Ecological assessment of logistics processes and systems
System definition Green Logistics

As of: 11/2012

- brief documentation -
Green Logistics

This presentation is an extraction of the detailed documentation »Ecological assessment of logistics processes and systems: System definition Green Logistics«, which is published in German on the project’s webpage (Link).
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Embedding the system definition in the cluster project Green Logistics

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<th>Inventory (internal &amp; external preliminary studies)</th>
<th>Analysis of requirements (logistics service providers, clients, shippers etc.)</th>
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<td></td>
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</table>

Gaps concerning method and data

Morphological process modules

Catalogue of requirements

System definition Green Logistics

Method for ecological assessment

Ecological assessment tool

Sector guidance
Goal of system definition

// Definition of the assessment scope for the ecological assessment of logistics processes and systems, i.e.
- Limitation of relevant sub-processes in the areas transport, logistics real estate, intralogistics
- Selection of – besides greenhouse gas emissions – relevant environmental impact categories

// Realization of a method,
- Which allows the ecological comparison between logistics service providers and, if necessary, among modes of transport
- Which is pragmatic and substantiated at the same time (effort vs. significance)
- Which considers the demands of the market and users, as well as, society and policy
- Whose results point out optimization opportunities to companies
Procedure for the development of the system definition

Relevance analysis by means of detailed studies, model calculation and literature study

Recommendation of partners

Not relevant:
- Today’s availability of data within
  - Companies
  - Public databases

Relevant:
- Requirements of
  - Market & users
  - Society & policy
- Effort vs. significance
- Option for differentiation
- Feasibility of influence by company
- Possibility for optimization
Assessment scope: Company-based approach

Focus on
- Company with its products and services
- All direct and indirect emissions (i.e. including scope 3 emissions)
- Timeframe of one year (i.e. accounting for seasonal effects)

(1) Referring to GHG protocol
Potential assessment scope at logistics service providers

**Scope 3 „upstream“**
- Production
- Transport with sub-contractors
- External real estates & auxiliary processes
- Production/Supply processes

**Scope 1 & 2 „value-added“**
- Transport with company fleet
- Company real estates & auxiliary processes
- Operating company-owned logistics buildings
  - electricity demand
  - diesel consumption
  - etc.

**Scope 3 „downstream“**
- Servicing and maintenance
- Disposal of technology/ infrastructure/ auxiliary materials/consumables
Relevance analysis

Transport and handling processes
Basis for the ecological assessment of transport processes forms EN 16258
- Goods transport, empty trips
- Provision of energy sources (fuels, etc.)

Decision:
Additional consideration required for
- Transport auxiliary processes, e.g.
  - Tugboat in sea ports, shunting movements rail
  - Transhipment and yard logistics
  - Air-conditioning of goods
- Life cycle environmental impacts of
  - Infrastructure (production and maintenance)
  - Means of transport (Production)
Empty trips of vehicles are usually required for the realization of transport services:
- Balancing the provision of vehicles and load units within the logistics network (e.g. to ensure efficient pairing)
- Empty trips for loading or empty return trips to the LSP site

Empty trips cause 60% to >80% of the maximum fuel consumption compared to fully laden trucks (depending on vehicle category)\(^{(1)}\)
- Estimation UPS: >1% of the company’s fuel consumption
- Additional consumption is usually recorded in the general fuel bill

Decision: Empty trips need to be assessed as well.

\(^{(1)}\) Own calculation based on HBEFA v3.1

TT– truck-trailer; AT – articulated truck
Relevance analysis road: Air-conditioning of goods

// Temperature-sensitive goods must be cooled during transport and at the sites

// Refrigeration units require refrigerants (e. g. CFCs\(^{(1)}\)) and operating power (e. g. diesel, electricity)
- In Germany 7,300 t refrigerants were used in 2010 in the mobile and stationary air-conditioning\(^{(2)}\)
- 25% of it for maintenance (i. e. 3.6 million t CO\(_2\)e)\(^{(2)}\)

// Unique selling proposition for »green« LSP
- Utilizing climate-neutral refrigerants (e. g. ammonia)
- Reduction of leakage

// Production of refrigerants (indirect emissions) is negligible compared to direct emissions (1: 200-600)\(^{(3)}\)

Decision: Cooling processes need to be assessed as well.

\(^{(1)}\) Chlorofluorocarbons
\(^{(2)}\) Federal Statistical Office of Germany 2011
\(^{(3)}\) Kranke et al. 2011
Relevance analysis air freight: Empty and position flights

Empty and position flights include i. a.
- Flights by the manufacturer for provision, training, test and ferry
- Aborted flights with change of aircraft

Share of the yearly consumption by empty and position flights in relation to total consumption
- Lufthansa Cargo: 0.36% in 2010
- Deutsche Post DHL:
  - 0.64% without sub-providers in 2011
  - 2.64% with sub-providers (Global Forwarding, Global Mail and the overnight airmail network D solely with sub-providers)

Decision: Relevance of empty and position flights needs to be checked by providers of air freight services.
A towage operation is the accompanying of big ocean vessels to the harbor area
- Ensure maneuverability of ocean vessels in narrow waterways and docks
- Consists of one empty and one loaded trip
- Depending on port location (e.g. coastal or inland port) the covered routes are very different

Sample calculation Hamburg – New York
- Main run: approx. 6,700 km
  - 1,302 t bunker consumption (> 8,000 TEU)
  - 339 t bunker consumption (1,000-2,000 TEU)
- Tug trips (approx. 200 km) account for approx. 0.1% of the total consumption in sea transport

Decision: Estimation of these processes by means of key figures. Database is missing so far.
Ships are connected to landside electricity grids during port times
- Cold Ironing or alternatively Marine Power

Thus users such as on-board electronics, light, cranes or refrigeration containers are supplied with electricity
- This enables emission reduction of sulphur dioxide or soot

Cold Ironing is still not a standard, as standardized connections for shore power are missing

Decision: Sea port processes (e.g. Cold Ironing) are to be assessed analog to bunker consumption.
Relevance analysis: Life cycle of means of transport

// Share of environmental impacts of production in the life cycle varies distinctly between transport carriers
- Light trucks: 104 g/tkm (9.2%)
- Heavy trucks: 6-15 g/tkm (5.8%)
- Goods train: 1.6 g/tkm (5.3%)
- Ships: < 1 g/tkm (< 2.5%)
- Aircraft: < 1.4 g/tkm (< 0.2%)

// Servicing and maintenance
- E.g. Aircraft: Share of consumables (oils, greases, binding agents, paints, washing water) low, i.e. < 0.0x% in comparison to kerosene consumption
- E.g. Truck: Vehicle workshops approx. 2% of the total electricity consumption of a LSP

Decision: Lump inclusion of production phase; Disposal negligible, review servicing and maintenance (negligible, if any)

Research based on Grießhammer 2010
Environmental impacts by logistics infrastructure (production, maintenance, disposal) vary absolutely, as well as, also proportionately depending on the transport carrier.

Environmental impacts of the infrastructure are relevant parameters in the life cycle of transports.

Decision: Negligence with comparisons concerning overall traffic impermissible. Illustration of general key figures reasonable.

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(1) Own representation on basis of the database of Frischknecht et al. (2011)
Relevance analysis: Operative logistics processes in intralogistics

Consumption of electricity, packaging, cargo securing, electricity, transport & packing material, electricity

Distribution center with picking operations:
- Unloading after delivery
- Incoming goods department/goods receipt
- Repack
- Transport to warehouse
- Warehouse
- Transport from warehouse
- Order-picking
- Packing area
- Shipping processing

Pure transhipment warehouse:
- Sorter
Relevance analysis: Operative logistics processes in intralogistics

Consumption of:
- poss. electricity
- electricity, poss. packaging, cargo securing
- electricity
- electricity, transport & packing material
- electricity

Distribution center with picking operations:
- Unloading after delivery
- Incoming goods department/goods receipt
- Repack
- Transport to warehouse
- Warehouse
- Transport from warehouse
- Order-picking
- Packing area
- Shipping processing

Pure transhipment warehouse:

E.g. transport & packing material:
- 15 t stretch foil
- 1 t bubble wrap
- 0.5 t strapping tape
- 14.5 t shipping carton
- 2 t filler material
- 0.5 t labels
- 0.7 t delivery note pockets

Emissions:
- Electricity, transport & packing material
- Emissions from electricity consumption
- Emissions from packaging, cargo securing

Green Logistics
Relevance analysis: Operative logistics processes in intralogistics

Electricity
800,000 kWh/a

Distribution across the different operative logistics processes

Greenhouse gas emission
electricity, transport & packing material

+ 9% site emission by material consumption

Decision: Besides the pure electricity consumption, further material consumption at logistics sites need to be assessed as well.
Relevance analysis: Total life cycle of intralogistics systems 1(2)

// Life cycle view of intralogistics components
- Cross-belt sorter
- Conveying belt (airport technology, warehouse system)
- Roller conveyor (warehouse system)
- Rack feeder

// Production phase causes 5-11% of the overall emissions
Relevance analysis: Total life cycle of intralogistics systems

// Share of upstream emissions at a logistics overall system

// Scenario 1: European distribution system
- Automated warehouse system (Transhipment, warehousing, order-picking) for unrefrigerated goods
- Share of the conveyor technique-upstream emissions approx. 1.25%

// Scenario 2: Distribution system with supply of European state warehouses
- Semi-automated logistics system (high bay warehouse, otherwise mainly manual processes) for unrefrigerated goods
- Share of conveyor technique-upstream emissions approx. 0.83%

// Comparable results for ground conveyors \(^{(1)}\)

- Decision: Upstream emissions of intralogistics components are negligible in the system boundary of logistics systems.

\(^{(1)}\) Jungheinrich 2012
Relevance analysis: Warehouses - building shell & MEP systems

// Life cycle analysis on the basis of an exemplary warehouse at Fiege Logistik
- Reinforced concrete supporting structure
- Facade & roof: steel-trapezoidal sheet metal construction
- 35,000 m² storage and logistics area
- Observation period: 41 years

Decision: All life cycle phases of a logistics real estate are to be considered, examining the integration of parallel procedures (e.g. DGNB-certification).
Relevance analysis: Yard logistics, transhipment of load units

// Yard logistics: Shunting of swap bodies, trailers and semi-trailers

// Transhipment of load units e. g. container transport in freight depots, intermodal transport terminals and ports by means of gantry cranes or reach stackers

// Depending on the area of study sample calculations result in a different relevance of these sub-processes in the overall system (up to approx. 2% of the fuel consumption)

Decision: Checking the relevancy of the sub-processes yard logistics and transhipment within the overall system.
Relevance analysis:
Administrations

- 84% of the transport companies own less than 10 trucks and are often carried out by automotive transport companies.
- Large-scale enterprises have disproportionally large administrations compared to transport fleet.
- Small transport companies have only few or no own customers and therefore take over the transport for forwarding agents.
- Many forwarding agents again own none or only one small transport fleet.

Decision: In an ecological assessment the administration of logistics businesses should be considered with their respective demand for electricity and heating.
Relevance analysis: Workshops

Workshops are used for the regular servicing and maintenance of automotive and industrial engineering.

Size varies depending on de-/centralized organizational structure and external contractors.

Environmental impacts occur due to consumption of electricity, lubricants, spare parts etc.

Exemplary studies clarify subordinated relevancies with concurrent complexity of an assessment.

Decision: Relevancy is negligible low; if necessary, assessment on key figures.
Relevance analysis: Employee mobility

Employee mobility covers
- Business trips
- Drives to workplace
  (only indirect influencing by employers possible)

34 times more business-related travels took place in 2005 than private trips \(^{(1)}\)

Survey of 600 German business travelers \(^{(2)}\):
Most business trips take place within Germany (86%) and by car (85%)

General passenger transport in Germany:
85% by car, 8% by train, 6% Local Public Transport

GHG Protocol \(^{(4)}\) demands an assessment on employee mobility as scope 3 upstream emissions
- Logistics services is not possible without employees

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\(^{(1)}\) BMVBS 2007 in Hanel 2008
\(^{(2)}\) Schneider 2009
\(^{(3)}\) Without Germany
\(^{(4)}\) GHG Protocol Scope 3 Standard
Relevance analysis: Employee mobility

Commuting

- Operational site (E.g.: distribution center)
  - 10% of the site emissions
  - 0.5-3% of the global goods distribution system
- Office and administration site (E.g.: Deutsche Post, Fraunhofer IML)
  - approx. one third of the site emissions

Business trips

- Logistics service providers total
  - 0.5% of the total emissions (Deutsche Post)
  - 0.03% of the total emissions (Hellmann)
- Research institution
  - 13% of the total emissions (Fraunhofer IML)

Commuting is relevant for the comparison of manual vs. automatized intralogistics processes

![Green Logistics](image)

Decision: To define system boundary, relevancy of the sub-process employee mobility needs to be examined within the overall system.

(1) Hellmann Sustainability Report 2011
System boundary: Process analysis

\begin{itemize}
  \item Goods transport:
    \begin{itemize}
      \item Fuel, electricity, additives
    \end{itemize}
  \item Shunting/empty trips:
    \begin{itemize}
      \item Fuel, electricity, additives
    \end{itemize}
  \item Transhipment and yard logistics:
    \begin{itemize}
      \item Energy, fuel
    \end{itemize}
  \item Air-conditioning of goods:
    \begin{itemize}
      \item Refrigerants, Reefer Container
    \end{itemize}
  \item Means of transport:
    \begin{itemize}
      \item Manufacturing of trucks, trains, ships, aircrafts
    \end{itemize}
  \item Production logistics infrastructure:
    \begin{itemize}
      \item E. g. roads, rails, canal
    \end{itemize}
  \item De-icing, heating:
    \begin{itemize}
      \item De-icing agent, energy
    \end{itemize}
  \item Production resources:
    \begin{itemize}
      \item Provisioning
    \end{itemize}
  \item Building shell incl. MEP:
    \begin{itemize}
      \item Resource consumption in construction, utilization and dismantling
    \end{itemize}
  \item Intralogistics:
    \begin{itemize}
      \item Electricity, material for transport packaging & safety
    \end{itemize}
  \item Vehicle workshop:
    \begin{itemize}
      \item Resource consumption by servicing & maintenance
    \end{itemize}
  \item Administration:
    \begin{itemize}
      \item Electricity, district heating, natural gas
    \end{itemize}
  \item Employee mobility:
    \begin{itemize}
      \item Energy, fuel
    \end{itemize}
\end{itemize}

Distinction:

- **Road:** Refrigerant; Production; painting; cleaning
- **Air:** Tug trips; collection trips; engine cleaning; maintenance engine oil, maintenance greases and oils, maintenance emptying of tanks; maintenance oil disposal; maintenance oil binding agents; painting water-based paint
- **Rail / Water:** no specification
- **Means of transport:** Disposal phase
- **Intralogistics:** Production & disposal phase
- **Workshops:** Operating technology
- **Waste:** Recycling processes
Relevance analysis
Environmental impact categories
## Relevance analysis: Environmental impact categories 1(2)

<table>
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<tr>
<th>Process</th>
<th>Emissions in logistics areas</th>
<th>Possibility of objectivization</th>
<th>Added value for certification system &amp; assessment result</th>
<th>Decision</th>
</tr>
</thead>
</table>
| GHG     | ✅  ✅  ✅  ✅  ✅                 | ✅                            | – Comparison of transport modes  
– Green measures | Assessment |
| SO₂     | ↓ EU  ✓  ✓  ✓  ✓  ↓             | ✅                            | – international context  
– Comparison of transport modes  
– Fleet age  
– Green measures | Assessment; in case of global LS based on key figures |
| NOₓ     | ✓  ✓  ✓  ✓  ✓  ✓              | ✅                            | – Comparison of transport modes  
– Fleet age  
– Green measures | Assessment |
| CO      | ✓  ✓  ✓  ✓  ✓  ✓              | ✅                            | – Comparison of transport modes  
– Fleet age  
– Green measures | Assessment; lump approach possible |
| unburned HC | ✅  ✅  ✅  ✅  ✅  ✅ | ✅                            | – Comparison of transport modes  
– Fleet age  
– Green measures | Assessment; lump approach possible |
| Waste water | ✅  ✅  ✅  ✅  ✅  ✅ | ✅                            | – Added value not being seen | No assessment |
### Relevance analysis: Environmental impact categories 2(2)

<table>
<thead>
<tr>
<th>Process</th>
<th>Emissions in logistics areas</th>
<th>Possibility of objectivization</th>
<th>Added value for certification system &amp; assessment result</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area</td>
<td>‹† ‡ †⁻⁻⁻⁻⁻⁻</td>
<td>(✓) Ecological value of an area</td>
<td>– Relevant in future&lt;br&gt;– Allocation on shipment difficult</td>
<td>Assessment; basic methodical development need still exists</td>
</tr>
<tr>
<td>Particulate matters</td>
<td>†⁻⁻⁻⁻⁻⁻⁻⁻⁻⁻</td>
<td>(✓) Connection particulate weight &amp; toxicity</td>
<td>– international context</td>
<td></td>
</tr>
<tr>
<td>Noise</td>
<td>††↑↑↑↑↑↑↑↑↑↑↑↑</td>
<td>(✓) subjective noise perception&lt;br&gt;– Average sound level &amp; maximum level&lt;br&gt;– Day / night</td>
<td>– Comparison of transport modes&lt;br&gt;– Green measures</td>
<td></td>
</tr>
</tbody>
</table>

- **Decision**: In the first step the methodology covers emissions of CO$_2$, SO$_2$, NO$_x$, CO and unburned hydrocarbons.
Conclusion

Demarcation of assessment aspects in logistics services
# Demarcation of assessment aspects in logistics services (1)

<table>
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<tr>
<th>Source</th>
<th>Partial aspect</th>
<th>Characteristic/alternative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road transport</td>
<td>Transport carried out on roads (own vehicle fleet, sub-contractors); consideration of propulsion, additives, provisioning of transportation means; upstream activities for means of transport, infrastructure, operating power</td>
<td>Tours between locations, collection/distribution tours, pre- and on-carriage of intermodal transport (Road Feeder Service), (un-)refrigerated</td>
</tr>
<tr>
<td>Rail transport</td>
<td>Transport carried out by rail (own trains, sub-contractors); consideration of propulsion, additives, provisioning of transportation means; upstream activities for means of transport, infrastructure, operating power</td>
<td>Short/long-distance traffic, combined traffic (e.g. rolling road), (un-)refrigerated</td>
</tr>
<tr>
<td>Inland navigation</td>
<td>Transport carried out on inland waters, (own ships, sub-contractors); consideration of propulsion, additives, provisioning of transportation means; upstream activities for means of transport, infrastructure, operating power</td>
<td>Ferries, RORO ships, LOLO ships, (un-)refrigerated, piece goods (e.g. wind turbines)</td>
</tr>
<tr>
<td>Maritime navigation</td>
<td>Maritime freight transport (own ships, sub-contractors); consideration of propulsion, additives, provisioning of transportation means; upstream activities for means of transport, infrastructure, operating power</td>
<td>High seas and nearshore, (un-)refrigerated, bulk goods</td>
</tr>
</tbody>
</table>
Demarcation of assessment aspects in logistics services (2)

<table>
<thead>
<tr>
<th>Source</th>
<th>Partial aspect</th>
<th>Characteristic/alternative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air transport</td>
<td>Transport carried out by air (own aircrafts, sub-contractors); consideration of propulsion, additives, provisioning of transportation means; upstream activities for means of transport, infrastructure, operating power</td>
<td>Freight only, belly freight, mail transportation in passenger aircrafts</td>
</tr>
<tr>
<td>Logistics sites</td>
<td>Transport at a logistics sites (e.g. yard logistics, tug drives in the port, shunting); conveying, sorting, warehousing; consideration of propulsion, energy, transport safety, waste; upstream activities for infrastructure, operating power, materials</td>
<td>With/without building shell, (un-)refrigerated; warehouse, supply/ distribution/ transhipment hub, mail/parcel center, (KV-)terminal, port</td>
</tr>
<tr>
<td>Administration</td>
<td>Energy demand for i.a. lighting, IT, heating/cooling</td>
<td>De-/centralized administration</td>
</tr>
<tr>
<td>Commuting</td>
<td>Transport of employees between home and work in company-owned and employee-owned means of transport, in public passenger transport</td>
<td>Company car, private car, public (train, bus, subway, tramway), pedestrian, bicycle</td>
</tr>
<tr>
<td>Business trips</td>
<td>Transport carried out via air (own aircrafts, sub-contractors); consideration of propulsion, additives, provisioning of transportation means; upstream activities for means of transport, infrastructure, operating power</td>
<td>flight, company/rental car, private car, public (train, bus, subway, tramway), pedestrian, bicycle</td>
</tr>
</tbody>
</table>
References


Griesshammer, Rainer; Brommer, Eva; Gattermann, Marah; Grether, Stefanie; Krüger, Malte; Teufel, Jenny; Zimmer, Wiebke (2010): CO₂ Einsparpotenziale für Verbraucher. Ed. Öko-Institut. Freiburg.


Personal information by Jungheinrich 2012
