Joint webinar of the GILA project and ETP ALICE
12 October 2023 | 15:30 – 17:00 CET

- GHG emissions quantification of logistics sites aligned with ISO 14083
  Jan-Philipp Jarmer, Fraunhofer IML

- Annual market studies & overall GHG performance indicators for logistics hubs
  Andrea Fossa, GreenRouter & Kerstin Dobers, Fraunhofer IML

- Possible solutions for decarbonising logistics hubs
  Sara Perotti, Politecnico di Milano

- Sustainability of hubs: a key driver for maintaining value over time
  Scarlet Romano, Arcadis Germany
Calculation of GHG emissions from logistics chains
The path to an international standard

- **2012**: EN 16258
  - Methodology for calculation & declaration of energy consumption & GHG emissions of transport services (freight & passengers)

- **2015**: IWA 16
  - International harmonized method(s) for a coherent quantification of CO2e emissions of freight transport

- **2016 & 2019**: GLEC Framework
  - Global Logistics Emission Council Framework for Logistics Emissions Accounting & Reporting

- **2019**: Fraunhofer Guide
  - Guide for GHG emissions accounting at logistics sites

- **2023**: ISO 14083
  - Greenhouse gases - Quantification and reporting of greenhouse gas emissions arising from transport chain operations

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EN 16258
IWA 16
GLEC Framework
Fraunhofer Guide
ISO 14083
Calculation of GHG emissions from logistics chains
Status quo and future developments

ISO 14083:2023 *Greenhouse gases - Quantification and reporting of greenhouse gas emissions arising from transport chain operations*
- Published in March 2023 and replaces EN 16258:2012
- Translations, e.g. in German (DIN EN ISO 14083)

GLEC Framework (Version 3)
- Publication was at the end of September 2023

Fraunhofer Guide on logistics hubs
- The update is scheduled for the end of 2023
There is a knowledge gap for logistics hubs regarding environmental performance, GHG emissions & reduction potentials

Market studies in the project GILA on energy efficiency & GHG emission intensities at logistics hubs

- Identify main influencing parameters on energy efficiency and GHG emissions at sites
- Elaborate average GHG emissions intensity values for sites and a reasonable classification scheme for sites

Thanks to all participating in and supporting this market study!

Let’s overcome this gap!

Project GILA - German, Italian & Latin American consortium for resource efficient logistics hubs & transport
07 / 2020 – 07 / 2023
Project lead: Fraunhofer IML
Market studies in GILA project
Extension of global coverage

1st study (2021)

<table>
<thead>
<tr>
<th></th>
<th>2021</th>
<th>2023</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hubs</td>
<td>159</td>
<td>843</td>
</tr>
<tr>
<td>Countries</td>
<td>14</td>
<td>33</td>
</tr>
<tr>
<td>Region</td>
<td>93% in Europe</td>
<td>85% in Europe</td>
</tr>
</tbody>
</table>

after 3rd study (2023)
KPI for companies and individual logistics hubs supported by REff Tool®

Online tool for GHG assessment with primary data
Generally, use at no cost possible
https://reff.iml.fhg.de/
Each company uses its individual database

Surveys for data collection
Updated surveys per site type for manual data input online

Aligned with ISO 14083
GHG emissions aligned with international harmonized method regarding scope, emission factors and reports

Data base with more than 900 sites
Annual market studies and update of average KPIs with anonymised data base of logistics sites worldwide

Online tool for GHG assessment with primary data

Surveys for data collection

Aligned with ISO 14083

Data base with more than 900 sites
Classification of site
- Type
  - Transhipment, warehouse, storage and transhipment, container
    terminal, liquid bulk terminal etc.
- Temperature level
  - ambient, chilled, frozen, mixed

Basic data
- Location (country), building year, size, operation

REff Tool® is available via: https://reff.iml.fraunhofer.de/
Input data needed

Online platform REff Tool®

Classification of site

Basic data

Annual data
- Throughput (tonnes or alternative unit)

Annual consumption
- Electricity,
- Heating energy (natural gas, district heating, steam etc.)
- Other energy (diesel, petrol, LPG etc.)
- Leakage of refrigerants (estimated by annual refill)
- Optional: transport packaging

Sustainability measures
Implementation or priorities of 31 measures

REff Tool® is available via: https://reff.iml.fraunhofer.de/
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  Scarlet Romano, Arcadis Germany
Data base for the elaboration of average key performance indicators based on three GILA market studies\(^{(1)}\) consolidated

- **843 hubs**
- **51 countries worldwide**
- **> 15.48 Mio. m\(^2\) logistical area (indoors)\(^{(2)}\)**

Real estates\(^{(2)}\): > 5.1 bill. tons (outbound)

Terminals\(^{(3)}\): > 2.4 bill. tons (outbound)

Countries with >50 hubs: Germany, Italy, Czech Republic, Spain, France, USA

\(^{(1)}\) conducted in 2021, 2022 and 2023

\(^{(2)}\) Hubs with storage and/or transhipment

\(^{(3)}\) Terminals (container, liquid bulk)
Completeness of provided data
Number of participating hubs & sample size for KPIs

- Participating hubs: n=843
- Total Carbon Footprint possible (acc. to ISO 14083): n=497
- No total Carbon Footprint possible (Partial CF): n=346

- kg CO$_2$e / ton:
  - Transhipment: n=62
  - Storage + Tranship.: n=67
  - Warehouse: n=52
  - Liquid bulk terminal: n=51

- kg CO$_2$e / m² logistics area:
  - Transhipment: n=68
  - Storage + Tranship.: n=167
  - Warehouse: n=159

- Further detailed per temperature level:
  - 138 ambient warehouse
  - 1 Cooled warehouse
  - 1 Frozen warehouse
  - 21 Warehouse with multiple temperature levels (mixed)

Conclusion: Further market studies necessary
Where do data gaps exist?

Availability of data

- **Use of electricity**: 93%
- **Use of heating energy**: 78%
- **Use of other energy carriers**: 85%
- **Refill of refrigerants**: 66%
- **Transport packaging**: 31% (1) - optional information in market study, no information or explicitly stated that no information available

- 60% of hubs use national electricity mix
- 32% purchase "green" tariff, though do not now the underlying mix
- esp. natural gas (83% of hubs), district heating and heating oil
- esp. diesel/biodiesel (91%), petrol/ethanol and propane
- esp. R-410A, R-717 (ammoniac), R-404A, R-134a, R-448a and R-744

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Sources of GHG emissions at logistics hubs
Focus logistics real estates

- Reduced data base:
  Analysis of hubs with an ISO aligned GHG emissions quantification (n=439);
  incl. emissions related to storage and use of transport packaging

- **90% of GHG emissions** of logistics real estates origin from
  the **use of energy**: 67% electricity, 22% heating, 1% other energy

- **4%** of GHG emissions relate to **refrigerant leakage** (estimated by the
  quantity of refill)

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(1) Hubs offering storage and/or transhipment (no terminals)
National electricity mix (so-called »location based«)
What is the electricity used for?
Allocation to predefined activity clusters

- **25% of hubs**\(^{(1)}\) have further detailed their electricity consumption.
- Theses hubs consume 43% of total electricity consumption of the study.
- 70% of hubs specified explicitly, that they do not have any transparency on detailed electricity use.

Almost 80% of the electricity consumption has been allocated to pre-defined activity clusters.

**Overall allocation of electricity:**
- 32% for temperature control of goods
- 27% for lighting indoors
- 18% for material handling

\(^{(1)}\) Focus logistics real estates (without terminals)
GHG emissions arising at logistics sites
Shares derived by GILA market studies (2021-2023)

- Material handling: 18%
- Lighting indoor & yard: 27%
- Cooling & freezing equipment for goods: 32%
- Other energy carriers: 6%
- Leakage of refrigerants: 1%
Emission intensity values for logistics hubs
- Work in progress -

**Carbon Footprint (CF)**
- Total CF of hubs
  kg CO\(_2\)e / a

**Emission intensity**
- based on throughput
  kg CO\(_2\)e / tonne

- Use as default value
  - if e.g., no primary data is available
  - in tools in combination with transport emissions
  - in GLEC Framework (version 3.0)
- option for the future: use as benchmark

<table>
<thead>
<tr>
<th>Work in progress!!</th>
<th>ambient</th>
<th>mixed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transhipment</td>
<td>0.6 kg CO(_2)e / t</td>
<td>n=65</td>
</tr>
<tr>
<td>Storage + transhipment</td>
<td>2.1 kg CO(_2)e / t</td>
<td>n=58</td>
</tr>
<tr>
<td>Warehouse</td>
<td>17.5 kg CO(_2)e / t</td>
<td>n=49</td>
</tr>
<tr>
<td>Liquid bulk terminal</td>
<td>3.1 kg CO(_2)e / t</td>
<td>n=22</td>
</tr>
</tbody>
</table>

- ISO 14083: kg CO\(_2\)e / tonne
  - Work in progress!!
Emission intensity values for logistics hubs
- Work in progress -

**Carbon Footprint (CF)**

- Total CF of hubs
  - kg CO$_2$e / a

**Emission intensity**
- based on logistical area (indoors)
  - kg CO$_2$e / m$^2$

<table>
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<tr>
<td>Transhipment</td>
<td>16.7 kg CO$_2$e / m$^2$</td>
<td>n=61</td>
</tr>
<tr>
<td></td>
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<td>Storage + transhipment</td>
<td>28.0 kg CO$_2$e / m$^2$</td>
<td>n=124</td>
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<td></td>
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<td>64.4 kg CO$_2$e / m$^2$</td>
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<tr>
<td>Warehouse</td>
<td>23.6 kg CO$_2$e / m$^2$</td>
<td>n=138</td>
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<tr>
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<td>22.8 kg CO$_2$e / m$^2$</td>
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Why participating in the market studies?

Transparency & own values

Participating companies receive their individual GHG emission intensity values
- aligned with ISO 14083
- one hub = 1 HOC (hub operation category)

Use of the REff Tool® prepares for calculating total CF & elaborating more specific KPIs, e.g.
- elaboration of emission intensity values covering a number of comparable hubs (= HOC with multiple hubs)
- allocation at activity level, e.g., two KPIs per hub
- support in case of data gaps using KPIs of anonymised data base

Support of overall research on sustainability of logistics hubs & elaboration of average emission intensity values

Sample size:
- electricity: 786
- heating: 655
- fuels: 720
- refrigerants: 559
- packaging: 259
Market studies in GILA project
Extension of global coverage

Annual market studies will continue!

Timeline
- Collection of annual data continuously possible
- Deadline: May 31st
- Start of analysis: June 1st
- Publication of values: August
  online: https://reff.iml.fhg.de/

Participation via
- Osservatorio Contract Logistics “Gino Marchet” of Politecnico di Milano
- REff Tool® of Fraunhofer IML

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after 3rd study (2023)
Support our annual market studies
It is more than just receiving a single KPI

ISO 14083 (normative scope)
- Transhipment sites
- Energy & refrigerant related GHG emissions
- For electricity: location-based approach

ISO 14083 (optional scope)
- Warehouses
- Energy & refrigerant & (re)packing related GHG emissions

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Individually electricity mix at hubs
- Market-based emission factors
- Self-generation of power on-site

Allocation of consumption
- Transparency for identifying fields of action & elaborating decarbonisation roadmap

GHG assessment of logistics networks
- Direct use of provided data
- Import of individual KPIs in other tools
- Publishing of average KPIs in standards and other tools
- Quantitative basis for cost vs. CO2e redesign

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- GHG emissions per tonne
- GHG emissions per m², …

- Decarbonised KPIs
- Estimates for decarbonisation potentials & successes
Support our annual market studies
It is more than just receiving a single KPI

Structuring data over time allows for further outcomes

- GILA growing database will allow for segmentation + YoY analysis
- Internal benchmarks on specific activities enriched by GILA values
- Quantitative support while defining priorities of action
Electricity consumption per logistical area indoors or logistical real estates

Performance of (partial) sample shows pattern

Segmentation based upon internal activity or automation level might be very useful

- we need a larger sample!

- ambient real estates, n=433
- chilled real estates, n=42
- frozen real estates, n=11
Which share do logistics sites contribute to the total of GHG emissions?

- Still difficult to say: Not addressed by national statistics

- Some assumptions published
  - 13% of logistics emissions related to logistics buildings (global) WEF 2009
  - 11 - 20% of transport emissions related to warehouses (UK, US) McKinnon 2018
  - 15% of logistics emissions related to logistics nodes (Germany) Rüdiger et al. 2017

Use of initial KPIs elaborated in GILA for new estimates

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<td>n=21</td>
</tr>
</tbody>
</table>

On average ~ 25 kg CO₂e/m²
Decarbonising logistics hubs

- Footprint of logistics sites
  - $\sim 300$ Mio m²
- Average GHG-KPI
  - $\sim 25$ kg CO$_2$e/m²

$$\times$$

- $= \sim 7.4$ Mio t CO$_2$e

- In comparison German road transport:
  - 145 Mio t CO$_2$e (2022) [UBA 2023]
  - $\Rightarrow$ 40% $\cong 60$ Mio t CO$_2$e in freight transport

$\Rightarrow$ 11% of logistics emissions

- 90% of the operational carbon footprint$^{(1)}$ of logistics sites result from energy use; 67% from electricity
- The transfer towards electricity basing on renewable energy sources will impact carbon footprint decisively.
Decarbonising logistics hubs

A second, very rough estimate...

<table>
<thead>
<tr>
<th>Footprint of logistics sites [m²]</th>
<th>Average GHG-KPI [kg CO₂e/m²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>~ 60+ Mio m²</td>
<td>~ 25 kg CO₂e/m²</td>
</tr>
</tbody>
</table>

= ~ 1.5 Mio t CO₂e

~ 4.8% of logistics emissions

90% of the operational carbon footprint\(^{(1)}\) of logistics sites result from energy use; 67% from electricity

The transfer towards electricity basing on renewable energy sources will impact carbon footprint decisively.

GILA sample size: 439 sites offering storage and/or transshipment

Source: World Capital/OSIL, Guizzo.eu

Average value for all logistics real estates

In comparison Italian road transport:
- 109 Mio t CO₂e [2022 ISPRA]
- \(\approx\) 27% road freight \(\approx\) 30 Mio t CO₂e
SUSTAINABILITY AND GHG PERFORMANCE AT LOGISTICS HUBS

Joint webinar of the GILA project and ETP ALICE

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  Jan-Philipp Jarmer, Fraunhofer IML
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Decarbonisation measures
Analysis of 31 design variables referred to 6 different areas of intervention

Green building & yard
- Thermal insulation, loading docks with insulated doors, cool roof, green roof, biodiversity

HVAC
- Heating, ventilation, air conditioning, MH - material handling, MHS – material handling systems

Lighting
- LED lamps, natural lighting & white walls, solar tubes, sensors for reducing lighting consumption

Material handling & automation
- Lithium-ion batteries, hydrogen powered fuel cell forklifts, hybrid forklifts, high frequency battery charging, sensors for reducing MHS consumption, energy recovery during braking

Materials management
- Packaging reduction, separation of waste fractions for better recycling, packaging reuse & recycle, use of renewable & biobased materials, use of recycled materials

Utilities
- Self-generated power, photovoltaic, solar panels, wind power, fuel cells or batteries for energy provision, smart HVAC systems, rainwater collection & reuse systems, smart metering/data collection

Operational practices
- Travel distance optimization for MHS, optimal planning for MH activities & battery charging, optimized location of charging equipment

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see also Perotti et al. (2023)
**Decarbonisation measures**

*Current adoption vs. prospective scenario: an overview*

- **Materials management** (91%), **lighting** (73%), and **operational practices** (68%) appear the major areas of intervention in terms of current adoption and priority for future interventions.

### Green measures at logistics sites

<table>
<thead>
<tr>
<th>Green building</th>
<th>Utilities</th>
<th>Lighting</th>
<th>Material handling &amp; automation</th>
<th>Materials management</th>
<th>Operational practices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implemented</td>
<td>Prioritised as high or medium</td>
<td>Sum</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Green building
Current adoption vs. prospective scenario

► 153 sites provided answers on the measure “Thermal insulation”, half of which have implemented it.
► Loading docks with insulated doors is another widespread solution (55 sites).
► Innovative solutions such as cool roof and green roof are still scarcely adopted.
Utilities
Current adoption vs. prospective scenario

- **Photovoltaic panels** (72 sites) for own use and **smart HVAC systems** (44 sites) are particularly widespread.

- Priorities for **future** interventions seem to highlight a market interest in **smart metering** (34 sites), followed by rainwater collection and reuse systems (25).
LED lighting (160 sites) together with sensors for reducing consumption (118 sites) are the most implemented solution by far.

A relevant share also uses natural lighting and white walls (49%) for energy efficient working conditions.
Current adoption is mainly concentrated on **forklifts**, especially on the implementation of lithium-ion batteries (85 sites), **high-frequency battery charging** (60 sites) or **fuel cell/battery hybrid forklift** (39 sites).

Lithium-ion batteries are **also prioritised** as high or medium for future implementation in 25 sites (18%).
Operational practices
Current adoption vs. prospective scenario

- Improvement by **optimising the location of charging equipment** of material handling system has been adopted by 50 sites, followed by **optimal scheduling of MH activities and battery charging** (42 sites).

- **Energy efficient behaviour** is also quite common (30 sites) and has emerged as a clear focus for future implementation (63%).
High adoption: the main levers for companies involve **actions on the packaging materials used**, according to two main strategies:

- adopting more sustainable **materials** (local sourcing, renewable/bio-based materials), and
- working on **processes** (packaging reduction, enhancing materials reuse and recycle)
Summary on decarbonisation measures

- Main focus on **lighting**, **materials management**, and **operational practices** with these latter two being the major areas in terms of **priority** for future interventions.

- **LED lighting** often coupled with **sensors for reducing consumption** are confirmed as particularly widespread.

- As per materials management, improved **materials** and more **efficient processes** appear as the key actions.

- Operational practices often entail both a focus on **MH optimisation** (charging location and scheduling) and an overall commitment towards **energy efficient behaviour**.
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In achieving a climate-neutral building sector (85-95 % of the building stock will exist in 2050), the existing buildings must be strongly considered and renovated.
Master model for sustainable prototype

► Assessment and Benchmarking of existing Construction types

**STEP 1**
18 Halls* were inspected in Germany in 2021 - 2022

**STEP 2**
Type of use
Asset type
Size
Year of construction / modifications
Energy certificate

**STEP 3**
3a Capex
3b Carbex

Capex = Capital Expenditure
Carbex = Carbon Expenditure

Data Collection via site visits & experience
Organization and Grouping of Information
Benchmarks
The benchmarks were separated into three tables based on the condition of the buildings at the time of assessment (good = markup of 1, fair = markup of 1,1, poor = markup of 1,2).

The life cycle costs of different building equipment to determine the required investment for maintenance were considered.

### Example:
An office building constructed in 1990 (age ca. 30 years) and a fair condition has the following Capex (€/sqm) for the next 10 years (2023 – 2032, depending on date of assessment):

<table>
<thead>
<tr>
<th>Year</th>
<th>Capex (€/sqm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2023</td>
<td>20,24</td>
</tr>
<tr>
<td>2024</td>
<td>80,96</td>
</tr>
<tr>
<td>2025</td>
<td>101,20</td>
</tr>
</tbody>
</table>

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**Master model for sustainable prototype**

- Assessment of existing Construction Types
- Capex = Capital Expenditure
The benchmarks were separated into three tables based on the condition of the buildings at the time of assessment (good = markup of 1, fair = markup of 1,1, poor = markup of 1,2).

The required investment to transform the existing buildings towards zero carbon buildings, were considered.

Example: An office building constructed in 1990 (age ca. 30 years) and a fair condition has the following Carbex (€/sqm) for the next 10 years (2023 – 2032, depending on date of assessment):
By considering Capex + Carbex, the following values per time span should be considered:

<table>
<thead>
<tr>
<th>Invest</th>
<th>Year 1</th>
<th>Years 2-5</th>
<th>Years 6-10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capex</td>
<td>20,24</td>
<td>80,96</td>
<td>101,20</td>
</tr>
<tr>
<td>Carbex</td>
<td>8,47</td>
<td>33,88</td>
<td>42,35</td>
</tr>
<tr>
<td>Sum</td>
<td>28,71</td>
<td>114,84</td>
<td>143,55</td>
</tr>
</tbody>
</table>

Results:

- Initial benchmarks for the respective clusters were produced. These benchmarks referred to similar asset classes on similar construction years, whereby the energy consumption, maintenance and repair costs, as well as CO2 emissions were determined and compared.

- From this evaluation, it was possible to see how legal changes to energy-saving measures (respective amendment of the EnEV and GEG) reduced the energy consumption including the respective emissions of the individual logistics halls.
Developing a Sustainable Asset Tool

The model/sustainable asset tool is developed as a dashboard with the objective to be:

- Easy to use and understand.
- Show numerous data visualizations side by side.
- Provide a general transparent summary information (quality related to the amount of information available).

The objective of this tool is to provide a platform for owners, FM, researchers, etc., to make better, more informed and data-driven decisions regarding actions that can be used as roadmap towards sustainable logistics sites.

The outcomes are:

- Embodied carbon benchmark
- Summary Report on Capex (Maintenance Technical Expenditures) and CarbEx (Carbon Expenditures)
- Summary Report on inflation rates
Dashboard - How our solution works?

1. Get Data
   - ESG
   - CDD
   - Reports
   - Clean, Prepare & Manipulate Data

2. Train Model & Validation
   - Benchmark/Data Set creation

3. Test Data
   - Dashboard creation

4. Improve
   - User input - test run

5. Benchmark expansion + Machine Learning
Dashboard visualization
Thank you for your participation!

Slides of the webinar are provided on [https://reff.iml.fhg.de](https://reff.iml.fhg.de).
References

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