Professional paper

Use the carbon footprint for the reduction of greenhouse gases – the case study of Port of Koper

Uroš **LUIN**[1], Franka **CEPAK**[2], Borut **POLJŠAK**[1*]

ABSTRACT

Carbon footprint is a calculating operation, which is used to calculate the volume of the produced greenhouse gases in CO_2 equivalents for a particular activity to be carried out on our planet. From the 18th century up to 2005, the amount of carbon dioxide (CO_2) in the atmosphere increased by 35 % (from 280 ppm to 380 ppm), showing a progressive upward trend in recent decades. The permissible annual emission of greenhouse gases (GHG), which nature can still neutralize, is around 2 tons of CO_2 equivalents per capita on the planet.

In Slovenia, the GHG emission is 10 tons of CO_2 per capita per year. Port of Koper implemented the port and logistics services and the trans-shipment in 2008 was 16.050.448 tons. Overall calculated level of emissions of CO_2 equivalents in 2008 was 43.009 tons. In 2008 the overall amount of GHG in the port, taking into account the simulated planed reduction measures, was about 32.000 tons of CO_2 equivalents or around 25 % less emission than in the current situation. Emissions would be much lower if the electricity in Slovenia was produced more eco-efficiently (up to 65 % lower emissions comparing to simulated reduction).

KEY WORDS:

Carbon footprint, Carbon dioxide, Greenhouse gases, Slovenia, Port.

Received: 20. 11. 2009

Accepted: 4. 12. 2009

[1] University of Ljubljana,
Faculty of Health Science,
Zdravstvena pot 5, 1000 Ljubljana,
Slovenia

[2] Port of Koper, Vojkovo nabrežje 38,
6501 Koper

[*] *corresponding author:*
E-mail: Borut.Poljsak@zf.uni-lj.si

INTRODUCTION

Climate change has been identified as one of the greatest challenges facing nations, governments, business and citizens over future decades. Climate change has implication for both human and natural systems and could lead to significant changes in resource use, production and economic activities. In response, international, regional, national and local initiatives are being developed and implemented to limit greenhouse gas (GHG) concentrations in the Earth's atmosphere. Such GHG initiatives rely on the quantification, monitoring, reporting and verification of GHG emissions and/or removals. Port of Koper takes part of the *Climeport Project*, an environmental project funded by the European Union involving the main Mediterranean ports with the aim of palliating the effects of climate change. One of the principal aims of the project is to assess the importance of ports in this geographical area in the struggle against climate change by monitoring greenhouse gases from port activity. The project also promote the use of less polluting energy and the use of cleaner and more balanced transport, allow tools to be designed for measuring and monitoring the results obtained through the implementation of environmental improvement plans. The result of this project will also lead to the harmonization of CO_2 footprint evaluation of participating ports and to benchmarking and to the best practice identification in reducing GHG emissions. No data for ports GHG emissions is available at the moment.

A carbon footprint relates to the amount of greenhouse gases (GHGs) produced in our day-to-day lives through burning fossil fuels for electricity, heating and transportation etc.

Many organizations are seeking ways to understand, demonstrate and improve their environmental performance. This can be achieved by efficient managing those elements of their activities, products and services that can significantly impact the environment. Port of Koper has already implemented the environmental management system (ISO 14001) in year 2001 and yearly assesses its environmental performance against environmental policy, objectives, targets and other environmental performance criteria. In year 2008 port has decided to calculate and monitor one additional and new environmental indicator, the carbon footprint. A carbon footprint is a measure of the impact of activities that they have on the environment, and in particular climate change. It relates to the amount of greenhouse gases (GHGs) produced in our day-to-day lives through burning fossil fuels for electricity, heating and transportation etc. The carbon footprint is a calculating operation, which is used to calculate the volume of the produced greenhouse gases in CO_2 equivalents for a particular activity. GHGs include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydro-fluorocarbons (HFCs), per-fluorocarbons (PFCs) and sulfur hexafluoride (SF_6). The gases listed above have global warming potentials (GWPs) [6,7]. A GWP compares the radiation forcing of a tone of a greenhouse gas over a given time period (e.g., 100 years) to a tone of CO_2. In Table 2 are listed GHG with GWPs used in company [6,7].

From the 18th century up to 2005 the amount of carbon dioxide (CO_2) in the atmosphere increased by about 35 % (from 280 ppm to about 380 ppm), showing a progressive upward trend in recent decades [1].

The average temperature of our planet has consequently risen by about 0.7 °C from the 19th century to the present [2]. The permissible annual emission of GHGs, which nature can neutralize, is around 2 tons of CO_2 equivalents per capita on the planet [3]. In Slovenia, the GHG emission is 10 tons of CO_2 per capita per year and it is equal to the European average [3]. In the USA the emission of GHG is as much as 20 tons of CO_2 per capita per year, which makes them one of the top emitters.

Carbon footprint is an important element of assessment to identify the sources of emissions and to reduce them by considering and introducing appropriate measures such as the use of green energy sources and the reduction of fossil fuel consumption, appropriate waste management and recycling, which saves material costs and energy. Among other things, carbon footprint is used to compare the greenhouse gas emissions between companies, institutions, products etc.

Carbon footprint is used to compare the greenhouse gas emissions between companies, institutions, products etc.

The port of Koper offers port and logistics services. The basic activities cover cargo handling and warehousing services for all types of goods, complemented by a range of additional cargo services with the aim of providing customers with a comprehensive logistics support. Port of Koper operates eleven specialized terminals in an area of 2 720 000 m^2 and 25 ship berths are available at 3 200 m of operating coast. The trans-shipment volume in 2008 was 16 050 448 tons. The following reasons led to calculating the carbon footprint of the Port of Koper:

- to ensure sustainable development and environmental awareness of the company;
- to identify the major sources of GHG emissions;
- to facilitate the development and implementation of a GHG management strategies and plans;
- to facilitate the ability to track performance and progress in the reduction of GHG emissions and/or increase in GHG removals.

This paper presents the methodology for the carbon footprint evaluation of the Port of Koper and future actions towards the reducing of GHG emissions.

METHODS

In order to calculate carbon footprint, the directions from the following standards were used:

ISO 14064-1: 2006: Greenhouse gases – Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals,

ISO 14064-2: 2006: Greenhouse gases – Part 2: Specification with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emission reductions or removal enhancements.

For the calculation of the carbon footprint selected steps were performed:

Once the key categories have been identified, the data collection should follow. Data collection is an integral part of developing and updating a greenhouse gas inventory.

- establishing operational boundaries (that is identifying GHG emissions and removals, categorizing GHG emissions and removals into direct emissions, energy indirect emissions and other indirect emissions);
- quantification of GHG emissions and removals (that is identification of GHG sources and sinks – GHG inventory, selection of quantification methodology, collection of GHG activity data, selection or development of GHG emission or removal factors, calculation of GHG emissions and removals).

Compiling a greenhouse gas inventory is the step-by-step process. The first step for the GHG inventory was to identify the key categories for the inventory so that resources have been prioritized. For a new inventory a preliminary assessment based on local knowledge and expertise about large emission sources and inventories should be performed. Assessing the key categories helps to focus effort and resources on the sectors that contribute most to the overall inventory or inventory uncertainty and so it helps to ensure that the best possible inventory is compiled for the available resources. Once the key categories have been identified, the data collection should follow. Data collection is an integral part of developing and updating a greenhouse gas inventory. Data collection activities should focus on the collection of data needed to improve estimates of key categories which are the largest, have the greatest potential to change. Port of Koper collects ancillary data during operations for other purposes (i.e. fuel and electricity consumption, number of ships, vehicles entering the port etc.). Emissions and removals are estimated following the methodological choice and data collection.

The most common methodological approach for the calculation of GHG emissions is to combine information on the extent to which a human activity takes place (called *activity data* or t_{AD}) with coefficients which quantify the emissions or removals per unit activity. These are called *emission factors* (f_e) (Table 1) [5]. The basic equation is therefore:

$$q_e = q_{AD} \bullet f_e$$

m_e produced emission CO_2 in a year (kg/a)
t_{AD} human activities or consumption of the source of the GHG (kg/a)
f_e emission factor of CO_2 (kg/kg)

For example, in the energy sector fuel consumption would constitute activity data, and mass of carbon dioxide emitted per unit of fuel consumed would be an emission factor.

All the port GHG emissions presented in this paper were obtained using the calculation methodology mentioned above, no measurement was performed.

In order to make estimates of greenhouse gas emissions in carbon dioxide equivalents, it was necessary to examine the process of port activities and analyze in detail the equipment, machinery, frequency and the time of entry and/or exit of the transshipment vehicles (ships, locomotives, trucks,...), heating/cooling techniques, power consumption, fossil fuel consumption, the amount of waste, business migration and all other sources of greenhouse gases.

In order to calculate carbon emissions, the following data were needed: the quantity of consumed fossil fuel, the quantity of consumed electricity, the quantity of waste disposal to landfill, water consumption from the water supply system, the amount of greenhouse gases from refrigeration systems and the leakage of fuel tank (vapor), etc.

In order to calculate carbon footprint, data from the different sources of GHG were multiplied by the appropriate emission factors [3,4] (Table 1) and thus quantified in tones of CO_2 equivalents.

Table 1:
Emission factors for different source of GHG.

Source of GHG	Emission factor for CO_2	Unit
Waste vessel oil	3.1500	kg/L
Vessel fuel	3.1500	kg/L
Diesel	2.6800	kg/L
Petrol	2.3100	kg/L
Liquefied petrol. gas	1.6800	kg/L
Waste landfill (estimated)	1.0000	kg/kg
Electricity in SLO	0.5500	kg/kWh
Waste water (calculated)	0.0002	(kg/kg

Table 2:
Global warming potential for gases used in the company (ISO 14064-1/2: 2006).

GAS	GWP (CO_2 in 100 years)
HCFC-22 R22	1.700
METHANE	21

The GWP is defined as the ratio of the time-integrated radiative forcing from the instantaneous release of 1 kg of a trace substance relative to that of 1 kg of a reference gas. Substance's GPW is not the constant during the time. Particular substance concentration in atmosphere changes in time period as result of changing substance's chemical structure, e.g. methane has a potential of 72 over 20 years but 21 over 100 years. Commonly, a time horizon of 100 years is the most used.

The overall calculated quantity of CO_2 equivalents emissions in the company Port of Koper for the year 2008 was **43,009.62 tons.**

RESULTS AND DISCUSSION

The current situation

The result of the GHG inventory and from the calculation of the GHG emissions in equivalents CO_2 revealed that the main source of CO_2 emission in port is because of:

- electricity consumption of machinery (i.e. electricity needed for the operation of cranes, lighting, shore side power supply, cooling, other);
- fuel consumption of merchant ships in port (i.e. operating of ships in the port);
- fuel consumption of port mechanization, port vehicles;
- fuel consumption due to towage of ships entering the port;
- incineration of ship waste oil;
- landfill of municipal port waste;
- fuel consumption from trucks entering the port.

Some other sources of GHG emissions are represented in Figure 1, but do represent a minor influence on the port carbon footprint.

Fossil fuel consumption is the main source of GHG – representing as many as 60.68 % of total emissions in the company. The fact that electricity in Slovenia is not adequately eco-efficient, is reflected in the emitted quantity of GHG, which is 13,321 t/a of carbon dioxide equivalents. It accounts for 31 % of total emissions in the company. The role of waste management has proven to be very important in the battle against greenhouse gas emissions, since despite the high level of recycling and re-use of waste, its contribution is 7.7 % of total emissions in the company. The consumption of potable water and leakage of gas from cooling systems are negligible sources of GHG. However, the gas in cooling systems makes a significantly higher percentage (5 %) in the case of discharge of the total quantity of refrigerant gas.

The overall calculated quantity of CO_2 equivalents emissions in the company Port of Koper for the year 2008 was **43,009.62 tons** (Figure 1).

Goals for GHG emission decreasing

In order to reduce CO_2 emissions in Port of Koper, the following long-term goals were set:

- the planned installation of photovoltaic power plant with an annual electricity production of 2000 MWh per year;
- the shift from fossil fuel to electricity for all port mechanization (electric service vehicles);
- promote and accommodate shore-side power;
- carbon footprint monitoring and management;
- reduction of the use of fossil fuels;
- further improve separate waste collection and recycling;
- further optimization of work processes in order to minimize energy consumption;

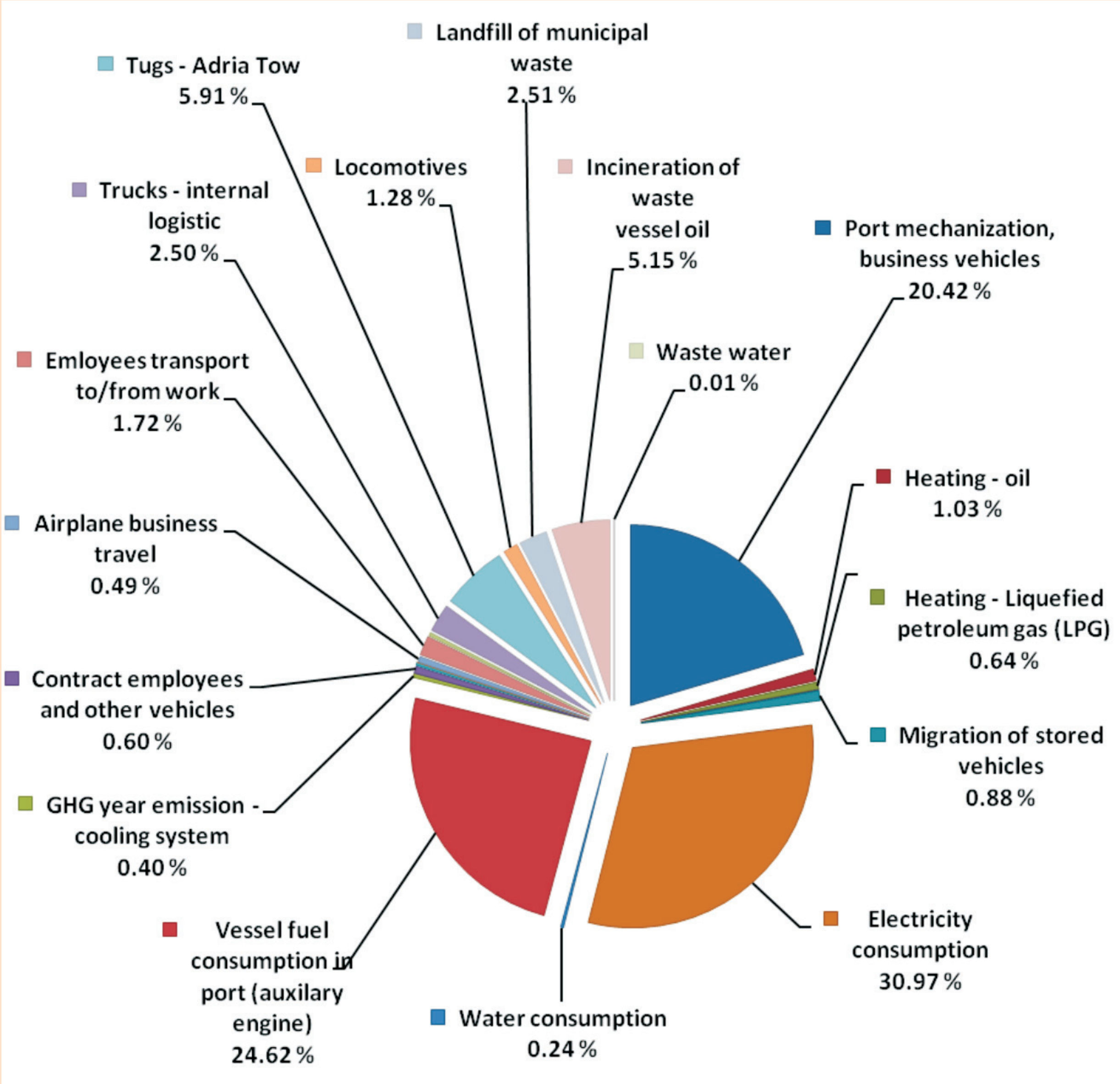

Figure 1:
Greenhouse gas emissions for particular segments of the company.

- replacement of greenhouse gases and ozone-depleting gases in cooling systems with the environment-friendly gases;
- increased environmental awareness of the population;
- lowering the energy consumption for lightening.

For the Port of Koper, the project of installing photovoltaic power stations with an annual electricity production of 2,000 MWh would result in emission reduction of 1,100 tons of CO_2 equivalents, or 2.3 % less emissions compared to the year 2008. The shift from fossil fuels to electricity to power the port machinery and service vehicles would result in the reduction of CO_2 emissions. Beside that it would also result in:

- reduction of noise;
- elimination of exhaust emissions due to winding up of the internal combustion engines;

Table 3:
Greenhouse gas emissions for all segments of the company.

SOURCE OF GREENHOUSE GASES		Emission CO_2 (t/a)	Portion (%)	Emission CO_2 (t/a)	Portion (%)	TOTAL Emission CO_2 (t/a)
ELECTRICITY CONSUMPTION	Electricity consumption	13,321.03	30.972	13,321.03	30.972	43,009.62
FOSSIL FUELS CONSUMPTION	Vessel fuel consumption in port (auxiliary engine)	10,587.82	24.617	26,098.28	60.680	
	Port mechanization, business vehicles fuel consumption	8,783.27	20.422			
	Tugs – fuel consumption	2,543.40	5.914			
	Internal logistic fuel consumption of trucks	1,075.14	2.500			
	Employees transport to/from work	739.50	1.719			
	Locomotives	552.30	1.284			
	Heating – oil	444.47	1.033			
	Migration of stored vehicles	380.16	0.884			
	Heating – Liquefied petroleum gas (LPG)	275.75	0.641			
	Contract employees and other vehicles	259.12	0.602			
	Airplane business travel	210.50	0.489			
	Mooring of ships	127.46	0.296			
	Ship pilotage	115.24	0.268			
	Fuel losses (vaporization)	2.57	0.006			
	Visitor tours – bus	1.58	0.004			
COOLING SYSTEM – GHG LOSSES	GHG year emission from cooling system	170.00	0.395	170.00	0.395	
WATER CONSUMPTION	Water consumption	102.20	0.238	102.20	0.238	
WASTE	Incineration of waste vessel oil	2,233.12	5.192	3,318.11	7.715	
	Landfill of municipal waste	1,080.00	2.511			
	Waste water	4.99	0.012			

- higher efficiency vehicles and consequently higher energy efficiency and reduction of emissions GHG (vehicles – fossil fuel about 20 % – electricity about 80 %);
- improved working environment.

The power supply for ships through the electrified piers would result in:

- elimination of noise from the operation of auxiliary vessel engines;
- elimination of direct GHG emissions and other exhaust gases and particulate matter in the port;
- increased energy efficiency and thereby reduced greenhouse gas emissions.

If taking into account the foreseen measures, the overall amount of GHG in the company Port of Koper in 2008 would be about 32.000 tons of CO_2 equivalents or around 25 % less emission than in the cur-

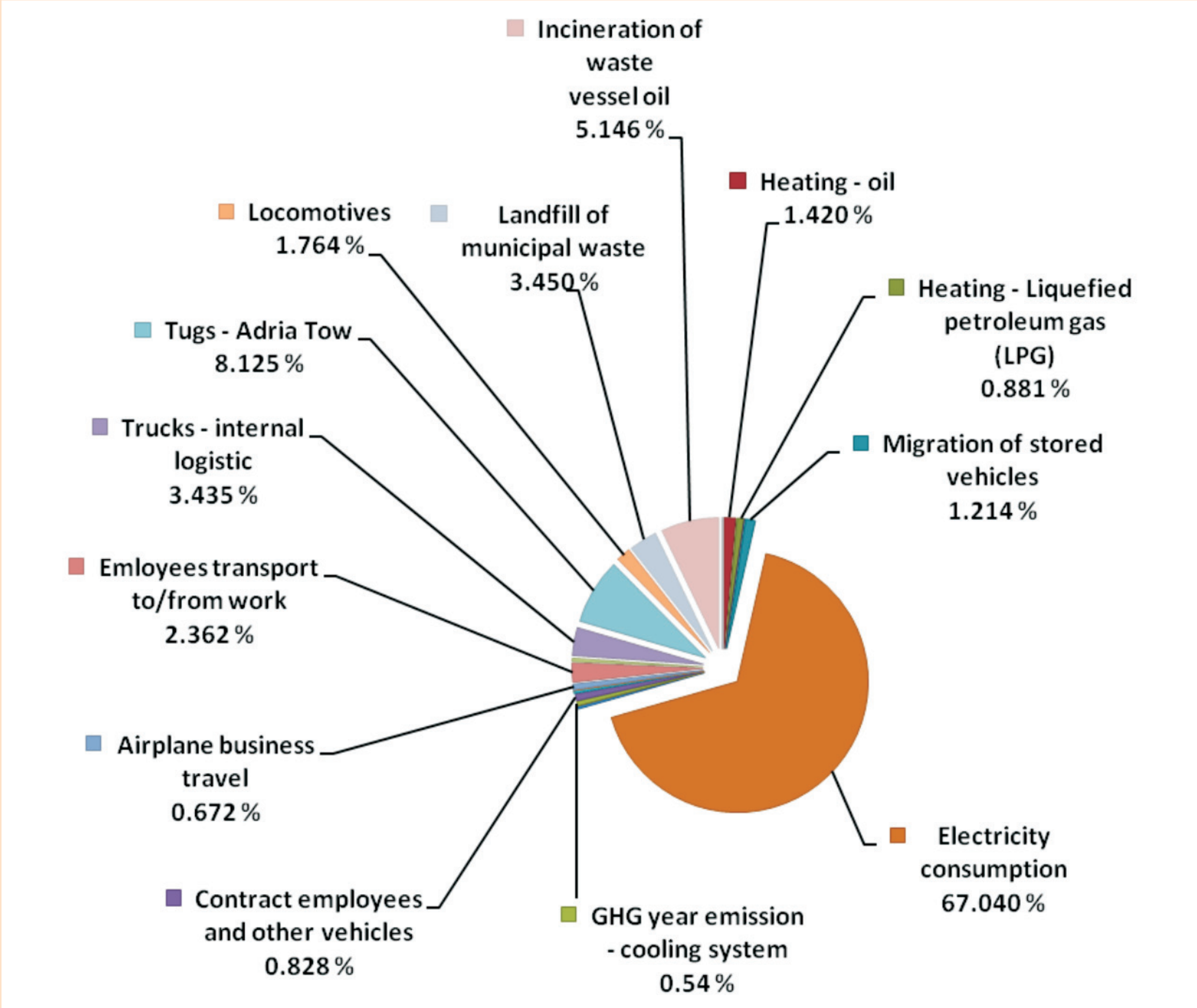

Figure 2:
Greenhouse gas emissions for individual segments in the company – a simulation.

rent situation. As we can see from the Figure 2, emissions would be much lower if the electricity in Slovenia was produced more ecologically (up to 65 % less or overall amount would be about 12.000 tones of GHG, if we were able to produce electricity based on zero emission technology).

CONCLUSIONS

Calculating the carbon footprint is only the beginning of the battle against the sources of greenhouse gases. Without taking the necessary measures to reduce emissions, this battle is worthless. Electricity production in Slovenia has the high emission factor due to the fact that one third of energy is produced by burning coal in thermal power plants (TE – Šoštanj, TE – Trbovlje, TE – Tol, etc.). In the future it is necessary to provide cleaner energy at the state level, primarily by reducing the use of fossil fuels, using renewable energy sources and new environmental technologies to generate power. By implementing these measures, greenhouse gas emissions could be reduced significantly, especially if it would be supplemented by the change in the technology of the transport.

The port of Koper demonstrates that the main reason for emissions of the greenhouse gases is the combustion of fossil fuels and electricity consumption.

The goal of Port of Koper is to develop balanced and harmonized actions in the whole group of participant Mediteran ports in the Climeport project in order to improve the weak points concerning greenhouse emissions of the ports. The carbon footprint has thus become a key environmental indicator which will be annually used as an environmental performance indicator. The carbon footprint for 2009 will show the effectiveness of implemented measures for climate change mitigation.

The port of Koper demonstrates that the main reason for emissions of the greenhouse gases is the combustion of fossil fuels and electricity consumption. Any activity is ultimately related to the use of fossil fuels and the production of GHG emissions. In the first stage the most efficient way of reducing the port carbon footprint is to use solar power. With this study we have now a better understanding of the port activities regarding GHGs emissions. This GHGs inventory has pointed out some problems that will be analyzed in the future in order to further optimization of the ports operations. The carbon footprint has also become an important indicator in choosing the best way of reducing GHGs emissions, in decision making. The reduction of GHGs has shown to be closely related to the usage of renewable energy and thus confirming port environmental strategy in using alternative energy sources. The future work will be also focused on checking the performance of different manufacturer/type of equipment, vehicles, crane, HVAC equipment, etc. using the carbon footprint as an indicator and thus making the GHG inventory even more detailed.

Future work on Climeport project will also give the opportunity to participating the Mediterranean ports to exchange best practice and to benchmark ports activities regarding energy efficiency and the GHGs emissions.

REFERENCES

[1] Raupach MR, at al. Global and regional drivers of accelerating CO_2 emissions. PNAS 104. 2007; 24: 10288-10293.

[2] Hansen J, at al. Global temperature change PNAS 103. 2006; 39: 14288-14293.

[3] Calculate your carbon footprint. Umanotera. http://www.umanotera.org/index.php?node=170 (7.6.2009).

[4] Environment Canada's National Inventory Report: Greenhouse Gas Sources and Sinks in Canada. 1990-2007. www.env.gov.bc.ca/epd/climate/ghg.../excel/emission-factors.xls (23.11.2009).

[5] IPCC Guidelines for National Greenhouse Gas Inventories 2006. http://www.ipcc- nggip.iges.or.jp/public/2006gl/index.html (23.11.2009).

[6] ISO 14064-1: 2006: Greenhouse gases -- Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals.

[7] ISO 14064-2: 2006: Greenhouse gases -- Part 2: Specification with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emission reductions or removal enhancements.