DANTES
DEMONSTRATE AND ASSESS NEW TOOLS
FOR ENVIRONMENTAL SUSTAINABILITY

LCA comparison for transport chains

- using Dantes strategy and LCALight

Dag Ravemark, ABB

2004

AKZO NOBEL ABB CHALMERS STORAENSO

ABSTRACT

This report was made within the project DANTES that is supported by the EU Life Environment Program.

The goal and scope of this report is to show how one can use the transport strategy developed in Dantes and LCALight (both available on www.dantes.info) to compare different transport scenarios.

The report evaluates the transport of 1000 kg cargo from Ludvika (Sweden) to New York (USA) and six different transport scenarios are identified. The transport scenarios are:

Direct air – lorry Ludvika to Arlanda, air cargo Arlanda to New York
Consignment air – lorry Ludvika to Arlanda, air cargo Arlanda to Frankfurt, air cargo Frankfurt to New York
Consignment air (Rail) – rail cargo Ludvika to Frankfurt, air cargo Frankfurt to New York
Consignment air (Lorry) – lorry Ludvika to Frankfurt, air cargo Frankfurt to New York
Ship (lorry) – lorry Ludvika to Gothenburg, ship cargo Gothenburg to New York
Ship (rail) – rail cargo Ludvika to Gothenburg, ship cargo Gothenburg to New York

The environmental impact of the different transport scenarios are calculated with LCALight and evaluated according to the classification method Global Warming Potential, GWP. The transport scenarios are then ranked according to their environmental impact.

Rank	Transport	Environmental impact kg CO2-eqv
1	Ship (rail)	189.60
2	Ship (lorry)	226,84
3	Consignment air (Rail)	8372,21
4	Direct air	8504,17
5	Consignment air (Lorry)	8508,32
6	Consignment air	10013,12

TABLE OF CONTENT

1. INTRODUCTION

This report was made within the project DANTES that is supported by the EU Life Environment Program.

The goal and scope of this report is to show how one can use the transport strategy developed in Dantes and LCALight (available on www.dantes.info) to compare different transport routes.

The intended users of this report are people that want to see how the Dantes transport strategy can be used and adopted to a problem and how one could environmentally evaluate different transport scenarios.

2. THE PROBLEM

The problem is to analyze the different transport scenarios for transporting a package weighting 1000 kg and 1 m3 from Ludvika to New York. There are different possible transport chains that one could use and the chain used is selected on criteria like cost/delivery time demands. The question is how do the different transports chains compare environmentally?

We evaluate and compare the transport chains by using the Dantes transport strategy and the Dantes tool LCALight and then rank the transport chains according to their relative environmental impact.

2.1 Transport options

1. "Direct air" – lorry Ludvika to Arlanda, air cargo Arlanda to New York
2. "Consignment air" – lorry Ludvika to Arlanda, air cargo Arlanda to Frankfurt, air cargo Frankfurt to New York
3. "Consignment air (Rail)" – rail cargo Ludvika to Frankfurt, air cargo Frankfurt to New York
4. "Consignment air (Lorry)" – lorry Ludvika to Frankfurt, air cargo Frankfurt to New York
5. "Ship (lorry)" – lorry Ludvika to Gothenburg, ship cargo Gothenburg to New York
6. "Ship (rail)" – rail cargo Ludvika to Gothenburg, ship cargo Gothenburg to New York

3. DANTES STRATEGY FOR TRANSPORT EVALUATION

The strategy' name is "Investigate and decrease the environmental impact connected to transport" and the headlines of the steps in the working procedure are (with comments and relevance to this work):

1. Define scope and limitations of the study
We will use the Dantes tool LCALight for evaluation of the six transport options described in chapter 2.1. The evaluation method used to compare the transports will be Global warming potential, GWP (i.e. emissions of greenhouse gases e.g. CO2).

2. Define a preliminary list of EPIs
Transports will only be evaluated on the total emission of greenhouse gases i.e. GWP.

3. Prepare a questionnaire for transport companies
Not relevant, LCALight data will be used.

4. Collect inventory data
Not relevant, LCALight data will be used.

5. Calculate transport distances
Distances will be estimated by using internet tools available on Dantes.info, e.g. SAS emission calculator for air transports, ViaMichelin or Emission calculation from Schenker logistics for land transport and MariTimeChain.com for sea transport.

6. Collect data on energy use and emissions
Not relevant, LCALight data will be used.

7. Calculate total emissions and energy use
We will only use weighted emissions that are the result from LCALight.

8. Analyze and draw conclusions from the result
The analysis will end with an environmental ranking of the different transport chains.

9. Prepare Environmental Performance Indicators
Not relevant.

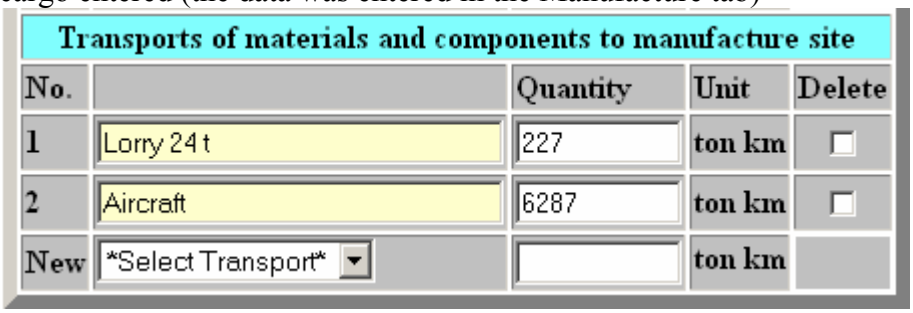
10. Write a report
This report…

4. EVALUATING TRANSPORT OPTIONS

Six transport options are described in chapter 2.1. The transport distances are estimated by internet tools and the environmental analysis is done with LCALight.

4.1 How the evaluation was done.

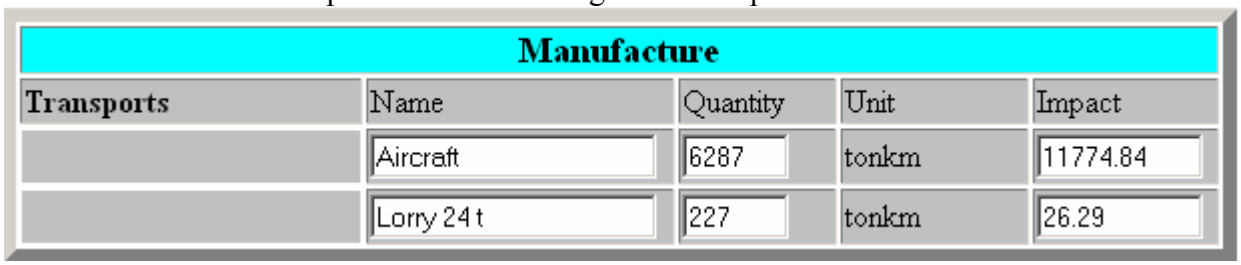
In LCALight the transport type was selected and the weight*distance of cargo entered (the data was entered in the Manufacture tab)



Transports of materials and components to manufacture site				
No.		Quantity	Unit	Delete
1	Lorry 24 t	227	ton km	☐
2	Aircraft	6287	ton km	☐
New	*Select Transport*		ton km	

Figure 1 Part of the input window in LCALight

Under the Report tab the following result was presented.



Manufacture				
Transports	Name	Quantity	Unit	Impact
	Aircraft	6287	tonkm	11774.84
	Lorry 24 t	227	tonkm	26.29

Figure 2 Part of the Report tab in LCALight

The results are presented for all the different transport chains below.

4.2 Result

4.2.1 Direct air

Transport; route	Distance	GWP 100 (kg CO2-eqv.)
Lorry 24t; Ludvika-Arlanda	227km	26,29
Aircraft Arlanda -New York,	6 287km	11774,84
Total		**11801,13**

4.2.2 Consignment air

Transport	Distance	GWP 100 (kg CO2-eqv.)
Lorry 24t Ludvika – Arlanda	227km	26,29
Aircraft: Arlanda – Frankfurt	1 222km	
Aircraft Frankfurt – New York	6 184km	
Total aircraft distance:	7 406km	13870,60
Total		**13896,89**

4.2.3 Consignment air (Rail)

Transport	Distance	GWP 100 (kg CO2-eqv.)
Rail Ludvika – Frankfurt	1 462km	33.22
Aircraft Frankfurt – New York	6 184km	11581.93
Total		**11615.15**

4.2.4 Consignment air (Lorry)

Transport	Distance	GWP 100 (kg CO2-eqv.)
Lorry 24t Ludvika – Frankfurt	1 462km	169.33
Aircraft Frankfurt – New York	6 184km	11581.93
Total		**11751.26**

4.2.5 Ship (lorry)

Transport	Distance	GWP 100 (kg CO2-eqv.)
Lorry 24t; Ludvika-Gothenburg	400km	46,33
Ship RoRo: Gothenburg -New York	6 075 km	180,51
Total		**226,84**

4.2.6 Ship (rail)

Transport	Distance	GWP 100 (kg CO2-eqv.)
Rail; Ludvika-Gothenburg	400km	9.09
Ship RoRo: Gothenburg -New York	6 075 km	180,51
Total		**189.60**

4.3 First Results

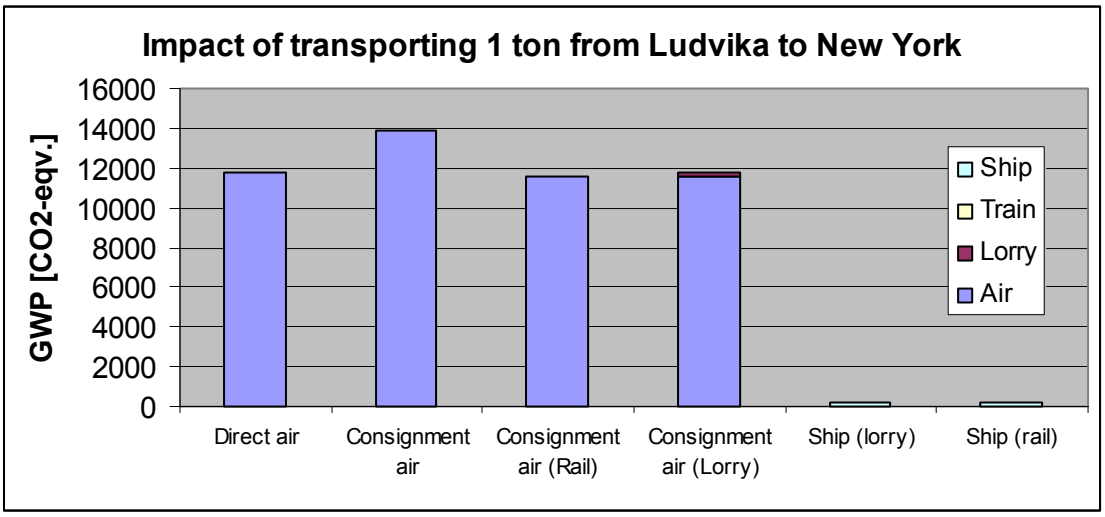


Figure 3 Preliminary results of the environmental evaluation of transports

In Figure 1, one can see that air transport is the major contributor to environmental impact. The reason for this is that the air transports are long (6-7000 km) and that air transports uses approximately 20 times the energy used by lorry transport (in ton km). Lorry transports uses 4 times the energy of ship and rail (that have similar energy requirements, per ton km)

Looking only at “Ship” transport options

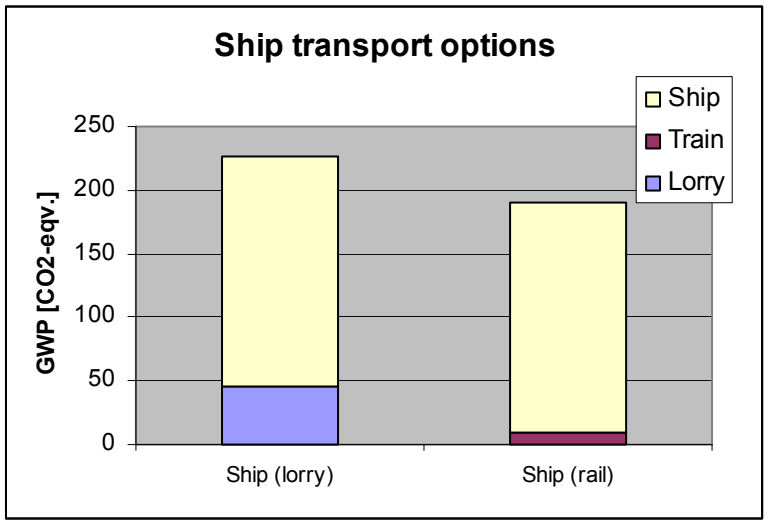


Figure 4 Ship transports

The difference is not large, only 36 kg of CO2-eqv. between the two transports. The rail part (Ludvika – Gothenburg) has about one quarter of the impact from lorry transport at the same distance. The impact from shipping is equal in both cases.

5. DISCUSSION

5.1 Meta data on used activities in LCALight

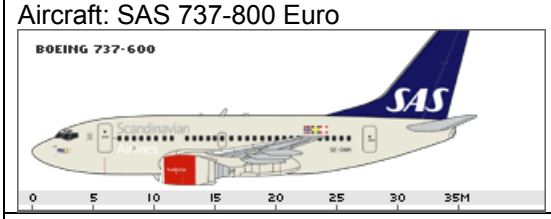
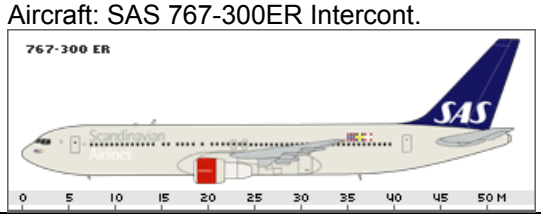
The meta data describes where the data used in LCALight is coming from.

Aircraft: Operation of MD-82 aircraft only is carrying cargo. The operation includes take-off, climb, cruise, descent and landing (including operations on the ground). Freight distance calculated at 600 km and utilization level 65%
Lorry 24t: Operation of a diesel driven heavy truck with engine manufactured after 1996 (Euro 2 environmental standard). The vehicle is mainly used for transportation of general (styckegods) and wholesale (partigods) goods. Utilization level is 70 %
Ship RoRo: Operation i.e. propulsion of Swedish flagged RoRo vessel, which are members of the Swedish ship owners' Association. The loading capacity is 2000 - 30000 deadweight tonnes. Utilization level is 50-60 %
Rail: Operation of freight train with an electrically driven RC engine. Electrically driven freight trains transport 95 % of the goods handled by train. Each truck of the trains may be assumed to have a loading capacity with regard to weight of 55 ton and a maximum gross weight of 80 ton. Utilization level 46 %

5.2 Discussion on air transports

Air cargo has the largest impact of the results and needs to be further analyzed.
The meta data says that aircraft data used are for short distance (600 km) airfreight, but the take-off and landing are the most fuel consuming maneuvers so the emission per ton km will probably be lower for a long distance flight like Stockholm - New York

Estimating the difference (Using SAS emission calculator http://www.sasems.port.se/):

Transport similar to "Aircraft" data	**Full distance**
Stockholm to Copenhagen	Stockholm to New York
Distance: 545 km	Distance: 6287 km
Aircraft: SAS 737-800 Euro 	Aircraft: SAS 767-300ER Intercont. 
Passengers: 145	Passengers: 188
CO2 emission: 0,171 kg/person km	CO2 emission: 0,137 kg/person km
SO2 emission: 0,054 g/person km	SO2 emission: 0,043 g/person km
NOx emission: 0,533 g/person km	NOx emission: 0,623 g/person km

NOx emissions are somewhat higher but the CO2 and SO2 emission/person km is reduced to 80% for the long haul compared to the short distance and one can assume that this is similar for air cargo transport in emissions/tonkm.
To get the evaluated emissions for long distance air transport, the impact from data set "Aircraft" is multiplied with 0.8.

5.3 Discussion on utilization level

Utilization level is the average fill level for a transport type.

The "Aircraft" dataset assumes a utilization level of 65% which is based on studies by NMT – Nätverket för Transporter och Miljön (The Network for Transport and the Environment, http://www.ntm.a.se/) based on Scandinavian air fright data. It is probably safe to assume that on long distance the air carrier operator would optimise the utilization level more so the impact from data set "Aircraft" is multiplied with 0.9 long hauls.

5.4 Comparing freight cost and transfer time

Average transfer time for cargo between Gothenburg and New York are;

- ship transport 16-27 days
- air transport 2 days.

The cost of air transport is for this type of cargo is aprox. 10 times the cost of ship transport.

5.5 New impact based on discussion

Direct air

Transport; route	Distance	GWP 100 (kg CO2-eqv.)
Lorry 24t; Ludvika-Arlanda	227km	26,29
Aircraft Arlanda -New York,	6 287km	(11774,84)
Adjusted Aircraft Arlanda - New York (see chapter 5,2 5,3)		8477,88
Total		8504,17

Consignment air

Transport	Distance	GWP 100 (kg CO2-eqv.)
Lorry 24t Ludvika – Arlanda	227km	26,29
Aircraft: Arlanda – Frankfurt	1 222km	
Aircraft Frankfurt – New York	6 184km	
Total aircraft distance:	7 406km	(13870,60)
Adjusted Total aircraft distance (see chapter 5,2 5,3)		9986,83
Total		10013,12

Consignment air (Rail)

Transport	Distance	GWP 100 (kg CO2-eqv.)
Rail Ludvika – Frankfurt	1 462km	33.22
Aircraft Frankfurt – New York	6 184km	(11581.93)
Adjusted Aircraft Frankfurt – New York (see chapter 5,2 5,3)		8338,99
Total		8372,21

Consignment air (Lorry)

Transport	Distance	GWP 100 (kg CO2-eqv.)
Lorry 24t Ludvika – Frankfurt	1 462km	169.33
Aircraft Frankfurt – New York	6 184km	(11581.93)
Adjusted Aircraft Frankfurt – New York (see chapter 5,2 5,3)		8338,99
Total		8508,32

The impact is reduced somewhat but the general conclusion does not change. Air cargo is the largest contributor to environmental impact.

6. RESULT

The impact ranking of the transport chains (in order of increasing environmental impact)

Rank	Transport	Environmental impact kg CO2-eqv
1	Ship (rail)	189.60
2	Ship (lorry)	226,84
3	Consignment air (Rail)	8372,21
4	Direct air	8504,17
5	Consignment air (Lorry)	8508,32
6	Consignment air	10013,12

"Consignment air" has the largest impact since the air distance is longest (7400 km compared to 6200 km for the other air transports).
"Consignment air (Lorry)" and "Direct air" has practically the same impact. The 100 km longer flight distance for "Direct air" is balanced by 1200 km more lorry transport.
The difference between "Consignment air (Rail)" and "Consignment air (Lorry) is 136 kg CO2-eqv. are the savings from transporting the gods 1400 km on rail compared to lorry.
Transfer on ship over the Atlantic will reduce the impact aprox. forty times compared to air transport.

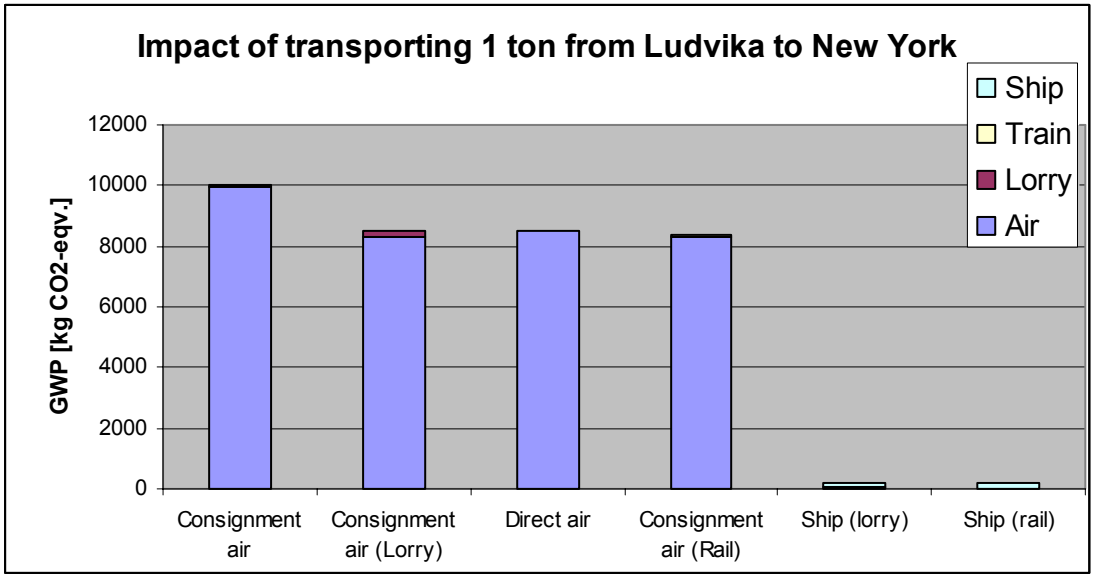


Figure 5 Final results of the environmental evaluation of transports

7. CONCLUSION

Main conclusions are; when cost and timing allow:

- choose ship over air transport
- minimize the distance with air transport
- choose rail over lorry