

## Lecture: Advanced Environmental Assessments



### Carbon Footprint and LCA

December 1, 2011



### Carbon Footprint and LCA

#### What we will learn today

- PAS 2050: the British standard on product carbon footprints
- Similarities and Differences to LCA standards ISO 14040 and 14044 and to draft WRI/WBCSD product standard

### Carbon Footprint and LCA

#### Contents

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- Introduction and carbon labels
- PAS 2050
- Modelling Principles
- Exercise

### Carbon Footprint and LCA

#### Introduction and carbon labels

#### Carbon Footprint of Sapporo Beer



CO2 Labels Proposed for Beer Cans by '09



## Does the Carbon Footprint figure cover ...

- chilled or non-chilled beer?
- which point of sale (Japan or island Hokkaido only)?
- including home transport and cooling at home?
- which end of life treatment of aluminium can?
- all greenhouse gases or CO<sub>2</sub> only?

Is CO<sub>2</sub> the most important environmental impact of beer?

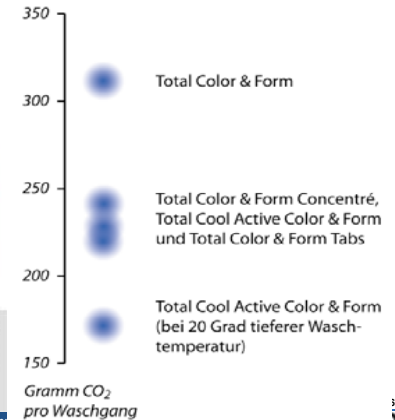
## Climatop label (mainly Migros)



**Total Cool Active  
Color & Form**  
Standard-Dosierung:  
60g



**Total Color & Form**  
Standard-Dosierung:  
100g



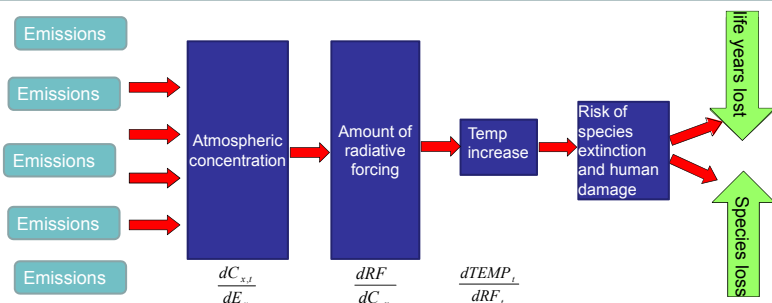
## By air label (Coop)



## By air label for food products

- air freight is climate neutral from a consumer's perspective
- Products are more expensive from a retailers perspective (climate change compensation)
- Incentive for retailer to reduce air freights

## From greenhouse gas emissions to damages



## Radiative Forcing: carbon footprint measure

$$GWP_i = \frac{\int_0^{TH} RF_i(t) dt}{\int_0^{TH} RF_r(t) dt}$$

IPCC: Global Warming Potential (GWP) is a simplified index based upon radiative properties that can be used to estimate the impacts of emissions of different gases upon the climate system in a relative sense

Substance	GWP (20yr)	GWP (100yr)	GWP (500yr)
Carbon dioxide (CO <sub>2</sub> )	1	1	1
Methane (CH <sub>4</sub> )	72	25	7.6
Nitrous oxide (N <sub>2</sub> O)	289	298	153
CFC-13	10800	14400	16400

## PAS 2050: First Chapters

- 1 Scope:
  - requirements for life cycle GHG emissions of products
  - single issue: global warming
  - no product specific requirements
  - no requirements for communication
- 2 Normative references:
  - reference to ISO and IPCC publications
- 3 Terms and definitions:
  - terms from ISO documents and terms required for mutual understanding

## General requirements

- Assessment of carbon footprint using LCA techniques
- ISO 14040 and 14044 shall apply
- If PAS contradicts to ISO, PAS takes precedence

## Principles

- Relevance: select appropriate data and methods
- Completeness: include all material contributions
- Consistency: enable meaningful comparisons
- Accuracy: reduce bias and uncertainty
- Transparency: allow associated decisions with confidence

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## Supporting data

- Document data supporting the assessment of the carbon footprint, including:
  - product and process boundaries
  - materials
  - emission factors and emissions
  - other data
- maintain a record suitable for analysis and verification
- during either 5 years or product's life expectancy

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## Implementation

- business to consumer (b2c, cradle to grave):  
Includes the emissions arising from the full life cycle
- business to business (b2b, cradle to gate):  
Includes the emissions released up to and including the point where it arrives at a new organisation

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## Scope of greenhouse gas emissions

- Global warming potentials (GWP)  
Example Methane (fossil): 25 kg CO<sub>2</sub>-eq per kg
- Aircraft emissions:  
no multiplier or other correction allowed

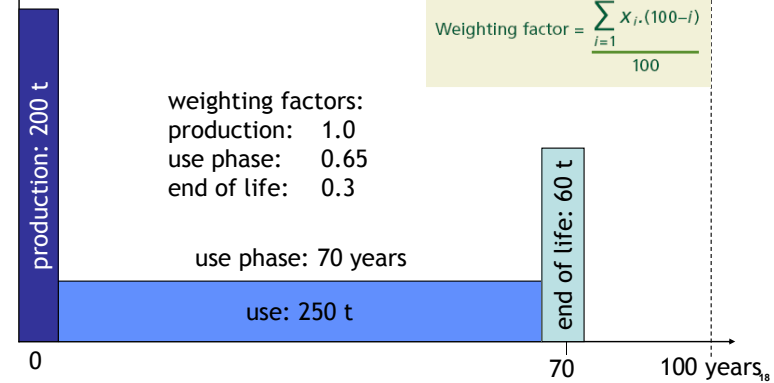
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## Time period of greenhouse gas emissions

- 100 year assessment period:  
CO<sub>2e</sub> impact of 100-year period following the product formation
- All emissions except from use and disposal phase treated as single release of emissions at the beginning of 100-year period
- More than one year emission period:  
weighted average time the emissions are present in the atmosphere during 100-year assessment period

## 100 years time frame: life cycle of a building

↑ CO<sub>2</sub> equivalents



## Sources of greenhouse gas emissions

- energy use
- combustion processes
- chemical reactions
- refrigerant loss and other fugitive emissions
- operations
- service provision and delivery
- land use change
- livestock and other agricultural processes
- waste

## Fossil and biogenic carbon sources

- Biogenic CO<sub>2</sub> emissions are **excluded**, except those from land use changes
  - Biogenic non CO<sub>2</sub> emissions (i.e. Methane, carbon monoxide) are **included**
  - GWP factor of biogenic non CO<sub>2</sub> emissions shall take into account sequestration of CO<sub>2</sub> that gave rise to the biogenic carbon source
- Example GWP of 1 kg biogenic Methane:  
 GWP CH<sub>4b</sub> = 25 minus 2.75 = 22.25 kg CO<sub>2</sub>-eq  
 Sequestration: 12/16 \* 44/12 = 2.75 kg CO<sub>2</sub>-eq

## Carbon storage in products

- Carbon storage shall be accounted for in the following cases:
- uptake of atmospheric CO<sub>2</sub>:
  - into non-living organisms
  - e.g. cement
- Carbon of biogenic origin forms part of product:
  - e.g. wood fibre in table

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## Eligible products for stored biogenic carbon

- not for human or animal ingestion (not a food or feed)
- 50% + of mass of biogenic carbon remains removed for 1 year + following production of product
- material obtained from
  - result of human actions (e.g. managed forests)
  - re-use or recycled from the above material

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## Treatment of stored biogenic carbon

- Disposal:  
Biogenic carbon not emitted during waste treatment is considered stored carbon
- Recycling (within 100-year period):  
Carbon storage is inherited to product using recycled biogenic material
- CO<sub>2</sub> emissions:  
Emissions from degradation of biogenic material are not taken into account  
Considered via share of carbon storage

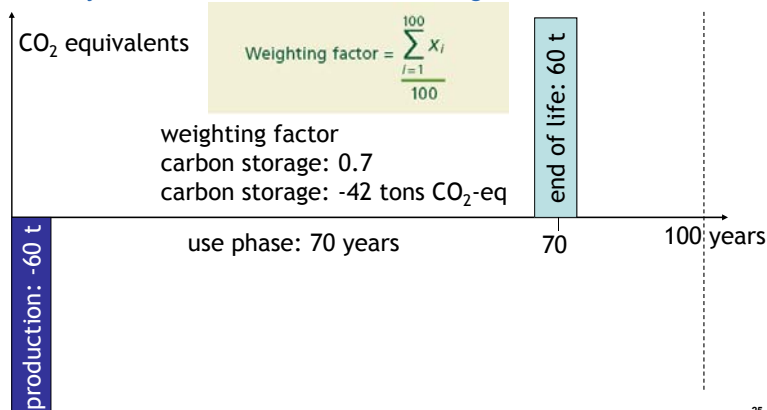
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## Calculation of CO<sub>2</sub> impact of stored biogenic carbon

- weighted average of biogenic or fixed carbon not re-emitted during the 100-year period
- Negative CO<sub>2e</sub> assigned to the stored biogenic or fixed carbon
- Data sources and carbon storage profile shall be documented

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## 100 years time frame: carbon storage wooden house



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## Land use change

- GHG emissions related to **direct** land use change occurring on or after 1 January 1990
- 5% of the GHG emissions due to direct land use are attributed to each year's production over the 20 years following the land use change
- GHG emissions related to **indirect land use** are **not included** (methods and data are not yet fully developed)

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## Traceability of agricultural products

Apply the following hierarchy to determine GHG emissions:

	country	former land use	GHG emissions approximate
1.	known	known	GHG emissions of country and particular land use
2.	known	unknown	highest potential GHG emissions of country
3.	unknown	unknown	highest potential emissions (forest to crop land in MY)

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## Soil carbon changes in existing agricultural systems

- tilling types
  - crop types
  - other management actions
- may lead to changes in soil carbon
- They are excluded from the assessment of GHG emissions

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## Carbon offsetting

- PAS is intended to reflect the GHG intensity of a product prior to the implementation of external measures
- GHG emissions offsetting mechanisms shall not be used at any point in the life cycle of a product
- Applies to voluntary, nationally or internationally recognised offset schemes
- Use of low carbon intensity energy (renewables or fossil with CCS) is not a form of offsetting

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## Example: T-shirt Continental Clothing Company

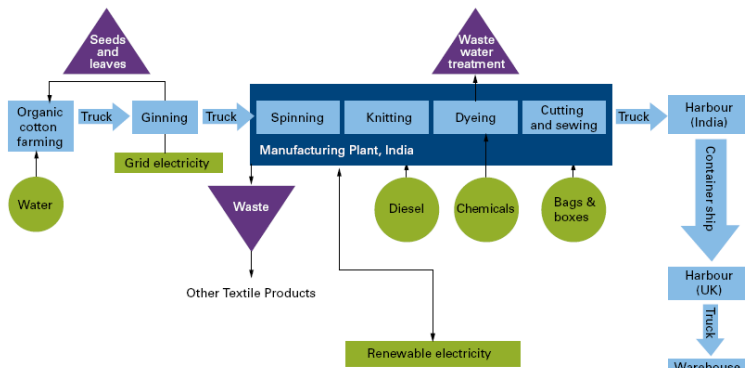
aparel line: EarthPositive®



- organic farming
- natural irrigation
- renewable electricity
- waste handling (used as fertilizer or in other products)
- waste water treatment
- Packaging: 100% biodegradable or recycled
- no airfreight policy

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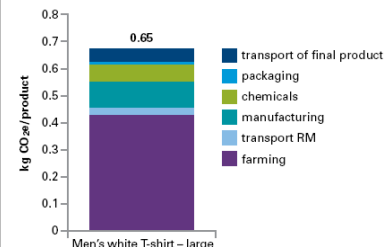
## T-shirt supply chain



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## Example: T-shirt Continental Clothing Company

Chart 2 Continental T-shirt carbon footprint



Source: Continental Clothing Company

**working with the Carbon Trust**



**650g CO<sub>2</sub> per garment**

**We have committed to reduce this carbon footprint**

The carbon footprint of this product is **650g**. This is the total carbon dioxide (CO<sub>2</sub>) and other greenhouse gases emitted from the raw materials, production and transport to the UK

This compares to the carbon footprint of an identical product manufactured without the use of renewable electricity which is **6,5kg** per garment

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### Unit of analysis

- Mass of CO<sub>2e</sub> emissions to be reported per functional unit for the product
- Show results with two significant figures
- Services:  
per time (annual emissions for an internal service) or  
per event (per night emissions for a hotel stay)
- internal organisation reporting may require different functional unit than consumer communication

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### System boundary

- materials and energy: cradle to gate, including waste management of production wastes
- capital goods: shall be **excluded**
- manufacturing and service provision: cradle to gate, including emissions associated with prototyping activities
- operation of premises (factories, warehouses, central supply centers, offices, retail outlets): cradle to gate

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### System boundary II

- transports by road, air, water, rail or other means: cradle to gate (excluding manufacture of transport means and infrastructures)
- distribution: average distance to retail outlet, either country average or country sales weighted average
- storage (inputs, products, scrap): to be **included**
- transport and storage to **include** emissions due to refrigeration

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### System boundary: use phase

- all emissions during the 100-year assessment period
- weighted average time emissions are present in the atmosphere
- determine use profile, order of preference:
  - 1 Product Category Rule
  - 2 published international standards
  - 3 published national guidelines
  - 4 published industry guidelines
 otherwise: determined by practitioner
- Impacts of the product on the use phase of other products shall be excluded

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## Mineral wool, helping to reduce energy consumption of buildings



## System boundary: final disposal

- GHG emissions arising from final disposal, e.g. landfill, incineration, burial, waste water treatment shall be included
- weighted average time emissions are present in the atmosphere during the 100-year assessment period
- GHG emissions from final disposal diverted to other systems (combustion of methane from landfills, combustion of waste timber fibres) are attributed to the other systems

## System boundary exclusions

- human energy inputs
- transport of consumers to and from retail outlet
- transport of employees to normal place of work
- animals providing transport services



## Data quality rules

Which data to prefer:

- time related coverage: most specific
- geographical coverage: most specific
- technology coverage: most specific
- accuracy: datasets with most accurate data, models and assumptions
- precision: data with lowest statistical variance

## Primary activity data

- data about processes owned, operated or controlled by the organisation implementing this PAS
- If contribution below 10%:  
first tier upstream suppliers (contribution >10%) must provide primary activity data
- Not applicable on
  - Methane emissions from livestock
  - N<sub>2</sub>O emissions from fertiliser application
- Conditions imposed on the supply of products:  
primary activity data applies on upstream processes

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## Secondary data

Preference order for secondary data:

- Use data verified as being compliant with PAS 2050
- Peer reviewed data together with data from other competent sources (e.g. national government, United Nations publications)
- other sources

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## Changes in the life cycle of products

Reassessment of the GHG emissions shall be carried out in the following cases:

- unplanned changes:  
>10% increase in GHG emissions for a period of >3 months
- planned changes:  
>5% increase in GHG emissions for a period of >3 months

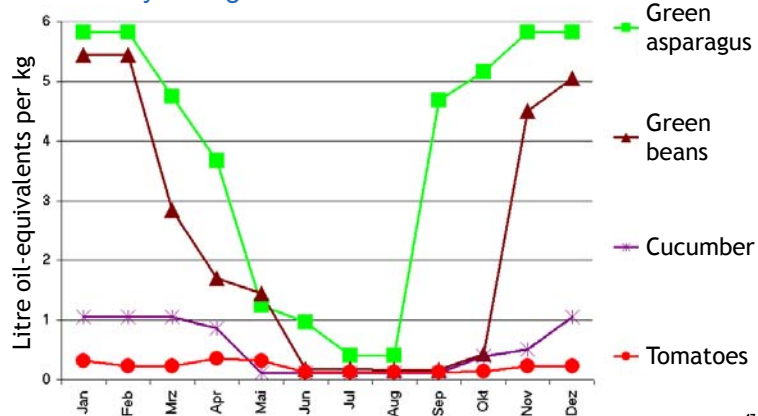
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## Variability in GHG emissions

- If GHG emissions of a product vary with time:  
use time period sufficient to establish average GHG emissions of a product
- Continuous availability of product:  
Provide annual average GHG emissions
- Seasonal products:  
Provide GHG emissions of the particular period associated with the production of the product

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## Seasonality of vegetables



## Data sampling

- If input to a process arises from multiple sources: representative sample of GHG emissions from those sources complies with this PAS
- Examples:
  - representative set of branches of a bank
  - representative sample of grain sources of a flour mill
  - representative sample of production lines of a factory

## GHG emissions from renewable electricity

Two conditions to be met

- process used this renewable electricity
- generation of this renewable energy does not influence emission factor of any other process or organisation

Else:

- use national annual average grid mix

## Validity

- Results are valid for a maximum of two years
- Exception: change in the product life cycle

## Disclosure

Communication to third party (consumer):

- Description of system boundary
- Description of use profile
- Description of the calculation of the impact of carbon storage
- Description of secondary data sources to be published at or prior to communication may be published via a website

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## Allocation of emissions to co-products

- divide process into subprocesses
- expand the system to include additional functions
  - identifying product which is being replaced
  - avoided GHG emissions represented by average emissions arising from provision of avoided product
- if both approaches are not applicable: use economic value of the co-products

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## Emissions from waste

- CO<sub>2</sub> from waste: only fossil CO<sub>2</sub> is accounted for
- Non CO<sub>2</sub> from waste: fossil and biogenic pollutants
- Methane (from waste) combustion **with** energy recovery:
  - GHG emissions from fossil carbon attributed to energy produced
- Methane (from waste) combustion **without** energy recovery:
  - GHG emissions from fossil carbon attributed to product giving rise to the waste

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## Emissions from Combined Heat and Power (CHP)

- energy production (e.g. electricity) is exported to outside the product system:
  - assess **avoided emissions** with average grid mix
- heat and electricity is used by more than one process:
  - amount of useful energy produced multiplied by GHG emission intensity
- GHG emission intensities:
  - boiler CHP: electricity / heat: 2.5 / 1
  - turbine CHP: electricity / heat: 2.0 / 1

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## Emissions from Transport

- Transporting more than one product:  
Allocation according to the limiting factor:
  - allocation by mass
  - allocation by volume
- Return journey to be included  
(for that proportion of the return journey where vehicle does not transport products)

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## Reuse and remanufacturing

- Determine life cycle GHG emissions, excluding use phase
- Divide by anticipated number of times of reuses
- Add GHG emissions arising from remanufacturing  
(to make it suitable for reuse)

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## Recycled material and recycling

$$\text{Emissions / unit} = (1 - R_1) \times E_V + (R_1 \times E_R) + (1 - R_2) \times E_D$$

where

- $R_1$  = proportion of recycled material input,
- $R_2$  = proportion of material in the product that is recycled at end-of-life,
- $E_R$  = emissions arising from recycled material input, per unit of material,
- $E_V$  = emissions arising from virgin material input, per unit of material,
- $E_D$  = emissions arising from disposal of waste material, per unit of material

- material input with recycled content from **same product system**
- Corresponds to “recycled content” (or “cut off”) approach

- material input from **other product systems**:  
allocation according to ISO 14044

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## Calculation of GHG emissions of products

- activity data times GHG emission factor  
20 litres of Diesel times 3.8 kg CO<sub>2</sub>/litre: 76 kg CO<sub>2</sub>  
20 litres of Diesel times 0.01 kg CH<sub>4</sub>/litre: 0.2 kg CH<sub>4</sub>
- cumulative GHG emissions times GWP factors  
76kg\*1kg CO<sub>2e</sub>/kg + 0.2kg\*25kg CO<sub>2e</sub>/kg = 81kg CO<sub>2e</sub>
- deduct carbon storage GHG equivalents from total
- sum it up to
  - full life cycle, use phase separately (b2c)
  - cradle to gate (b2b)
- scale GHG emissions to account for any minor contributions omitted

### Claims of conformity

- Scope: all provisions of the PAS shall be addressed
- Types of conformity assessments:
  - independent third party certification
  - other party verification
  - self verification
- Statement:  
 “Greenhouse gas emissions calculated by XX in accordance with PAS 2050, YY certified / ZZ validated / self declared.”

### PAS 2050 and ISO 14040/14044

- System delimitation:
  - PAS: 95% minimum coverage
  - PAS: exclusion of capital equipment
  - ISO: cut-off rules (mass, energy, environmental impact)
- Assessment period:
  - PAS: 100 years, time dependent reduction of impact
  - ISO: no time limitation
- biogenic carbon fixation and GWP:
  - PAS: taken into account (reduced GWP of non CO<sub>2</sub>)
  - ISO: same GWP for biogenic and fossil Methane

### PAS 2050 and ISO 14040/14044, cont.

- Biogenic carbon storage:
  - PAS: taken into account (related to 100-years period)
  - ISO: disregarded
- Allocation:
  - PAS: step 2 “physical relationships” does not apply
  - ISO: three steps procedure
- Conformity claims:
  - PAS: allows for self declaration (made explicit)
  - ISO: requires third party review panel in selected cases

### WRI/WBCSD standard and draft ISO 14067

- No time limitation  
 WRI: same GWP for prompt and postponed emissions  
 ISO: report time period of postponed emissions
- Offsetting: emission credits NOT allowed
- Allocation and recycling:  
 “recycled content” and “end of life” approaches explicitly supported
- Avoided emissions NOT accountable
- Strong emphasis on assurance  
 (verification; aligned with financial accounting processes)

## PAS 2050: explicit practical advices/prescriptions

- Data:  
when and where to use primary/secondary data
- System delimitation:  
what to include, and what to exclude
- Use phase:  
how to anticipate/model it, how to avoid ambiguity
- Offsetting mechanism:  
clear statement: to be excluded
- Land use change:  
Default emission factors

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## Exercise

- Danish wooden furniture with LED lighting
- 50 years life time
- heat produced in manufacture is partly sold
- carbon offsets to compensate diesel consumption
- incineration with heat recovery at end of life

## Questions

- contributions of different phases to carbon footprint
- overall carbon footprint (PAS 2050 compliant):  
b2b and b2c perspectives

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