REPORT

The ILCD Handbook in a NUTSHELL

A brief analysis of the ILCD Handbook and the Draft Guidance on Product Environmental Footprint

Med svensk sammanfattning

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Report Summary

Project title

The ILCD Handbook in a NUTSHELL

Project sponsors

The Swedish Steel Producers' Association
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Title and subtitle of the report

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A brief analysis of the ILCD Handbook and the Draft Guidance on Product Environmental Footprint

Summary

The ILCD Handbook is an attempt to describe a harmonized European life cycle assessment (LCA) methodology that can be used by industry and for policymaking. It is to a large extent based on and compliant with the ISO 14040 and ISO 14044 standards on LCA, but adds further requirements. It contributes with technical descriptions and methodologies in much more detail than the ISO standards can. Important deviations from previous LCA guidelines include the following:

- The ILCD Handbook is based on three archetypical cases of LCA rather than the distinction between attributional and consequential LCA that is used in modern good LCA practice.
- The impact assessment is designed to quantity approximations of the actual environmental impacts, while previous LCA guidelines aimed at little more than aggregating LCI results.
- The ILCD Handbook assumes that 2-4 iterations will be done in most LCAs, while previous guidelines and practice includes iterations only when called for.
- The requirements on reporting and on the assessment of data quality are strict.

The Handbook is very ambitious, but its large volume, tangled structure and internal inconsistencies makes it difficult to use in practice. Instead of updating the documents to make the methodological guidance more accessible, the EU seems to spend its efforts on developing a new document: the Product Environmental Footprint (PEF) Guide.

The PEF Guide is designed to be an effective handbook, which means it might become widely used. During the authoring of this report, the Guide was in its second draft and it had not yet been decided for what LCA applications the guide should be applied. Any wide-spread use of the PEF methodology is likely to affect future environmental assessments and decision making in Swedish industry.

We recommend the different industrial sectors and companies to participate in the development of the Product Footprint Category Rules, in order to be able to give feedback and influence the methodologies and requirements on the PEFs. We recommend to the Swedish Environmental Protection Agency and other authorities to participate in the discussions within EU and to stimulate the use of the PEF Guide. IVL is prepared to assist in these discussions and developments.

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Foreword

This study was co-financed by the Swedish Forest Industries Federation (Skogsindustrierna), the Swedish Steel Producers' Association (Jernkontoret), the Swedish Plastics and Chemicals federation (Plast- och Kemiföretagen), and the Foundation for the Swedish Environmantal Research Institute (SIVL).

The preliminary results of this project were presented on the 1st of December 2011 with very valuable reflections and discussions.

The main target audience for this report is experts within industry, authorities, research and practitioneers familiar with LCA and the ISO 14040/14044 standards. The report includes an extended executive summary in Swedish, including also non-experts as a target audience.

The steering group for the project consisted of Cecilia Mattsson at the Swedish Environmental Protection Agency, Helene Axelsson at the Swedish Steel Producers' Association, Ingrid Haglind, at the Swedish Forest Industries Federation, and Anders Normann at the Swedish Plastics and Chemicals Federation. IVL thanks the steering group forvaluable input and comments in seminars and on the report.

Summary

The goal of this study is to clarify the background to the existence of the ILCD Handbook, describe its methodological contents and how it compares to common life cycle assessment (LCA) practice. The possible implication towards Swedish industry will also be touched upon, and suggestions for future work will be given. The main target audience for this report is experts within industry, authorities, research and practitioneers familiar with LCA and the ISO 14040/14044 standards. The report includes an extended executive summary in Swedish, including also non-experts as a target audience.

The ILCD Handbook is an attempt to describe a harmonized European LCA methodology that can be used by industry and for policymaking. It is to a large extent based on and compliant with the ISO 14040 and ISO 14044 standards on LCA, but adds further requirements. It contributes with technical descriptions and methodologies in much more detail than the ISO standards can, and links the methodology in the LCA more closely to its intended application. One specific conclusion, for example, is that the ILCD Handbook in most cases stimulates material recycling but does not stimulate the use of recycled materials in the studied products. The ISO standards are neutral in this respect.

The ILCD handbook is not the first attempt at a harmonized LCA methodology. Important deviations from previous LCA guidelines include the following:

- The ILCD Handbook is based on three archetypical cases of LCA rather than the distinction between attributional and consequential LCA that is used in modern good LCA practice.
- The impact assessment is designed to quantity approximations of the actual environmental impacts, while previous LCA guidelines aimed at little more than aggregating LCI results.
- The ILCD Handbook assumes that 2-4 iterations will be done in most LCAs, while previous guidelines and practice includes iterations only when called for.
- The requirements on reporting and on the assessment of data quality are strict.

The Handbook is very ambitious, but its large volume, tangled structure and internal inconsistencies makes it difficult to use in practice. Instead of updating the documents to make the methodological guidance more accessible, the EU seems to spend its efforts on developing a new document: the Product Environmental Footprint (PEF) Guide.

The PEF Guide is designed to be an effective handbook, which means it might become widely used. During the authoring of this report, the Guide was in its second draft and it had not yet been decided for what LCA applications the guide should be applied. Any wide-spread use of the PEF methodology is likely to affect future environmental assessments and decision making in Swedish industry.

The PEF Guide gives clear guidance in which methodologies to use and has specific requirements for the user. Since the ILCD Handbook was used at development of the PEF Guide, besides the existing ISO standards and those under development, it has played an

important role as a background to coming product policies and applications. However, applying the ILCD Handbook to LCAs of different products and products categories do not ensure comparability, since the Handbook allows for several methodological choices in the different phases of the LCA. The different parts of the Handbook are not always consistent.

The PEF Guide is a draft in continuous development and it is likely that the available version of the guide will see major changes in the future. It was tested by a number of industrial groups in 2011. The goal is that the Guide will develop into an accepted common European LCA methodology that enables product comparisons and may stimulate companies to take important decisions to change products and services towards products with higher environmental performance.

We recommend the different industrial sectors and companies to participate in the development of the Product Footprint Category Rules, in order to be able to give feedback and influence the methodologies and requirements on the PEFs. We recommend to the Swedish Environmental Protection Agency and other authorities to participate in the discussions within EU and to stimulate the use of the PEF Guide. IVL is prepared to assist in these discussions and developments.

One concern is how the guides can be applied for small and medium-sized enterprises (SMEs). This is an issue that is already in the discussions, and we suggest having simplified guides for each product sector for SMEs.

Contents

Summary in Swedish for non-experts

ILCD handboken – vad är det - på svenska!

ILCD står för International Reference Life Cycle Data System Handbook. Syftet med vår rapport är att beskriva uppkomsten och innehållet i ILCD-handboken och jämföra de rekommenderar som ges jämfört med god praxis inom livscykelanalys (LCA). Vi fångar också upp den första tillämpningen av handboken som är preliminära riktlinjer för ”Environmental Footprints”, och då speciellt ”Product Environmental Footprints” (PEF). Riktlinjer för dessa Footprints finns i en preliminär ”PEF Guide”. Rapporten tar i första hand upp metodfrågor, krav och riktlinjer för miljöprofiler/footprints för produkter, men det finns även motsvarande riktlinjer för organisationer.

ILCD-handboken är skriven för LCA-experter. För att branschföreningar, företag och myndigheter ska kunna utnyttja den här rapporten i sin pågående dialog med EU-kommissionen kring PEF-guiden har den skrivits för läsare som har en god kunskap eller åtminstone baskunskap om LCA-metodiken.

Denna sammanfattning på svenska är inte en direkt översättning av den engelskspråkiga rapportsammanfattningen utan en fristående kortversion av rapportens innehåll och budskap som inte kräver expertkunskap för att förstå. Det innebär då att den inte tar upp alla detaljfrågor utan försöker närma sig frågeställningen utifrån ett helikopterperspektiv.

LCA – en kort historik

Livscykelanalys har sitt ursprung i energianalyser av produkter ”från vaggan till graven” från 1960-talet, men började tillämpas i sin nuvarande form i slutet av 1980-talet. Ett vanligt tidigt studieobjekt var jämförelser av olika förpackningsmaterial. LCA fick tidigt ett rykte om sig att vara svårt och kostnadskrävande samtidigt som resultaten inte alltid sågs som tillförlitliga. Grunden till detta rykte var delvis bristen på en enhetlig metodik men kanske framför allt att det inte fanns tillgång till representativa data för alla steg i produktens livscykel.

Bristen på en vetenskapligt robust och enhetlig metodik fick den vetenskapliga och oberoende internationella organisationen SETAC1 att ta fram en ”Code of Practice” 1992. Uppförandekoden togs fram med hjälp av cirka 50 europeiska och amerikanska ”LCA-experter” från industri, myndigheter och akademi. Dokumentet blev ett viktigt inspel i det arbete som Internationella Standardiseringsorganisationen (ISO) drog igång kort därefter för standardisering av miljöledning m.m. (ISO 14000-serien). I detta arbete ingick också innefattade framtagning av en LCA-standard: ISO 14040-serien. LCA-standarden kom ut som en serie delstandarder under 1990-talets andra hälft, där varje del motsvarade en del av den struktur som ISO tog fram för LCA:

- Definition av studien mål, syfte och omfattning (eng. Goal & Scope)

[1] Society of Environmental Toxicology and Chemistry

- Inventering, framtagning av en modell som innehåller alla delar som ingår i produktens livscykel för beräkning av material- och energiflöden inklusive alla utsläpp till luft, mark och vatten (eng. Inventory)
- Miljöpåverkansbedömning, där utsläppen bidrag till olika former av miljöpåverkan bedöms (eng. Impact Assessment), och
- Tolkning, där olika verktyg som exempelvis känslighetsanalyser används för att tolka studiens resultat (eng. Interpretation).

Något tidigare startade ett parallellt arbete för att ta fram ”Nordic Guidelines on Life-Cycle Assessment”. Detta arbete finansierades av Nordiska Ministerrådet och utfördes av LCA-experter från Danmark, Finland, Norge och Sverige. Många av dessa personer deltog också i ISO-arbetet. ISO-standarden blev en procedurstandard, det vill säga den pekade inte ut några specifika detaljerade metoder utan ställde enbart upp kvalitetsvillkor för de metoder som får användas och rangordnade olika principiella ansatser. Den fokuserade i övrigt på hur en LCA och dess metodval skulle rapporteras. Nordic Guidelines från 1995 hade nästan samma upplägg som ISO:s första delstandarder som gavs ut mellan 1997 och 2000. Den pekade på olika möjligheter, diskuterade för- och nackdelar samt gav råd. Det faktum att den var nordisk, ej nationell, gav flexibilitet i metodval samt innehöll förklarande text gjorde att den fick en global spridning.

Mycket av det som Nordic Guidelines och andra tidiga LCA-guider tog upp runt målbeskrivning och inventering finns i grova drag kvar än idag i exempelvis ILCD-handboken. Mycket har givetvis förädlats under de 20 år som LCA-metodiken i dagens mening funnits, men grunderna är desamma.

Den största förändringen som skett rör den tredje delen av LCA-metodiken: miljöpåverkansbedömningen. Då – liksom nu – bestod detta steg av två möjliga ansatser: en beräkning av olika utsläpps bidrag till ett antal påverkanskategorier (klimatpåverkan, försurning, övergödning m.m.) och/eller en viktning av alla bidrag till ett enda indikatorvärde. Det är den första ansatsen som idag skiljer sig från den inriktning som gällde vid 1990-talets början. Då fanns två dokument som beskrev metoder för detta steg: Nordic Guidelines och holländska CML Guide 92. Dessa två ansatser var i stort överensstämmande, trots att de utvecklats på olika håll.

I de två tidiga guiderna sågs inte miljöpåverkansbedömningen som en bedömning av faktisk miljöpåverkan. Syftet var istället främst att aggregera de stora datamängder (emissionsdata) som kom ut ur inventeringen till mer hanterlig information, som fortfarande var relevant. Lösningen på problemet var ”ekvivalenter”. Man räknade till exempelvis om utsläppen av olika försurande ämnen till motsvarande mängd svaveldioxid och kunde summera dessa till en mängd ”svaveldioxid-ekvivalenter”. Detta gjordes för alla kategorier: klimatpåverkan, övergödning m.m. Vissa ämnen såsom kväveoxider, bidrar till mer än en påverkanskategori men dock inte samtidigt. Detta valde man att bortse ifrån, vilket innebar att man dubbelräknade viss miljöpåverkan. Hela utsläppet av kväveoxider räknades exempelvis om till svaveldioxidekvivalenter (försurning) och dessutom till fosforekvivalenter (övergödning).

Resultaten av en LCA var med andra ord inget annat än aggregerade emissionsdata. Vilken påverkan dessa utsläpp kunde få fick bedömas med andra verktyg. Fördelen var att ansatsen var transparent, och samtidigt gav ett mått på livscykelns tekniska prestanda i termer av aggregerade utsläpp.

I slutet av 1990-talet påbörjades dock arbeten med att hitta metoder som på ett ungefärligt sätt kunde ta hänsyn till utsläppens spridning och mottagande områdens känslighet i hela livscykeln. Sådant arbete pågick vid IVL i samband med utveckling av EPD[2]-systemet. Just det arbetet övergavs bland annat därför att det ansågs att en EPD ska redovisa produktens tekniska prestanda i ett livscykelperspektiv utan möjlighet att produktionens lokalisering maskerade denna. Den kommande metodutveckligen inom LCA som helhet kom dock att följa denna ansats att försöka uppskatta någon form av faktisk skada (eng. damage) och inte bara indikera potentiell påverkan genom att räkna fram aggregerade utsläpp.

LCA i ett tidigt EU-perspektiv

EU-kommissionen (KOM) arbetade under 2000-talets inledande år med IPP, integrerad produktpolitik. Syftet var att flytta miljöpolitiskt fokus från produktionsanläggningar till produkter i ett livscykelperspektiv. KOM publicerade sitt IPP-meddelande 2003. I detta förklarar man att sin ambition är att få producenter att redovisa sina produkters miljöprestanda i ett livscykelperspektiv, det vill säga att använda LCA. Man påpekar också att företagen behöver stöd vad gäller dataförsörjning och metodik om detta ska komma till stånd.

Som en del av arbetet hade EU:s gemensamma forskningscentrum, JRC[3], redan 2002 tagit ett initiativ till att utveckla en gemensam struktur för LCA-databaser. Detta följdes upp med bildandet av en europeisk LCA-plattform 2005: EPLCA[4] Plattformen utvecklades som ett projekt vid JRC Ispra åren 2005–2008 genom en överenskommelse mellan DG JRC och DG Miljö.

EPLCA skulle öka tillgänglighet, utbyte och användning av kvalitetsäkrade livscykeldata, metoder och studier för att ge tillförlitligt beslutstöd inom europeiskt näringsliv och policyarbete. Detta är nog den formella grunden till framtagningen av ILCD-handboken.

Inom EU:s forskningsprogram hade LCA använts sedan slutet av 1990-talet. Många forskningsprojekt innehöll en LCA-del för att ge resultaten ett helhetsperspektiv. Några egentliga insatser för att utveckla LCA-metodiken gjordes dock inte inom EU-forskningen.

Handbokens syfte, position och allmänna egenskaper

ILCD-handbokens syfte är att ge bästa möjliga metodikanvisningar för tillämpningar av LCA i näringsliv och policyarbete. Den bygger på existerande praxis. Det finns inga ambitioner att utveckla nya metoder.

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[2] Environmental Product Declaration, miljövarudeklaration
[3] Joint Research Center
[4] European Platform on Life Cycle Assessment

I alla LCA-guider måste man göra en avvägning mellan flexibilitet (möjlighet att tillämpas inom många områden och tillämpningar) eller jämförbarhet (säkerställa att alla gör på samma sätt).

Handboken betonar flexibilitet och är därför inte någon färdig handbok utan en plattform för andra mer sektors- eller produktgruppsspecifika guider. Miljövarudeklarationssystem (EPD-system) använder sig av så kallade PCR-dokument (Product Category Rules) som strikt anger beräkningsregler för specifika produktgrupper för att säkerställa jämförbarhet.

Handbokens ligger mellan ISO 14040-serien (egentligen ISO 14044:2006) och riktade regelverk som exempelvis PCR-dokument. Handboken är, trots detta, mycket detaljerad. Den är skriven för LCA-experter och har målsättningen att ta upp varje fråga av betydelse inom LCA-metodiken, och att ange vad som kan anses vara god praxis. Den är således ett gediget uppslagsverk för LCA-experter men målsättningen att täcka allt har också blivit dess största nackdel. Den är extremt svårläst med korsreferenser och inte alltid helt konsekvent.

Handboken består av flera olika dokument där det senaste lanserades i november 2011. Övriga delar med det huvuddokument som förknippas med handboken publicerades våren 2010. Den har också fått kritik för att vara alltför omfattande och svårläst. Det synes också vara så att inte alla LCA-experter har läst hela handboken av detta skäl.

Handboken i jämförelse med god praxis och andra riktlinjer

Handboken ska bara fånga upp god praxis inom området på ett sätt som ger flexibilitet. Handbokens instruktioner är dock inte så flexibla som den klassiska LCA-metodiken, som i stort säger att studiens mål och omfattning helt avgör metodval. Här går man längre än så och ger rekommenderade metoder baserat på hur resultatet är tänkt att användas.

I huvudsak motsvarar handbokens instruktioner god praxis idag. Att den detaljrikt beskriver praxis gör den till ett värdefullt uppslagsverk för den som ska utföra en LCA-studie. I många delar är de klargöranden som är mycket konstruktiva, men det finns dock andra instruktioner som kan diskuteras eftersom de till exempel kan göra en LCA-studie mer tidskrävande. Den engelskspråkiga rapporten tar upp exempel på detta, vilka då ligger på LCA-expertnivå.

Det finns dock några nyheter, vars konsekvenser inte är analyserade i denna studie. En sådan gäller när så kallad konsekvensanalys får tillämpas. Handboken är väsentligt mer restriktiv på denna punkt än den praxis som tillämpas i nordiska länder. En annan är att man tydligt pekar ut en rekommenderad uppsättning av metoder för bedömning av miljöpåverkan. Det finns idag många metoder publicerade och de ger alla olika relativa resultat, så metodval påverkar vad som ter sig stort respektive smått. Det finns ett antal mindre detaljfrågor av denna typ. Det största frågetecknet är dock inte handboken, utan den första tillämpningen av handboken; den preliminära guiden för Product Environmental Footprint, PEF.

PEF-guiden – den första tillämpningen av handboken

Under senare år så har flera nya ”footprint”-koncept lanserats och blivit föremål för standardisering, exempelvis av ISO. Det handlar om LCA-baserad produktinformation avseende en enda typ av miljöpåverkan, klimatpåverkan eller vattenförbrukning, det vill säga enfrågedeklarationer. När KOM lanserade begreppet ”Product Environmental Footprint” (PEF), som skulle redovisa alla former av miljöpåverkan tolkade nog många detta som en form av miljövarudeklaration (eng. Environmental Product Declaration; EPD). Syftet med PEF är att det ska vara ett verktyg i arbetet mot mer hållbar produktion och konsumtion enligt de färdplaner för ett resurseffektivt Europa som KOM ställt upp.

Under 2011 togs ett antal PEF fram inom olika branscher som fallstudier för att ge erfarenhet och praktiskt testa den preliminära metodik som JRC i Ispra tagit fram baserad på ILCD-handboken. PEF-guiden fanns i en första preliminär version som ej fick kommenteras för dessa fallstudier, men kom ut i en andra preliminär version i oktober 2011 i en version som var avsedd för i stort öppen konsultation. Den analys som ges i den engelskspråkiga rapporten avser metodfrågor i denna andra preliminära version av PEF-guiden.

PEF-guiden fokuserar uttalat på jämförbarhet, det vill säga vill minimera flexibilitet. Det är en princip som alla system för LCA-baserade miljövarudeklarationer följer, till exempel det Internationella EPD-systemet. När man väl avgränsat sitt mål med metodanvisningar till ett område, exempelvis miljövarudeklarationer, så kan man ange strikta metodval som passar för just detta område och därmed få full jämförbarhet. PEF-guiden är starkt influerad av de metodval som görs i det Internationella EPD-systemet, men blandar detta med andra riktlinjer som snarast är generell LCA-metodik.

PEF-guiden är en operativ handbok, men den är inte skriven för ett tydligt tillämpningsområde som exempelvis en miljövarudeklaration. Den synes vara avsedd också för andra tillämpningar än deklarationer, som exempelvis i produktutveckling samt som underlag för krav vid upphandling och för eco-design. En tolkning IVL gör är att detta är en slags ersättning för den svåranvända ILCD-handboken och inte bara en begränsad tillämpning.

PEF-guiden anger vilken metod som ska väljas i alla de valsituationer som finns i LCA-metodiken, exempelvis:

- Miljöpåverkansbeskrivning
- Återvinning
- Elförbrukning

Den anger 14 miljöpåverkanskategorier som utgångspunkt. Det finns dock en möjlighet att dra ifrån eller lägga till i denna lista om det kan motiveras.

PEF-guidens regler för hur återvinning av material från slutanvända produkter ska hanteras skiljer sig från EPD-systemet och den Europastandard för EPD av byggmaterial och byggprodukter som fastställdes i januari 2012 (EN 15804:2012). Detta är en viktig fråga för industrin som alltid diskuterats i LCA-sammanhang. De två senare gynnar användning av återvunnet material i produkten, då miljöbelastningar som uppstått i tidigare livscykler inte tas med i beräkningen. Användning av skrot eller returpapper som råvara är "gratis" ur en miljösynpunkt. I PEF-guiden däremot belastas produkten delvis av miljöbelastningar som uppstått i tidigare led. PEF gynnar i motsats till EPD produkter som är återvinnbara när de tjänat ut. Svenskt stål baseras delvis på inhemsk malmråvara och gynnas då mer i PEF än exempelvis i en EPD som baseras på EN 15804:2012. Den senare kommer dock att få ett stort genomslag då det finns en tydlig koppling till den nya byggproduktförordningens (CPR) krav på att miljöinformation ska ges med en EPD.

PEF-guidens regler för elanvändning som bl a inte tillåter att specifik elanvändning redovisas är sannolikt ett misstag som kommer att rättas till i kommande versioner.

Den har i ILCD-handbokens anda mycket höga krav på rapportering och dokumentation. Kraven på exempelvis dokumentation av datakvalitet är akademiskt fullgoda, men så arbetskrävande att de knappast är genomförbara i rutinmässig användning.

Vilka konsekvenser en PEF-guide i nuvarande form kan ge är inte analyserat. Guiden är dock när denna rapport skrivs fortfarande preliminär. Det antas att det krävs flera år av tester innan en helt genomarbetad och accepterad metodik för PEF finns. Eftersom PEF-guiden ger maximala bruttokrav rekommenderas det också att man utvecklars.k. PFCR[5]-dokument (inspirerade av de PCR-dokument som används inom olika EPD-system) för olika produktgrupper. PEF-tillåter avvikelser från guidens krav om det kan motiveras, t.ex. i valet av relevanta miljöpåverkanskategorier.

Den engelskspråkiga rapporten tar upp dessa frågor på en detaljnivå som oftast kräver god kunskap om LCA metodiken och dess terminologi. Att skriva en rapport som förklarar alla frågor skulle ge rapporten en omfattning som ej ingått i denna studie.

[5] Product Footprint Category Rules

1 Goal of this report

The goal of this study is to clarify the background to the existence of the ILCD Handbook (JRC-IEA, 2010a), describe its methodological contents and how it compares to common LCA practice. The possible implication towards Swedish industry will also be touched upon, and suggestions for future work will be given. The intended audience is those with an in-depth knowledge of LCA methodology and an interest of the contents of the ILCD handbook.

During the authoring of this report, the EU Product Environmental Footprint Guide was in its second draft and available for public consultation (JRC-IEA, 2011). As the guide constitutes the first operational guidelines based on the ILCD handbook, it was also analyzed as part of this study.

2 The ILCD Handbook

2.1 Contents and structure

The ILCD Handbook (here referred to as "the Handbook") is a series of technical documents developed by the JRC-IES (Joint Research Center – Institute for Environment and Sustainability) of the European Commission. Despite the name, the Handbook is not a completely operational handbook since there are, for instance, no lists of characterization factors for the recommended impact assessment methods.

The main document, "ILCD Handbook - General guide for Life Cycle Assessment - Detailed guidance", provides technical guidance for detailed Life Cycle Assessment (LCA) studies and provides the technical basis to derive product-specific criteria, guides, and simplified tools, according to the authors. The principle target audience for the guide is the LCA practitioner as well as technical experts in the public and private sector dealing with environmental decision support related to products, resources, and waste management.

The complete set of guides contains the following parts (available for download at http://lct.jrc.ec.europa.eu/):

- General guide for Life Cycle Assessment (LCA), in two "versions":
  - Detailed guidance
  - Provisions and action steps
- Specific guide for Life Cycle Inventory (LCI) data sets
- The Life Cycle Impact Assessment Guide, consisting of three parts:
  - Framework and requirements for Life Cycle Impact Assessment (LCIA) models and indicators

  - Analysis of existing Environmental Impact Assessment methodologies for use in Life Cycle Assessment (LCA)
  - Recommendations for Life Cycle Impact Assessment in the European context
- Guidelines on Review:
  - Review schemes for Life Cycle Assessment (LCA)
  - Reviewer qualification for Life Cycle Inventory (LCI) data sets

The ILCD Handbook is the result of several years of increased life cycle thinking in EU policy, which is still under development. The latest document in the handbook series is the document "Recommendations for Life Cycle Impact Assessment in the European context", which was released in November 2011.

2.2 LCA development in EU policy

For the past several years, LCA has gained in acceptance as a tool for policy-making, particularly in Europe. Life cycle thinking is integrated in many parts of the policy documents of the European Commission:

- the Communication on Integrated Product Policy (EU, 2003),
- the amended Directive on Packaging and Packaging Waste (EU, 2004),
- the Thematic Strategy on the Sustainable Use of Natural Resources (EU, 2005a),
- the Thematic Strategy on the Prevention and Recycling of Waste (EU, 2005b),
- the Sustainable Consumption and Production Action Plan (EU, 2008a),
- the Waste Framework Directive (EU, 2008b),
- the Renewable Energy Directive (EU, 2009a),
- the Fuel Quality Directive (EU, 2009b), and
- the Directive on Ecodesign of Energy-Related Products (EU, 2009c).

In its 2003 Communication on Integrated Product Policy (IPP), the European Commission underlined the importance of life cycle assessment and the need for promoting the application of life cycle thinking among the stakeholders of IPP. In response and in parallel to the development of the IPP, DG JRC launched an initiative in 2002 to elaborate a common reference system for LCA data and methods (Rydberg and Pennington, 2003; Rydberg et al., 2004). Following that, the European Platform on Life Cycle Assessment (EPLCA) was established in 2005 as a project to be carried out during 2005–2008, under agreement between DG JRC and DG Environment (Pretato et al., 2008). EPLCA was mandated to promote the availability, exchange, and use of quality-assured life cycle data, methods, and studies for reliable decision support in EU public policy and in business.

In 2002, the United Nations Environment Programme (UNEP) and the Society for Environmental Toxicology and Chemistry (SETAC) launched their partnership "The Life Cycle Initiative" (Solgaard and de Leeuw, 2002), to promote the global uptake of life cycle thinking. The UNEP/SETAC and other non-EU initiatives, as well as the fact that product value chains are global, highlighted the need to act in an international collaborative approach. Therefore, the ILCD (initially the International Life Cycle Data Network) was established with DG JRC as the driving force.

2.3 Position, purpose and overall characteristics

The purpose of the ILCD handbook is to provide good practice methodology guidance for Life Cycle Assessment (LCA) in policy and business, in-line with and expanding on the ISO 14040/14044 standards (ISO, 2006b; 2006c). The Handbook is compliant with the ISO standard but adds a number of more strict rules. These rules are generally (but not always; see Section 2.4) based on common LCA practice, as there is no intention to develop any new methods.

While the Handbook builds upon the ISO standards, it may in itself also be the basis for more detailed product group or sector-specific guidelines, such as the Product Environmental Footprint Guide, the General Programme Instructions of The International EPD System or the European standard for environmental product declarations within the construction sector known as EN 15804:2012 (IEC, 2008a; CEN, 2012).

Flexibility for the LCA practitioner is the guiding principle of the ILCD handbook as it is intended to be a guide for various applications of LCA. All LCA guides have to make a balance between flexibility for the practitioner and comparability of the results. The focus on flexibility differentiates the handbook with methodology guides for Environmental Product Declaration (EPD) systems, such as The International EPD System. They are designed to make the end results (EPDs) comparable, something that requires very strict rules and less flexibility.

2.4 The Handbook compared to common LCA practice and standards

The Handbook addresses all possible issues of concern when conducting a LCA at a very high level of detail. It uses mainly a scientist's view, which may differ from the practitioner's view. The authors appear to have aimed for completeness and perfection, why the handbook is not easy to read or use in practice. It is not likely that many people will read the whole document as the documents are very comprehensive. For instance, the "Detailed Guidance" handbook is a 417 pages document, while the short version (which only contains the provisions) is 163 pages long. Many practitioners will likely use it as a reference document.

In 2010, the finalized Handbook was peer reviewed by selected LCA experts. The major concerns were then that the documents were far too comprehensive, difficult to read due to many internal cross-references, and not always internally consistent in its guidance. This is a problem since the Handbook has a lot of merits as a valuable technical contribution to LCA. If made more available it will also be a strong contribution to a harmonized European LCA methodology.

The Handbook claims to build on common practice, but there are instructions, which go beyond what IVL considers to be common practice. These are discussed in more detail in the following sub-sections.

2.4.1 Three types of LCAs

The Handbook identifies three archetypical cases on when LCA is used, which are assumed to cover all types of applications:

- A. Micro-level decisions (products)
  - Decisions:
    improvements, comparisons, procurement
  - Labelling: Type 1 criteria, EPD, carbon footprint
- B. Meso-macro level decisions (policy)
  - Identifying improvement potentials
  - Policy development
- C. Accounting (products & policy)
  - Monitoring & reporting at all levels

This is an innovative way to structure LCA studies compared to previous standard and methodology guides. The Handbook uses this structure to provide methodological guidance/provisions linked to each case. One such example is the choice between attributional and consequential LCA. This choice has always been a critical issue in LCA, since it may have a strong influence on the study results. The linking of the LCA methodology to an intended use of the results is very welcome, but the approach might be more elaborated to make the different cases useful for an LCA practitioner.

For more information regarding attributional or consequential LCA; see Section 9.1.

2.4.2 Follows the ISO procedure with an emphasized iterative approach

The Handbook follows the procedure described in the ISO 14040/14044 standards, i.e. Goal & Scope, Inventory, Environmental Impact Assessment, and Interpretation, and the iterative nature of the LCA procedure is strongly emphasized. The Handbook assumes 2-4 iterations as the default case.

The iterative procedure was a fundament in early LCA methodology, and goes back to the Nordic Guidelines on LCA (Lindfors et al., 1995). This guideline recommended a first screening exercise to identify what data were most important for the results. The next step would then be to gather better data for those parts, i.e. improve quality in a cost-effective manner. As the emphasis on the iterative nature of LCA has somehow been lost in more recent literature, it is very welcome to see it return in the ILCD handbook, even though four iterations may be rather extreme for a typical LCA study.

2.4.3 Goal & Scope

The Goal & Scope part is perhaps the most important part of and LCA study in the sense that this is where the study is defined. The Handbook uses a lot of space for this part which is very valuable.

The intended audience of the LCA study shall be specified in detail; internal, restricted external, or public as well as technical or non-technical. It shall also be stated if the study is comparative or includes a comparative assertion. This is a simple and very useful structure that would benefit most LCA studies.

The requirements for a critical review and the type of review in the handbook are linked to the "intended audience." The Handbook provides more strict requirements for critical review than the ISO 14040/14044 standards. The ISO rules for public comparative assertions based on an LCA study are quite strict and are associated with rather high costs. One may interpret the ILCD handbook as extending this requirement to all public comparative studies (not just comparative assertions). If this is the case, the cost for critical reviews of LCAs based on the ILCD handbook may be substantially increased compared to conventional LCA studies based on the ISO standards.

The Handbook goes on to give a wider and improved view on the functional unit concept. It opens up for the inclusion of qualitative data and recommends adding a photo of the product in order to better define the function. This is a positive development, which may solve some problems associated with the traditional functional unit, which is only described quantitatively.

System boundaries are set in a rather conventional manner, but the Handbook strictly excludes accidents, indoor and workplace exposure. This could be a limit in terms of for which applications an LCA study may be used compared to an ISO 14040/14044 LCA, where the setting of the system boundary is left to the practitioner and relates to the goal of the study.

The handbook specifies that all cut-offs of a study shall be listed, which has been a requirement in e.g. The International EPD System for long, and something that would benefit most LCA studies.

The Handbook states that all impact assessment methods shall be free of double counting and value choices. The latter is a mission impossible, but the intention is probably "as far as possible". No double counting is an interesting approach since early impact assessment in LCA did include double counting. The intention was then only to aggregate inventory data in e.g. "acidification equivalents", "eutrophication equivalents", etc. It was a way to aggregate inventory data and an indicator of the technical properties of the studied system, but not any attempt to calculate actual environmental impacts. Emissions of nitrogen monoxide and nitrogen dioxide would thus be calculated as contributing to both acidification potential and eutrophication potential.

In contrast to this, the Handbook has a clear ambition to focus on damage and actual environmental effects as far as possible, not only to aggregate inventory data. This means that uncertainties associated with impacts models are added to the uncertainties associated with the inventory model. The impact models may be difficult to understand and thus less transparent

2.4.4 Inventory

The life cycle inventory of an LCA is the modeling of the product system, which results in an extensive list of resources as inputs and emissions to nature (air, water or soil) as outputs. The inventory part of the Handbook is mostly based on common practice, but there are parts that stand out:

- The allocation procedure almost follows the ISO standard for LCA. As in ISO, avoiding allocation, sub-division, or virtual sub-division (sub-division based on causalities) are the primary alternatives. After that, system expansion (substitution) is the recommended method. The latter recommendation deviates from ISO, but is closer to the Nordic Guidelines 1995. Only as a third approach is allocation based on market prices, mass, etc., allowed.

- Open loop recycling. This is described in Section 9.2.

- It is not allowed to group substances in the inventory analysis into new substance groups. A few common ones, such as chemical oxygen demand (COD) and biological oxygen demand (BOD) are allowed, but it appears as through nitrogen oxides (NOx) are required to be specified individually (NO, NO2). This is welcome as the potential environmental impact of the different molecules may differ.

- No double counting is allowed in the inventory, e.g. the LCA practitioner must choose between reporting COD or BOD. This is rather strange since BOD and COD are measures of two different properties, but likely due to avoid double-counting in the impact assessment part of the study.

- Energy content per mass unit shall be declared for all energy resources. This requirement is obviously correct from a theoretical point of view, but may increase the complexity of the study. The exception to this requirement is nuclear ore.

- Energy from renewable energy sources, such as sun and wind shall be given as net energy ("usable energy"), i.e. electricity from solar cells, or energy in wood, and not as total incoming solar energy. This is an improvement as common practice on how to describe primary energy from these sources may vary a lot between studies.

- No geographical differentiation of resources shall be made in the inventory. This is a quite strange provision in terms of common LCA practice. Even though this information is not used in later phases of the LCA, such as the impact assessment, it seems strange to forbid the inclusion of additional information in the inventory.

- Inert materials, such as extracted rock when mining for metals, shall be included in the inventory in order to make calculations of mass balances possible. This requirement is obviously correct from a theoretical point of view, but may increase the complexity of the study.

- Future emissions (defines as occurring more than 100 years into the future) shall be reported separately from other inventory results. This means that "time" is now included in LCA inventories for the first time.

- Biogenic and fossil carbon dioxide emissions and removals shall be reported separately in the inventory results. This is an important statement, since common practice varies, and will likely increase the transparency of LCA studies.

- Delayed emissions are accounted for during a maximum of 100 years with a "discounting rate" of 1% per year. For instance, if an emission of 1000 kg of carbon dioxide occurs during year 99, only 10 kg carbon dioxide (1 percent) should be accounted for.

- The Handbook introduces a semi-quantitative assessment of data quality linked to different data quality requirements. This is a very time consuming exercise, but the requirements are similar to those in the International EPD System.

The handbook specifies that the sum of all allocated emissions shall equal the total impact of the unallocated process (the "100% rule"). This may be seen as the only correct approach, but there are applications that do not follow this rule. In EPDs, it might be important for the credibility of the EPD not to underestimate the environmental impact of your own product, which means that a conservative allocation approach might be suitable. The Nordic Guideline 1995 had a rule stating that if the allocation had no influence on the result all burdens could be allocated to the studied system.

2.4.5 Impact Assessment

Impact assessment is the aggregation of life cycle inventory results into midpoint (e.g. "climate change") or endpoint (e.g. "damage to ecosystems") impact categories. The Handbook recommends 14 midpoint impact categories and calculation methods as "best choice" in the document "Recommendations for Life Cycle Impact Assessment in the European context". This document does also discuss endpoint categories but concludes that very few such methods are robust enough to be recommended at any of the three levels the Handbook uses to rank the various methods.

As mentioned above the recommended impact assessment methods are damage-oriented, aiming at actual impacts, not potentials, and to avoid double counting. The main problem here, if any, is perhaps a transparency issue. It is not possible for other than experts to understand the information these methods provide. The early approach only to aggregate inventory data was much more transparent in this sense (see Section 2.4.3).

The recommended midpoint impact categories listed in Table 1.

Table 1. Recommended midpoint impact assessment categories in the ILCD Handbook.

Impact category	Model	Source
Climate Change	Bern model - Global Warming Potentials (GWP) over a 100 year time horizon.	Intergovernmental Panel on Climate Change, 2007
Ozone Depletion	EDIP model based on the ODPs of the World Meteorological Organisation (WMO)	WMO 1999
Ecotoxicity – aquatic, freshwater	USEtox model	Rosenbaum et al, 2008
Human Toxicity - cancer effects	USEtox model	Rosenbaum et al, 2008
Human Toxicity – non-cancer effects	USEtox model	Rosenbaum et al, 2008
Particulate Matter/Respiratory Inorganics	RiskPoll model	Rabl and Spadaro, 2004
Ionising Radiation – human health effects	Human Health effect model	Dreicer et al. 1995
Photochemical Ozone Formation	LOTOS-EUROS model	Van Zelm et al, 2008 as applied in ReCiPe
Acidification	Accumulated Exceedance model	Seppäläet al.,2006, Posch et al, 2008
Eutrophication – terrestrial	Accumulated Exceedance model	Seppäläet al.,2006, Posch et al, 2008
Eutrophication – aquatic	EUTREND model	Struijs et al, 2009 as implemented in ReCiPe
Resource Depletion – water	Swiss Ecoscarcity model	Frischknecht et al, 2008
Resource Depletion – mineral, fossil	CML2002 model	Van Oers et al 2002
Land Transformation	Soil Organic Matter (SOM) model	Milà i Canals et al, 2007

This is a very extensive list compared to many LCA studies performed today, and to other methodology guides, such as the International EPD System. The latter requires the use of five impact assessment methods by default: climate change, acidification, eutrophication, photochemical oxidant formation and stratospheric ozone depletion. The EPD system also quantifies the renewable and non-renewable resources used, waste and hazardous waste as well as emissions of toxic substances. The European standard for EPDs of construction products (EN 15804:2012) has a list of seven mandatory impact categories, but several more resource indicators

2.4.6 Interpretation

The interpretation phase of an LCA is where the results from the inventory analysis and the impact assessment are analyzed to draw conclusions and provide recommendations. The recommendations about interpretation in the ILCD handbook is based on common practice: identification of significant issues, completeness check, sensitivity check, consistency check, as appropriate.

2.4.7 Reporting

The Handbook makes a distinction between three levels of reports with increasing requirements:

1. Internal report, where no provisions are given but a recommendation is given to orient towards "third party report"
2. Third party report, and
3. Comparative studies disclosed to the public

There are very detailed report formats and comprehensive requirements provided for level 2 and 3, including an executive summary, technical summary, report, annexes with all collected data, and a confidential report. Concerning content they follow ISO, but more details are listed. One detail is that a full LCI data report is required, which few business actors are willing to give away. However a confidential report is an option if required.

2.4.8 Critical Review

The first draft document on critical review was considered by experienced reviewers to be far too demanding e.g. concerning accreditation of reviewers. The costs associated with a review could cause commissioners to avoid critical reviews. The documents at hand today are on the other hand very pragmatic only reflecting common practice. The Handbook specifies a scheme for ranking and self-declaration of reviewers' qualifications which is a very useful contribution. It is simple to understand and it is balanced. We expect that it will contribute to improving the critical reviews.

The critical review process itself is common practice, and it follows the ISO procedure. However, the ILCD handbook can be interpreted as requiring a third-part review of all public comparative studies, and not just comparative assertions. If this is the case, the cost for critical reviews of LCAs based on the ILCD handbook may be substantially increased compared to conventional LCA studies based on the ISO standards. This is something that should be clarified in future revisions of the Handbook.

3 The first operational guide based on the Handbook – the Draft PEF Guide

The draft guide for Product Environmental Footprints (PEF) is – together with the draft Organisation Environmental Footprint (also known as Corporate Environmental Footprint) – the first fully operational guidelines based on the ILCD Handbook. The PEF Guide is still under development, why comments below should be seen as an example of an ILCD Handbook application as the final version of the PEF Guide may look quite different.

The PEF Guide is positioned between the ILCD Handbook and other sector or product group specific guidelines such as PCR documents according to ISO 14025:2006. It seems to be similar to General Program Instructions of the International EPD System and the European standard EN 15804:2012, which both are "PCR guides" for EPDs according to ISO 14025:2006. The main difference is that a PEF does not need to be an EPD, but may be used for a variety of purposes. However, several requirements seem to be inspired by current ISO 14025 EPD systems, such as The International EPD System. Also, the requirements are to large extent in line with the requirements of the draft standards ISO 14067 on Carbon Footprints of Products, PAS 2050 and the GHG Protocol, which are all stated as methodology guides that were considered.

The PEF Guide itself is written in a way that deviates from other similar documents such as the above-mentioned "PCR guides". The latter are framework documents that provide general requirements. The more specific requirements are given in various PCR documents which add requirements to the general ones. The PEF Guide is written the other way around. It provides all requirements for any type of product, which may then be altered or removed in the optional Product Footprint Category Rules (PFCR) document, if justified. For example, the draft PEF Guide includes the same set of 14 default impact categories as the ILCD Handbook, including recommended methods for calculating impact scores. PFCRs may, however, add or remove impact categories from the default list.

3.1 What is a PEF?

During the time of writing this report, it was not clear to what extent PEF will be used in future policy making in the EU, but there was a public consultation of potential measures related to Sustainable Consumption and Production, including the PEF Guide. It is thus not (yet) obvious what a product environmental footprint is, an EPD or any type of product LCA intended for ecodesign, improvements, comparative assertion, etc.

The focus in the draft PEF Guide is on comparability, as EPD, which means strict requirements and less flexibility. The guide is, however, a mix of LCA and EPD guidelines.

The PEF Guide launched 2011 is a draft in continuous development. It is assumed that it will take two to three years of tests and consultations before a common and accepted methodology is at hand.

4 A brief comparison of ILCD and the draft PEF Guide with other systems

Several initiatives are under way in EU member states, on EU level, or internationally, having the purpose to harmonize methods for specific purposes.

A review of some methods for Carbon Footprint has been carried out recently (E&Y, 2011) based on interviews of different stakeholders. The study included both voluntary and mandatory systems. The results were that PAS 2050, the GHG Protocol, the Draft ISO 14067, the Japanese PCF system and the Sustainability Consortium are widely applied and have wide potential to extend its use on the market6.

Examples of guidelines, standards and handbooks which are interesting to compare concerning different requirements and basic characteristics are the below mentioned.

The Japanese government established the Carbon Footprint Program in 2008 and launched the Labelling Pilot Project in April 2009. However, this program has not been included in the comparison.

France introduced the AFNOR/Ademe BP X30-323 and holds a one year experimentation phase as from July 2011.

The International EPD System – General Programme Instructions of the International EPD System (www.environdec.com) is probably the system with the longest experience with declarations from products and services from all different major sectors. A new version of the programme instructions will be published during 2012.

The ISO Product Carbon Footprint standard is now in the Draft in Standard phase: ISO 14067 – DIS Draft in standard for Product Carbon Footprint. This DIS standard describes a single issue, and builds on ISO 14044 and ISO 14025.

The GHG Protocol product standard was launched in September 2011: Greenhouse Gas Protocol, Product Life Cycle Accounting and Reporting Standard, World Business Council for Sustainable Development and World Resource Institute, USA, September 2011. The Standard is detailed and descriptive.

CEN 350 EN 15804:2012 – European standard for EPDs of construction products was established in January 2012.

[6] For a list of abbreviations, see Section 10.

The PAS 2050 specification was originally published in 2008, and updated in 2011. It has been applied by many companies worldwide. PAS 2050:2011, Specification for the assessment of the life cycle Greenhouse gas emissions of goods and services, British Standard Institute, 2011.

As the draft PEF Guide share many similarities with the General Programme Instructions of the International EPD System, some important points are compared below:

- **Impact categories:** The draft PEF Guide includes the 14 default midpoint impact categories including resources recommended in the ILCD handbook. The number of impact categories in the International EPD System is normally five, complemented by specification of LCI data, such as resource use, waste and water use.

- **PCR/PFCR contents:** Product group or sector specific PFCR documents are optional, but not required. For most applications, the PEF Guide may be used as a stand-alone document. The International EPD System always requires product group-specific PCR documents. The same type of open consultation process seems to be planned for PFCR documents and PCR documents. PFCR – shall be based on existing PCRs that exist in ISO 14025 systems, if not possible to adopt directly. PFCR documents overrule the PEF Guide, if justified. PCR documents may overrule the Programme instructions in the International EPD System

- **PCR/PFCR hierarchy:** The PFCR structure is based on a recognized product classification system, CPA. PCR documents in the International EPD System are based on UN CPC codes, which are very similar. The difference is that UN CPC system is global, while the CPA system is European.

- **Inventory:** The same "10% rule" for data quality requirements as in EPD. Greenhouse gases "off-sets" shall not be accounted for, nor shall temporal storage or delayed emissions of greenhouse gases. System expansion is the preferred allocation method in the draft PEF Guide. System expansion is not allowed in The International EPD system mainly due to data quality problems and additionality.

- **Electricity mix:** In the PEF Guide, there use of a supplier-specific or contract-specific electricity mix is not mentioned. In the International EPD System, this is the primary alternative for electricity used in core processes.

- **Open loop recycling**: For more information, see Section 9.3

- **Results:** Qualitative information may be provided in "additional environmental information" as in EPD, and in line with ISO 14025 on Type III Labelling. In the draft PEF Guide, weighting is allowed but optional. The text makes reference to "provided weighting factors", but also provides the possibility to additionally include other weighting factors. There is no weighting allowed in the International EPD System.

The following table outlines the characteristic method and procedure choices made in a selection of guideline, harmonization or standardization initiatives (Table 2).

Several requirements of the PEF Guide are in line with the ISO 14067 requirements. Such requirements are to include biogenic carbon, but report the results separately, to include direct land use change when relevant, but not indirect LUC and to include emissions of GHG from soil and from manure and livestock. However, the requirements for carbon storage are different. In ISO 14067 it is required to not include storage in the CFP number (Carbon Footprint of Product number). But, as additional information, the effect of carbon storage may be included. In the PEF Guide Carbon storage can be included based on the 100 year perspective in the carbon footprint number.

Table 2. A brief overview of characteristics of selected LCA-based guideline / standardization initiatives. For explanations of the systems, see the text.

System Characteristics	ILCD	PEF (2nd draft)	AFNOR (PEP, draft)	International EPD system	ISO 14067 (DIS Draft)	GHG Protocol	EN 15804	PAS 2050
What decision is to be informed by the study?	Various ("Situation A, B, C1, C2")	Purchase decisions, comparisons	Product comparison	Customer communication comparisons	Product, preferability in GHG emissions	Purchase decisions, comparisons	Purchase decisions, comparisons	Purchase decisions, comparisons
What impacts are of concern - What impacts are not important?	Flexible	14 default categories	5 default indicators	5 default (mandatory) categories	GHG	GHG		GHG
Product Category Rules (PCR) requirement	No	Yes (PFCR), recommended	Yes	Yes	Yes, if applicable	Recom-mended	No	No
Communication requirements	No	Yes, for selected impact categories	Unclear, many different ways to communicate	EPD or Climate declaration	Label, declaration or claim			Label with figure
Treatment of biogenic carbon	Included, documented separately	Included, documented separately	Not known	May be included, separately	Included, documented separately			Delayed emissions included
Attributional or consequential LCI model?	Attributional except at allocation and markets affected	Attributional, except at allocation	Attributional	Attributional	Attributional	Attributional	Attributional	Attributional
Allocation at open-loop recycling	Four methods	Allocation to first product in proportion to loss in economic value; the rest to the last product	Cut-off or double counting of benefits	Cut off	Modularity, no requirements or restrictions			
Requirements on electricity data		1 National consumption mix, 2 EU mix	Not known	Site specific mix or national mix	1 Specific product 2 national mix			

5 Impact on Swedish industry and policy

The LCA procedure presented in the handbook is mainly based upon what IVL considers to be common practices, why the ILCD Handbook in itself is not likely to have any significant effect on Swedish industry or Swedish policy-making. The large volume, tangled structure and internal inconsistencies make it difficult to use in practice. However, the handbook also includes instructions that go beyond common practice (see Section 2.4).

Instead of updating the documents to make the methodological guidance more accessible, EU seems to spend the effort on developing the PEF Guide. The PEF Guide is designed to be an effective handbook, which means it might become widely used. During the authoring of this report, the Guide was in its second draft and it had not yet been decided for what LCA applications the guide should be applied. Any wide-spread use of the PEF methodology is likely to affect future environmental assessments and decision making in Swedish industry. We have looked into a few, potentially important methodological aspects:

- Open-loop recycling: the draft PEF Guide (pp. 108-109) gives a clear credit to products that are recycled after use but not so clear credit to products that contain recycled material.

- Electricity production: the ILCD Handbook (p. 2 in the Detailed general guide) states that electricity production should be modeled using average data for the electricity market. If the electricity production belongs to the foreground system, it should preferably be modeled using supplier-specific data. The draft PEF Guide on the other hand specifies that a national electricity consumption mix should be used, and if this is not available, the EU electricity mix should be used. If this requirement stays until the final version, this may have significant implications for companies that purchase supplier-specific electricity mixes in order to reduce their environmental impact.

- Water use: the draft PEF Guide (p. 31) states that water depletion should be accounted for, using the Swiss Ecoscarcity model. This model takes into account the abundance or scarcity of water on a national level.

- Biogenic carbon: the draft PEF Guide (p. 43) states that uptake and emissions of biogenic carbon should be reported separately from fossil emissions.

- The ILCD LCIA recommendation and the draft PEF Guide define a set of 14 default impact categories, including the recommended methods for calculating impact scores (of different maturity/quality). It is not clear what impact this choice may have. PFCRs may add or remove impact categories from the default list.

- The semi-quantitative assessment of data quality in the ILCD Handbook is linked to data quality requirements. This is a very time consuming exercise.

- The ILCD scoring system for reviewer qualifications will probably improve the critical review process.

All this indicates that the Swedish industrial companies do not need to worry about being unfairly treated in the LCAs. The requirements for electricity production is however an issue that affects companies operating in Sweden and other countries, and where it often would be negative for the environmental profile to use a national electricity mix instead of a supplier specific mix.

6 Conclusions

The ILCD Handbook complies in most parts with previous LCA guidelines, with the international standard for LCA, and also with good LCA practice. It links to more strict requirements for critical review. Rules for comparative assertions are extended to all comparative studies (why critical review requirements for a comparative assertion should be followed, the selection of environmental impact categories, etc.).

The handbook recommends attributional LCA, and seldom the application of consequential LCA or marginal data. Regarding requirements and recommendations for allocation at recycling, it is not so clear when accounting or consequential methodology is recommended. When recycled material is used, the upstream production of the virgin material from natural resources is only allocated to the downstream products to the degree that material is lost (e.g. upstream tissue production is allocated to tissue for dissipative use).

Important deviations from previous LCA guidelines include the following:

- The ILCD Handbook is based on three archetypical cases of LCA rather than the distinction between attributional and consequential LCA that is used in modern good LCA practice.
- The impact assessment is designed to quantity approximations of the actual environmental impacts, while previous LCA guidelines aimed at little more than aggregating LCI results.
- The ILCD Handbook assumes that 2-4 iterations will be done in most LCAs, while previous guidelines and practice includes iterations only when called for.
- The requirements on reporting and on the assessment of data quality are strict.

All in all, the ILCD Handbook is very ambitious and risks making the LCA procedure too cumbersome to be feasible. The Handbook itself is also too long and too poorly structured to be of great practical use.

The PEF Guide, in comparison, is concise and more clearly structured. It can be considered a first implementation of the ILCD Handbook; however, it includes some deviations from the Handbook.

The PEF Guide is in many aspects similar to the EPD General Program Instructions and EN 15804:2012 (which however represents only one large sector). The main goal for the use of the Guide is for product and service footprints, for ecodesign, improvements, comparisons, etc. Comparability is focused, and a major principle. No new methodologies have been developed; the guide refers to methodologies already existing.

Important characteristics for the PEF Guide, which are of importance for the company applying it, are the following:

- Product PFCRs are optional, and should to the extent possible be in conformity with existing PCRs
- A consultation process with relevant stakeholders is required when developing PFCR:s
- The requirements of the PFCRs overrule the more general requirements of the PEF Guide
- The corresponding ”10% rule” for the share of data with lower data quality is required, similar to the EPD system
- Qualitative information in the ”additional environmental information” can be added, which may add value to the stakeholders using the declarations
- The principle of modularity is applied
- System expansion is recommended
- There is credit for products being recycled, but not as clear credit for the actors that use recycled materials
- The choice of the most important category indicators may be dependent on the involved experts (panel, third party experts or multi stakeholder group)
- For electricity production, a national electricity consumption mix should be used, and if this is not available, the EU electricity mix should be used. If this requirement stays until the final version, this may have significant implications for companies that purchase supplier-specific electricity mixes in order to reduce their environmental impact. The PEF Guide is only in a draft version, however, and there have been indications that this might be reevaluated in upcoming versions (Galatola, personal communication).
- The documentation requirements on data quality are not reasonable
- Water depletion using the Swiss Ecoscarcity model is required, where water scarcity on a national basis is taken into account, but not on a local basis.
- Normalisation according to e.g. current emission levels, and weighting according to e.g. political goals, is possible. However, it is unclear how it can be applied, how comparability is kept in that case, and how sub-optimisation and value based selection of weighting methods is avoided.

7 Next step

We have the following recommendations to industrial companies in different sectors:

Explore the consequences by applying the draft PEF Guide and by developing Draft PFCRs for the own product or service sector. By developing and applying PFCR, the challenges, limitations and important decisions will be clearer. Also, Swedish and other industries can be more prepared and influence the PFCR, future versions of the PEF Guide and its applications such as Eco labels, Declaration systems, Eco-Design Directives and Green Public Procurement.

It would be interesting to go further to analyse how the PEF Guide could be further developed in order to be fair, neutral with respect to technology and material, and fair with respect to energy system, and still scientifically based. It would also be interesting to study how the PEF Guide can be developed in order to stimulate development of new products with better environmental performance. Another important element is to avoid sub-optimisation and burden shifting, specifically when the most significant impact categories are selected, and not all categories are included in the environmental profile.

One large challenge for the EU Commission is how small and medium sized companies will be able to develop life cycle based environmental performance information about their products and services. Which methodologies will be available? Which tools? Will it be possible for SMEs to use simplified methodologies? And, in that case, will they be fair and pointing in the right direction and leading to better informed purchase decisions and products with better environmental performance? Which problems are attached to the application of simplified methods? How can information modules such as gate to gate information modules be reflected in PCRs and such EPDs developed and applied? Which requirements are needed to avoid double counting and to avoid missing parts?

Modularity is a key concept in the PEF guide. How can this be illustrated and exemplified? How can complicated and continuously changing products and services such as cloud services be addressed and illustrated?

In this study we have identified several good characteristics of the PEF Guide. We suggest that these are identified and listed, and that the advantages of these are communicated. One such part of the process is the open consultation process.

How can the experiences from Sweden with PCRs, EPD, LCAs and applications of LCA be exchanged and fed into the PEF Guide development and the learnings communicated? Are there cases to present when the PCR and/or EPDs were wrong or led the wrong way? In which cases are product footprints not the right choice? Can it be used for system or product development?

What is the gap between fair and simplified methods? How can they be combined? (compare the results of the Eco-design directive for Energy using products.

A gap analysis between mainstream LCAs of today and LCAs based on the PEF and ILCD Handbook can be performed.

The drawbacks and disadvantages of weighting can be visualised, in order to present potential problems of sub-optimisation.

The consequences of using different methodologies for recycling modelling, allocation at recycling, system expansion and so called avoided emissions can be modelled, illustrated and visualised for different sectors.

The consequences of using different impact categories and units can be illustrated. In which cases do we need complementary information in order to develop and illustrate complementary methods for environmental performance? What are the major weaknesses of the impact category indicators of the PEF Guide?

We can perform a screening of which simplifications of the PEF Guide that we can suggest from a Swedish point of view?

The uncertainties of e.g. toxicity can be illustrated. The deviations and sub optimisations can be illustrated and visualised.

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9 Appendix A

9.1 Attributional LCA vs. Consequential LCA

The ILCD Handbook states that the modeling in the life cycle inventory analysis (LCI) relates to the concepts of attributional and consequential modeling (p. 36 in the Detailed general guide), The distinction between attributional and consequential LCI was originally made at an international workshop on electricity data in 2001, although similar distinctions had earlier been done by several authors, using different terminologies and slightly different definitions (Ekvall 1999). Curran et al. (2005) report that the 2001 workshop stated that attributional and consequential LCI respond to different types of questions:

- Attributional LCI aims to answer "how are environmentally things (pollutants, resources, and exchanges among processes) flowing within the chosen temporal window"?
- Consequential LCI aims to answer "how will flows change in response to decisions"?

The outcome of the 2001 workshop has been interpreted differently and/or been slightly revised by other authors. Finnveden et al. (2009), for example, state that:

- Attributional LCA is defined by its aim to describe the environmentally relevant physical flows to and from a life cycle and its subsystems.
- Consequential LCA is defined by its aim to describe how environmentally relevant physical flows will change in response to possible decisions.

The ILCD Handbook itself states (p. 71) that:

- The attributional LCI model describes its actual or forecasted specific or average supply chain plus its use and end-of-life value chain, all embedded into a static technosphere.
- The consequential LCI model describes the supply chain as it is theoretically expected in consequence of the analysed decision, embedded in a dynamic technosphere that reacts to a change in the demand for different products.

With all of these definitions, consequential LCI should be used for Situations A and B in the ILCD Handbook, since it states (p. 37) that, when LCA is used as decision-support, the LCI model should reflect the consequences of the decision.

Surprisingly, however, the ILCD Handbook explicitly recommends attributional modeling for micro-level decisions (p. 82) and for most of the life cycle when meso- and macro-scale decisions are investigated. One exception is processes where the decision causes big changes (p. 41, p. 85). Changes are judged to be big if they correspond to more than 5% of the total production capacity of the production system or to more than the annual replacement of production capacity in the system (p. 42). The only other exception given (p. 13) is sensitivity analyses, where attributional modeling can be displaced by consequential modeling to evaluate the robustness of the study results and conclusions.

Attributional and consequential modeling are different in terms of, for example, the choice of input data, and also in the approach to allocation problems. Finnveden et al. (2009) state that attributional LCI is based on average data that represent the actual physical flows. The ILCD Handbook (p. 71) basically agrees with this, but it is more specific and states that producer-specific data should ideally be used for modeling the production of goods and services for which the supplier is known. Average data are adequate only when the supplier is unknown or when the products "stem from a wide mix of producers and technologies".

For consequential LCI, Finnveden et al. (2009) states that marginal data are used when relevant to model consequences. Marginal data represent changes that are small enough to be approximated as infinitesimal. Azpagic & Clift (1999) state that such changes "are in effect very small and do not cause a change in the way the system is operated". Ekvall (1999) claim that marginal data can still be used to model the effects of many actions on the production of bulk materials, energy carriers, and services for which the total production volume is very high.

It is often useful to distinguish between short-term and long-term marginal changes. Short-term effects are changes in the utilization of the existing production capacity in existing production plants (Weidema et al. 1999). Long-term effects involve changes in the production capacity and/or production technology. Ekvall & Weidema (2004) argue that long-term effects are relevant in most cases, because the environmental studies are typically driven by a concern for the long–term situation.

The ILCD Handbook (p. 85) requires long-term marginal data to be used to model production systems where the decision causes big changes. Hence, it agrees with previous authors that long-term marginal data are adequate to model certain consequences. Unfortunately, it disagrees regarding whether marginal data should be used to model small or large changes (see Table 1).

Table 3. The choice of input data in LCI models aiming to assess decisions according to Azapagic & Clift (1999) and the ILCD Handbook.

Data to model…	Azapagic & Clift (1999)	ILCD Handbook
…small changes in production volume	Marginal	Average
…significant changes in production volume	Incremental	Marginal
…complete change of production system	Average	?*

* Not clearly specified

The previous authors are not a homogenous group, but most of them would agree with the view of Azapagic & Clift (1999), that small changes should be modeled using marginal data.

Average data should be used when the change involves a complete elimination or change of a production system. This is reasonable because average data describes the production system as a whole. Azapagic & Clift also argue that changes that affect not the full production system but a significant share of the production volume should be modeled using scale-dependent, incremental data.

The ILCD Handbook, in contrast, requires that average data are used to model small changes. Marginal data are used only to model changes that are big enough to have a direct, large-scale effect on the production capacity of the system (p. 42, p. 170). We have not found an upper limit to the use of marginal data. This could be interpreted to mean that marginal data should be used even to model complete changes of production systems. Such a recommendation seems absurd, however, and we have not found it explicitly stated in the ILCD Handbook.

The view of the ILCD Handbook might be defended by stating that a small change cannot be empirically observed. It will drown among all other changes that constantly occur in the economic system. Frischknecht & Stucki (2010) use the mental models of a lake with a moderate swell and a stormy sea to illustrate this. The ripples of a pebble thrown into the lake will not be visible in the swell of the lake. In a stormy sea, even the splash of a boulder might go unnoticed.

Such a defense of the choice of data is consistent with the positivistic view that the input data in an LCA should be empirically based. However, it seems to neglect the voluminous findings and developments of mental models within economic theory. It also makes little intellectual sense to argue that since a small change cannot be empirically observed, it should be modeled through the use of average data.

A better defense of the ILCD Handbook might be to observe that the uncertainty in the marginal data is often large and that significant time and effort are required to understand and reduce this uncertainty. It is reasonable to spend this time and effort only on the parts of the system that are greatly affected by the decision. It is also reasonable to spend more of this kind of effort in LCAs done to support policy-decisions and other strategic decisions, i.e., in Situation B. Average data can be used in other parts of the system, and in other studies, to reduce the maximum error introduced.

However, to be consistent with this line of thought, the recommendation would not be to recommend the use of marginal data to model changes that are big enough to have a direct, large-scale effect on the production capacity of the system. Instead, it would be better to recommend the use of marginal or incremental data to model changes when such data are easily available or when the changes are important for the environment.

Attributional and consequential LCI also differ in the approach to allocation. In a consequential LCI, allocation problems are often avoided through system expansion. Weidema (2003) even argues that all allocation problems in consequential LCIs should be avoided through system expansion. In attributional LCI, partitioning according to some allocation method is often considered to be the correct approach; however, Finnveden et al. (2009) state that system expansion can be used also in attributional LCI, if the purpose of the study is to investigate a combination of life cycles.

The ILCD Handbook distinguishes, like the international standard for LCA, ISO 14044, between allocation at multifunctional processes and allocation at open-loop recycling. For multifunctional processes, i.e., processes that deliver more than one good or service, the Handbook (pp. 8-9) recommends avoiding allocation by subdivision or so called virtual subdivision. Virtual subdivision seems to be more or less identical to what ISO 14044 calls "partitioning that reflects underlying physical relationships". When subdivision or virtual subdivision is not possible, the ILCD Handbook recommends substitution for all cases expect Situation C2. Allocation is listed as the third and last option.

Substitution is equivalent to system expansion, which is closely related to consequential LCI (see above). To recommend substitution over allocation does not seem consistent with the explicit ambition to apply attributional modeling (cf. p. 82, p. 85, p. 87). The ILCD Handbook argues that substitution fits within attributional as well as consequential modeling. The presentation of this argument is not internally consistent and clear, however:

- p. 43 states that substitution can be classified as a third, "interactional" modeling principle, which fits into attributional as well as consequential modeling.
- p. 354 indicates that substitution is interactional only when used in accounting studies (Situation C1), but consequential when used in LCAs that support decisions (Situations A and B).
- p. 82 and p. 85 state that attributional modeling should be applied also in most decision-situations.

The concept of "interactional" modeling is not further explained in the document, nor well established in the LCA community.

Ranking substitution below subdivision and, in particular, below virtual subdivision, does not seem consistent with the explicit ambition to conform to the international standard for LCA (cf. p. iv, p. 1). ISO 14044 ranks system expansion together with subdivision as the first option to deal with allocation problems. The recommendations for allocation at multifunctional processes might be a compromise between ISO 14044, which does not distinguish between attributional and consequential LCA, and the established attributional methodology. Unfortunately, the result of this compromise is not quite consistent with either one.

Allocation at open-loop recycling is discussed in some detail in the following two appendices.

9.2 Open-loop Recycling in the ILCD Handbook

The ILCD Handbook (Annex C; Sections 14.4 and 14.5 in the Detailed general guide) presents two approaches for modeling recycling in attributional LCA and two approaches for consequential LCA. The two consequential approaches are easily justified, but it is difficult to justify two different attributional approaches for other purposes than sensitivity analysis. The Handbook is also unclear regarding when to use consequential or attributional modeling of recycling.

We include a simple, conceptual case of recycling to illustrate the different approaches. In this case, a material from one product is fully recycled into another product, without losses in quantity or quality of the material. The second product is to 100% produced from the recycled material (see Figure 1). The primary production (V) of 1 kg material causes 10 kg CO_2-equ. The recycling (R) causes 4 kg CO_2-equ., and the waste disposal (WM) causes 2 kg CO_2-equ.

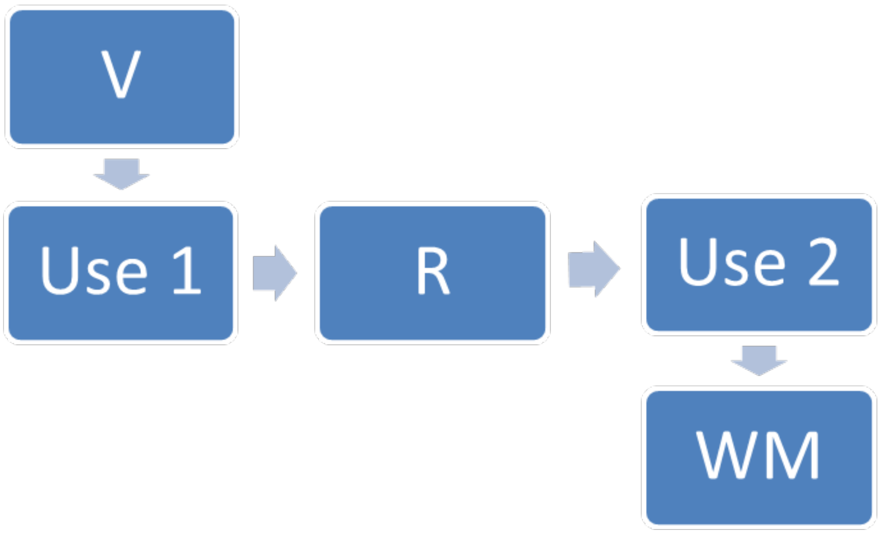

Figure 1. A hypothetical case of recycling, where a material is used in two products before waste disposal.

The choice between the two attributional approaches depends on whether the market value of the material to be recycled is below zero at some point in the waste-management system.

When market value never goes below zero ("ILCD Attr >0" in Figure 2), the environmental impacts of primary production, all recycling processes, and the final waste management are equally distributed among the products in which the material is used (p. 352). This approach is reasonable in an attributional LCA. It can be argued that primary materials production, recycling processes, and final waste management are all necessary to facilitate the combined functions of the recycled materials, or the reused part. Based on this argument, the approach can be considered fair (Ekvall & Tillman 1997). For materials that are degraded in the recycling, such as paper, the price ratio between secondary and primary material can be used as a correction factor in the equation, but it is not clear from the Handbook how this correction factor should be used.

When the market value of the material to be recycled is negative at some point ("ILCD Attr <0" in Figure 2), the ILCD Handbook (pp. 353-354) seems to require that the primary production be allocated in proportion to the economic value between the products where the material is used. Each recycling process is allocated in proportion to the economic value between the waste management of the product to be recycled and the material production for the subsequent product. The final waste management is not allocated but fully accounted for in the life cycle where it occurs. This approach is more difficult to defend. It is difficult to see a reason why final waste management should be excluded from the allocation just because the market value of the waste-to-be-recycled is below zero.

The consequential approaches to recycling are called, with a joint name, "the recyclability substitution approach" (pp. 355-357). It results in different models depending on whether all secondary, i.e., recycled material is used in new products or not. In the most common case, when all recycled material is used in new products ("ILCD Cons Rec" in Figure 2), the primary production and final waste management is allocated to a product to the extent that it is not recycled into a new product. A product that is not recycled at all will carry the burden of the primary production and waste management of all material in the product, regardless of whether this material has been used in other products earlier. The environmental impacts of the recycling process are allocated to the product that is sent to recycling. Recent findings in the on-going research programme Towards Sustainable Waste Management indicate that this is a reasonable approximation of the consequences that can be expected in reality. In cases where the material is degraded in the recycling, the ILCD Handbook (pp. 359-360) requires that the reduction in quality is taken into account. One way to do this is to multiply the quantity of secondary material by the market-price ratio of the secondary material to the displaced primary material.

In the uncommon case, when some of the recovered material is not used in new products but disposed of ("ILCD Cons Disp" in Figure 2), the primary production and final waste management is instead allocated to a product to the extent that it is based on primary material. The impacts of the recycling process are allocated to the product to the extent that it is recycled after use (p. 357). The latter is an odd thing. It means that a product that is produced from 100% recycled material but disposed of at a landfill after use will not carry any burdens from primary production, recycling or waste management (see Figure 2). To be more reasonable, the impacts of the recycling process should in this approach be allocated not to the extent that it is recycled after use, but to the product to the extent that it is based on recycled material. With this adjustment, the method would also result in a reasonable approximation of the consequences that can be expected in reality.

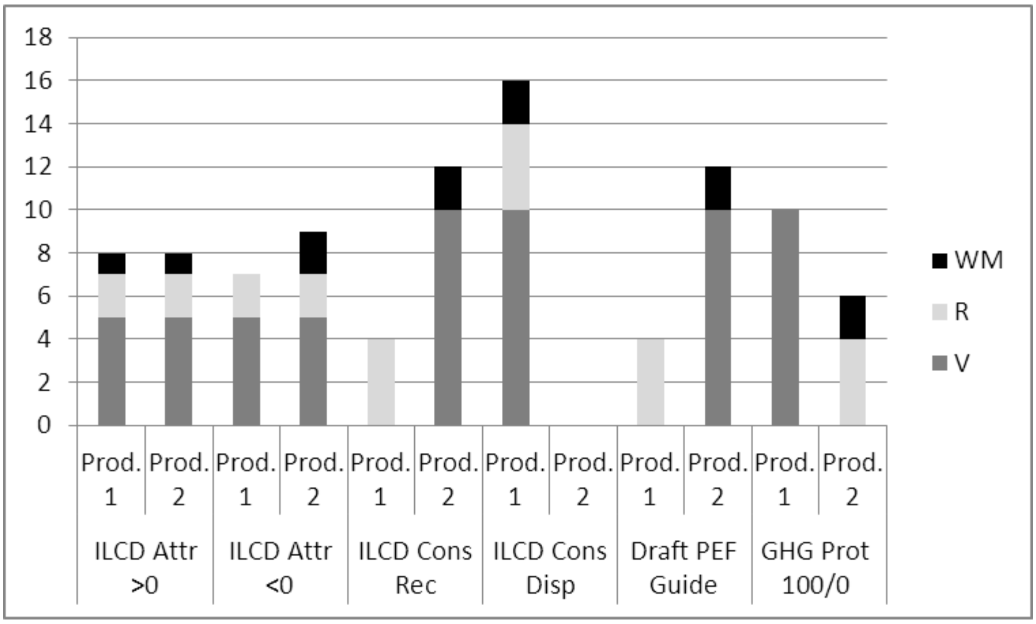

Figure 2. Allocation results in the hypothetical case of recycling described in Figure 1. The results are presented in kg CO_2-equ. per kg of material.

It is not clear from the ILCD Handbook, when attributional or consequential approaches to recycling should be used. The provisions in Section 6.5.4 (pp. 90-91) refer to the description of consequential approaches in Sections 7.2.4 and 14.5. Section 6.5.4 is valid for all case studies, i.e., for Situations A, B, and C (p. 81). This indicates that the consequential approaches to recycling, or simplifications thereof, should be used in all case studies.

However, Section 2.2.4 (pp. 12-13) states that the consequential methodology in Section 7.2.4 should be used only to model processes that undergo big changes as a result of meso- or macro-level decisions and in sensitivity analysis in LCAs that support such decisions (Situation B). This indicates that the attributional approaches to recycling should be used in most case studies.

All approaches are, by themselves, reasonable. However, it would be better to have a single approach for attributional LCA. Choosing between the two attributional approaches, the one that takes into account not only primary production and recycling processes but also final waste management is the easiest to defend.

9.3 Open-loop recycling in the PEF Guide and the GHG protocol

The draft PEF Guide (Annex III; pp. 108-109) includes only one approach for modelling recycling. This is more or less identical to the ILCD approach for consequential modelling where all recycled material is used in new products. The small difference is that the PEF Guide in effect presents the market-price ratio as the only way to account for degradation of the material in recycling.

Another set of approaches to modelling recycling is presented in the Product Life Cycle Accounting and Reporting Standard of the Greenhouse Gas Protocol Initiative (WRI/WBCSD 2011). This initiative is a multi-stakeholder partnership convened by the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD). The draft standard includes two different approaches for modelling recycling in LCA:

- Closed-loop approximation ("GHG Prot CL Approx" in Figure 2): a case of system expansion, similar to the PEF Guide approach but without a method to account for material degradation.
- The recycle content method ("GHG Prot Cut-off"): a simple cut-off method. This means that the life cycle investigated carries no part of the environmental impacts that occur in other life cycles.

WRI/WBCSD (2011, p. 71) states that the closed-loop approximation should only be applied when the recycled material has the same inherent properties as the virgin material input. It also requires that the product is modelled as if produced from 100% virgin materials (p. 72).

WRI/WBCSD (2011, pp. 74-75) states that the recycled content should be used, for example, when the product contains recycled material but is not recycled after use. However, using one approach to allocation at the beginning of a recycling cascade and a different method at the end will result in double counting of environmental burdens and/or benefits. Referring to Figure 1, neither of the two products would carry the burdens of primary materials production, but both products would carry the burdens of the recycling process. We discourage the use of such inconsistent use of different methods.

10 Appendix B: List of abbreviations

EPA	Environmental Protection Agency
EPD	Environmental Product Declaration
EPLCA	European Platform on LCA
GHG	Greenhouse gases
ISO	International Organisation for Standardisation
JRC-IEA	Joint Research Center – Institute for Environment and Sustainability
LCA	Life Cycle Assessment
LCIA	Life Cycle Impact Assessment
LCI	Life Cycle Inventory
OEF	Organisation Environmental Footprint (also Corporate Environmental Footprint)
PCF	Product Carbon Footprint
PCR	Product Category Rules
PFCR	Product Footprint Category Rules
PAS	Publically Available Specification
PEF	Product Environmental Footprint
SETAC	Society for Environmental Toxicology and Chemistry
SME	Small and medium-sized enterprise
UNEP	United Nations Environment Programme