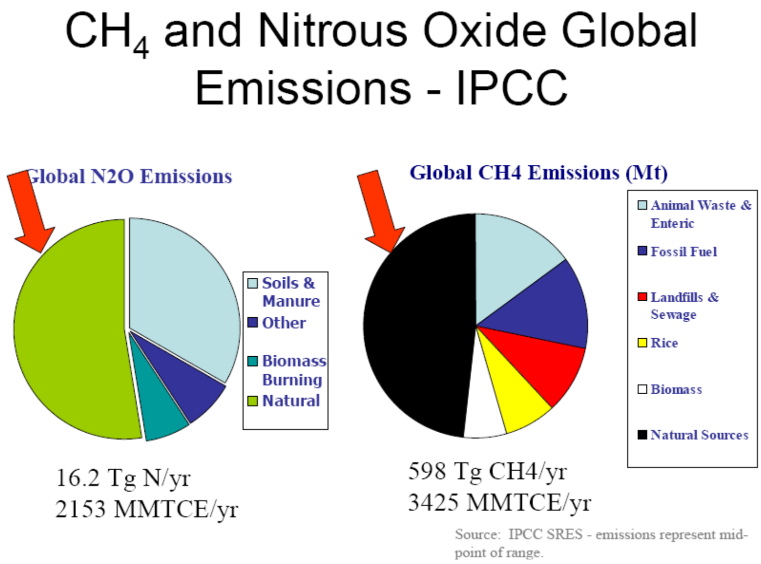
Fundamental sector-specific issues that need to be dealt with in implementing CFP in the food sector are related to the nature of emissions from agricultural production, as well as the characteristics and structure of food sector and feature of food products.

Emissions from agricultural production

In general N_2O and CH_4 emissions are the most significant sources of greenhouse gases from food production[26]. CO_2 dominates the overall CO_2 equivalent emissions in the other sectors. Most N_2O and CH_4 emissions for food products originate from agricultural production and are material, activity and condition dependent (Figure 9). Most impacts of agricultural production originate from biological processes. They are not easy to measure and scientific knowledge about them is expanding. Furthermore, land-use and land-use change impacts on CO_2 emissions are high and have been neglected in past food LCA studies. Therefore, representative estimates for environmental impacts of agricultural production are not easy to get, even in principle.

[26] There are exceptions. In some cases, for example, the use phase is the most important emission source (e.g. oat porridge (Katajajuuri et al. 2003, Katajajuuri et al. 2004)). However, the use phase is difficult to include in the carbon footprint value of a product because it depends on different user practices. E.g. PAS 2050 (PAS 2050, 2008) suggests including information on the user phase impacts in business-to-consumer communication for the carbon footprint of a product.

*Figure 9. Three out of the top five global anthropogenic sources of the greenhouse gasses methane and nitrous oxide by MMTCE (2000) are directly linked to food production and one more indirectly linked: N_2O – Agricultural Soils, CH_4 – Enteric Fermentation, CH_4 – Natural Gas, CH_4 – Landfills, CH_4 – Rice Cultivation. Global warming potentials are used to convert greenhouse gases to carbon dioxide equivalents – they can be converted to carbon equivalents by multiplying by 12/44 (the ratio of the molecular weight of carbon to carbon dioxide). The formula for carbon equivalents is: MMTCE = (million metric tonnes of a gas) * (GWP of the gas) * (12/44).*



The (conservative) defaults for N_2O and CH_4 emission sources are maybe the only possibility for calculating the carbon footprint of the food products. Such default values should be defined in PCRs or other sector-specific documents. In the beginning the default values should be as extensive as possible, to cover the most important emission sources. Subsequently more specific default values for different situations should be defined.

Variation in technology used by producers is significant for GHG emissions – this is true not only for agricultural producers but also for small industries. Perhaps the most marked example is energy source choice during greenhouse production. Energy consumption dominates total greenhouse gas emissions for greenhouse products, and the footprint of a greenhouse product can be decreased by 90% by changing the energy source from fossil fuels to renewables. More generally, the scales of potential variability for various technological processes are largely unknown (because of a lack of comparable LCA results). This variability will be defined by use of activity base data in modelling and calculation, sharing and comparing information on them. Regarding agricultural production, research and development work (in relation to data acquisition, monitoring, modelling and sharing) is needed before this kind of technology sensitive activity data become available. This relates to progress in traceability for food. The reference scales of variability can also be produced from a more theoretical basis, for instance by using demonstrative precision-farming systems, facilitated by equipment for energy use measurement This also needs support from research, but could be the first step towards large-scale production of CFPs. The reference scales could then be used by various producers to define their ceiling levels for emissions. By improving the efficacy of energy use they can then move into a better position, or by changing the technology, move to a new (better) scale of reference.

There are challenges in calculation related to variation in annual product-specific emissions. Variation in climate and ambient weather conditions affect the quantity of emissions. The emission/impact values per food product vary greatly from one year to another. This issue was discussed in Chapter 4.3.2, electricity being used as an example and guaranteed levels represented as a solution. Variability of seasons has to be taken into account when the guarantee and ceiling levels of emissions are defined in the (chain) monitoring plan. The number of seasons over which the variation has to be assessed is case specific and could be defined in PCR through co-operation with an advisory or a research institution. By monitoring the production processes linked with seasonal conditions, each particular stakeholder can gradually get an overview of the enterprise-based variation of production.

<u>Structure of food sector – Consumption of food</u>

Food consumption has diversified and there are currently countless people involved and numerous daily purchasing situations in the sector. Consumers make decisions between products on a daily basis, either in the context of public catering or private purchase. Food represents a major material flow in public procurement. The popularity of eating out catering is increasing. Carbon footprints of products have to be comprehensive and easily available, which is possible using a flexible, cost-efficiency system in conjunction with consumer demand and political pressure. Such issues constitute the core starting points for the creation of the CFP system described in this report, and should be kept in mind when the system is to be implemented.

Food consumption, both private and public, is governed by many efficient driving forces, including nutritional requirement, culture, economics, social issues, and environmental impacts. Potential changes in food consumption are influenced by many drivers in addition to those related to climate impacts. These represent a challenge, especially for developing a steering mechanism and data production. Definition of the functional unit is an issue that has to be solved at the PCR level (see Figure 4). The primary option for a functional unit related to food is CO_2-eqv per kg or litre, but the next step considers the functions of food in relation to their carbon footprint. This is crucial regarding public catering and other catering services (a serving or nutrition service as a final product)[27]. However, the basic data production for raw materials constituting a serving(s) should be based on the functional unit of a kg or litre also in these cases.

<u>Structure of food sector – Production of food</u>

The food production sector consists of a range of actors, the majority of which are SMEs. There are, for example, thousands of farms producing the raw materials that go into making food products. On the other hand, there are some major participants in the food sector, mostly in secondary production and trade. It is likely that generation of carbon data will be channelled through these central players, several of which have already been very active in environmental management issues. One impending challenge is the participation of other actors in PCR and data production with respect to their own carbon footprints (i.e. modular data). Broad participation in PCR production is important for producing a comprehensive set of rules that can be applied throughout the production chain. It is to everyone's advantage that this is made possible. Data production, however, might be more complicated because it will incur extra costs and inconveniences. In some cases some of the chain actors might reap most economic benefits (downstream actors), while other actors have to defray the main costs (upstream actors). Development activities and costs (to decrease emissions) are expected to be directed at agricultural primary production, but the downstream actors (brand owners) might easily benefit from the lower production costs through lower purchase prices, increased competition and possibly higher value of more climate-friendly marketed end products. Attempts should be made to avoid such a situation for pursuing justification and acceptability, as well as total sustainability and corporate responsibility. The system should promote total sustainability and corporate responsibility, and it should be fair and attractive for small actors too. The first steps might be taken via the contract producer systems for which data production for carbon footprints could be part of quality management, enabling economic benefits to be shared among the business partners. In addition, data production for agricultural primary production based on public funding needs to be developed for a broad client base by researchers and the agricultural sector. The R&D work should include at least development of emission modelling, data sharing methods (linked to traceability)

---

[27] In the ConsEnv project a lunch serving was applied as a functional unit producing climate impact and eutrophication impact for various home-made, ready-meal and school lunches (Kurppa et al. 2009, Saarinen et al. 2009).

and development of administrative/political steering systems (e.g. environmental support).

One of the first steps in developing agricultural data production for the CFP system could be to integrate it into the prevailing EU Agri-Environmental Schemes[28], taking account of the potential growing conditions in the future[29]. Such an environmental support system requires farmers to produce comprehensive information about their production, which is related to political aims and tools. The environmental aims and tools regarding agriculture evidently need to be considered in relation to climate impacts and should include the challenges associated with product-oriented environmental data production. If the incentive were to be linked to an agri-environmental scheme, the support could be directed to the appropriate stakeholders, in contrast to what might occur were a standard trading system to operate.

In terms of the purchase of raw materials from the food industry, the growing challenge is that industrial suppliers (and trade regarding own labels) are in constant flux, and often change rapidly. Use of imported materials makes data acquisition more difficult, which is a basic challenge for manufactures and highlights the importance of traceability as the primary task to encourage business responsibility. Purchase processes of manufactures should be actively developed to be more supportive of traceability. In principle, a product with an untraceable production chain could not be included in the CFP system.

[28] http://ec.europa.eu/agriculture/envir/index_en.htm

[29] http://ec.europa.eu/agriculture/publi/fact/climate_change/2008_en.pdf

6 Conclusions and discussion

The outline of the CFP system described in this report, and the road map(s) for moving towards it, aim at catalysing the uptake of reliable carbon footprint generation in Finland for a broad range of products. The proposed CFP system guarantees reliability of information and aims to keep the costs of information management within tolerable limits. The EU Emission Trade System (EU-ETS) includes the energy sector and some other heavy industry sectors. Despite the EU-ETS sectors' large share in total emissions, the EU-ETS on its own is not sufficient to mitigate climate change. Consumption in its widest sense has to be taken into account in the steering mechanisms. Accordingly, decision makers, including consumers and other purchasers, need information on the climate impacts of products in order to make informed decisions.

The outlined CFP system was designed in conjunction with an envisaged feedback system for households. That feedback system informs households individually about the cumulated greenhouse gas emissions of their purchases over time. A pilot version of the feedback system was developed and tested in the Climate Bonus project. The CFP system is able to produce information on carbon footprints of products of which the purchases are to be reported in the feedback system. Yet, the CFP system can just as well be used for carbon labelling, eco-design, and development of production processes with the aim to lower their carbon footprints.

It should be appreciated that highly *accurate* carbon footprint values are very effective as they simultaneously affect multiple actors. They can alter the competitiveness of products in the marketplace and provide support for the eco-competitiveness of low-carbon products. They enable consumers to ponder particular product choices regarding their climate impacts and to draw up exact balance sheets of the climate impacts of household consumption. Accurate carbon footprints are also virtually indispensable for a sophisticated 'climate-design', as they enable manufacturers to develop less carbon-intensive products that take into account the whole product chain. Obviously this also supports the control of the effectiveness of design changes. Inaccurate estimates do not reflect the actual reduction in greenhouse gas emissions attributable to the climate-design efforts, and they hinder positive feedback and hamper effective redesign of new climate-friendly products and services.

Traceability for different goods is becoming increasingly sought after, especially in the food sector. The outlined CFP system is in harmony with the rising demand for traceability thanks to the use of activity-based data and the requirement for chain data management. However, it requires an effort and continued commitment from all those involved in the entire production chain.

It is evident that a large scale deployment of the CFP system will not arise just by itself. Such a deployment stands a better chance if the Finnish Ministry of the Environment together with other relevant ministries (e.g. the Ministry of Trade and Economy and the Ministry of Agriculture and Forestry) promote the development by following the road map described in Chapter 5. Another organisation that might take on such a role is the Finnish Standards Association SFS, maybe even jointly with the mentioned ministries.

Public co-funding will be necessary during the early stages e.g. with respect to various basic research needs related to reliable and replicable data generation (e.g. in the food chain), and possibly also in some subsequent stages e.g. to promote uptake of the operational CFP system by means of demonstration projects and the establishment of a CFP promotion programme or so-called voluntary agreement for CFP. The required sums are probably rather modest, in the order of magnitude of a few millions during a couple of years. When the deployment is progressing the CFP system should be increasingly funded within a normal market context through adequate product placement of low emission alternatives. Furthermore, the joint emergence of the CFP system *and* the feedback service for consumers adds options for self-financing capacity within the overall system (see also the report of WP6).

It is recommendable to embed the development and deployment of the CFP system in a process of national deliberation. In this report we introduce the idea of a structured data production system and some crucial steps towards achieving it. There remain many questions as to how the CFP system would function in practice and how to encourage maximum participation among those involved in the production chains. These questions need to be addressed during the initial phases of deployment of the CFP system, but it is evident that broad participation among those representing various interest groups is essential. Furthermore, the CFP system should be able to function (later on) also in an international environment, because similar initiatives are emerging in various countries. This international dimension will produce new analytical and managerial complications.

Regarding further research needs, in addition to those related to the food sector, development of a web-based ICT system is a key factor for successful development and operation of the CFP system. Its further development should start immediately based on the calculation and data sharing logic defined in this report. Furthermore, next to the food and the energy sector also passenger transportation, and various other selected products groups seem to merit systematic generation of accurate, replicable and certified carbon footprints.

References

Bergman N. – Haxeltine A. – Whitmarsh L. – Köhler J. – Schilperoord M. – Rotmans J. (2008): Modelling Socio-Technical Transition Patterns and Pathways. Journal of Artificial Societies and Social Simulation, Vol 11, No. 3, http://jasss.soc.surrey.ac.uk/11/3/7.html

BSI (2008a): PAS 2050:2008 – Specification for the assessment of the life cycle greenhouse gas emissions of goods and services. http://www.bsigroup.com/en/Standards-and-Publications/Industry-Sectors/Energy/PAS-2050 (visited 18 March 2009)

BSI (2008b): Guide to PAS 2050: How to assess the carbon footprint of goods and services. http://www.bsigroup.com/en/Standards-and-Publications/Industry-Sectors/Energy/PAS-2050

Carnegie Mellon University Green Design Institute (2008): Economic Input-Output Life Cycle Assessment (EIO-LCA) model. http://www.eiolca.net (visited 1 June 2008)

Concawe (2008): Description and detailed energy and GHG balance of individual pathways. Well-to-Wheels analysis of future automotive fuels and powertrains in the European context, Well to tank Report Version 3.0 November 2008, WTT Appendix 2.

EA (2008): EA-6/03. EA Guidance for Recognition of Verification Bodies Under EU ETS Directive (rev02, July 2008). EA – European Co-operation for Accreditation (http://www.european-accreditation.org/)

EC (2007): COMMISSION DECISION (2007/589/EC). Establishing guidelines for the monitoring and reporting of greenhouse gas emissions (MRG2) pursuant to Directive 2003/87/EC of the European Parliament and of the Council. http://ec.europa.eu/environment/climat/emission/mrg_en.htm

EC (2009a): Verified Emissions for 2007-2008 and allocations 2008 (.xls) – 20/04/2009 http://ec.europa.eu/environment/climat/emission/citl_en.htm.

EC (2009b): Directive 2009/28/EC of the European parliament and the council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing directives 2001/77/EC and 2003/30/EC. Official Journal of European Union 5.6.2009.

EEA (2008): Application of the Emissions Trading Directive by EU Member States reporting year 2008. EEA Technical report No 13/2008. ISSN 1725–2237

EMV (2009): Communication of the Energy Market Authority. In Finnish "Taantuma pienensi päästökauppasektorin päästöjä (1.4.2009)". (Recession decreased emissions in emissions trading sector in 2008, Energy Market Authority, Finland)

EMV (2009a): Comparison of electricity prices (a web based public ICT system, Energy Market Authority, Finland) http://www.sahkonhinta.fi/

EMV (2009b): FINETS system (a web based ICT system for emissions trading in Finland with public partitions) . https://www.paastolupa.fi/

EMV (2009c): Todentajaohje, Versio 2.0. Energiamarkkinavirasto Dnro 244/330/2009 (report in Finnish). National EU-ETS Verification Guidance, Energy Market Authority, Finland.

EMV (2009d): Annual Report 2008. Energy Market Authority, Finland.

EMV (2007): Energiamarkkinavirasto. Energiamarkkinaviraston ohje Kioto-kauden päästöluvan hakemista varten. Kehitysversio 1.3 Päivätty 15.8.2007 (in Finnish). Guidance for an Application for EU-ETS Emission Permit, Energy Market Authority, Finland. Draft 1.3. http://www.emvi.fi/files/Kioto_tayttoohjeet.pdf

Energiateollisuus ry. Sähkötilasto. http://www.energia.fi/fi/tilastot/sahkotilasto. Energy industry association. Statistic of electricity. http://www.energia.fi/en/statistics

European Platform on LCA (2009): International Reference Life Cycle Data System (ILCD) Handbook.

European Commission – Joint Research Centre – Institute for Environment and Sustainability.

http://lct.jrc.ec.europa.eu/eplca/deliverables/international-reference-life-cycle-data-system-ilcd-handbook (visited 29 June 2009)

Finnish Energy Industries (2009): Labelling - Recommendation for product spesification of electricity, updated 29.6.09 (In Finnish, Labelling – suositus sähkön tuoteselosteeksi, päivitetty 29.6.09, Energiateollisuus ry.)

Fischer-Kowalski M. – Rotmans J. (2009): Conceptualizing, Observing and Influencing Social-Ecological Transitions. Ecology and Society, Vol 14, No. 2, art. 3, http://www.ecologyandsociety.org/vol14/iss2/art3/

Grönroos J. – Seppälä J. (toim.) (2000): Maatalouden tuotantotavat ja ympäristö. Helsinki, Suomen ympäristökeskus. Suomen ympäristö 431. 243 s.

Grönroos J. – Seppälä J. – Silvenius F. – Mäkinen T. (2006): Life cycle assessment of cultivated rainbow trout. Boreal environment research 11: 401–414.

Gunnarsson J. – Kivioja M. – Pyrko J. (2009): It must be Yeti! – Tracking carbon footprints on the web. ECEEE Conference proceedings, pp. 1811–1819.

Helsingin Sanomat (22.3.2009): Tanja Vasama, Eurolla hyvä omatunto.

Hertwich E. – Larsen H. N. – Pettersen I. N. – Solli C. (2008): Climate calculators and expert systems.

Proceedings: Sustainable consumption and production: Framework for action, 10–11 March 2008, Brussels, Belgium. Conference of the sustainable consumption research exchange (SCORE!) network

Hongisto M. – Perrels A. – Nissinen A. – Katajajuuri J. M. – Hyvönen K. (2008): Miten kotitaloudet voisivat seurata ja ohjata kulutuksensa ilmastovaikutusta? Ympäristö ja Terveys 39,10, 42–45. (in Finnish) (How households could follow and steer climate impacts of their consumption?)

IPCC (2003): Good Practice Guidance for Land Use, Land-Use Change and Forestry. Intergovernmental Pane on Climate Change (IPCC). National Greenhouse Gas Inventories Programme. http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf.html

IPCC (2006): 2006 IPCC Guidelines for National Greenhouse Gas Inventories. National Greenhouse Gas Inventories Programme, Intergovernmental Pane on Climate Change (IPCC) http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html

ISO (2007): ISO 14065 standard – new tool for international efforts to address greenhouse gas emissions. International Organization for Standardization. Published 17 April 2007. http://www.iso.org/iso/pressrelease.htm?refid=Ref1054 (visited 3 July 2009)

ISO (2009): International Organization for Standardization. http://www.iso.org (visited 15 May 2009)

ISO 14020 series. Environmental labels and declarations – General principles http://www.iso.org/iso/catalogue_detail.htm?csnumber=34425

ISO 14040 series. Environmental management – Life cycle assessment – Principles and framework http://www.iso.org/iso/catalogue_detail?csnumber=37456

ISO 14050:2009 Environmental management – Vocabulary. http://www.iso.org/iso/catalogue_detail.htm?csnumber=41492

ISO 14065. Greenhouse gases – Requirements for greenhouse gas validation and verification bodies for use in accreditation of other forms of recognition http://www-iso.org/iso/catalogue detail?csnumber=40685

ISO 17024. Conformity assessment – General requirements for bodies operating certification of persons. http://www.iso.org/iso/catalogue_detail?csnumber=29346

ISO/IEC Guide 65:1996 "General requirements for bodies operating product certification systems. http://www.iso.org/iso/catalogue_detail.htm?csnumber=26796

Katajajuuri J.-M. (2007): Experiences and Improvement Possibilities - LCA Case Study of Broiler Chicken Production, In: 3rd International Conference on Life Cycle Management, Zurich, Switzerland, 27–29 August 2007, 6 p.

Katajajuuri J.-M. – Grönroos J. – Mikkola A. – Näkkilä J. – Voutilainen P. (2007): Environmental impacts of Finnish greenhouse cucumber production systems, Book of proceedings of the 5th International conference LCA in Foods, 25–26 April 2007, Gothenburg, Sweden. The Swedish Institute for Food and Biotechnology, pp. 133–137.

Katajajuuri J.-M. – Virtanen Y. – Voutilainen P. – Tuhkanen H.-R. (2004): Life cycle assessment results and related improvement potentials for oat and potato products as well as for cheese. Life Cycle Assessment in the Agri-food sector, Proceedings from the 4th International Conference, DIAS report Animal Husbandry, no. 61, October 2004, pp. 222–225. Bygholm, Denmark, 6–8 October, 2003.

Katajajuuri J.-M. – Voutilainen P. – Tuhkanen H.-R. – Honkasalo N. (2003): Elovena-kaurahiutaleiden ympäristövaikutukset. Maa- ja elintarviketalous 33. MTT.

Kurppa S. – Grönroos J. – Hyvärinen H. – Katajajuuri J.-M. – Kauppinen T. – Mäkelä J. – Nissinen A. – Nousiainen J. – Saarinen M. – Usva K. – Viinisalo M. – Virtanen Y. (2009): Environmental impacts on a lunch plate – challenges to interpret the LCA results? Proseedings of Future of the Consumer Society Confence, 28–29 May 2009, Tampere, Finland

Minx J. – Wiedmann T.– Barrett J. – Suh S. (2007): Methods review to support the PAS process for the calculation of the greenhouse gas emissions embodied in goods and services. Report to the UK Department for Environment, Food and Rural Affairs by Stockholm Institute at the University of York and Department for Bio-Based Products at the University of Minnesota. Defra, London, UK, 92 s. http://randd.defra.gov.uk/Document.aspx?Document=EV02074_7070_EXE.pdf (visited19 May 2008)

MTI (2005): Government Decree on Notification of Origin of Electricity (233/2005)

MTI (2003a): Act on Verification and Notification of Origin of Electricity (1129/2003)

MTI (2003b): Government Decree on Verification of Origin of Electricity (1357/2003)

Mäenpää I. (2005): Analysis of environmental impacts of consumption in Finland. In: Sustainable Consumption: The Contribution of Research, Workshop 10–12 February 2005, Gabels Hus, Oslo, pp. 1–21. Norwegian University for Science and Technology (NTNU), Industrial Ecology program, Report 1/2005, Trondheim, Norway. ISBN 82-7948-046-3. www.indecol.ntnu.no/scworkshop.php

Neste Oil (2009): Neste Oil Oyj. Annual Report 2008. http://www.nesteoil.com/

Nissinen A. – Grönroos J. – Heiskanen E. – Honkanen A. – Katajajuuri J.-M. – Kurppa S. – Mäkinen T. – Mäenpää I. – Seppälä J. – Timonen P. – Usva K. – Virtanen Y. – Voutilainen P. (2006): Developing benchmarks for consumer-oriented LCA-based environmental information on products, services and consumption patterns. Journal of Cleaner Production, Vol. 15(6), pp. 538–549.

Nissinen A. – Seppälä J. (2008): Product labels that indicate climate impacts, In Finnish, Tuotteiden ilmastovaikutuksista kertovat merkit) commissioned by the Office of the Prime Minister, Valtioneuvoston kanslian julkaisusarja no. 11/2008, Helsinki.

Rotmans J. (2006): Tools for Integrated Sustainability Assessment – a two-track approach. International Journal of Assessment, Vol 6, pp. 35–57.

Saarinen M. – Mäkelä J. – Viinisalo M. – Kurppa S. – Nissinen A. (2009): Application of lunch plate model for communication of environmental impacts of the consumer’s food choices. Future of the Consumer Society, 28–29 May 2009, Tampere, Finland.

Seppälä J. – Mäenpää I. – Koskela S. – Melanen M. – Katajajuuri J-M. – Nissinen A. – Virtanen Y. – Usva K. – Myllymaa T. – Härmä T. (2006): Environmental impacts of material flows caused by the Finnish economy Market Opportunities in Life Cycle Thinking. In: Jørgensen, Andreas, Molin. First symposium of the Nordic Life Cycle Association, October 9–10, 2006, Lund, Sweden. p. 27.

Seppälä J. – Mäenpää I. – Koskela S. – Mattila T. – Nissinen A. – Katajajuuri J.-M. – Härmä T. – Korhonen M.-R. – Saarinen M – Virtanen Y. (2009): Environmental impacts of material flows caused by the Finnish economy (ENVIMAT), manuscript 12.3.2009. (In Finnish, Suomen kansantalouden materiaalivirtojen ympäristövaikutusten arviointi ENVIMAT-mallilla). Project web pages in English: www.environment.fi/syke/envimat

SETAC Europe LCA Steering Committee (2008): Standardisation Efforts to Measure Greenhouse Gases and 'Carbon Footprinting' for Products. Editorials. Int J LCA 13 (2) 87–88 (2008)

SFS-EN ISO 14040. Environmental management. Life cycle assessment. Principles and framework (ISO 14040:2006) http://www.sfs.fi/luettelo/sfs.php?standard=SFS-EN%20ISO%2014040

SFS-EN ISO 14044. http://www.sfs.fi/iso14000/standardit_iso14000/

SFS ISO 14025. Environmental labels and declarations. Type III environmental declarations. Principles and procedures http://www.sfs.fi/luettelo/sfs.php?standard=SFS-ISO%2014025

SFS EN 45011. General requirements for bodies operating product certification systems. http://www.sfs.fi/luettelo/sfs.php?standard=SFS-EN%2045011

Statistics Finland (2009): Greenhouse Gas Emissions In Finland 1990–2007 DRAFT National Inventory Report to the European Union. 15 January 2009.

Statistics Finland (2009a): Fuel classification 2006 (version 3.4.2006). http://www.stat.fi/tup/khkinv/khkaasut_polttoaineluokitus.html

Statistics Finland (2009b): Fuel definitions 2006. http://www.stat.fi/tup/khkinv/khkaasut_maaritykset.html

TC207 (2009): International Organization for Standardization's (ISO) Technical Committee 207 on Environmental Management. http://www.tc207.org (visited 15 May 2009)

Tukker A. – Huppes G. – Guinée J. – Heijungs R. – de Koning A. – van Oers L. – Suh S. – Geerken T. – Van Hol-derbeke M. – Jansen B. – Nielsen P. (2006): Environmental Impacts of Products. Analysis of the life cycle environmental impacts related to the final consumption of the EU-25. European Commission, Joint Research Centre; European Science and Technology Observatory; Institute for Prospective Technological Studies.

http://ec.europa.eu/environment/ipp/pdf/eipro_report.pd (visited 1 June 2008)

http://ec.europa.eu/environment/ipp/pdf/eipro_annex.pdf (visited 1 June 2008)

UNFCCC (2006): Updated UNFCCC reporting guidelines on annual inventories following incorporation of the provisions of decision 14/CP.11. http://unfccc.int/resource/docs/2006/sbsta/eng/09.pdf

University of Bath (2009): Integrated Environmental Management. Learn about carbon. http://www.learnaboutcarbon.net > http://www.learnaboutcarbon.net/qa/which-standards-apply-carbon-footprints (visited 15 May 2009)

Usva K. – Saarinen M. – Katajajuuri J-M. – Kurppa S. (2009): Supply Chain Integrated LCA Approach to Assess Environmental Impacts of Food Production in Finland. Agricultural and food science in Finland. submitted.

Virtanen Y. – Katajajuuri J-M. – Usva K. (2007): An analysis of the total environmental impact of barley-malt-beer chain. 31st EBC Conference, Venice 2007.

VTT (2006): Mäkinen T. – Soimakallio S. – Paappanen T. – Pahkala K. – Mikkola H.: Greenhouse gas balances and new business opportunities for biomass-based transportation fuels and agrobiomass in Finland (in Finnish). VTT Research Notes 2357. 134 pages + app. 19 p. ISBN 951-38-6825-7.

VTT (1999a): Green energy criteria and life cycle assessment in assessing environmental competiveness of energy products (in Finnish, Vihreän energian kriteerit ja elinkaariarviointi energiatuotteiden ympäristökilpailukyvyn arvioinnissa). Mälkki Helena – Hongisto Mikko – Turkulainen Tarja – Kuisma Jaakko – Loikkanen Torsti (1999): VTT, Espoo. 117 p. + app. 24 p. VTT Research Notes: 1974. http://www.vtt.fi/inf/pdf/tiedotteet/1999/T1974.pdf

VTT (1999b) : ExternE – National Implementation Finland. Pingoud Kim – Mälkki Helena – Wihersaari Margareta – Hongisto Mikko – Siitonen Sari – Lehtilä Antti – Johansson Matti – Pirilä Pekka – Otterström Tomas (1999): VTT, Espoo. 119 p. + app. 131 p. VTT Publications : 381 http://www.vtt.fi/inf/pdf/publications/1999/P381.pdf

VTT (2008) : Status and outlook for biofuels, other alternative fuels and new vehicles. Nylund,Nils-Olof – Aakko-Saksa Päivi – Sipilä Kai: VTT, Espoo. 161 p. + app. 6 p. VTT Research Notes: 2426 ISBN 978-951-38-6989-2; 978-951-38-7196-3

VTT (2009). Assessing the sustainability of liquid biofuels from evolving technologies. A Finnish approach. Soimakallio, Sampo; Antikainen, Riina; Thun, Rabbe 2009. VTT, Espoo. 220 p. + app. 41 p. VTT Research Notes: 2482
http://www.vtt.fi/inf/pdf/tiedotteet/2009/T2482.pdf

Weng C. K. – Boehmer K. (2006): Launching of ISO 14064 for greenhouse gas accounting and verification. ISO Management Systems, March–April 2006. http://www.iso.org/iso/greenhouse.pdf (visited 3 July 2009)

Appendices

Annex 1. The standards and technical reports in the ISO 14040 and 14020 series

Number	Name	Short description
ISO 14040:2006[*)]	Environmental management – Life cycle assessment – Principles and framework	Describes the principles and framework for LCA including goal and scope, phases, reporting, critical review and limitations
ISO 14044:2006[*)]	Environmental management – Life cycle assessment – Requirements and guidelines	Specifies requirements and provides guidelines for conducting an LCA.
ISO/TR[1)] 14047:2003	Environmental management – Life cycle impact assessment – Examples of application of ISO 14042	Provides examples on current practice in carrying out a life cycle impact assessment in accordance with ISO 14042.
ISO/TR 14048:2002	Environmental management – Life cycle assessment – Data documentation format	Provides requirements and a structure for a data documentation format, to be used for transparent and unambiguous documentation and exchange of LCA and LCI data.
ISO/TR 14049:2000	Environmental management - Life cycle assessment – Examples of application of ISO 14041 to goal and scope definition and inventory analysis	Provides examples on current practice in defining LCA goal and scope and in carrying out a life cycle inventory analysis in accordance with ISO 14041.
ISO 14020:2000	Environmental labels and declarations – General principles	Establishes guiding principles for the development and use of environmental labels and declarations.
ISO 14021:1999	Environmental labels and declarations – Self-declared environmental claims (Type II environmental labelling)	Specifies requirements for Type II environmental labels based on manufacturer's self-declared environmental claims about a product's environmental aspect (e.g. recycled material content).
ISO 14024:1999	Environmental labels and declarations – Type I environmental labelling – Principles and procedures	Establishes the principles and procedures for developing Type I environmental labeling programmes. Type I labels are granted by a third party (either government or private) to products meeting a set of predetermined criteria.
ISO 14025:2006	Environmental labels and declarations – Type III environmental declarations – Principles and procedures	Establishes the principles and specifies the procedures for developing Type III environmental declaration programmes and Type III environmental declarations. It specifically establishes the use of the ISO 14040 series in the development of these programmes and declarations. Type II declarations are produced by the company making the product or service, and are often certified by a third party.

[*)] The standards ISO 14040:2006 and ISO 14044:2006 revised, cancelled and replaced the previous standards "ISO 14040:1997 Environmental management – Life cycle assessment – Principles and framework", "ISO 14041:1998 Environmental management – Life cycle assessment – Goal and scope definition and inventory analysis", "ISO 14042:2000 Environmental management – Life cycle assessment – Life cycle impact assessment" and "ISO 14043:2000 Environmental management – Life cycle assessment - Life cycle interpretation".
[1)] Technical Report (TR) is not a standard but aims at facilitating the application of a standard.

Annex 2.

There are currently numerous Type III environmental product declaration programmes (EPD programmes, see the ISO 14025 definition in section 3.1.1) and similar types of product declaration and/or labelling approaches that include more specific calculation rules. Type III environmental product declarations are intended to provide quantified environmental information on the life cycle of a product, not only on greenhouse gas emissions, but also the calculation rules developed in these programmes, which typically include rules for greenhouse gas emission calculations. The Global Type III Environmental Product Declarations Network (GEDnet) was founded in 1999 (see www.gednet.org) to promote co-operation and harmonisation among these programmes. GEDnet is an international non-profit association of Type III Environmental Product Declaration organisations and practitioners. The overall purpose of the network is to promote co-operation and encourage information exchange among its members and other parties operating or developing product declaration programmes, and to discuss key issues in developing such programmes. Currently there are nine members in the network (Table A2). All the programmes are based on voluntary participation, and the programme operators include different types of organisation, both governmental and non-governmental. The only member programme that aims at international applicability, is the Swedish one, which is based the International EPD® system. The International EPD® system has also begun to develop single-issue EDPs that focus only on greenhouse gas emissions, i.e. Climate Declarations. There are also other associations that promote the development of environmental declarations or labels, e.g. the Global Ecolabelling Network (www.globalecolabelling.net).

In addition to these GEDnet member programmes, there is a large variety of other similar types of national, regional and international programmes and labelling schemes. They include both more general and single-issue climate programmes. Some of them are industry sector-specific programmes (e.g. the Carbon Footprint Framework developed by the Confederation of European Paper Industries and the RT Environmental Declaration by the Finnish Building Information Foundation) and some more general programmes for all types of product, developed by different types of organisation, including commercial companies.

Table A2. Members of the GEDnet

Name of the programme and/or internet address	**Programme operator(s)**
Eco-Leaf programme, www.jemai.or.jp/english/ecoleaf	Japan Environmental Management Association for Industry, public corporation organized by the membership of about 1 100 companies.
International EPD® system, www.environdec.com	International EPD Consortium, an international non-profit organisation, secretariat located currently in Stockholm, Sweden, staffed by the Swedish Environmental Management Council (previously: Swedish Environmental Management Council, a company owned jointly by the Swedish Government, the Confederation of Swedish Enterprises and the Swedish Association of Local Authorities and Regions)
Green Mark eco-labeling program, www.edf.org.tw	Environment and Development Foundation, Taiwan, independent non-governmental organization
Environmental Labelling Program in China, www.sepacec.com	China Environmental United Certification Center Co., Ltd, a company established by State Environmental Protection Administration of China
www.fivewinds.com	Five Winds International, a private consultant company
www.force.dk/en	Force Technology, Denmark, a private company
NHO EPD programme, www.epd-norge.no	Næringslivets Stiftelse for Miljødeklarasjoner, Norway
Environmental Declaration of Products, www.koeco.or.kr/eng	South Korea Eco-Products Institute, a non-profit organisation, South Korea Ministry of Environment
no working address available	Australian Environmental Labelling Association Inc.

Annex 3. Default emission factors (only direct emissions to the atmosphere from combustion) for various fuel categories

CLASSIFICATION 2006 /Statistics Finland | **Generated based defaults based on Fuel Classification 2006**

Applicable Factors for CFP monitoring purposes and Consumers

Heading	Fuel-specific unit	CO_2 default emission [t/TJ]	Average default calorific [GJ/unit]	NB	Defaults for direct "easy to use emission factors"	Carbon neutrality (Preliminary judgement)
Fossil fuels						
Petroleum products						
Petroleum gases						
Refinery gas	t	65,0	51,9		**3,37** kgCO2/kg,substance	No
LPG (Liquefied petroleum gas)	t	65,0 *	46,2 *		**3,00** kgCO2/kg,substance	No
Light distillates						
Naphtha	t	72,7	44,3		**3,22** kgCO2/kg,substance	No
Motor gasoline	t	72,9 *	43,0		**3,13** kgCO2/kg,substance	No
Aviation gasoline	t	71,3 *	43,7		**3,12** kgCO2/kg,substance	No
Medium distillates						
Kerosene (jet fuel)	t	73,2 *	43,3		**3,17** kgCO2/kg,substance	No
Other kerosenes	t	73,2 *	43,1		**3,15** kgCO2/kg,substance	No
Diesel oil	t	73,6 *	42,8		**3,15** kgCO2/kg,substance	No
Light fuel oil (heating fuel oil)	t	74,1	42,7 *		**3,16** kgCO2/kg,substance	No
NEW!! Gasoil (for non-road use)	t	73,2 *	42,8 *		**3,13** kgCO2/kg,substance	No
Other medium distillates	t	74,1	42,7 *		**3,16** kgCO2/kg,substance	No
Heavy distillates						
Heavy fuel oil, sulphur content < 1%	t	78,8 *	41,1		**3,24** kgCO2/kg,substance	No
Heavy fuel oil, sulphur content ≥ 1%	t	78,8 *	40,5		**3,19** kgCO2/kg,substance	No
Other heavy distillates	t	78,8 *	40,2 *		**3,17** kgCO2/kg,substance	No
Petroleum coke	t	97,0	33,5		**3,25** kgCO2/kg,substance	No
Recycled and waste oils	t	78,8 *	41,0		**3,23** kgCO2/kg,substance	No, might include neutral components
Other petroleum products	t	78,8 *	30,0		**2,36** kgCO2/kg,substance	No
Coal						
Hard coal						
Anthracite	t	94,6	33,5		**3,17** kgCO2/kg,substance	No
Hard coal, bituminous	t	94,6	25,5		**2,41** kgCO2/kg,substance	No
Other coal						
Semi-bituminous coal, brown coal, lig	t	108,0	20,0		**2,16** kgCO2/kg,substance	No
Coal briquettes	t	108,0	30,0		**3,24** kgCO2/kg,substance	No
Coal tar	t	90,0 *	37,0 *		**3,33** kgCO2/kg,substance	No
Other non-specified coal	t	108,0	10,0		**1,08** kgCO2/kg,substance	No
Coke	t	108,0	29,3		**3,16** kgCO2/kg,substance	No
Coke oven gas	1000 m^3	41,5 *	16,7		**0,69** kgCO2/Nm3,gas	No

(continues)

	Fuel	Unit							
	Blast furnace gas	1000 m^3	263,7 *	3,8		**1,00**	kgCO2/Nm3,gas		No
	Natural gas								
	Natural gas	1000 m^3	55,0 *	36,0		**1,98**	kgCO2/Nm3,gas		No
	Peat								
	Peat								
	Milled peat	t	105,9	10,1		**1,07**	kgCO2/kg,substance		No
	Sod peat	t	102,0	12,3		**1,25**	kgCO2/kg,substance		No
	Peat pellets and briquettes	t	97,0	20,9		**2,03**	kgCO2/kg,substance		No
	Renewable and mixed fuels								
	Biomass								
	Forest fuelwood								
	Firewood (stems and split firewood)	t	109,6	10,6	BIO	**1,16**	kgCO2/kg,substance		Yes
	Chips from roundwood	t	109,6	10,4	BIO	**1,14**	kgCO2/kg,substance		Yes
	Forest residue chips	t	109,6	8,5	BIO	**0,93**	kgCO2/kg,substance		Yes
	Industrial wood residue				BIO				
	Bark	t	109,6	6,3	BIO	**0,69**	kgCO2/kg,substance		Yes
	Sawdust, cutter shavings etc.	t	109,6	6,1	BIO	**0,67**	kgCO2/kg,substance		Yes
	Wood residue chips	t	109,6	10,4	BIO	**1,14**	kgCO2/kg,substance		Yes
	Unspecified industrial wood residue	t	109,6	6,5	BIO	**0,71**	kgCO2/kg,substance		Yes
	Other industrial wood residue	t	..	..	BIO				Yes, might include non-neutral fossil compo
	Black liquor and other concentrated	t_{ka}	109,6	11,7	BIO	**1,28**	kgCO2/kg,dry-matter		Yes, might include non-neutral fossil compo
	Other by-products from wood proce industry	TJ	109,6	..	BIO				Yes
	Recovered wood	t	109,6	13,0	BIO	**1,42**	kgCO2/kg,substance		Yes
	Wood pellets and briquettes	t	109,6	16,0	BIO	**1,75**	kgCO2/kg,substance		Yes
NEW!!	**Vegetable-based fuels**	t	109,6	15,0 *	BIO	**1,64**	kgCO2/kg,substance		Yes, might include non-neutral fossil compo
NEW!!	**Animal-based fuels**	t	109,6	35,0 *	BIO	**3,84**	kgCO2/kg,substance		Yes, might include non-neutral fossil compo
	Other biofuels and mixed fuels								
	Biogas								
	Landfill gas	1000 m^3	56,1	15,0	BIO	**0,84**	kgCO2/Nm3,gas		Yes
	Biogas from wastewater treatment	1000 m^3	56,1	20,5	BIO	**1,15**	kgCO2/Nm3,gas		Yes
	Industrial biogas	1000 m^3	56,1	15,0	BIO	**0,84**	kgCO2/Nm3,gas		Yes
	Other biogas	1000 m^3	56,1	15,0	BIO	**0,84**	kgCO2/Nm3,gas		Yes
	Liquid biofuels	t	77,4	30..40 *	BIO	**2,32**		3,096	Depend on fuel
	Mixed fuels (fossil and non-fossil)								
	Recovered fuels	t	31,8	20,0	1)	**0,64**	kgCO2/kg,substance		Neutrality of the content must be studied m
	Demolition wood	t	17,0	15,0	1)	**0,26**	kgCO2/kg,substance		Neutrality of the content must be studied m
	Impregnated wood (chemically treate	t	11,4	12,0	1)	**0,14**	kgCO2/kg,substance		Neutrality of the content must be studied m
	Other mixed fuels	t	110,0	10,0		**1,10**	kgCO2/kg,substance		Neutrality of the content must be studied m
	Gasified waste	1000 m^3	..	..	2)				Neutrality of the content must be studied m

(continues)

Other energy sources					
Nuclear energy					
Nuclear energy	TJ	–			Indirect emission sources
Others					
Other by-products and wastes used as fuels					
Plastics waste	t	74,1	33,0	**2,45** kgCO2/kg,substance	No, might include neutral components
Rubber waste	t	90,0	33,0	**2,97** kgCO2/kg,substance	No, might include neutral components
Hazardous waste	t	75,0	30,0	**2,25** kgCO2/kg,substance	No, might include neutral components
Other waste	t	75,0	30,0	**2,25** kgCO2/kg,substance	No, might include neutral components
Exothermic heat from industry	TJ	–			Indirect emission sources
Secondary heat from industry	TJ	–			Indirect emission sources
Electricity	MWh	–			Indirect emission sources
Steam	MWh	–			Indirect emission sources
Hydrogen	1000 m^3	0,0	10,8		Indirect emission sources
Other non-specified energy sources	TJ	..	..		No, if nothing is known about the origin

NB
BIO = biofuel, whose carbon dioxide emissions are not counted in the total emission amounts of Finland's greenhouse gases, nor are they taken into account in emissions trading.
1) CO_2 factor of mixed fuels is an estimate taking into account only the share of fossil carbon.
2) Gasified waste is reported in fuel categories according to the source materials of gasification.

Emission factors are updated when necessary.
* Revised values.

VATT TUTKIMUKSET -SARJASSA ILMESTYNEITÄ
PUBLISHED VATT RESEARCH REPORTS

137. Räty Tarmo – Aaltonen Juho – Kirjavainen Tanja: Tuloksellisuuden ja tuottavuuden mittaus ammattikorkeakouluissa. Helsinki 2008.

138. Räty Tarmo – Harava Maiju: Kokonaistuottavuuden kehitys yliopistoissa. Helsinki 2008.

139. Honkatukia Juha – Forsström Juha: Ilmasto- ja energiapoliittisten toimenpiteiden vaikutukset energiajärjestelmään ja kansantalouteen. Helsinki 2008.

140. Lyytikäinen Teemu: Studies on the Effects of Property Taxation, Rent Control and Housing Allowances. Helsinki 2008.

141. Lehtonen Sanna – Lyytikäinen Teemu – Moisio Antti: Kuntien rahoitus- ja valtionosuusjärjestelmä: Vaihtoehtoja uudistuksen toteuttamiseksi. Helsinki 2008.

142. Pekkala Johanna: Tuloerojen ja terveyden välinen yhteys Suomessa. Helsinki 2009.

143:1. Perrels Adriaan – Hongisto Mikko – Hyvönen Kaarina – Katajajuuri Juha-Matti – Nissinen Ari: A quick scan of climate policy services and of underlying data system approaches. Climate Bonus project report (WP1). Helsinki 2009.

144. Karvinen Anni-Mari: Maahanmuuttajien poismuutto Suomesta. Helsinki 2009.

145. Sahari Anna – Perrels Adriaan: Ekotehokkuutta parantavat investoinnit kesämökeillä. Helsinki 2009.

146. Tuovinen Tarja: Ääriarvomenetelmät sähkömarkkinoiden riskinarvioinnissa. Helsinki 2009.

147. Honkatukia Juha – Kinnunen Jouko – Marttila Kimmo: Väestön ikääntymisestä johtuvien julkisten kulutusmenojen kasvun rakenteelliset vaikutukset. Helsinki 2009.

148. Kari Seppo – Kröger Outi: Osakkeiden normaalituoton verovapaus: Norjan osakeverotuksen malli. Helsinki 2009.

149. Mälkönen Ville – Seppälä Timo: Terveyspalvelusetelien hyvinvointi- ja kustannusvaikutukset jonotetuissa toimenpiteissä. Helsinki 2009.

150. Honkatukia Juha: VATTAGE – A dynamic, applied general equilibrium model of the Finnish economy. Helsinki 2009.

151. Räty Tarmo: Julkaisujen vaativuus tieteenaloittain. Helsinki 2009.

143:3. Perrels Adriaan – Nissinen Ari – Sahari Anna: Reviewing key building blocks of an integrated carbon footprinting and consumer purchases' monitoring & reward system – interaction with the consumer. Climate Bonus project report (WP4). Helsinki 2009.

143:4. Hyvönen Kaarina – Saastamoinen Mika – Timonen Päivi – Kallio Arto – Hongisto Mikko – Melin Magnus – Södergård Caj – Perrels Adriaan: Kuluttajien näkemyksiä kotitalouden ilmastovaikutusten seuranta- ja palautejärjestelmästä. Climate Bonus -hankeraportti (WP5). Helsinki 2009.

VALTION TALOUDELLINEN TUTKIMUSKESKUS
STATENS EKONOMISKA FORSKNINGSCENTRAL
GOVERNMENT INSTITUTE FOR ECONOMIC RESEARCH

Valtion taloudellinen tutkimuskeskus
Government Institute for Economic Research
P.O.Box 1279
FI-00101 Helsinki
Finland

ISBN 978-951-561-890-0
ISSN 0788-5008