ENVISHIPPING

Total Environmental Footprint of Ships

EnviShipping Workshop

Piraeus 14.11.2014

Workshop Agenda

15:30 – 15:40	**Opening Address** (G. Gratsos, Hellenic Chamber of Shipping) **Opening Address** (Ai. Stamou, Ministry of Shipping and the Aegean) **Opening Address** (D.V. Lyridis, Laboratory for Maritime Transport) **Written Message** (from Prof. H.N. Psaraftis (former Head of LMT))
15:40 – 14:20	**The EnviShipping Research Project** (N.P. Ventikos, NTUA) **EnviShipping Methodology** (S. Chatzinikolaou, NTUA) **EnviShipping Tool** (G. Dimopoulos, DNV.GL)
16:20 – 16:40	**Invited Speech** (T. Longva, DNV.GL)
16:40 – 17:00	**Coffee Break**
17:00 – 17:50	**Panel Discussion: Life Cycle Thinking in Environmental Issues of Ships** (Prof. A. Papanikolaou, T. Longva, P. Zachariadis, G. Gratsos, S. Daniolos, Ai. Stamou)
17:50 – 18:00	**Workshop Closure**
18:00 – 18:30	**Light snacks / Drinks**

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The EnviShipping Research Project

Dr. Nikolaos P. Ventikos

Assistant Professor
School of Naval Architecture and Marine Engineering
National Technical University of Athens, GREECE

EnviShipping Workshop
Piraeus 14.11.2014

Project Info

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- **Title:** **Total Environmental Footprint of Ships – EnviShipping**
- **Greek Title:** **Πράσινη Αποτύπωση Θαλάσσιων Μεταφορών**

- **Duration:** May 2011 – October 2014 (41m including 5m extension)
- **Budget:** 340,714.00 € (funding 220,768.00 €)
- **Leader:** NTUA – Laboratory for Maritime Transport (LMT)
- **Coordinator:** Prof. H. Psaraftis (2011 – 2013), Ass. Prof. N. Ventikos (2013 -2014)

Project Info

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ΕΥΡΩΠΑΪΚΗ ΕΝΩΣΗ
ΕΥΡΩΠΑΪΚΟ ΤΑΜΕΙΟ
ΠΕΡΙΦΕΡΕΙΑΚΗΣ ΑΝΑΠΤΥΞΗΣ

ΑΝΤΑΓΩΝΙΣΤΙΚΟΤΗΤΑ
ΕΠΙΧΕΙΡΗΜΑΤΙΚΟΤΗΤΑ
ΕΠΑΝ ΙΙ

η περιφέρεια στο επίκεντρο της ανάπτυξης

ΕΣΠΑ
2007-2013
πρόγραμμα για την ανάπτυξη

Υπουργείο Παιδείας και Θρησκευμάτων, Πολιτισμού και Αθλητισμού
ΓΓΕΤ – ΕΥΔΕ-ΕΤΑΚ

Ε. Π. Ανταγωνιστικότητα και Επιχειρηματικότητα (ΕΠΑΝ ΙΙ), ΠΕΠ Μακεδονίας - Θράκης, ΠΕΠ Κρήτης και Νήσων Αιγαίου, ΠΕΠ Θεσσαλίας - Στερεάς Ελλάδας - Ηπείρου, ΠΕΠ Αττικής

ΔΡΑΣΗ ΕΘΝΙΚΗΣ ΕΜΒΕΛΕΙΑΣ: «ΣΥΝΕΡΓΑΣΙΑ»

ΠΡΑΞΗ Ι: «Συνεργατικά έργα μικρής και μεσαίας κλίμακας»

The research project is partially funded (65% of the total budget) by the Greek General Secretariat for Research and Technology under the National Strategic Reference Framework scheme (2007 – 2013)

Project Partners

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- **National Technical University of Athens**
  (Laboratory for Maritime Transport)
- **DNV.GL** (Strategic Research & Innovation, Greece)
- **HELLENIC SEAWAYS**
- **POLYEKO**
- **HELMEPA**
- **NAFS – Hellenic Chamber of Shipping**
  (Company of Shipping Development Support and Cooperation)

!!! Ariston Navigation Corp has provided voluntarily support to the project (case studies phase) replacing Naftotrade SA .

Project Site

http://www.envishipping.gr/

Project Goal

The development of methodologies and tools for the assessment of the environmental footprint of ships from a life cycle perspective

Project Structure

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1st Phase
Data Collection
- Questionnaire to shipping companies
- Hierarchy – Ship Environmental drivers
- Identification of LCA Framework

2nd Phase
Methodology
- Database
- Parametric Analysis
- Life Cycle Inventory
- LCA Framework Adjustment

3rd Phase
Tools - Analysis
- LCA tool development
- LCA case studies
- Tool Calibration

4th Phase
Results
- Ship Life Cycle Assessment Methodology
- LCA Tool
- Total Environmental Footprint of Ships
- Technical Files – Solutions

Project Achievements

Deliverables

The project has produced 15 technical reports (deliverables) as planned in the contractual agreement

Methodology

A new methodology for incorporating the concept of life cycle thinking in shipping environmental assessments has been developed

Tools

A novel ship life cycle analysis tool has been developed

A systematic Inventory of technical (design and operational) solutions for improving the environmental footprint of ships has been formulated

Publications / Academic

Four peer reviewed conference papers

Three journal papers (under review and/or in preparation)

Part of the research is included in a doctoral study at NTUA (S.D. Chatzinikolaou)

The EnviShipping Methodology

Stefanos Chatzinikolaou

Research Engineer (PhD Candidate)
Laboratory for Maritime Transport
School of Naval Architecture and Marine Engineering
National Technical University of Athens, GREECE

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Project's Methodology

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Methodology features:

- Life Cycle approach (Shipbuilding – Operation – Repairs – Dismantling)
- Systems Engineering (detail the ship into its components)
- Process analysis/modeling
- Systematic Inventory of ship emissions and wastes
- Ship total environmental footprint
- Life cycle impact assessment estimations

Life cycle thinking prevents problem shifting:

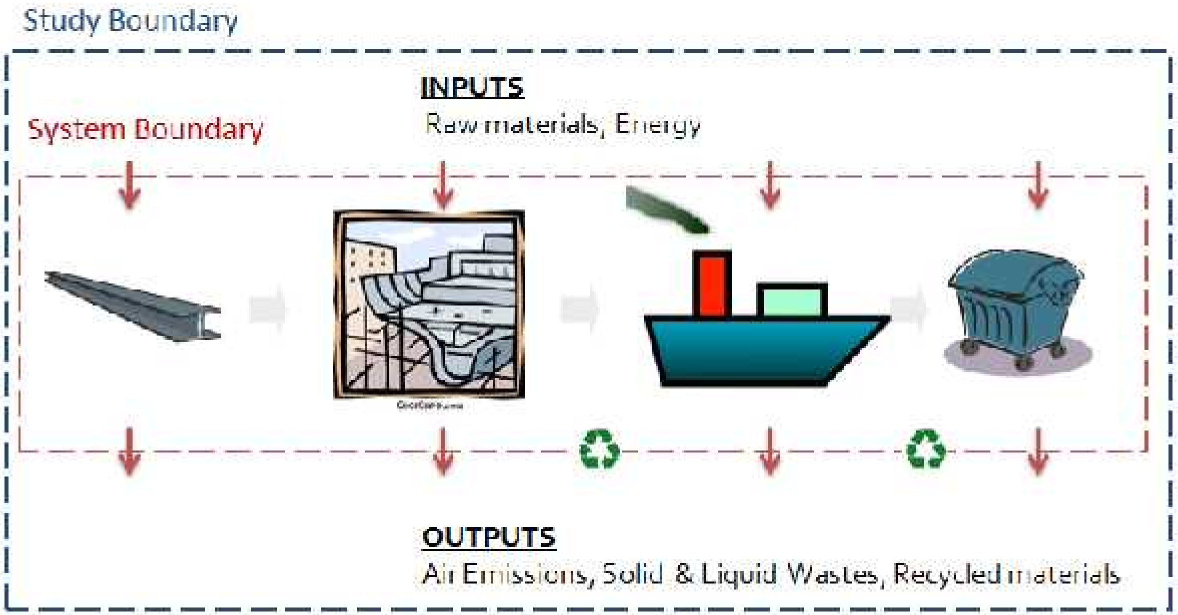
- to other life cycle stages
- to other environmental problems
- to other countries
- to the future

1. Helps avoiding the externalization of environmental costs
2. Provides the cornerstone for a sustainable system

Life Cycle Assessment, LCA

What is the LCA?

ISO 14040: "*LCA is the compilation and evaluation of the inputs, outputs and the potential environmental impacts of a system throughout its life cycle*"



How can the LCA help?

Identifies trade-offs among alternatives (materials, designs etc)

Identifies opportunities for process environmental improvements

LCA supports environmental decision making

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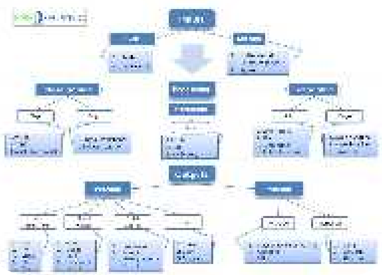
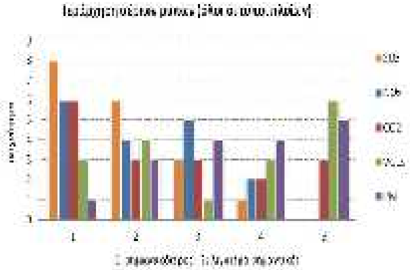
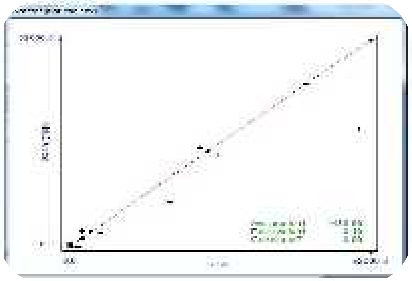
1st phase



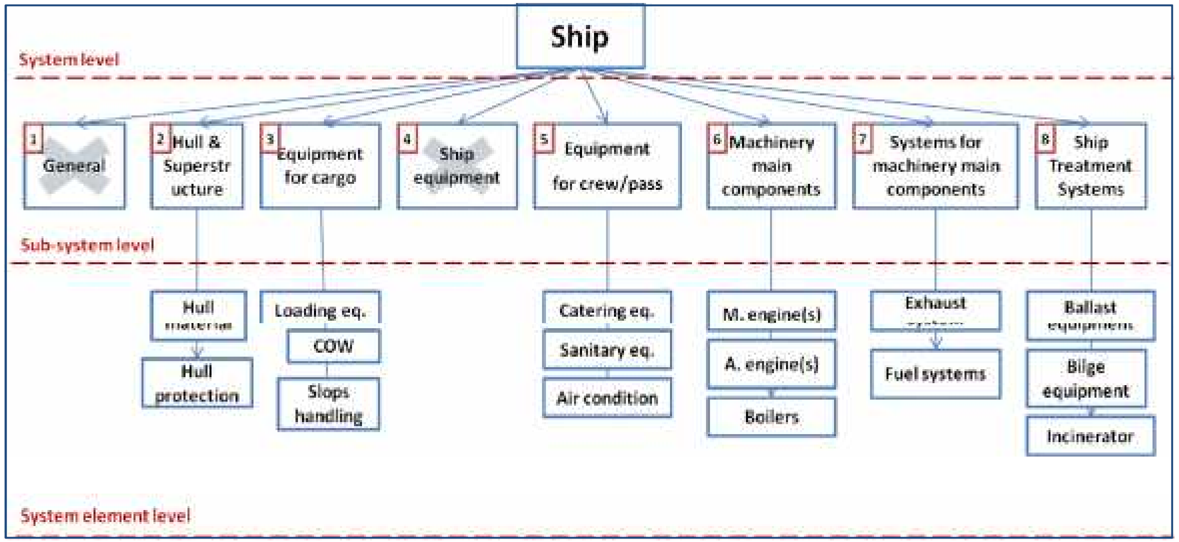
Identification of Ship Processes (D1.1)



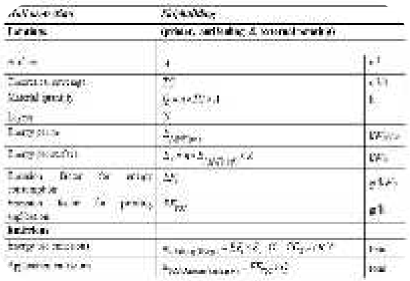
Questionnaire - Hierarchy (D2.1)



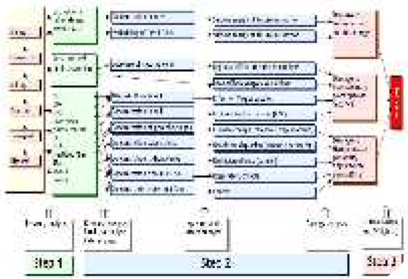
Parametric Analysis - Database (D2.1, D2.2)



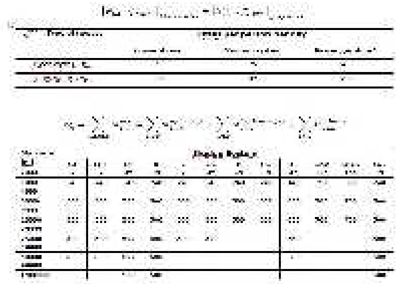
2nd phase



Process Algorithms (D3.1)



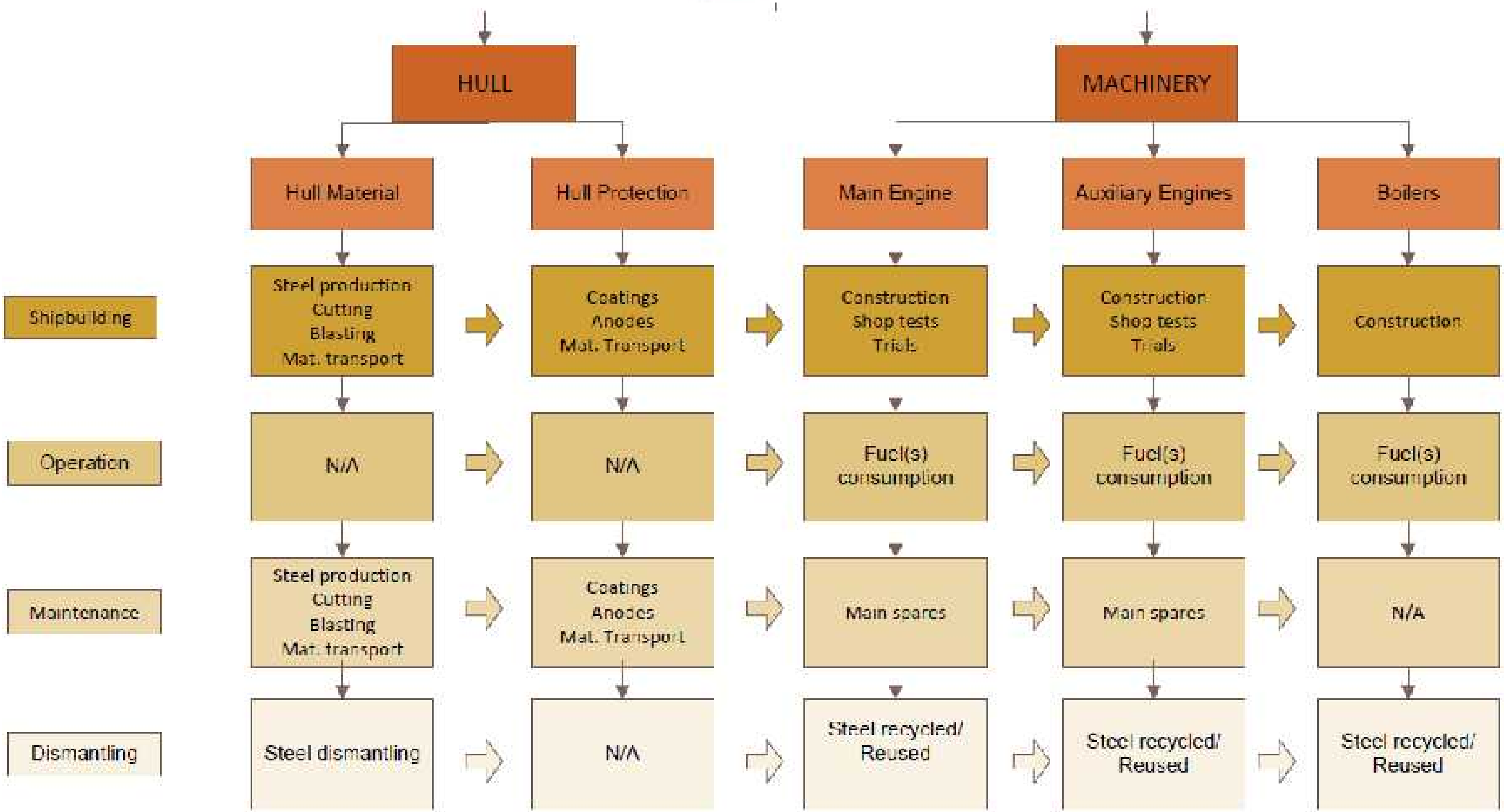
Life Cycle Assessment Methodology (D1.2)



Life Cycle Inventory (D3.1)

Ship Life Cycle Framework

Example: Air Emissions Life Cycle



Process Example

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Process: Coatings

Calculation is performed per ship's surface

Primer, antifouling, top coatings are included

Paints spec info is utilised (theoretical coverage, emission factors for VOC etc.)

Calculation of total emission from process

Hull protection	*Shipbuilding*	
Paintings	**(primer, antifouling & external painting)**	
Surface	A	m^2
Theoretical coverage	TC	m^2/lt
Material quantity	$Q = n \times TC \times A$	lt
Layers	n	
Energy per m^2	$F_{PAINT(1m^2)}$	kWh/m^2
Energy per surface	$E_A = n \times F_{PAINT(1m^2)} \times A$	kWh
Emission factor for energy consumption	EF_i	gr/kWh
Emission factor for painting application	EF_{VOC}	gr/lt
Emissions		
Energy use emissions	$m_{i(Painting,Energy)} = EF_i \times E_A, (i = CO_2 \ldots etc)$*	tons
Application emissions	$m_{VOC(Painting(Application))} = EF_{VOC} \times Q$	tons

Process Example

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Process: cathodic protection

Step1: Calculation of total wetted surface and ballast tanks surface

Step2: Calculation of zinc anodes quantity for hull and wetted surfaces

Step3: Emissions factors for production of anodes, seawater dissolution

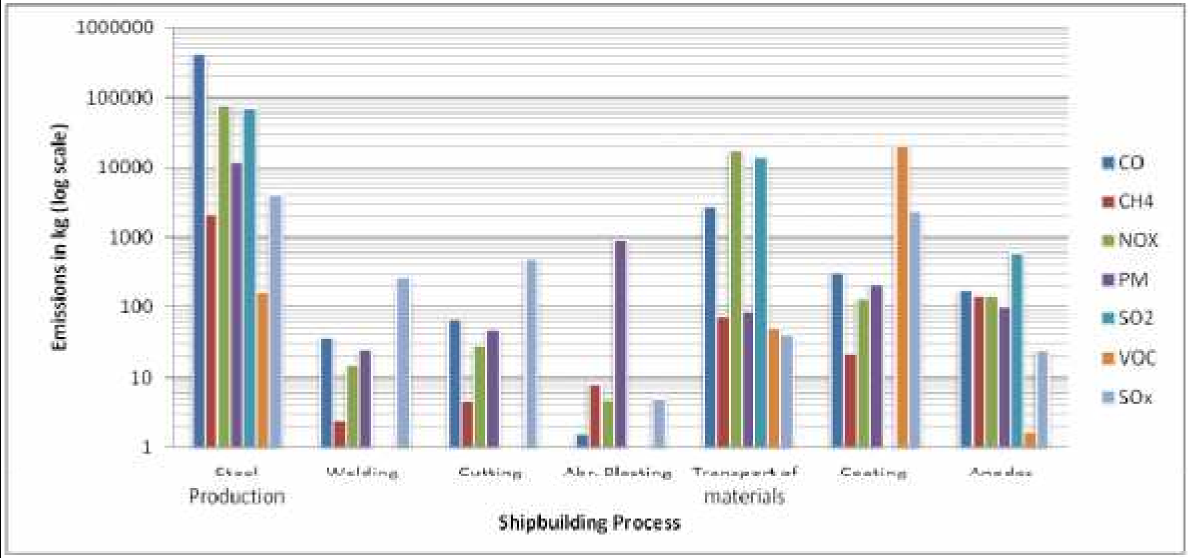
Step 4: Calculation of total emissions from process

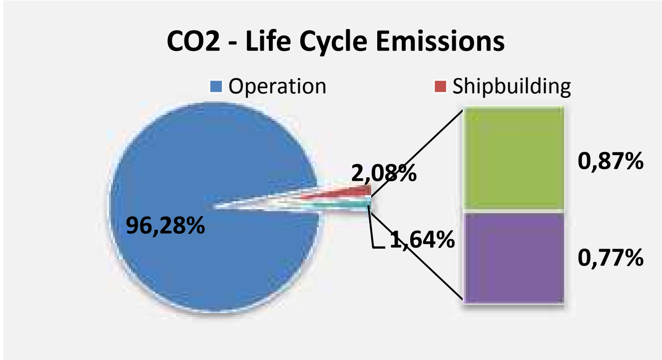
Cathodic protection algorithm		Units
Wetted Surface	A_{Wetted}	m^2
Ballast tanks surface	$A_{Ballast}$	m^2
Required el. current density	i_c	mA/m^2
Time spent in water	t	h
El. capacity of anode in seawater	ε	A×h/kg
Utilisation factor	u	-
Zinc anodes quantity for hull wetted surface	$Q_{Wetted} = \frac{(A_{Wetted} \times i_c) \times t \times 10^{-3}}{\varepsilon \times u}$	kg
Zinc anodes quantity for ballast tanks	$Q_{Ballast} = \frac{(A_{Ballast} \times i_c) \times t \times 50\% \times 10^{-3}}{\varepsilon \times u}$	kg
Emission factor	$EF_{i/zinc}$	gr/ton
Emissions calculation	$m_{i/zinc} = \sum_{j=1}^{n} (EF_i \times Q_j)$ $(i = CO2,\ldots)$ $(j = \text{wetted, ballast})$	kg

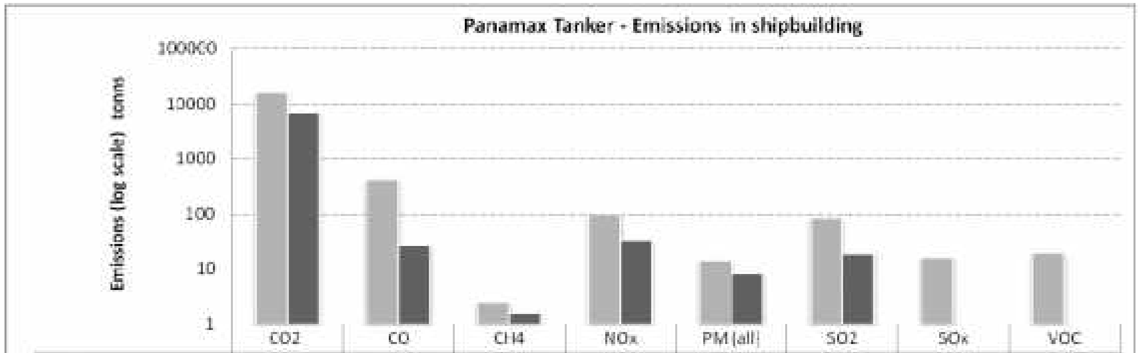
Life Cycle Emissions Inventory

75, 000 dwt Panamax Oil Tanker

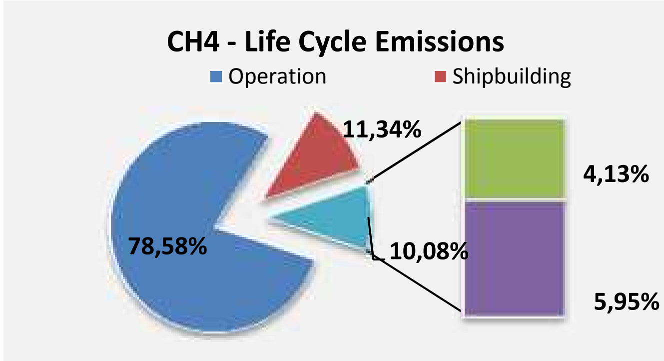
Shipbuilding processes, The Inventory of emissions in shipbuilding per process (all emissions except for CO2)







	CO2	CO	CH4	NOx	PM (all)	SO2	SOx	VOC
Hull sub system	16048,73	425,46	2,49	95,26	14,47	84,07	15,83	20,00
Machinery sub system	6970,46	27,55	1,58	34,18	8,49	19,60		

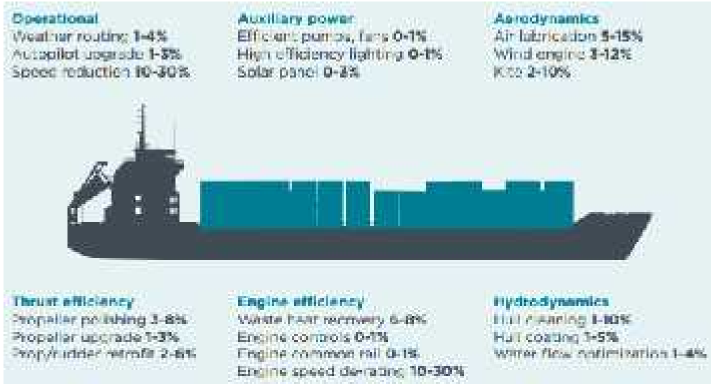


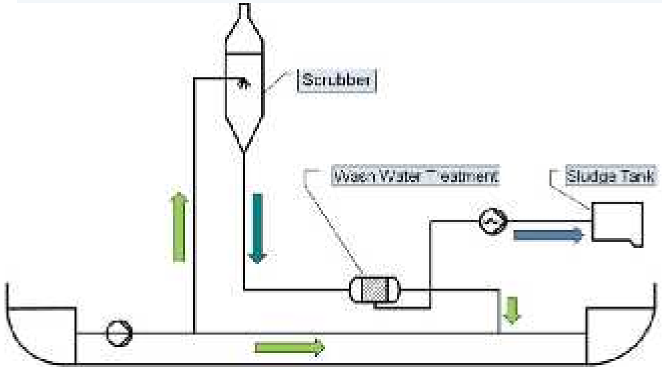
Subsystems comparison, Hull vs. Machinery emissions in shipbuilding

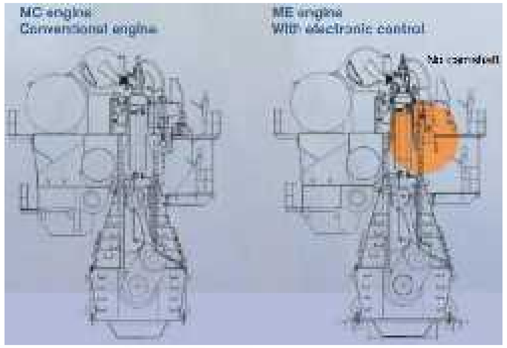
Making the footprint greener…

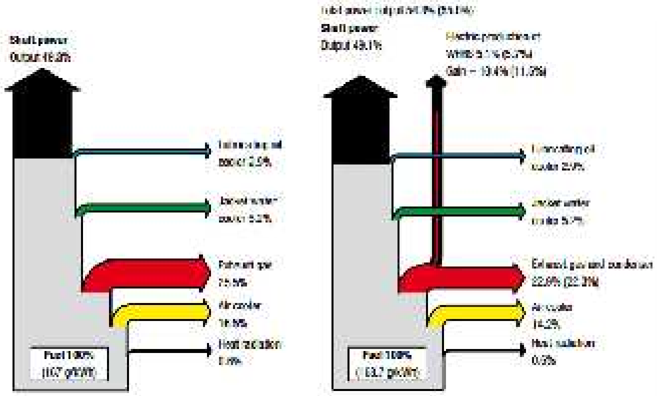
Envishipping Technical Solutions Files (D3.2)

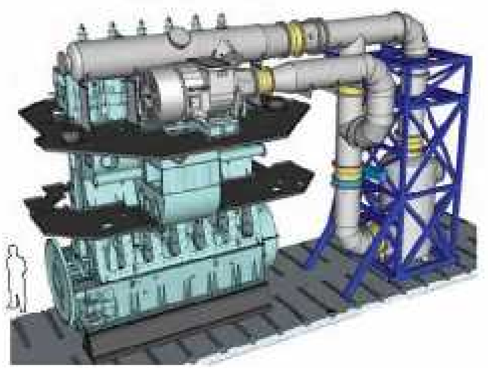
- Technical solutions (design and retrofitting)
- Operational solutions (no changes in ship structure & equipment)

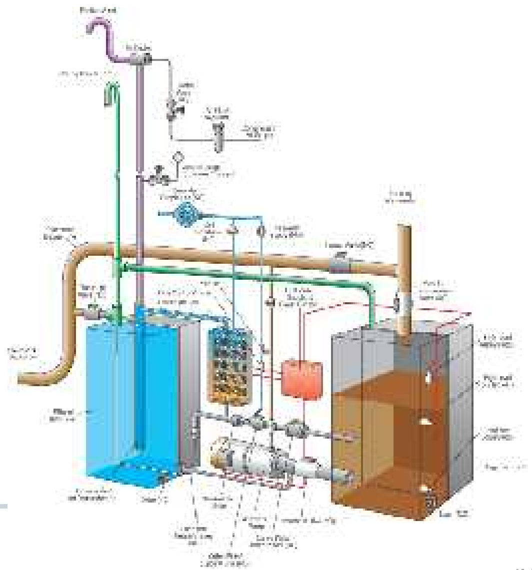




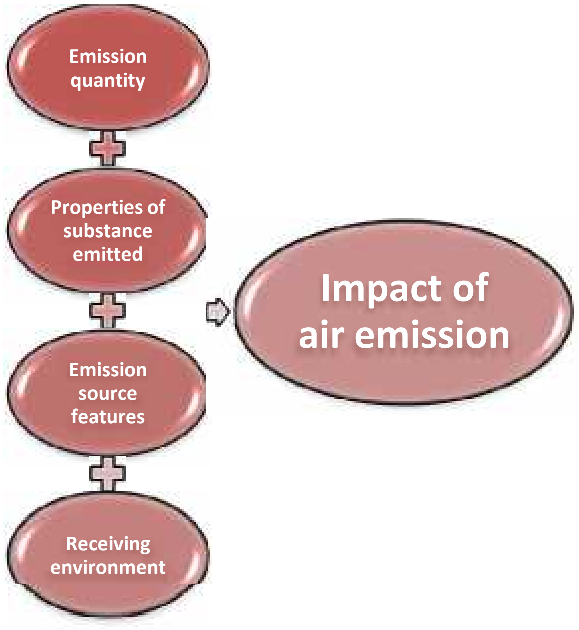








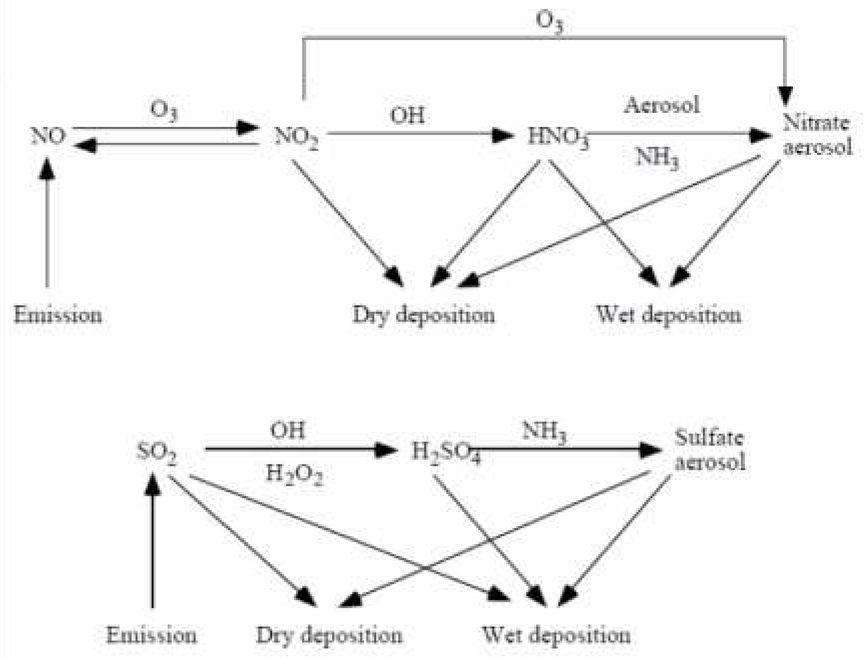
Impact Assessment



Impact assessments usually consider only the **first two** parameters

- **For global impacts** (climate change), this is not a problem since the impact is independent of where the emission occurs.
- **For air pollution impacts** (acidification, eutrophication, health effects etc) having local or regional characteristics, all impact parameters are important and should be taken into account .

Example: Impact of NOx emissions on ozone formation



Shipping: NOx is transported much less efficiently upward than land based emissions; there is much less convection over the oceans than over land at mid-latitudes.

Aviation: NOx emissions are not us much as those from road traffic and shipping, but they cause the largest ozone perturbation because the lifetime of NOx increases with height!

Future work (initiated at NTUA)

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- **Stochastic Ship LCA – Uncertainty analysis:** (e.g. Accept input parameters as stochastic variables and identify their probability distribution).
- **Life Cycle Impact Assessment:** Development of impact /damage models for the specific case of shipping, investigate impact methods that can adequately monetise the impact
- **Sustainability Assessment:** Integration of Costing and Social Assessment to Life Cycle studies.

Total Environmental Footprint of Ships

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