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A NEW METHOD FOR ASSESSING CO_2-FOOTPRINTS OF CONTAINER TERMINALS IN PORT AREAS;

Deltalinqsontbijt – 18th of April 2012

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Introduction

- Ron van Duin and Harry Geerlings
  - affiliated to PRC (Delft) and ESPR (Rotterdam)

- Presentation of new methodology
  - present new insides
  - published and presented in journals and conferences
  - academic interest: potential to become a standard
  - business perspective: optimization of operations
  - interest from China, Malaysia and Germany (EU-project)

- Structure of presentation

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The Context

- At present considerable attention is given to climate change and global warming
- Transport systems have significant impacts on climate change, accounting for between 20 and 25 per cent of world energy consumption and CO_2-emissions (in Europe 35%)
- There is increasing pressure on governments and industries to come forward with (more) climate-friendly strategies
- Rotterdam joined the RCI (voluntary)
  - 50% CO_2 reduction in 2025 compared to situation 1990

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Expected Trends

- Due to the rapidly growing flow of containers from Asia, mainly from China, it is expected that this growth will accelerate:
  - International shipping grew 60% between 1990 and 2006,
  - It is expected that the number of container handlings will rise from 11 million per year in 2008 to 33 million per year in 2033;
- There is increasing attention for Corporate Social and Environmental Responsibility
- Customers demand is reflected in the logistic chain: Procter & Gamble, IKEA a.o. are interested to know how much CO_2 is involved in their container handling (source: Maersk lines)
- Synchromodality will introduce new rules of the game

Objective of this meeting

The main purpose of this presentation is to present a well based bottom-up methodology to analyze the CO_2-emissions from container terminals in the Netherlands.

- provides new insight on terminal planning and operations
- anticipates on logistic requirements
- reduce the energy bill of terminals
- option to become more green and lean
- good to have a general accepted standardized method

Observation

- There is a strong pressure on the sector to become (more) sustainable:
  - many research projects and related and activities, lot of data, etc.

However:

- There are many studies on multi-modality, the environmental perspective on the terminal is not taken into consideration
- there is no standardized method and a lack of proposed policies how to reduce the CO_2-emissions in this sector

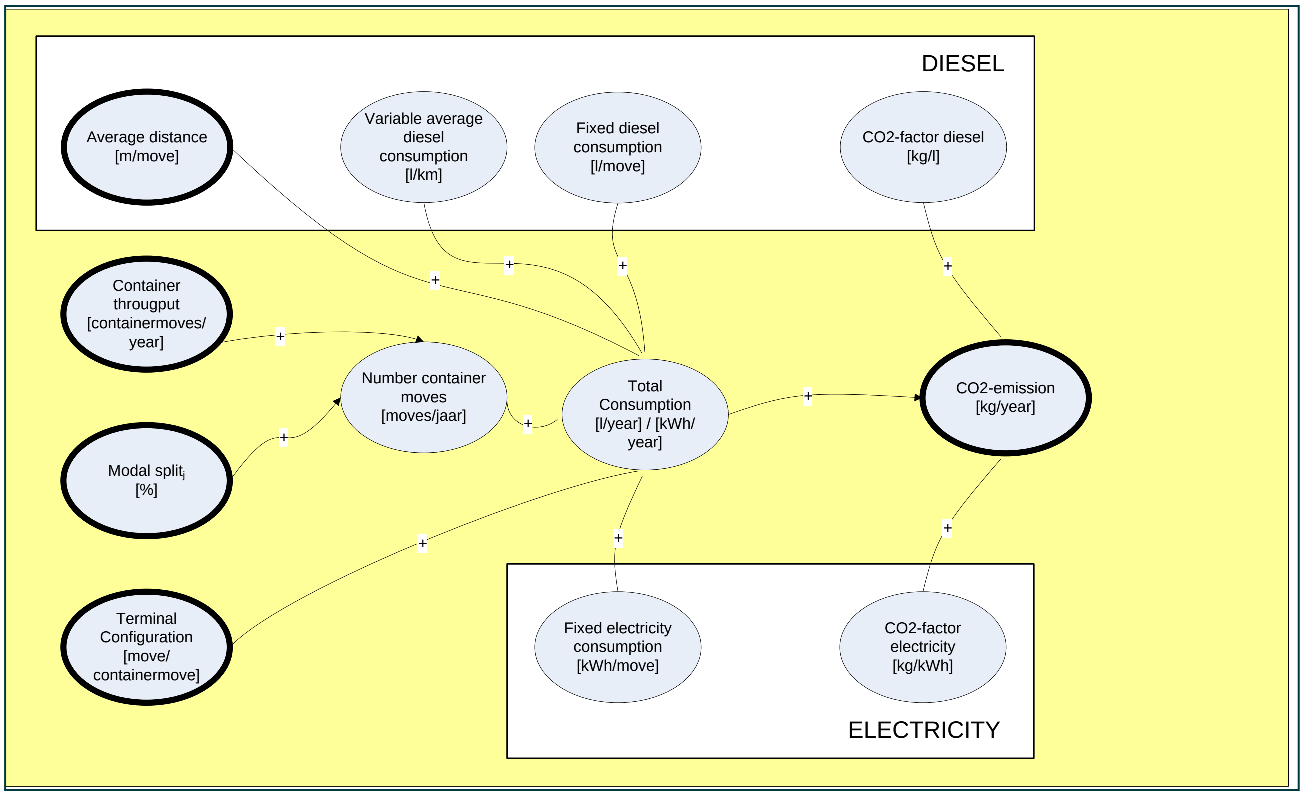
The model:

Since CO_2-emissions are the direct consequence of energy used by the transshipment process, it is important to obtain an idea of the factors in the transshipment processes that consume energy.

These factors include:

- the equipment used by each sub-process,
- the energy-consumption pattern of various types of equipment,
- the deployment of the equipment in each sub-process,
- the average distance within a sub-process.

The conceptual model for calculating CO_2 emissions at terminals:



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Input variables:

- The overall transshipment performance by means of the total container throughput at a terminal in one year
- Modal split: the breakdown of the transshipment to the various forms of pre-and post –transport
- Terminal configuration: deployment of equipment per sub-process
  - Quay cranes (QCs)
  - Barge cranes (BCs)
  - Rail cranes (RCs) or gantry cranes
  - Automated Stacking Cranes (ASCs)
  - rail-mounted Stacking Cranes (RSCs) or gantry cranes
  - Automated guided vehicles (AGVs)
  - ReachStackers (RS)
- Terminal layout: average distances of equipment to sub-processe

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Energy	Type of equipment	Fixed consumption per containermove	Variable consumption	Terminals	Source
ELECTRIC	QC: Quay Crane	6.00 kWh		ECT-D, ECT-Ho, ECT-Ha, APM, RST, UNP	(TNO, 2006)*
	BC: Barge Crane	4.00 kWh		ECT-D, APM, BCT, CTN, WIT	(TNO, 2006)*
	RC: Rail Crane	5.00 kWh		ECT-D, APM	(TNO, 2006)*
	ASC: Automated Stacking Crane	5.00 kWh		ECT-D	(TNO, 2006)*
	RSC: Railmounted Stacking Crane	7.25 kWh		ECT-Ha, RST, UNP	ASC**
	P: Platform	5.00 kWh		RST	ASC**
DIESEL	AGV: Automated Guided Vehicle	1.10 l	1.80 l/km	ECT-D	(TNO, 2006)*
	SC: Straddle Carrier	0.80 l	3.50 l/km	ECT-D, ECT-Ho, APM, RST	(TNO, 2006)*
	TT: Terminal Tractors		4.00 l/km	ECT-D, ECT-Ho, ECT-Ha, RST, UNP	(TNO, 2006)*
	MTS: Multi Trailer System		4.20 l/km	ECT-D, ECT-Ho, APM, UNP	(TNO, 2006)*
	RS: Reach Stacker / Top Lifter		5.00 l/km	ECT-D, ECT-Ho, ECT-Ha, APM, RST, UNP, BCT, CTN, WIT	(TNO, 2006)*

* Based on op TNO project by Oonk **(TNO Built Environment and Geosciences, 2006)**
** Based om a comparision with the ASC on the ECT Delta terminal, in which the reach of the equipment (stack length) is taken into consderation.

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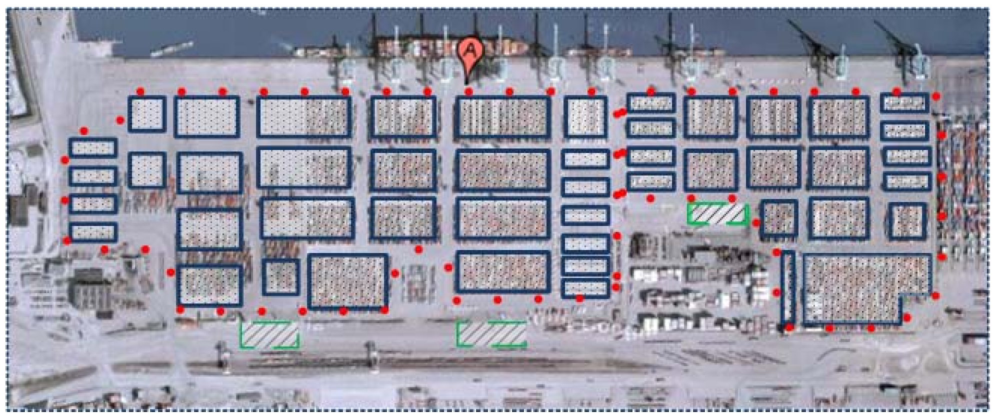

stack

gate freight truck

centre point stack

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Formalisation

The total CO2-emissions of ‘Terminal x’ can be calculated as: the total sum of emissions by equipment (i) and the sub-processes to tranship to another modality (j). This leads to the next formula:

$$W_X = \sum_{i=1}^{11} \sum_{j=1}^{5} \left(\left(v_{i,j} \times f_D \right) + \left(P_{i,j} \times f_E \right) \right)$$

where:

W_x = Total weight of CO_2-emission produced at terminal x
$V_{i,j}$ = Yearly consumption of diesel in litres with equipment *i* to modality *j*
f_D = Emission factor in kilogrammes of CO_2-emission per lit diesel (= 2.65)
$P_{i,j}$ = Yearly power consumption of electricity in kWh for equipment *i* to modality *j*
F_E = Emission factor in kilogrammes of CO_2-emission per kWh (= 0.52),

combined with:

$V_{i,j} = n_{i,j} * (C_{i,j} + c_{i,j} * X_{i,j})$ $\forall\, i, j \in T$

$P_{i,j} = n_{i,j} * (p_{i,j})$ $\forall\, i, j \in T$

where:

$n_{i,j}$ = Number of rides with equipment i to modality *j*
$C_{i,j}$ = Fixed usage (for example lifting operations) per ride in litres
$c_{i,j}$ = Variable usage per km in litres (see Table 1)
$X_{i,j}$ = Distance travelled according Manhattan-metric for equipment *i* to modality *j*
$p_{i,j}$ = Fixed usage per ride in KWh Table 1 for equipment *i* to modality *j*

The case of the Delta terminal

- The Delta terminal is currently the largest and most automated container terminal in the Port of Rotterdam.

- The terminal covers an area of 293 hectares and has an annual cargo of 4.5 million TEUs.

- In 2006 the Delta terminal achieved a throughput of around 4.3 million TEUs. Of these, 3,096,129 were destined for or, originating from the hinterland with the following breakdown on the modalities:
  - Road 49%
  - Inland 34%
  - Rail 17%

- The terminal is characterized by the fully-automated handling of containers from sea by means of the use of AGVs and ASCs.

- Depending on the modality, the use of terminal equipment varies.

- At the Delta terminal, the following sub-processes can be distinguished:
  - Throughput from the sea to stack, vice versa: QC> AGV> ASC;
  - Transshipment of inland waterways to stack, vice versa: QC> AGV> ASC or BC> MTS> SC> ASC;
  - Throughput on the way to stack, vice versa: SC> ASC;
  - Transshipment of rail to stack, vice versa: RC> MTS> SC> ASC;
  - Inter-terminal transport (Stack - Stack): (ASC> SC>) MTS> SC> ASC.

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Equipment contribution per type of modality

	SEA	BARGE	ROAD	RAIL	ITT
QC	1	0.71	0	0	0
BC	0	0.29	0	0	0
RC	0	0	0	1	0
ASC	1	0	1	1	1
RSC	0	0	0	0	0
P	0	0	0	0	0
AGV	1	0.71	0	0	0
SC	0	0.29	1	1	0.9
TT	0.02	0.01	0	0.02	0.1
MTS	0	0.06	0	0.2	0.18
RS	0.02	0.01	0.02	0.02	0.1

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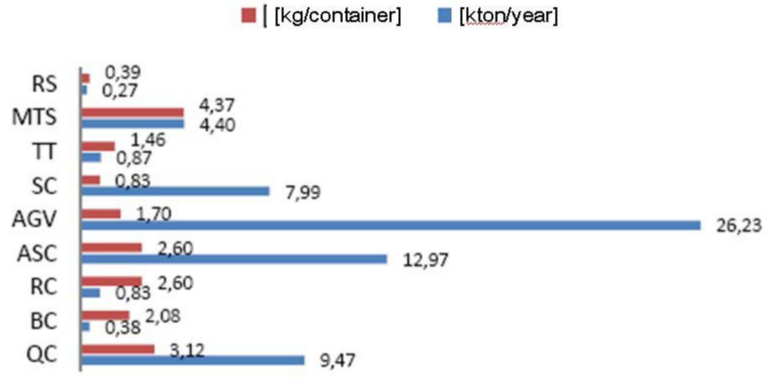

CO_2-emissions per type of equipment

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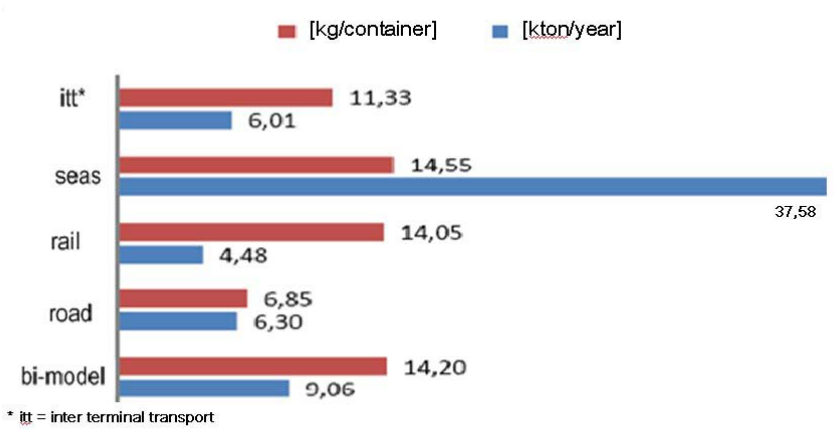

CO_2-emissions per mode

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Application of the model to all terminals

	Terminal	Model Estimates			Real consumption			
		l/year	l/TEU	l/cont	l/year	l/TEU	l/cont	difference %
Diesel	ECT Delta	15,005,338	3.52	5.81	17,654,322	4.14	6.83	-15.0
	ECT Home	4,577,564	4.40	7.27	4,190,952	4.03	6.65	9.2
	ECT Hanno	324,718	5.62	9.28	684.000	11.84	19.54	-52.5
	APM	11,827,265	5.38	8.87	Unknown			
	RST	2,285,928	2.29	3.78	1.900.000	1.65	2.72	20.3
	UNIPORT	1,366,188	3.87	5.73	1.100.000	2.91	4.32	24.2
	BCT	90,222	0.38	0.58	99,788	0.42	0.64	-9.6
	CTN	69,099	0.41	0.69	61,429	0.36	0.61	12.5
	WIT	140,731	0.76	1.35	154,390	0.83	1.48	-8.8

	Terminal	Model Estimates			Real consumption			
		kWh/year	kWh/TEU	kWh/cont	kWh/year	kWh/TEU	kWh/cont	difference %
Electricity	ECT Delta	45.503,821	10.67	17.61	47,142,857	11.06	18.25	-3.5
	ECT Home	4.691,736	4.51	7.45	7,500,000	7.22	11.90	-37.4
	ECT Hanno	640,544	11.09	18.30	1,250,000	21.65	35.71	-48.8
	APM	10,489,636	4.77	7.87	Unknown			
	RST	9,498,600	8.24	13.59	11,000,000	9.54	15.74	-13.6
	UNIPORT	6,313,260	16.70	24.78	6,960,000	18.41	27.31	-9.3
	BCT	480,401	2.03	3.10	505,976	2.13	3.25	-4.7
	CTN	301,276	1.78	2.99	315,501	1.87	3.13	-4.5
	WIT	232,628	1.26	2.23	219,788	1.19	2.11	5.8

Yearly CO_2 production per terminal

Terminal	CO_2 Kton/year (actual)	CO_2 Kton/year (model)	CO_2 kg/TEU based on diesel	CO_2 kg/TEU based on electricity
ECT Delta	71.3	63.4	9.33	14.88
ECT Home	15	14.6	11.67	14.02
ECT Hanno	11.9	24.6	14.90	20.67
APM		35.9	14.03	16.34
RST	10.9	10.7	5.25	9.54
UNIPORT	6.9	6.5	9.58	18.26
BCT	0.53	0.52	1.1	1.1
CTN	0.33	0.32	1.0	1.0
WIT	0.46	0.52	2.2	0.7

Policy implications for terminals

From a theoretical perspective, the CO_2-emissions of container terminals can be addressed in three different ways:

- By reducing the impact of specific modes through technological means, e.g. vehicle design, hybrid vehicles, engine technology, improved energy efficiency, etc.
- By shifting to less damaging modes of transport or forms of behaviour, e.g. alternative fuels, driving stile, etc.
- By reducing the total amount of transport undertaken, e.g. optimal terminal layout and organisational measures.

Recommendations

The most effective measure for CO_2 reduction is undoubtedly the adaptation of the terminal layout. This would make it possible to reduce the CO_2-emissions of the current terminals by nearly 70 per cent.

The other two policy proposals to reduce CO_2-emissions from the existing terminals may be simpler, but their impacts are far less.

- The first perspective is the establishment of policies which aim at replacing obsolete equipment by new (state-of-the-art) equipment, which can achieve a 20 per cent reduction in CO_2-emissions if all diesel-powered equipment is replaced by equipment that operates 20 per cent more efficiency.

- The second perspective is the shift to less damaging modes of transport or alternative fuels, etc.

Observations (1)

- The proposed model has the potential to become a standard as the proposed methodology delivers realistic outcomes

- The outcomes are suitable for the development of a benchmark system for terminals and terminal operation

- There are significant difference between terminals in their CO_2-performance;

- The outcomes of the modal offer more opportunities for performance improvements

- A standardized benchmark will lead in the first instance to awareness raising; actions can follow

Observations (2)

- What we like is to do is:

  V4 - Approach

  - **V**ergroten: database uitbreiden en valideren,
  - **V**errijken: sea/vessels, gebouwen, wagenpark, etc.
  - **V**erfijnen: Iso 14064, ruststand equipment, etc.
  - **V**ernieuwen: what if scenarios, interest to become connected to green award?

- Support for the Rotterdam port community

- Is there a basis for cooperation to come to 1 standardized method?

after the Rotterdam Rules…

Now the Rotterdam Standards?

The End