**INTERNATIONAL SYMPOSIUM INDUSTRY AND ENERGY**

**Logistics: climate protection measures**

**for small and medium-sized enterprises**

***Logística: medidas de protección del clima***

***para las pequeñas y mediana empresas***

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**Abstract:**

* **Problem:** Companies are facing major challenges regarding their logistics services processes and systems. Because traffic volume, consumption of natural resources and occurrence of climate catastrophes are increasing, also the awareness of consumers as well as political and social attention are growing. The goal is to shape logistical processes and systems in an energy- and resource-efficient way to make them climate-friendly. The high number of available measures makes it difficult, especially for small and medium-sized enterprises, to identify the relevant ones and to evaluate them.
* **Aims:** The following research questions should be answered:

(1) Which political measures promote climate protection for small and medium-sized enterprises in Germany?

(2) Which climate protection best practices exist in Germany in the logistics sector?

(3) How can small and medium-sized enterprises be supported in choosing and prioritising climate protection measures?

* **Methodology:** The methodological basis is a literature analysis. Different assessment methods were selected, used and adapted.
* **Results and Discussion:** Climate protection best practices in logistics in Germany were researched and analysed. A way of presentation was developed that enables companies to quantitatively evaluate measures based on scientifically developed criteria. The final result is an open catalogue of measures, which facilitates the selection of climate protection measures for companies.
* **Conclusions:** A contribution is made to applied research in climate protection in logistics. The method can be transferred to other countries, regions and economic areas or used globally.

**Keywords:** Logistics; Sustainability; Small and medium-sized enterprises; Climate protection; Climate protection measures

***Palabras Claves:*** *Logística; Sostenibilidad; Pequeñas y medianas empresas; Protección del clima; Medidas de protección del clima*

1. **Introduction**

**1.1 Climate protection, climate change, carbon footprint**

Climate protection is part of environmental protection and defines measures that are taken to counteract global warming and the associated climate change [1]. Important in this context is sustainability. Sustainability means " development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It is important to equally consider the three dimensions of sustainability - economically efficient, socially just and ecologically viable. In order to preserve our global resources in the long term, sustainability should be the basis of all political decisions". [2]

The climate is essential for nature and human life. The Earth's climate system is highly complex, so that even small changes have an impact on the system as a whole. In recent decades, our climate has changed dramatically. The reasons are greenhouse gases, especially carbon dioxide (CO2), but also methane, nitrous oxide or the fluorinated gases HFC, PFC and SF6. CO2 is mainly released by burning fossil fuels to generate electricity, to supply heat in buildings, in industry or in transport. (cf. [3][4])

There are various approaches to protect the climate. The German government, embedded in the European Union and the global context (especially the G20), is trying to set the course for more climate protection through laws, regulations and subsidies. Due to the need for action, all sectors of the economy are urged to do more for climate protection in order to achieve the climate protection goals. [5] The consequences of climate change must be mitigated or prevented.

There are several options to achieving the climate protection goals. In general, the principle of "avoidance before reduction before compensation" applies. The highest priority is to avoid harmful greenhouse gases. If this is not possible, these gases should be reduced. The next group of measures considered is the compensation of unavoidable relevant emissions through, for example, the purchase of emission mitigation certificates from recognised climate protection projects. The last category comprises adaptation measures that are necessary if global climate protection measures are not sufficient to avoid negative consequences.

Possible options for action in the climate crisis are:

(1) Climate protection through **sufficiency** (saving by doing without e.g. superfluous packaging)

(2) Climate protection through **consistency** (savings through other, cleaner technologies - running electric engines on low CO2 energy)

(3) Climate protection through **efficiency** (savings of energy and resources - more fuel-efficient engines)

(4) Climate protection through technical or biological **CO2 storage**

(5) **Adaptation** measures to increase resilience (mitigation of negative impacts).

These groups of measures correspond to a prioritisation.

In order to ensure one's own climate neutrality or to identify one's own optimisation potential, a carbon footprint should be drawn up. [6]

**1.2. Relationships between climate change and logistics**

Logistics as a service is provided by companies that can be classified as 1PL to 5PL. [7] They are Internal self-provision of logistics (1 PL), Individual service provider (2PL), Association service provider (3PL), System service provider and Network Integrator (4PL) and Network Manager (5PL).

The logistics sector is a source of emissions through its technical infrastructures, systems and processes (e.g. transport: road, water, air, rail, intralogistics solutions, global supply chains for procurement, production, distribution and disposal). The positive change of logistics processes, systems and infrastructure (options 1 to 4) can make an effective contribution to climate protection and offers important parameters for reducing necessary energy and emissions. The logistics sector thus has an important role in climate protection, alongside other sectors, such as energy, agriculture or industry.

At the same time, logistics itself is directly affected by climate change. Extreme weather events (e.g. storms, heat, hail or heavy and continuous rain) often lead to damage to infrastructure. This has a negative impact on e.g. safety, economic efficiency, adherence to schedules or even the basic feasibility of logistics processes. For manufacturing companies, meeting deadlines is very important: delays or failures of transports influence production processes or entire supply chains. High temperatures, for example, overheat the interiors of vehicles with a negative impact on workers and transported goods or it can cause damage to roads and infrastructure. The same applies to rail transport. Heavy rain can flood and wash out rails. Intense heat can lead to deformation of the rails. Storms can cause damage to overhead lines. These are just some of the effects that can affect transport (cf. [8]). Acting on these impacts corresponds to option 5 “adaption” and addresses issues such as how to upgrade infrastructure and logistics processes, systems and objects to make them more resilient to climate change.

In order to provide support for small and medium-sized logistics companies, the following research questions are to be answered:

(1) Which political measures promote climate protection for small and medium-sized enterprises in Germany?

(2) Which climate protection best practices exist in Germany in the logistics sector?

(3) How can small and medium-sized enterprises be supported in choosing and prioritising climate protection measures?

**2. Methodology**

The methodological basis is a literature analysis. It was conducted on the internet, as many original sources coming from political institutions are only published online. On this basis, the research results were systematically recorded in terms of data and condensed into overviews. For the implementation of the evaluation, evaluation methods were selected, used and adapted. From the available repertoire (cf. [9]) of more than 60 methods, the classic utility-cost analysis, the CIS spider and the portfolio analysis were selected as evaluation methods and applied case-specifically, including the definition of evaluation variables and tables, the determination of weighting factors, the performance of a reference evaluation and the discussion of the results. The selection and definition of the evaluation criteria as well as their quantification and combination are the scientific challenges. In addition, there was the requirement not to carry out a complicated pseudo-assessment, but to develop a simple and transparent tool for direct application in companies.

On the one hand, the approach of the Climate Change Performance Index (CCPI) was used as a methodological basis. [10] CCPI is an independent monitoring tool for tracking countries` climate protection performance. It enables comparison of climate protection efforts and progress made by individual countries. The climate change performance is assessed in four categories:

(1) GHG Emissions (40% of overall score);

(2) Renewable Energy (20% of overall score);

(3) Energy use (20% of overall score);

(4) Climate policy (20% of overall score) [10].

These four aspects, their weighting and the underlying indicators of the CPPI were modified in order to evaluate measures taken by companies.

On the other hand, a similar approach was taken to the examination and evaluation of municipal draft resolutions for climate relevance [11]. In this way, the influencing variables were described qualitatively.

**3. Results and Discussion**

**3.1 Result 1: Support programmes for climate protection measures**

There are various laws and regulations that are intended to create incentives and have a regulating effect. (cf. [12]) Funding programmes are particularly interesting: They help companies with climate protection by providing financial support for climate-relevant measures. As result 1 to answer research question 1 (Which political measures should promote climate protection for small and medium-sized enterprises in Germany?), an excerpt of a compiled current overview of support programmes for companies with climate protection measures with a focus on logistics follows. (cf. Table 1)

Table 1: Excerpt of relevant funding programmes of the Federal Government with a focus on climate protection and logistics (own elaboration)

|  |  |
| --- | --- |
| Funding programme | Explanation |
| Energy consulting  (cf. [13]) | Subsidy for consultancy costs for measures to improve energy efficiency in companies (buildings, systems, user behaviour). |
| Efficient buildings  (cf. [14]) | Grant / loan for measures to promote efficient buildings (e.g. building shell, systems engineering, renewable energies for heating, connection, heating optimisation and digital consumption optimisation).  Must be used for at least ten years for the intended purpose. |
| Increasing energy efficiency in cross-sectional technologies  (cf. [15]) | Grant/loan for measures to replace or acquire new high-efficiency systems and aggregates for industrial and commercial use (e.g. motors, drives, pumps, fans, compressed air systems, insulation of industrial systems) |

Continuation Table 1

|  |  |
| --- | --- |
| Funding programme | Explanation |
| Increasing electric mobility in companies (cf. [16]) | Subsidy for measures to promote charging infrastructure in companies, thus promoting electromobility  Purchase and construction of charging stations for e-vehicles that are permanently connected to the power grid. |
| Increase in fuel cell-powered industrial trucks in companies (cf. [17] [18]) | Subsidy for measures concerning fuel cell-powered industrial trucks (industrial truck fleets)  e.g. forklift trucks, refuelling infrastructure, on-site production of hydrogen  Minimum number of ten vehicles required. |
| Climate-friendly trucks [Cf. [19]) | Subsidy to support the switch to environmentally friendly trucks (pure battery electric vehicles and fuel cell vehicles for freight transport)  Total weight of at least 7.5 tonnes. |
| … | … |

**3.2. Result 2: Collection and evaluation of best practices in climate protection**

Result 2 for answering research question 2 (Which climate protection best practices in logistics exist in Germany?) comprises the collection and analysis of relevant best practices. It represents an open collection that should be permanently supplemented. The measures are based on different starting points.

Examples of best practices in climate protection are:

* Means of transport (shift to environmentally friendly modes of transport, reduction of transport volume (bundling, consolidation), increase in transport efficiency (no empty runs, transport capacity utilisation), improved equipment (lightweight construction, energy-saving tyres)).
* Propulsion (electric motor with battery/hydrogen/synth fuels, hybrid technology)
* Packaging and loading aids (material, reusable, mass, optimisation of dimensions, handling)
* New link between production and logistics through new digital technologies such as 3D printing (most logistical flows are information; programmes, instructions and data are sent from source to destination and the product is manufactured directly at the destination).
* Warehousing (need for storage, cross docking, storage duration, storage conditions).
* Intralogistics (flexibility and modularity in new acquisitions, recuperation systems)
* Digitalisation (electronic documents (freight documents, loading lists, pick lists), telematics systems, improved route and tour planning, parking management)
* Employee deployment, training and motivation (home office, paperless office, energy saving, consumption-minimising driving, ideas for improvement)
* Buildings (insulation, use of renewable/solar energy, combined heat and power, smart and efficient lighting)
* Energy management systems (cooperation, location)
* Holistic optimisation of logistics chains (including production, procurement, distribution, disposal) and influencing customer requirements.
* Creation of green/blue infrastructure (greening/planting, water storage, water consumption)

Table 2 explains three exemplary measures in terms of the associated advantages, disadvantages and requirements.

Table 2: Small excerpt of climate protection measures (best practices) in logistics  
(own elaboration)

|  |  |  |  |
| --- | --- | --- | --- |
| Measure | Advantages | Disadvantages | Requirements |
| Change of packaging  e.g. [20] | * Reduction of packaging volume * Reduction of shipping costs * Reduction of resource consumption/ energy demand/ costs * Avoidance of packaging steps (process improvement) * Cheaper disposal, if necessary, reusable packaging for short delivery route | * Costs for alternative packaging can be higher * Great variety of packaging due to more packaging variants | * Testing suitability of alternatives |

Continuation Table 2

|  |  |  |  |
| --- | --- | --- | --- |
| Measure | Advantages | Disadvantages | Requirements |
| Software for ecological  Route Planning  e.g. [21**]** | * Low fuel consumption * Emission reduction * Air pollution reduction | * System changeover can lead to difficulties at the beginning | * Procurement. Installation, training and use of the software |
| Inter-company cooperation (e.g. freight exchange)  e.g. [22**]** | * Optimum utilization of cargo space * Reduction of partial loads * Reduction of costs * Reduction of fuel consumption * Reduction of air pollution | * High organizational effort * Cost of uniform ordering system | * Confidence * Uniform quality level * Similar customer structures * Similar products * Comparable volume * Exchange of sensitive data (customers, costs, prices) |
| … |  |  |  |

**3.3. Result 3: Assessment of climate protection measures**

Result 3 answers research question 3 (How can small and medium-sized enterprises be provided with an overview and support in prioritising climate protection measures?) All measures (political, best practices, supplemented by own, company-specific measures) should be evaluated holistically. Before concrete measures are tackled, an analysis and discussion of the company's strategic orientation should take place within the company. This step corresponds to the so-called materiality analysis in sustainability reporting, whereby the interests of the company stakeholders as well as the relevance of various company activities for sustainability aspects are compared - in other words, it is examined: What is relevant for the company and at the same time relevant for climate protection? (cf. [23])

The following criteria are used as examples and quantified in evaluation tables. They consider individually and in part summarily the effect of the measures according to type and scope (minor to major):

* Climate friendliness (CO2 savings in %, savings of other greenhouse gases in %, reduction of soil sealing, change in people's thinking for more climate protection).
* Energy efficiency (efficiency in %, share of renewable energy) (cf. [24] [25])
* Resource efficiency (abiotic and biotic raw materials, soil movements, water consumption, air pollution (cf. [26] and [27], consideration of the entire life cycle)
* improvement of processes (e.g. time, quality, performance, effort, area, volume, resilience, safety)

And on the other side the implementation and use conditions:

* Investment (investment costs, grant/loan, cost savings).
* Implementation period (implementation time)
* Useful life (useful life in years)

By assigning points and comparing the totals, different measures become comparable. For the evaluation, seven value tables were drawn up and standardised with 0 to 5 points or 1 to 5 points.

The weighting factors were not determined by a weighting procedure, but by asking experts, and were deliberately weighted equally. Subsequently, the evaluation of the measures was carried out on the basis of the evaluation tables. An example is shown in Table 3. The contribution to process improvement can also be evaluated (+1 for minor improvements or +2 for mayor improvements) additionally to the evaluation regarding to the climate protection effect. This contribution to process improvement, which is essential for logistics, was recorded separately.

Table 3: Example for the valuation of climate protection measures: Non-monetary benefits part  
(own elaboration)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Climate protection benefits | | | **Subtotal**  **Climate protection effect** | Benefit in terms of  the improvement of processes |
| Climate protection measure | Climate friendliness | Energy efficiency | Resource efficiency |
| KSM1 Change of packing | 3 | 0 | 1 | **4** | 0 |
| KSM2 Ecological route planning | 1 | 0 | 2 | **3** | 1 |
| KSM3 Inter-company cooperation | 3 | 0 | 2 | **5** | 2 |
| KSM4 E-TRUCK | 5 | 3 | 0 | **8** | 0 |

Three indicators were selected to simplify the assessment of the investments. (cf. Table 4) There are three classic ways of taking costs into account: using the costs separately as a monetary value, forming quotients from the ratio of points and costs or transforming the costs into points (cf. Table 4). The third option, the formation of points and sums, was omitted here.

Table 4: Example for the evaluation of climate protection measures: Investment appraisal  
 (own elaboration)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Investments | | | **Subtotal**  **Investments** |
| Climate protection measure | Cost | Realization time | Service  life |
| KSM1 Change of packing | 3 | 5 | 3 | **11** |
| KSM2 Ecological route planning | 3 | 4 | 5 | **12** |
| KSM3 Inter-company cooperation | 1 | 1 | 3 | **5** |
| KSM4 E-TRUCK | 1 | 1 | 3 | **5** |

Figure 1 shows the summary presentation of the assessment results from tables 3 and 4 in a portfolio. From this, the recommended order KSM4, KSM1, KSM2, KSM3 can be seen. This prioritisation of climate protection measures provides small and medium-sized enterprises with a recommendation for action.

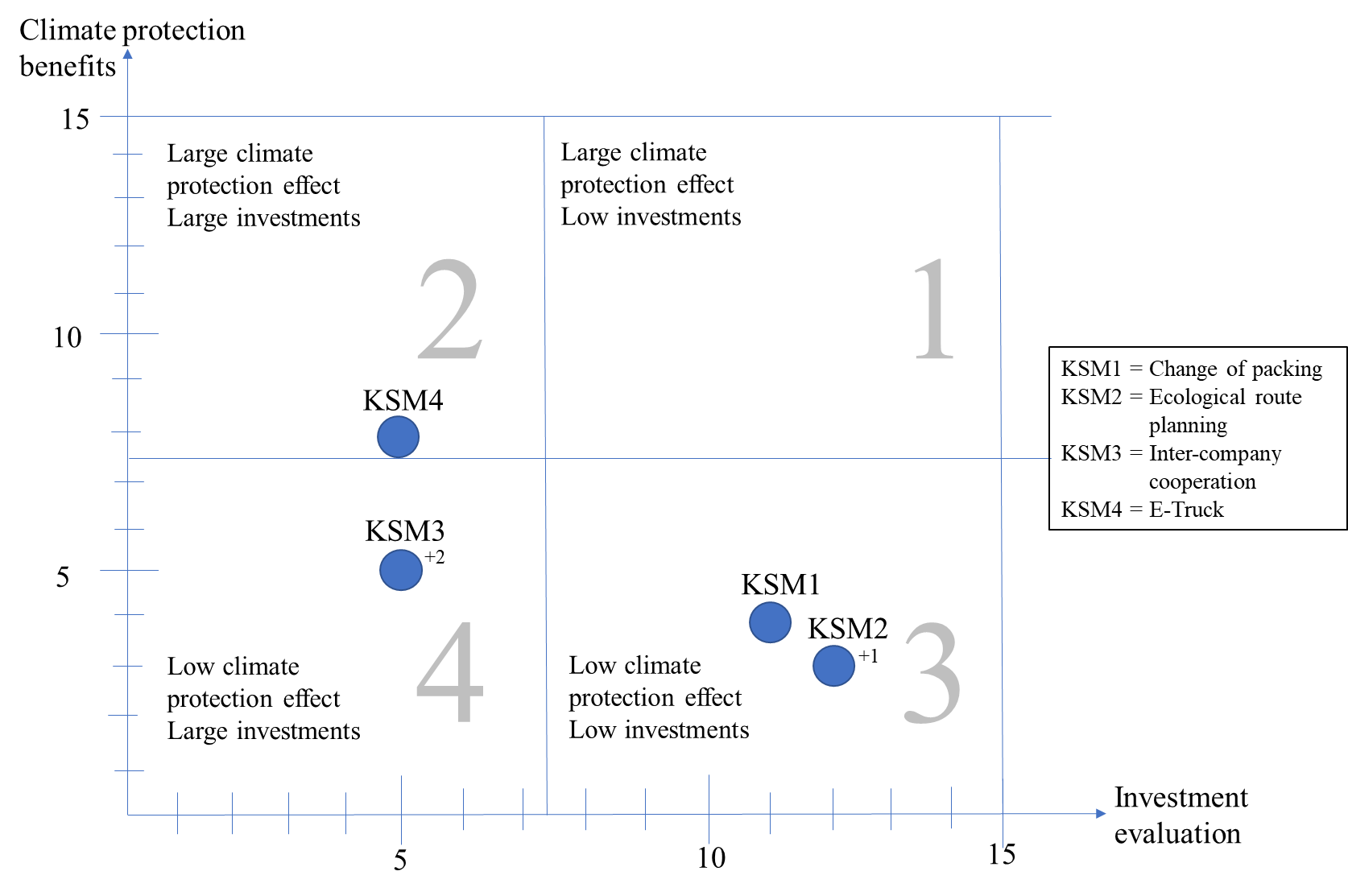


Figure 1: Example for the evaluation of climate protection measures

(own elaboration)

**4. Conclusions**

In summary, it can be said that it is not only necessary but also possible to successfully implement climate protection measures in companies with regard to logistics. This was shown by the examples from the companies, especially the "best practices".

The evaluation of the measures based on the criteria makes it clear that not all goals can be fully achieved. There are trade-offs that have to be prioritised on the basis of internal company goals and climate aspects that are considered relevant. For example, CO₂ emissions can be reduced, but since this requires the use of resources, simultaneous conservation of resources is not well possible.

Due to the topicality of the issue, many companies are eager to implement measures in their own companies. This was shown by the research during the processing. The companies receive support from the federal government's funding programmes, which serve as an incentive and motivation for the companies. The evaluation method developed contributes to applied research in climate protection in logistics. It helps to address the frequently perceived contradiction between climate protection and cost optimisation in a structured way and thus to solve it. The method can be transferred to other countries, regions and economic areas or used globally. The experience gained from the application of the method should be used to validate the method in terms of its usefulness. Further measures and best practices should be integrated and evaluated with the presentation method. While the urgency for implementing climate protection measures increases with time and climate change, it is becoming increasingly difficult to achieve further savings in the ongoing process of reducing emissions.

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