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Sustainable Strategies for Ports

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Sino-German Cooperation on Mobility and Fuels Strategy (MFS) as a Contribution to the Mobility and Transport Transition

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Sustainable Strategies for Ports

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Preface

The study “Sustainable Strategies for Ports“ (Topic 3) developed within the scope of the MKS China mobility and fuel strategy was carried out by the Fraunhofer Institute for Material Flow and Logistics IML and the PTV Group in cooperation with the ‘Gesellschaft für Internationale Zusammenarbeit’ (GIZ) in China and the Tianjin Research Institute for Water Transport Engineering (TIWTE). In parallel the studies “Analysis and evaluation of energy efficiency in automated container terminals“ (Topic 1) and ”Shore-to-Ship power“ (Topic 2) were developed.

The port of Tianjin is the main port of the Beijing region in China and is situated approximately 60 km east of the city of Tianjin on the western shore of Bohai Bay. In 2018 a handling capacity of 15.97 millions TEU (Twenty Foot Equivalent Unit) was reached. (Tianjin Port Development Holdings Limited 2019)

Within the last year the Tianjin Port (Group) Co. Ltd. established its ”Three-year Plan for Construction of an Intelligent Tianjin Port”. (TJBH 2018) That covers 29 projects in five fields focusing on the development of an information-based, worldwide leading, and modern port by modernization and transformation. In addition to economic goals also those of sustainability should be attained, so that the port of Tianjin is developing not only to an intelligent one, but also to a green one.

A green transformation is not new for the port of Tianjin. Environmental protection had been started here already in the 1970ies. In the course of this many efforts were made to improve the environmental quality of the port, e.g. by realizing the ”Green Water Project“ aiming on protecting the port waters against contamination. The realization of the „Blue Sky Project“ served to improve the air quality of the port as well as to boosting environmental management.

Objective of this study is to make a comparison analysis of measures of Chinese ports and international ports and to classify the sustainable port development and strategy of Chinese ports. For this purpose, single measures will be registered and structured in view of their effects, common features and deficits will be identified and discussed. The analysis is developed from works and input by TIWTE and the GIZ and on those being made for the Chinese ports on the one hand. On the other hand, those were used to be able to compare them with strategies and measures on the German and international side. Due to the limited project frame, interviews and discussions with representatives in China were not possible. Against this background, this study has to be understood as a simple, comparing analysis on green ports in China and Europe serving for deducing further recommendations for action.

1 Introduction

The following chapter serves as an introduction to the background of the study (cf. chapter 1.1) as well as the clarification and objective of the study on hand (cf. chapter 1.2). Finally, the resulting proceeding of the study will be explained (cf. chapter 1.3).

1.1 Thematic background

The necessity of green and sustainable strategies is indispensable in the field of logistics. Nevertheless, in the past relevant topics in sea ports were subordinated to port strategy or considered as additional effort and therefore applied only locally. Sustainability considered pure ecological aspects, only. Nowadays, sustainability has matured to a fundamental pillar of the entire port strategy and covers an equally important consideration of the even contrary ecological, social and economic aspects aiming on the realizability of environmental and social compatibility with simultaneous economic success. (Wels and Kettner 2016) As a result, ports find themselves on the fine line between the factors of efficiency, growth, sustainability, transport and logistics. So, ecological sustainability increasinlgy comes into the focus of local politics and port operators and customers as well. (Parola et al. 2017)

“Green Logistics“ is not imaginable and resp. realizable without “Green Shipping“. Regarding road as transportation mode, within the past years there was no consequent development to reduce the emission of pollutants, which is to be reduced considerably in the coming 10 years. In the course of this development the transport means ship is far behind, since now fossil fuels like heavy oil or diesel generators are being applied for power generation during the turnaround times of the ships. Therefore, shipping is one of the main CO2-emittents. (Wissenschaftlicher Beirat für Verkehr 2008)

The rethink within port strategies mentioned above is caused by climatic change, a growing destruction of the environment and shortage of natural resources. (Straube et al. 2010) As a result, politics and industry respond with installing tighter limit values. Furthermore, the availability of alternative drive technologies as well as fuels and improved frame conditions are due to the rethink and a driver for ”Green Shipping“. (Ehrmann 2017)

1.2 Objective

Improving the sustainability within its operational processes the port of Tianjin attained important milestones in the field of green logistics in the past. Based on this the study will use the collected experience and achievements of the port of Tianjin to furthermore identify other fields and measures of the port of Tianjin, which have been scarcely or not considered until now. These measures will be examined more detailed and forwarded as summarized recommendations for action.

The primary objective of the study "Green Ports – Sustainable Strategies for Ports" is to support the port of Tianjin as well as other Chinese sea ports in further sustainable development and to accelerate further measures within defined fields of action. With the aid of a comparison of measures to be taken in selected international and Chinese ports to realize green port strategies the recommendations for action mentioned above will be made. Furthermore, the "Standard for Green Port Grade Evaluation" (JTS/T 105-4-2013) will be explained and its deficits identified so that – in addition to technological recommendations for action for port operators – also organizational recommendations for action for political decision makers can be made.

1.3 Proceeding

The theoretical part of the report categorizes the term of green logistics and demonstrates its relevance. Furthermore, it deals with green logistics in sea ports (cf. chapter 2).

The main part is divided into two sections and based on the data exchange as well as on data acquisition between the PTV Group, GIZ, TIWTE and Fraunhofer IML. The first sector describes five fields of action. The fields of action are the starting point for a search of measures within international context (Best Practices). The searched resp. inquired measures within the fields of action will be compared with each other and described (cf. chapter 3) on the one hand. On the other hand, the "Standard for Green Port Grade Evaluation" will be explained and evaluated (cf. chapter 4). For this purpose GIZ provided an English translation. The chapter „Recommendations for action" concludes the second section of the main part and recommends measures in the context of sustainable development of sea ports in China as well as also further additions for the use of the "Standard for Green Port Grade Evaluation" for political decision makers (cf. chapter 5). A final examination (cf. chapter 6) completes the study. Figure 1 visualises the schematic structure of this study.

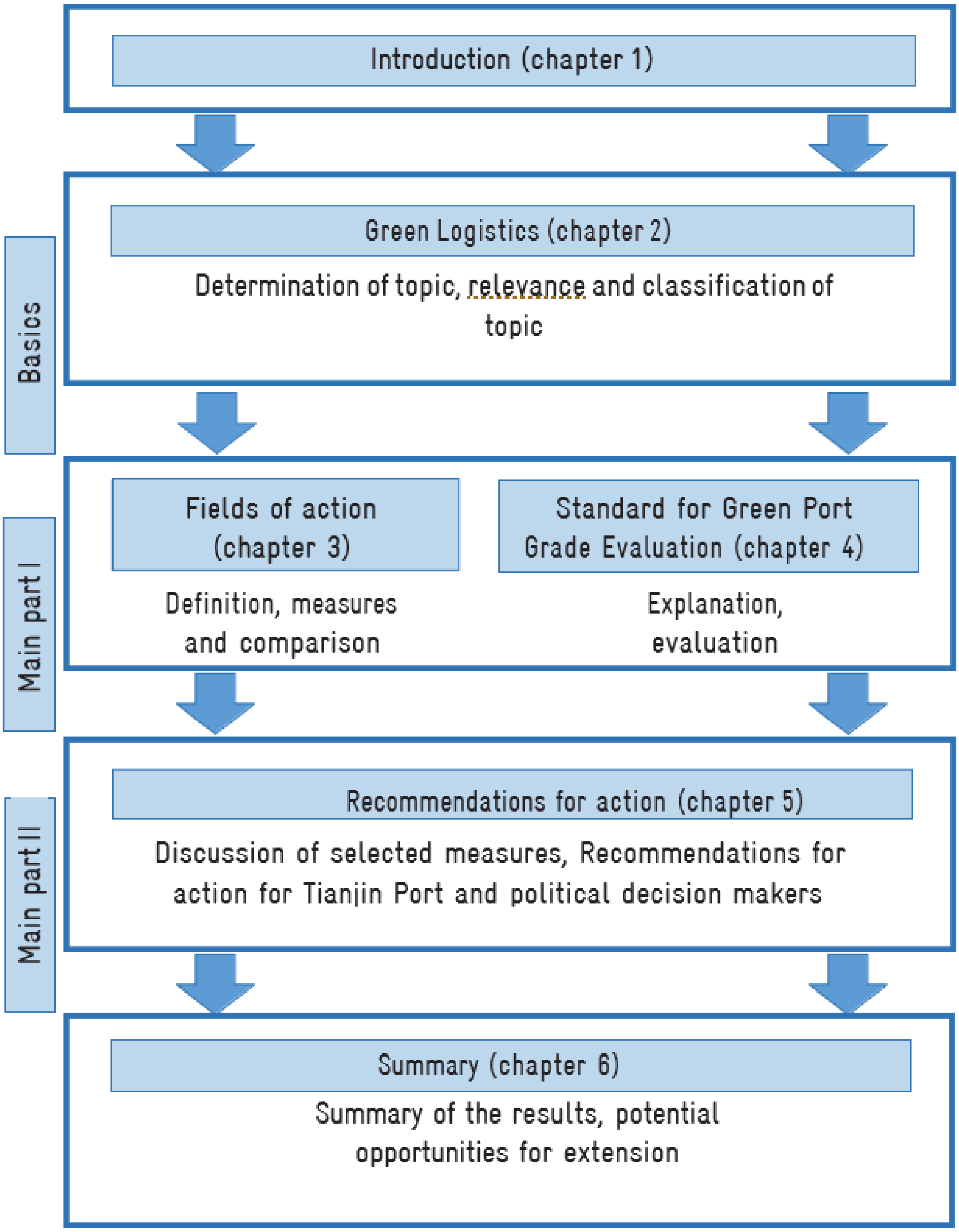


Figure 1: Schematic Structure of the Study

2 Green Logistics

The following chapter serves to categorize the term of green logistics (cf. chapter 2.1). Furthermore, the relevance of the ecologic sustainability of logistic processes in sea ports will be examined (cf. chapter 2.2).

2.1 Definition of Term and Relevance

Green logistics stands for ecological evaluation of logistic activities in various fields. Methods and solutions for a comporehensive, integrative, standardized evaluation in conformtity with origin can be determined. In detail these factors mean the examination of environmental effects, a transparent, consistent and comparable proceeding (Best Practices) as well as standards and regulations being developed and put in concrete terms. (Green Logistics Network) According to Lohre 2010 green logistics covers all measures reducing transport and transport-related emissions, e.g. grouping and tour optimization as well as utilization optimizations. In general green logistics means the attempt to reduce transport-related environmental impacts.

Kriwall et al. are defining logistics as a business unit making up a large part of the detrimental environmental impacts as e.g. emissions, area sealing, noise. Therefore, logistics provides a high ecological optimization potential. (Kriwall et al.)

Within sea ports logistics cannot be understood as part of a business unit. This, however, is more a part of an overall logistic system, i.e. serves for the realization and maintenance of global supply chains.

In addition to maritime emissions caused by ships and those caused by harbour hinterland transports, port terminals as complex systems have numerous potential sources for carbon dioxide emissions. (Yang et al. 2017) Those will be analyzed in detail in the scope of the scientific consulting by the German Federal Ministry of Transport and Digital Infrastructure (BMVI) on the mobility and fuel strategy "MKS China: Green Ports Topic 1: Analysis and evaluation of energy efficiency in automated container terminals". Here they only serve as an overview of the variety of emission sources and demonstrate the relevance of green logistics in ports being dealt with more detailed in the following chapter. The following figure visualizes direct and indirect emission sources of a port-integrated logistic system.

2.2 Green Logistics at Sea Ports

Sea ports play an important role as gateway to worldwide trade and therefore fulfil more than just the function of handling goods. The area of influence of sea ports does not only reach to the sea, but also far into the hinterland. The port strategy is closely linked with interest groups and stakeholders. Due to this a local as well as a global link are existing. Therefore, within the transport chain a sea port has the potential to socially and ecologically influence the efficiency of the entire transport system. (Bergqvist and Monios 2019)

The Kyoto Protocol, concluded in 1997 and has become effective since 2005, covering legally binding emission guidelines, does not examine the aspects of aviation and navigation (Cullinane, K. and Cullinane, S. 2013), because those are not classified as being directly and locally detrimental to health for human beings. (World Health Organization 2016) The "Paris Agreement" currently integrates aviation and navigation in the focus of a sustainable examination. It is, however, noticed that definite steps or measures have been still missing and finally only demands towards the International Civil Aviation Organization (ICAO) and the International Maritime Organization (IMO) are existing. (Europäisches Parlament, 2015; Deutscher Bundestag)

The maritime sector is a field providing an enormous potential for CO2 saving. Previ-

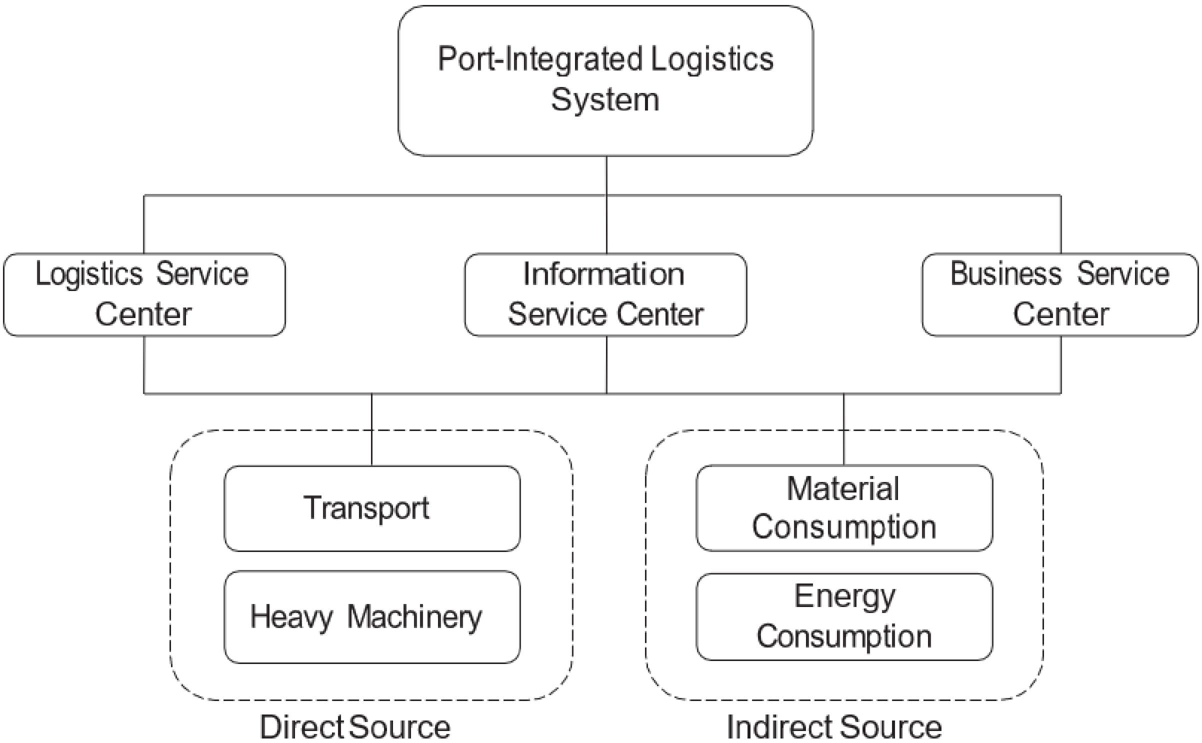


Figure 2: Emission sources in a port-integrated logistic system (Yang et al. 2017)

ous studies especially focused on the emission of pollutants of ships (Smith et al. 2014), in view of a sustainable green strategy in ports, however, it is necessary to take more factors as noise, dust, waste and water pollution into consideration. (Ng and Song 2010) Therefore, a green port strategy has to cover also the wide field of the protection of eco-systems and their sustainability. In consequence, socio-economic aspects play a big role to develop a green comprehensive port strategy. (Schipper et al. 2017)

Various activity fields of green logistics in sea ports can be distinguished which are applied not only locally in the port itself. Shipping companies, harbour hinterland protagonists as well as political decisions are playing an important role. The field of activity directly situated in sea ports covers emissions of ships to be reduced by cold ironing during a stay, by the use of liquified natural gas (LNG) as fuel and by a speed control. (Bergqvist and Monios 2019) In the following these measure will be described in detail.

Cold ironing of ships describes the process of keeping the generators of a ship in operation during the time the ship is in port to maintain all other funcions on board. This kind of electricity supply should reduce the emissions of ships during their stay in port. The reduction to be potentially attained is, however, dependent on the regenerative energy used or on the power supply of the respective country, otherwise the presumed positive effect will be offset. (Bergqvist and Monios 2019) Studies by Winkel et al. showed that the potential use of regenerative energies in the year 2020 by all European ports can lead to a reduction of 800 m tons of CO2. (Winkel et al. 2016) The minimal relevance of this factor is demonstrated by the low number of 28 ports worldwide supplying ships by cold ironing. (WPCI 2018) Reasons for this are to be found in the investment costs of the respective infrastructure on side of port as well as in the connection system on ships which is amortizing only at a high degree of utilization. (Sciberras et al. 2017, Innes and Monios 2018) For the latter the utilization of electricity is very attractive, since it is significantly cheaper than corresponding fuel.

The utilization of LNG as drive type is an attractive variant to reduce CO2 emissions. (Styhre et al. 2017) Simultaneously challenges are rising regarding the infrastructure on the open sea such as charging stations and their supply. The utilization of LNG is nearly emission-free, that being an important factor especially concerning sea port situated near to towns. In addition to that the investment costs are lower than for utilizing cold ironing, however there is no reduction of the sound volume of ship motors.

Additionally, preventive reduction of the vessel speed can also serve to reduce fuel and thus emissions, too. (Winnes et al. 2015) Furthermore, small and medium ports have the opportunity to actively reduce their emissions, as e.g. modern handling systems, differentiated port and terminal costs as well as the implementation of a modern energy system. (Wilmsmeier 2016) A general energy management system and the generation of own green energy (wind power, solar cells, thermal power stations) by the port shows that it can manage supply and need independently and simultaneously potentially reduce costs and environmental impacts. (Acciaro et al. 2014) With the aid of turbinese ans solar cells ports are able to generate power and to apply it for electricity supply. Especially countries with a sustainable power generation have the potential of maintaining sustainable supply. (Bergqvist and Monios 2019) Furthermore potential general handling fields can be detected. Differentiated port fees as well as a transport shifting to the hinterland reduce the emissions of the entire system of a port. (Bergqvist and Monios 2019)

Concluding, sea ports are commercially operating enterprises, respectively, and therefore do not make investments being unprofitable for the short term from their pont of view. For this reason it is important to take the future challenges and limitations as well as political developments into consideration. A stricter regulation control and the application of best practice methods should facilitate new green technologies and their adaption. Finally it is the task of the port operators, governments and other regulating authorities to plan and realize a sustainable green port strategy. (Bergqvist and Monios 2019)

3 Fields of Action

This chapter first defines the different fields of action (cf. chapter 3.1). In the following the single measures within the fields of action being applied in selected European and Asian ports are listed up (Best Practice Inquiry). In addition to that a comparison or query, resp. with/of the measures already carried out in the ports of Tianjin, Ningbo-Zhoushan and Tangshan is made to identify potential recommendations for action (cf. chapter 3.2).

3.1 Definition

To be able to present potential measures for Chinese ports a best practices inquiry will be carried out in selected international ports. To allow a better analysis of measures, in the preliminary stage fields of action have been determined by the project partners. The best practices inquiry was done in the following ports: Rotterdam (Netherlands), Los Angeles (United States), Singapore (Singapore), Hamburg (Germany) and Risavika (Norway). In the course of this several measures, as e.g. the intermodal transport between road and rail or rail and barge were identified from a study by the port of Rotterdam. (Samadi et al. 2016)

Simultaneously to the best practices inquiry a survey was made in the Chinese ports of Ningbo-Zhoushan, Tangshan and Tianjin. The goal is to compare the best practices of implemented measures within the ports of China.

In the following the five fields of action mentioned above are categorized and defined:

<u>Field of action 1: Adaptation of the transport structure</u>

This field of action optimizes routes and route times to avoid e.g. empty journeys and shunting movements as well as the search for slots.

<u>Field of action 2: Multimodal transport</u>

Multimodal transports use different (minimum two) transport modes within a definite period of time. The intention of this field of action is the aimed change of transport means to benefit from the particular advantages and the emission-reducing factors as well. Here all potentials to obtain possible CO2 savings are to be used.

<u>Field of action 3: Intelligent port</u>

The application of digital technologies and information-technological opportunities, as for example automatically guided transport systems, tracking of handling equipment and storage of data in great quantities as well as intelligent parking systems are covered by this field of action.

<u>Field of action 4: Utilization of clean and renewable energies</u>

This field of action comprises the application of technologies being efficient and low-emission ones as well. Those, among others, include alternative drives for any terminal equipment and renewable energies. Thus, the development and implementation of alternative drives for transport carriers and floor conveyors as well are paramount.

Field of action 5: Energy monitoring and management

This field of action focuses the management of energy data as well as their optimization. Furthermore, the programs for a future energy management will be developed and new technologies examined in this direction.

3.2 Measures within the Fields of Action

In the following, the five fields of action defined before will be listed up as table and the content completed with international best practice examples. Goal of this comparison is to identify opportunities of improvement within the measures already carried out in Chinese ports. Furthermore, the single place of application and the respective source are listed. A query with the data recorded from China allows an analysis with regard to the measures already carried out and is both contributing to supplement and newly implement measures. In the tabular presentation the areas hatched light-blue are symbolising partial activities in the respective field. Dark-blue areas represent inactive measures.

It is important to emphasize the exemplary character of the focus clustering, to show the fields which still require the need of action. However, the table does not raise the claim to cover the entire spectrum of measures. Table 1 presents the field of transport structure and shows only exemplary measures that have been applied not at all or just in isolated cases in Chinese ports.

In the field of multimodal transport the transferred data show that it is not carried out in the port of Tianjin. Table 2 serves as comparison with international, but also national measures.

Field of action	Place of application	Best practices	Inquiry China
Adaptation of the transport structure	Port of Los Angeles	Sustainable truck fleet program: Access control by port. Only models from the year 2014 may use the port, Port Drayage Truck Registry (PDTR)	Access to port is refused for trucks with high fuel consumption and old technology
	Port of Los Angeles	Speed controls and limitations	There do no speed controls exist
	Port of Hamburg	Transport control, warranting safe transport management and flow. Uses real transport data	No inquiry of live transport data

Table 1: Field of action: Adaptation of the transport structure

Field of action	Place of application	Best practices	Inquiry China
Multimodal transport	Rotterdam	Transplacement of load transport from road to rail and inland vessel	No multimodal transport (only Tianjin)
	Risavika Port	Application of drones: To reduce road transport and emissions generally it is necessary to realize cost-efficient multimodal transports over short distances	No multimodal transport (only Tianjin)
	Ningbo-Zhoushan	Transplacement of load transport from road to rail	No multimodal transport (only Tianjin)

Table 2: Field of action: Multimodal transport

Table 3 below shows the field of intelligent port systems and exclusively lists up exemplary technologies or measures being not yet applied in the port of Tianjin.

Field of action	Place of application	Best practices	Inquiry China
Intelligent port	Port of Hamburg	GPS sensors for measuring temperature, wind speed and direction as well as air pollution	GPS sensors installed in domestic ports, no use for data measurement
	Port of Hamburg	WiFi link for tug boats	No WiFi application
	Port of Hamburg	Mobile terminal devices for digital control: e.g. quality of infrastructure	No availability of mobile terminal devices, no monitoring of the infrastructure or terminal equipment

Table 3: Field of action: Intelligent port

Table 4 enlists measures being already carried out and also those still not being carried out in the field of clean and renewable energies.

Field of action	Place of application	Best practices	Inquiry China
Clean and renewable energies	Tangshan, Tianjin	Cold ironing during turnaround time	Being carried out
	Tangshan, Tianjin	Utilization of energy-saving lights	Being carried out
	Tangshan, Tianjin	Use of heat pumps	Being carried out
	Port of Los Angeles	Low-emission terminal equipment	Partially, but not entirely
	Risavika Port	Utilization of alternative drives (e.g. LNG)	No use of natural gas vehicles

Table 4: Field of action: Clean and renewable energies

Table 5 below shows fields of energy monitoring and management being partially carried out in the port of Tianjin and needing further improvement in respect of international comparison.

Field of action	Place of application	Best practices	Inquiry China
Energy monitoring and management	Tianjin	Development planning and determining internal standards on energy saving	Being carried out
	Tangshan	Automatic reference and analysis of energy consumption	Being carried out
	Port of Los Angeles	Testing and setting up guidelines for "Zero-emission trucks"	Guidelines do not exist

Table 5: Field of action: Energy monitoring and management

4 Standard for Green Port Grade Evaluation

To explain and evaluate the "Standard for Green Port Grade Evaluation" (JTS/T 105-4-2013) an English translation is provided by GIZ. First, the standard is explained. This covers its score division being schematically shown (cf. chapter 4.1). Then the "Standard for Green Port Grade Evaluation" is evaluated and deficits are determined on the base of the defined fields of action (cf. chapter 4.2).

$$E = \sum_{i=1}^{4} P_i \times w_i$$

E	total score
P	category score
w	category quantifier
i	counting variable for categories

4.1 Explanation

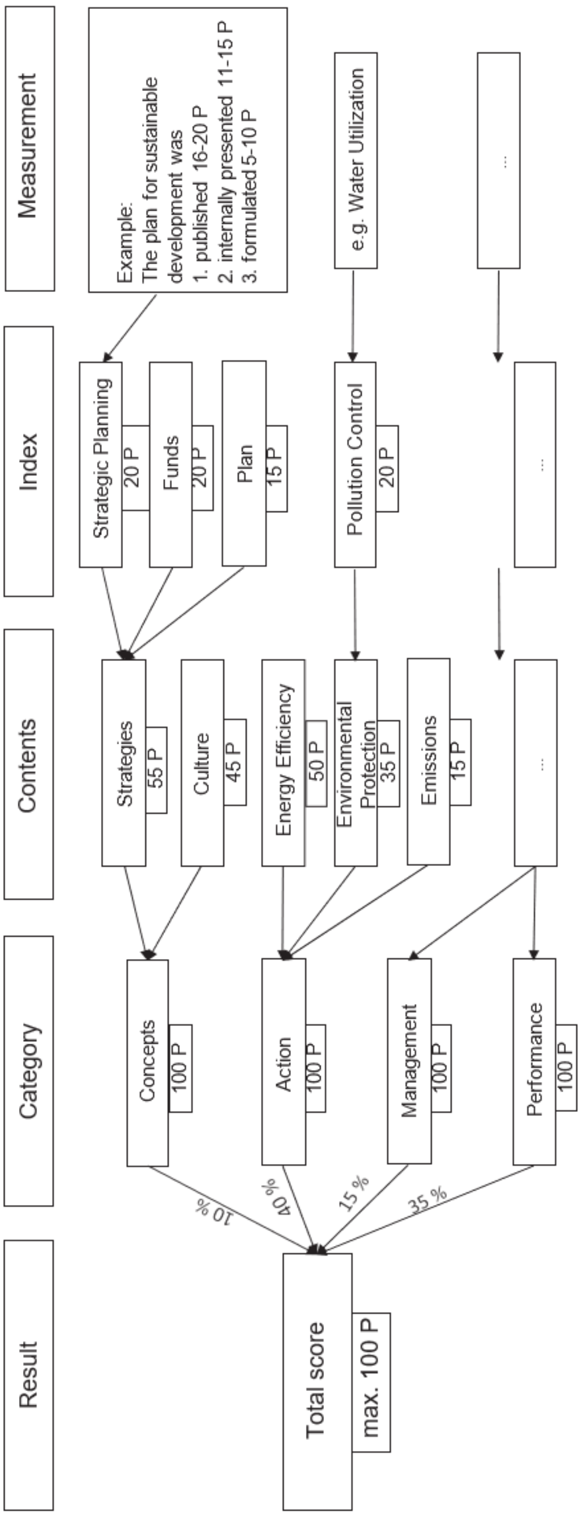
The standard developed in China describes a method for the ecological evaluation of port facilities. The standard tries to quantify the activities and measures of ports in view of the degree of sustainability. For evaluation points are awarded and a total score is then identified. The highest attainable score is 100 points. The valuation schedule of the standard (cf. Figure 3) provides a classification in four categories (concept category, action category, management category, performance category). Each category has a score of maximum 100 points attainable and a category-specific score quantifier. The total score results from the attained and quantified points of all four categories.

Each category has determined content priorities for awarding points. There are determined indices for each content priority. Each index is characterized by a selection of measurements, with the aid of which measures can be valuated or quantified.

The standard distinguishes three port areas (container terminal, bulk goods terminal and liquid bulk terminal) with different measurements. According to examined port area, the distribution of scores varies for the content priorities of energy efficiency, environmental protection and emissions.

Figure 3 shows the schematic design of the standard by the example of container terminals.

The number of fulfilled measurements decides on the amount of scores. There are three levels (3 stars, 4 stars, 5 stars) possible as result of the evaluation, with 3 stars representing the lowest level and 5 stars the highest level. For the clas-



Example (from left to right):

The total score (max. 100 points) considers with 10 % the concept category. The points of the concept category are determined by the content priorities „Strategies“ and „Culture“. The content priorities are divided into indices. The content priority „Strategies“ again is divided into the indices „Strategic Planning“, „Funds“ and „Plan“. The indices can be quantified trough the measurements, e.g. the publication of specific reports. The index „Strategic Planning“ would be rated with 16-20 points if a plan for sustainable development was published.

Figure 3: Scheme of „Standard for Green Port Grade Evaluation“ based on container terminals

sification in the valuation stages various requirements to be fulfilled (cf. Table 6) exist. The total score and the points in the action category are examined. In addition to this, a selection of measurements is explicitely checked. So, for example, a minimum score of 75 points has to be achieved for a 3 star valuation, and 70 points minimum in the action category. Furthermore the port operator has to formulate a special fund for sustainable development, hast to publish an annual sustainability report and has implemented a target valuation system.

<u>Exemplary calculation:</u>

TIWTE provided calculations from the years 2015 and 2018 for a container terminal of the port of Tianjin (Tianjin Port Pacific International Container Terminal). Based on the index of pollution in a container terminal the applic-tion of the standard is exemplarily explained. An excerpt of the results shows Figure 3.

There are six identified measurements to determine the score for the index pollution control:

1. Water utilization (e.g. process water)
2. Watersaving technologies
3. Irrigation technology
4. Separation of toxic substances
5. Noise protection
6. Emergency plans against environemental pollution

Level	3 stars	4 stars	5 stars
Total score E	$75 \leq E < 85$	$85 \leq E < 95$	$E \geq 95$
Score of action category P2	$70 \leq P2 < 80$	$80 \leq P2 < 90$	$P2 \geq 90$
Sustainable development plan is formulated	-	-	√
Fund for sustainable development is set up	√	√	√
Annual sustainability report is published	√	√	√
Target valuation system is established	√	√	√
Environmental certification (ISO 14001) exists	-	√	√
Utilization of cold ironing	-	-	√

Table 6: Requirements

For the index “pollution control” 20 points maximum can be achieved. A measurement is considered fulfilled only if a target valuation degree of 50 % at minimum is fulfilled. In the example on hand all six measurements are fulfilled, but not for all a target valuation degree of 100 % is reached (cf. Table 7). For the measurements minimum targets are defined, for example with respect to consumption shares, number of technologies or existing measures, so that it will be possible to calculate a target achievement degree. The measurement “water utilization“ is determined by the 15 %-portion of process water of the total water consumption. The mimimum target of 50 % is defined for a portion of 10 % of process water usage. A target achievement degree of 100 % is defined for a 30 % portion of process water usage. The target achievement degree is determined by interpolation as follows:

Target achievement degree $_{\text{water utilization}}$

$$= ((a - b) \div c * d + e) * 100$$

a	Share of process water in total water consumption
b	Minimum proportion of process water in total water consumption
c	Interpolation interval share of use
d	Interpolation interval degree of target achievement
e	Min. degree of target achievement

Target achievement degree $_{\text{water utilization}}$

$$= ((0{,}15 — 0{,}1) \div 0{,}2 * 0{,}5 + 0{,}5) * 100$$

a = 0,15	Share of process water in total water consumption
b = 0,1	Minimum proportion of process water in total water consumption
c = 0,2	Interpolation interval share of use
d = 0,5	Interpolation interval degree of target achievement
e = 0,5	Min. degree of target achievement

Target achievement degree $_{\text{water utilization}}$ = 62,5 %

Thus a target achievement degree of 62.5 % results for the measurement “water usage“. Due to the specification of the standard, for all six measurements fulfilling a target achievement degree of at least 50 %, 17 up to 20 points can be awarded. In case of only five measurements fulfilled, only 13-16 points could be awarded, in case of four 10-12 points, for three 7-9 points, for two 4-6 and for only one measurement fulfilled 1-3.

In the example on “pollution control“ the 17 points are base points awarded only for the fulfilment of the six measurements. The remaining 3 points are distributed by interpolation.

$Score_{Pollution\ control}$

$= ((v — w) \div x \times y + z)$

v Arithmetic mean of the six criteria

w Min. target achievement degree

x Interpolation interval target achievement degree

y Interpolation interval score

z Base points

$Score_{\ Pollution\ control}$

$= (0{,}8542 - 0{,}5) \div 0{,}5 * 3 + 17$

v = 0,8542 Arrithmetic mean of the six criteria

w = 0,5 Min. target achievement degree

x = 0,5 Interpolation interval target achievement degree

y = 3 Interpolation interval score

z = 17 Base points

$Score_{Pollution\ control} = 19{,}13$

In this example 19.13 points of at maximum 20 possible points can be calculated for the index "pollution control". The values for the exemplary calculation refer to the year 2015. For the year 2018 the container terminal achieves 19.6 points for the index "pollution control", that resulting from a higher usage of process water and the application of other watersaving technologies.

The scores achieved for the indices are summed up according to the sceme in Figure 3 and aggregated to a total score with the aid of the quantifiers. For the year 2015 the container terminal of the port of Tianjin achieved 90.39 points and, according to Table 6, can thus be classified in the "4 star" level, because the action level P2 achieved 93.97 points and the other necessary measurements were fulfilled. For the year 2018 the container terminal of the port of Tianjin achieved 97.20 points and is, according to Table 6, at

Measurements	2015	2018
1. Water usage	62.5 %	85.3 %
2. Watersaving technologies	50 %	75 %
3. Irrigation technology	100 %	100 %
4. Separation of toxic substances	100 %	100 %
5. Noise protection	100 %	100 %
6. Emergency plans against environmental pollution	100 %	100 %
Total score 'pollution' (max. 20 points)	**19.13**	**19.6**

Table 7: Measurements and degrees of target achievements for a container terminal at the port of Tianjin

the ”5 star“ level, because the action category P2 showed 96.75 points and the other necessary measurements were fulfilled. For the year 2018 the container terminal of the port of Tianjin achieved 97.20 points and is, according to Table 6, at the ”5 star“ level, because the action category P2 showed 96.75 points and the other necessary measurements were fulfilled.

4.2 Deficits of the Standard

A detailed examination of the “Standard for Green Port Grade Evaluation“ shows that the fields of action defined (cf. chapter 3) are not completely covered by this standard. In addition to the mere handling of goods sea ports play an important role in the organization of transport chains and in the distribution of goods, e.g. to the hinterland. As described in chapter 2, a sea port is thus having the potential to influence the efficiency of the entire system. The above standard is currently examining only measures in the port area which can be assigned to the following fields of action: ”Intelligent port“, ”Use of clean and renewable energies“ and ”Energy monitoring and management“. The fields of action of “Adaptation of the transport structure“ and “Multimodal transport“ being effective outside the port area are currently not covered by this standard and are not considered in the evaluation.

Furthermore, challenges in the practical use of the “Standard for Green Port Grade Evaluation“ have been determined during the exchange of information with GIZ and TIWTE. A selection of these challenges occurring by the use of the standard are:

- The objectivity of the measuring methods on the level of the indices or measurements is insufficient. Subjective suggestions or evaluations are complicating the reproducibility of the application of the standard.
- For some of the indices or measurements in the action category it is difficult to determine the intensity of use. The number of the installed or newly implemented technologies does not allow conclusions on the savings, e.g. watersaving technologies.
- Insufficient recording of the energy consumption, e.g. horizontal transports in container terminals are not considered.
- Predetermined (evaluation) measurements are not or only hardly realizable or transferable, e.g. direct loading is not possible at every quay or landing place.

Fields of action	Coverage by the standard
1. Adaptation of the transport structure	-
2. Multimodal transport	-
3. Intelligent port	√
4. Use of clean and renewable energies	√
5. Energy monitoring and management	√

Table 8: Evaluation focus of the ”Standard for Green Port Grade Evaluation“

5 Recommendations for Action

Based on the preceding explanations recommendations for action for Chinese ports are deduced in chapter 5 – distinguishing between recommendations for action for ports and port operators (cf. chapter 5.1) and recommendations for action for political decision makers (cf. chapter 5.2).

5.1 Recommendations forAction for Port Operators

With the aid of the comparison of measures in chapter 3.2 fields could be identified in which Chinese ports can intensify their actions by appropriate measures. In this chapter potential measures are added by examples and grouped in form of recommendations for action for Chinese ports. In the following recommendations for action are made for the port process of

- Shore-to-Ship Power Supply
- Terminal and yard management
- Synchromodality

<u>Ship-to-Shore Power Supply</u>

Concerning measures to improve the sustainability of ships at quay ("Shore-to-Ship Power Supply") Chinese ports have undertaken many and complex measures being less implemented in Europe. Topic 2 of the MKS China Studies deals with that more intensively and determines specific recommendations for action.

<u>Terminal and yard management</u>

Great influence on emissions in sea ports has the further transport of loads to the hinterland or the sea-sea handling, so-called sea hubs. In sea-sea handling a great number of containers are transshipped from ingoing sea vessels to smaller feeder ships. The ocean- going ships are unloaded at the port terminal and containers intermediately stored at the terminal area. For the port of Hamburg the handling of 1.7 million containers with destination Baltic Sea area was the most important European market mainly served by feeder transports. Special handling vehicles are provided for the transport on the terminal area being still usually driven by Diesel motors or old lead batteries. Yard management, i.e. the control and application planning of the handling vehicles for the shipment of the containers, plays an important role in respect of a more efficient and low-emission planning. Ways and sorting processes have to be kept as low as possible. Here IT systems are applied which are to warrant an optimum handling. Terminals are more and more replacing Diesels and lead-battery driven vehicles by modern Lithium ion handling vehicles (e.g. Container Terminal Altenwerder in Hamburg/Germany). With the aid of this measure Hamburg aims on a reduction of the annual CO2 emissions of 15,500 tons and NOX emissions of 118 tons.

A further reduction of emissions could result from a combination of IT and electric vehicles. It becomes obvious in chapter 3.2 that a bundle of measures is covering this field of Chinese port activities quite well. Potentials are surely to be found in the transferability and scalability of the measures to European ports. This may be analyzed and evaluated by more detailed studies.

Synchromodality

The development of the hinterland can no longer be separated from the port activities. The hinterland determines catchment and delivery area. Customer serving in these areas often is intensively disputed by the port operators. So, along the Rhine, the port of Rotterdam supplies the Ruhr region and the south-western part of Germany. Hamburg covers regions of southern Germany and central and south-eastern Europe. Here an efficient rail system is the backbone for Hamburg. In 2017 42 % of the containers were transported to the hinterland by rail. These strategic considerations are supported by a targeted development of the infrastructure and links of the hinterland, and a reduction of emissions is achieved by the efficient application of intermodal transport modes.

The ports of Rotterdam, Hamburg and Antwerp determined target values for their modal split. So, in 2030 only 35 % of the transports in the port of Rotterdam should be done on road. The remaining 65 % should be carried out by the transport modes inland vessel and rail.

The endeavors of the ports of Rotterdam, Hamburg and Antwerp in the field of modal split to set up measures emphasize the necessity to implement a multimodal transport approach. It serves, among others, for avoiding congestions at in- and out-gates as well as for opportunities to transport significantly more loading volume to the hinterland. Furthermore, the transport modes rail and water are reducing the output of greenhouse gases. A further development of the multimodal approach is the implementation of synchromodal transport planning.

Synchromodality is defined as the hinterland transport from and to the sea port where logistic service providers have the opportunity to determine the selection of the transport mode according to available real-time information. Real-time information means availability of provided capacities or the traffic situation on road. Here intelligent port systems play a significant role. The use of digital technologies (mobile terminals) and the link of those with the respective equipment at the port as well as the link among the vehicles of the harbour hinterland transport allows the implementation of synchromodal transport planning.

The concept of synchromodality was developed and implemented by the local terminal operators ECT along with the development of the Maasvlakte 2 port area in the port of Rotterdam. In the year 2016 already 800,000 TEU were scheduled with the aid of this planning concept, with increasing tendency. Basic prerequisite for a synchromodal transport management is a close communication between the transport orders (forwarders) and the

logistic and transport service providers. Such platforms can take over a bundling function and thus open up further efficiency potentials. Case studies on the quantification of the environmental effect of synchromodal transport management are not available, they, however, have a big potential for the reduction of CO2 emissions. The examinations made supplied scarce data and findings on the organization and opening up of the harbor hinterland in China. For this reason, we assume that modal split and an increased use of intermodal transport modes is still not part of the 'Standard for Green Ports'.

5.2 Recommendations for Action for Political Decision Makers

The "Standard for Green Port Grade Evaluation" (JTS/T 105-4-2013) described in chapter 4 explains a method for the ecological evaluation of port facilities. The Standard examines the activities and measures of ports in view of the degree of sustainability. The analysis of the standard is a methodically consistent approach allowing the comparability of ecological measures between port terminals. Thus, the method of the "Standard for Green Port Grade Evaluation" is considered a suitable instrument to classify port strategies as being developed by the ports of Hamburg and Rotterdam, but also by many other ports.

From the evaluation of the measures explained in chapter 3.2 as well as of the deficits of the standard detected in chapter 4.2 a recommendation for action can be deduced to supplement the "Standard for Green Port Grade Evaluation" by the following fields of action:

- Adaptation of the transport structure
- Multimodal transport

So the endeavors of the port being effective outside the port area would be covered and appropriately considered in the sustainability evaluation of the ports. Furthermore, the field of intelligent port systems can be additionally extended to the measures already done.

We would therefore recommend the extension of the standard and to include measures on a more efficient and more sustainable link of hinterland terminals and transport networks, and to take the experience from European initiatives and best practices into consideration.

Especially the emission evaluations and environmental effects of synchromodality missing until now are to be addressed by analyses.

6 Summary

Objective of the "Sustainable Strategies for Ports" (Topic 3) was to carry out a comparative analysis of measures of Chinese and international ports as well as to classify the sustainable port development and strategy of Chinese ports.

Relevant fields of action (cf. chapter Table 3) have been defined and described. For this purpose, single measures in the international context were recorded by inquiries as well as measures in Chinese ports (Ningbo-Zhoushan, Tangshan and Tianjin) and structured in respect of their effects, common features and gaps were identified and discussed.

The comparison of measures shows that Chinese ports are well positioned in the fields of action "Intelligent port", "Clean and renewable energies" and "Energy monitoring and management" realizing a variety of innovative measures.
For the fields of action "Adaptation of the transport structure" and "Multimodal transport" this study provides a selection of possible supplementary measures being currently not implemented in Chinese ports.

The description and analysis of the "Standard for Green Port Grade Evaluation" (JTS/T 105- 4-2013) discovered fields currently still not covered by the evaluation. This also applies to the fields of action "Adaptation of the transport structure" and "Multimodal transport" as well. Furthermore, challenges in the application of the standard have been outlined.

Starting from the recommendations for action determined feasibility studies, project planning and the realization of further measures should be focused now.

7 Abbreviations

CO_2	Carbon Dioxide
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
ICAO	International Civil Aviation Organization
IML	Institute for Material Flow and Logistics
IMO	International Maritime Organization
ISO	International Organization for Standardization
LNG	Liquefied Natural Gas
Mio	Millionen
MFS	Mobility- and Fuelstrategy
NO_x	Nitrogen oxides
PDTR	Port Drayage Truck Registry
TEU	Twenty Foot Equivalent Unit
TIWTE	Tianjin Research Institute for Water Transport Engineering

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