北美港口与船舶排放清单和前沿问题
Port and shipping emission inventory and emerging issues in North America

船舶空气污染物排放控制国际研讨会

2014年2月27日

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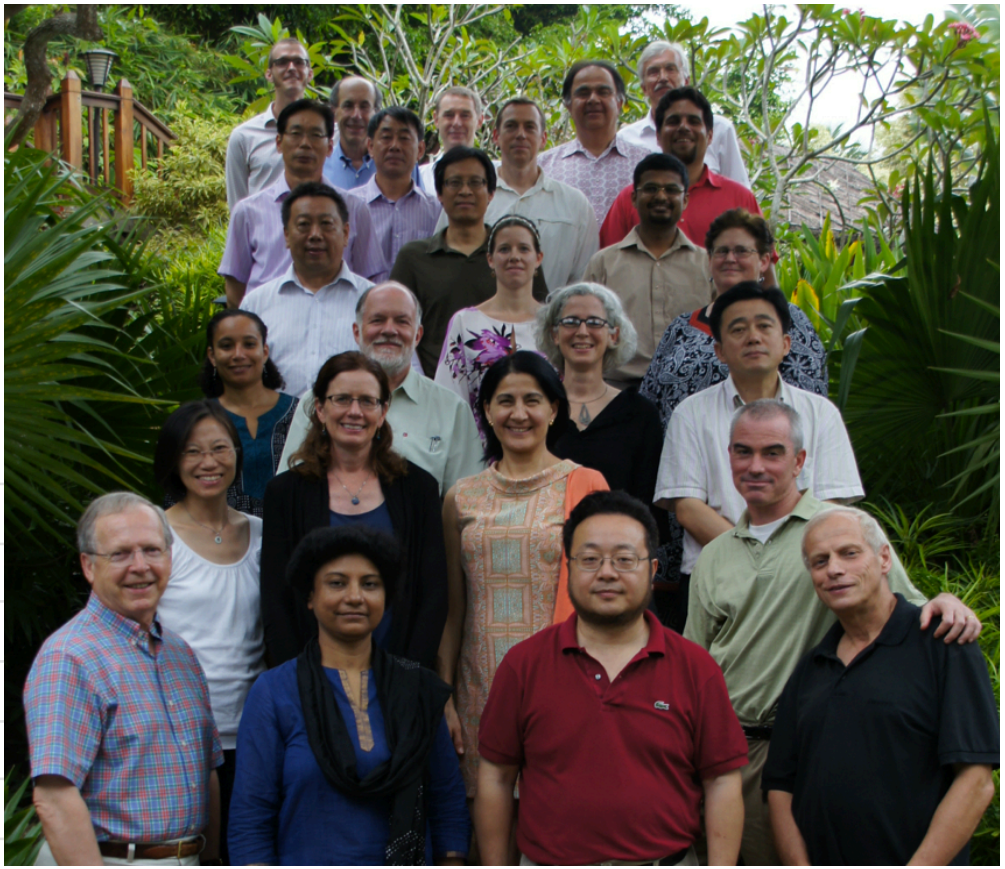
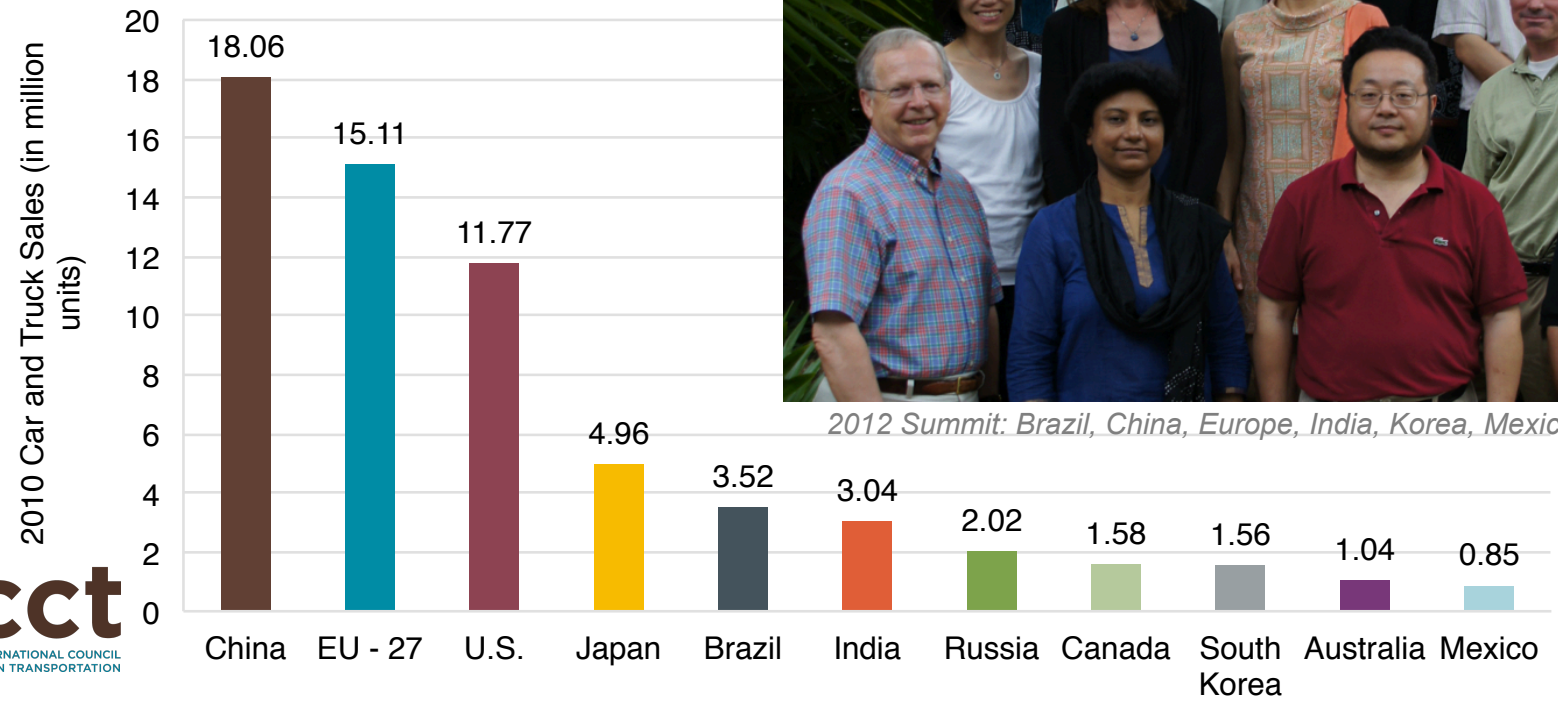
国际清洁交通委员会
The International Council on Clean Transportation



2012 Summit: Brazil, China, Europe, India, Korea, Mexico, Russia, US



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大纲
Outline

- 北美船舶和港口概述
- Overview of port and shipping activities and regulations in North America
- 港口和船舶排放清单
- Emission inventory from ports and shipping
  - 方法、结果和趋势
  - Methodology, results, and trends
  - 前沿问题
  - Emerging issues
- 结论
- Conclusion

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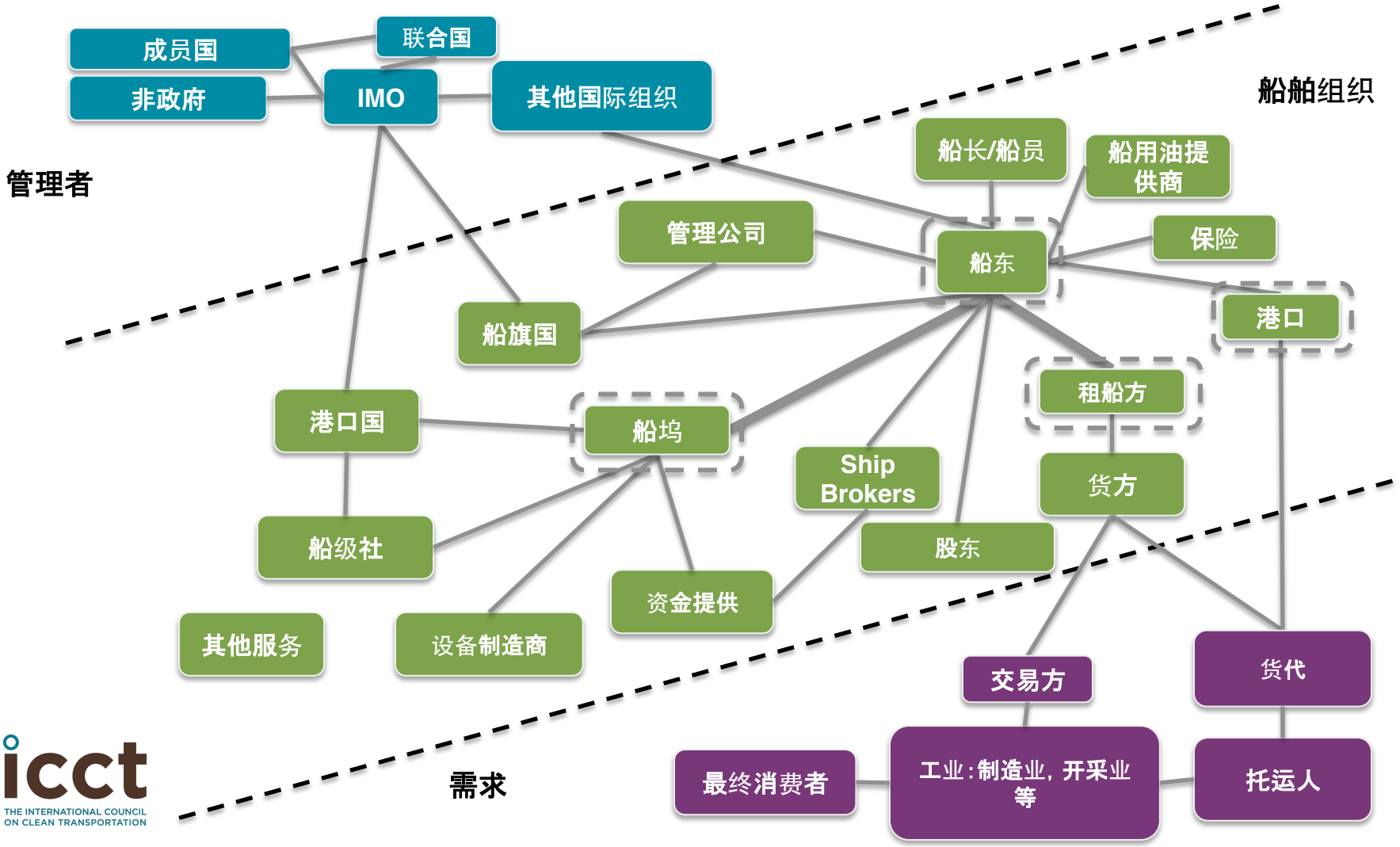
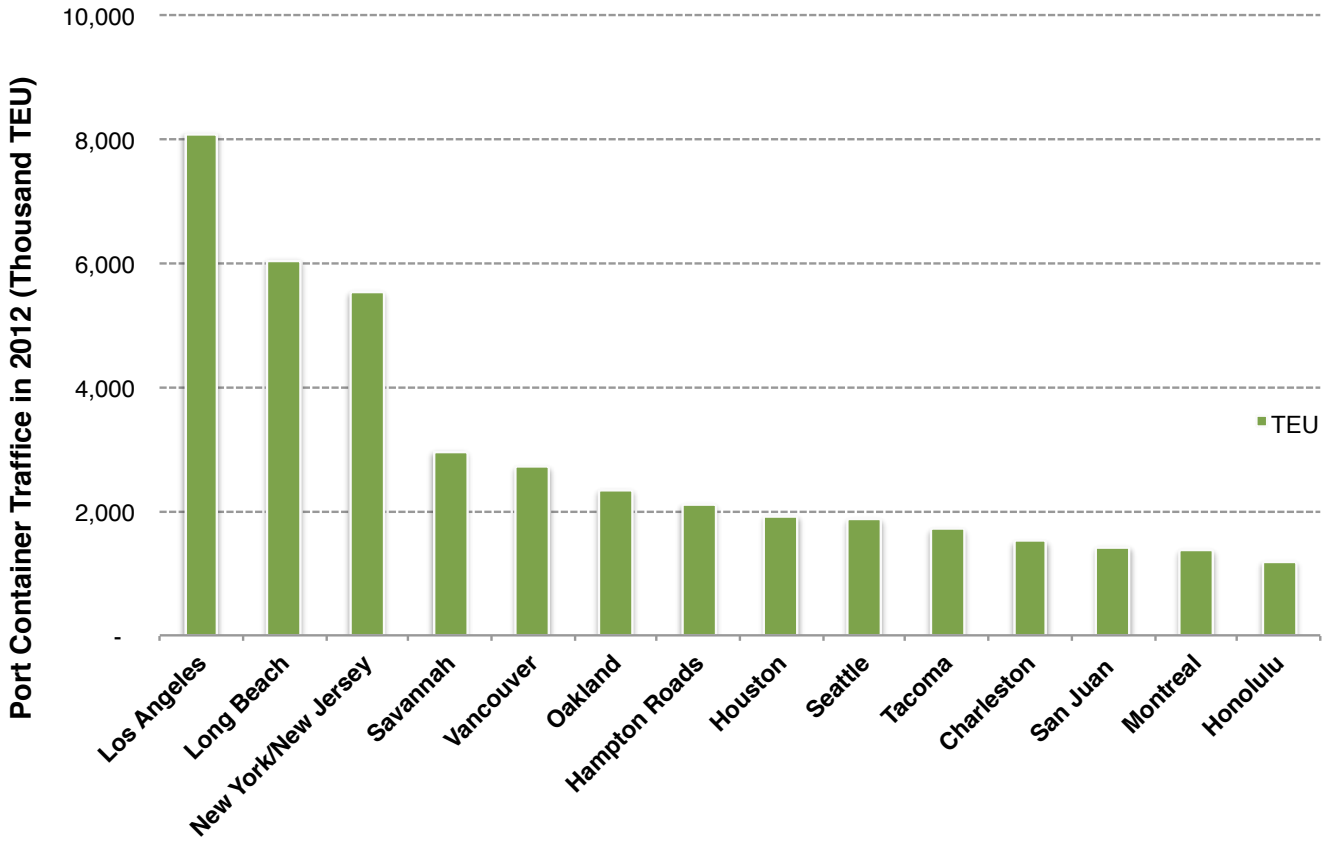
政策必须考量复杂的行业结构
Ports and shipping have a complicated industry structure



北美集装箱吞吐量
Container throughput in North America

- 北美集装箱吞吐量超过一百万标箱的港口有14个，2个在加拿大，12个在美国
- 14 container ports with annual throughput higher than 1 million TEU; 2 in Canada, 12 in North America



Data Source: American Association of Port Authorities

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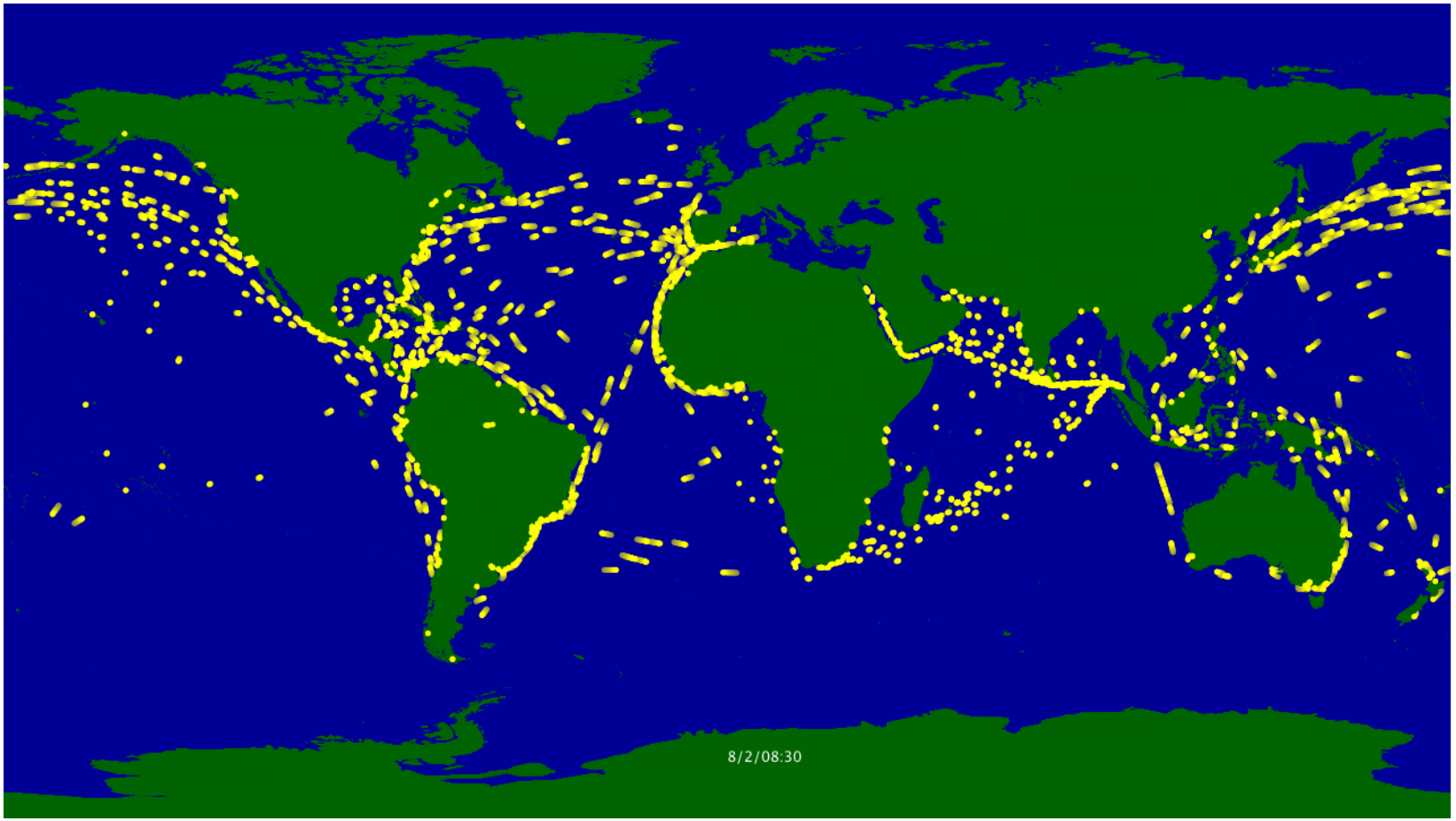
2011年全球船舶运行
2011 Ship activity based on AIS data



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Courtesy of Dr Martin Austwick at CASA in University of College London

港口和船只排放清单
Emission inventory from ports and ships

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方法
Methodology

- 活动分析法＋数据收集和采样
- Activity-based approach + Complete data survey

$$E = Power \times Activity \times LF \times EF \times FCF \times CF$$

- 功率和活动：港口，采样，数据交换
- Power and Activity: port, survey, marine exchange
- 负载系数：由速度决定
- Load factor: determined by speed
- 排放因子，控制系数和油品调整系数：系统化数据
- Emission factors，control factors, and Fuel adjustment factors: standardized input

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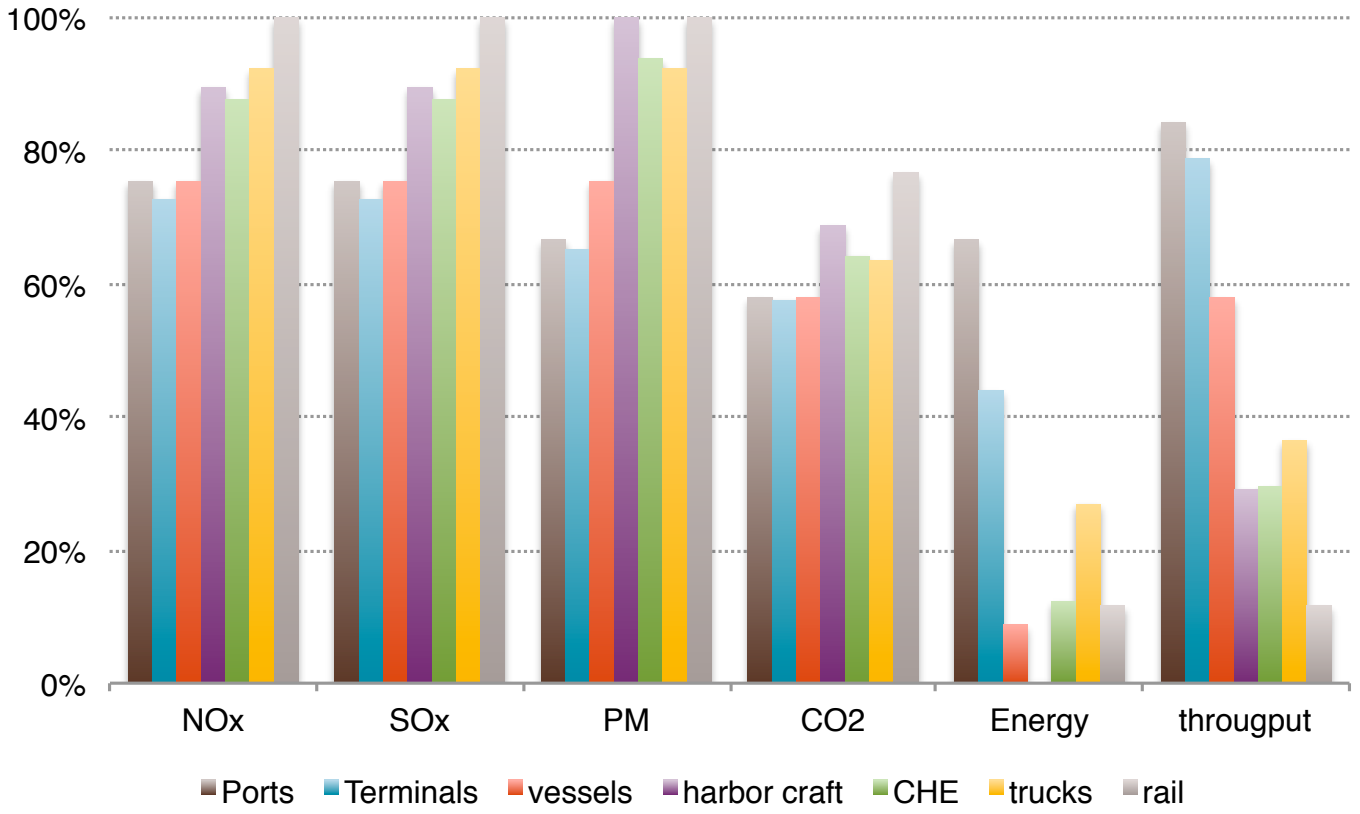
港口减排项目
Emission reduction programs in ports

- 大多数港口检测并治理常规污染物
- Most ports monitor and reduce conventional pollutants



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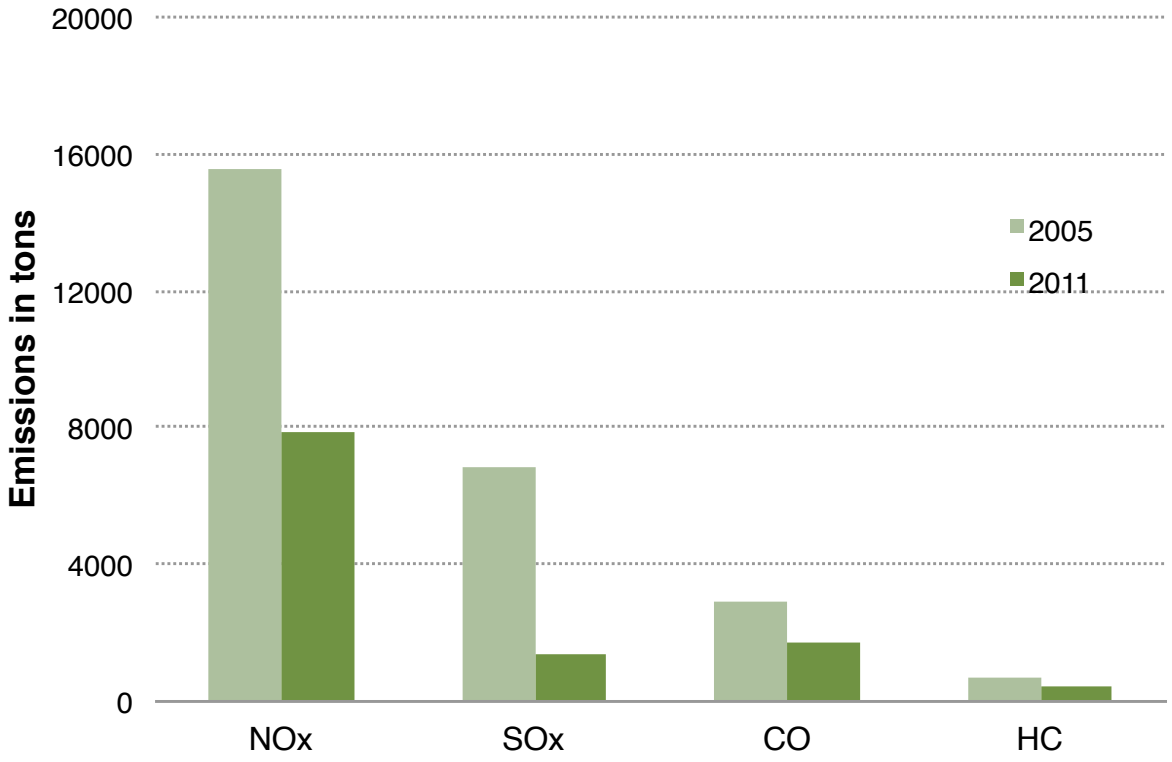
趋势
Trend

- 港口减排成果显著
- Significant improvement in port emission reduction



Data source from POLB inventory, 2012

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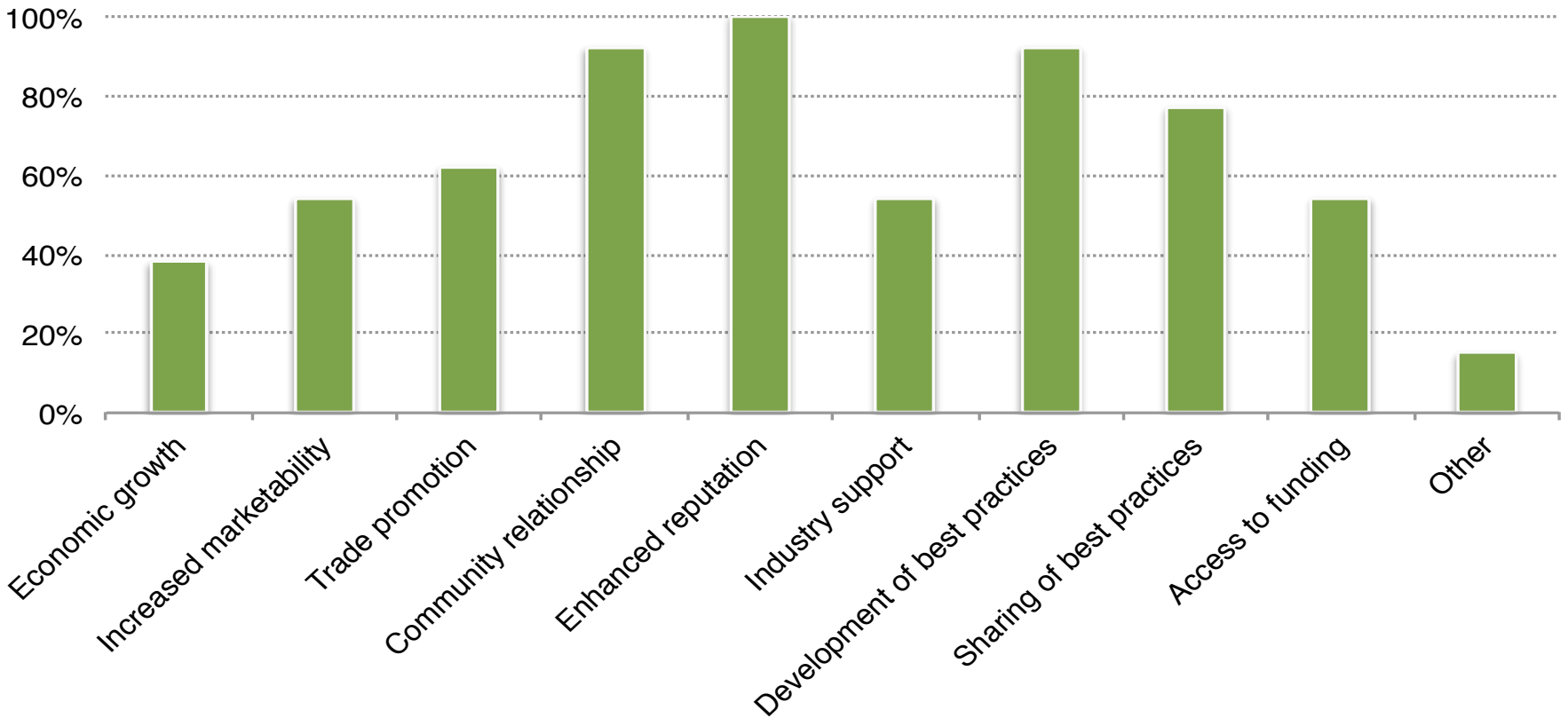
港口减排的原因
Incentives to reduce port emissions

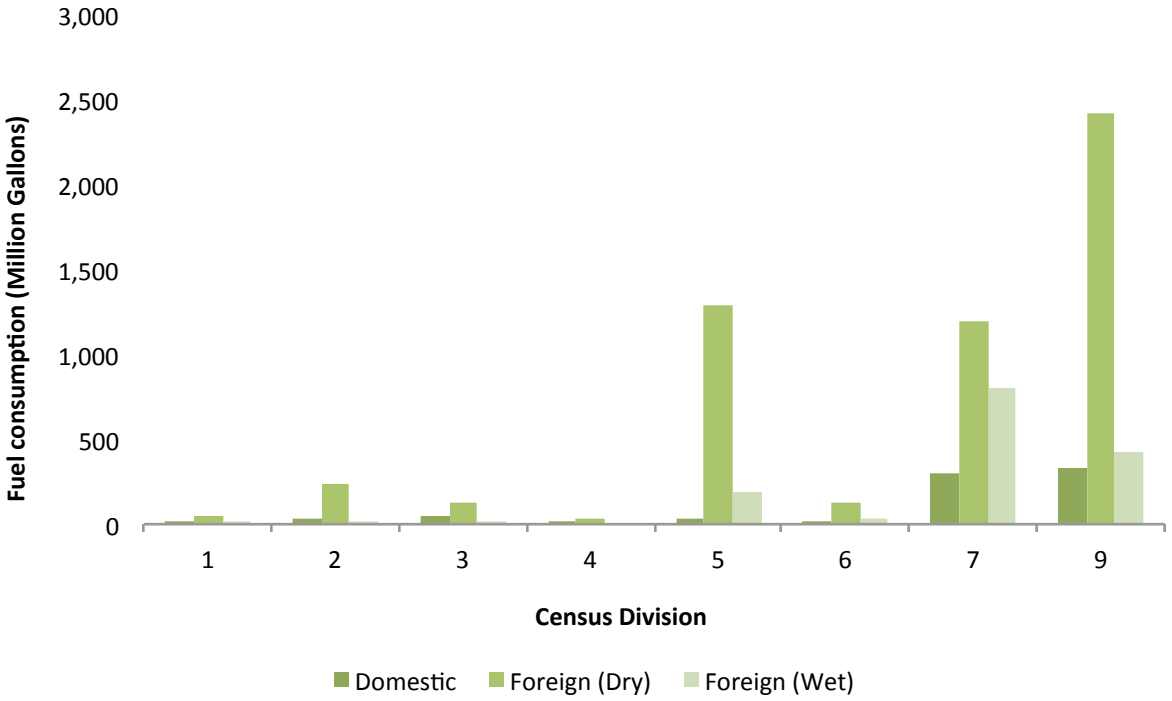
- 港口减排给港口带来名誉和经济上的利益
- Reducing emissions give ports both reputational and economic benefits



远洋船数据清单的编制和方法
Methodology and inventory on OGVs

- 2004年船舶排放清单，方法与结果
- Shipping inventory in 2004, by census district

$$\text{Fuel Used (gallons)} = \Sigma_c \left(Pwr_p \times LF_p \times SOFC_p + Pwr_a \times LF_a \times SOFC_a\right) \times \text{Activity}/3630$$



ICF (2009) Non-highway freight model, final report to EIA

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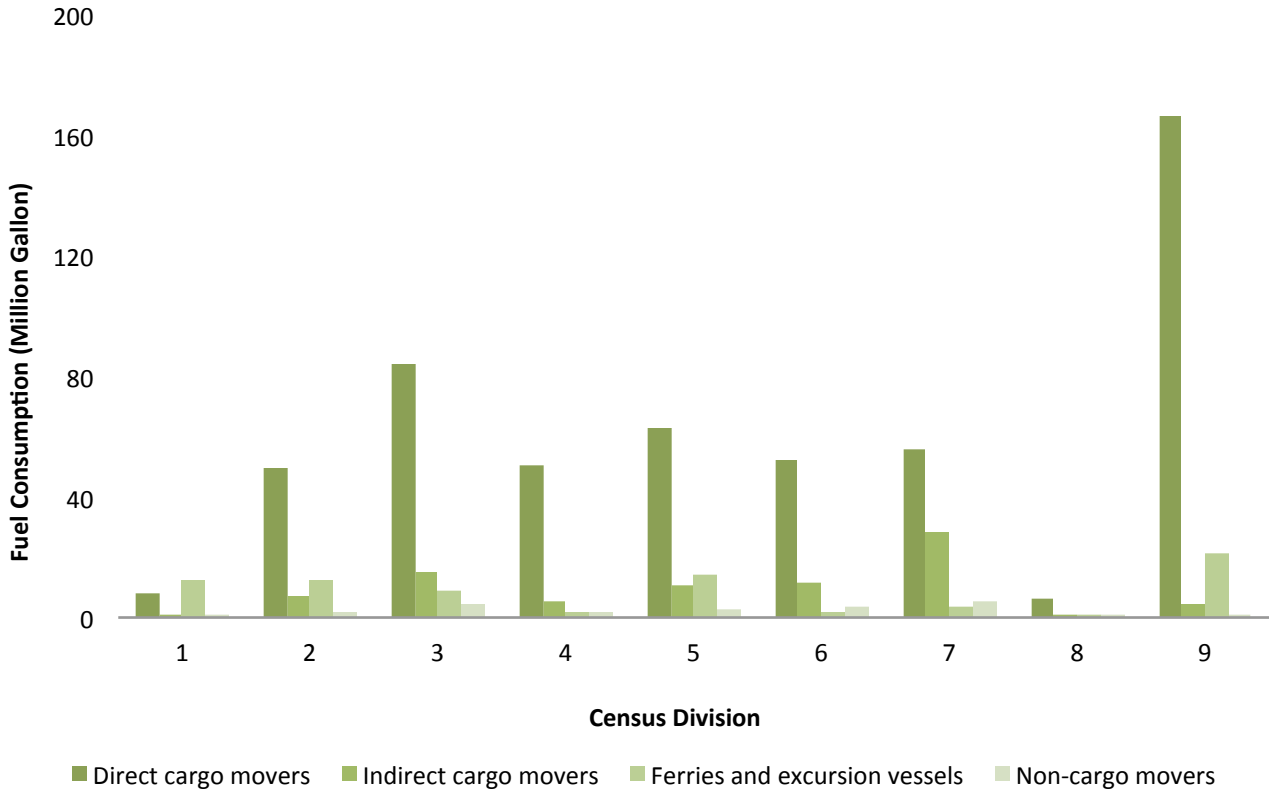
港口和内河船排放清单
Harbor craft and inland vessel inventory

- 活动分析法＋数据收集和采样
- Activity-based approach + Complete data survey
- 更多的不确定性
- More uncertainties



ICF (2009) Non-highway freight model, final report to EIA

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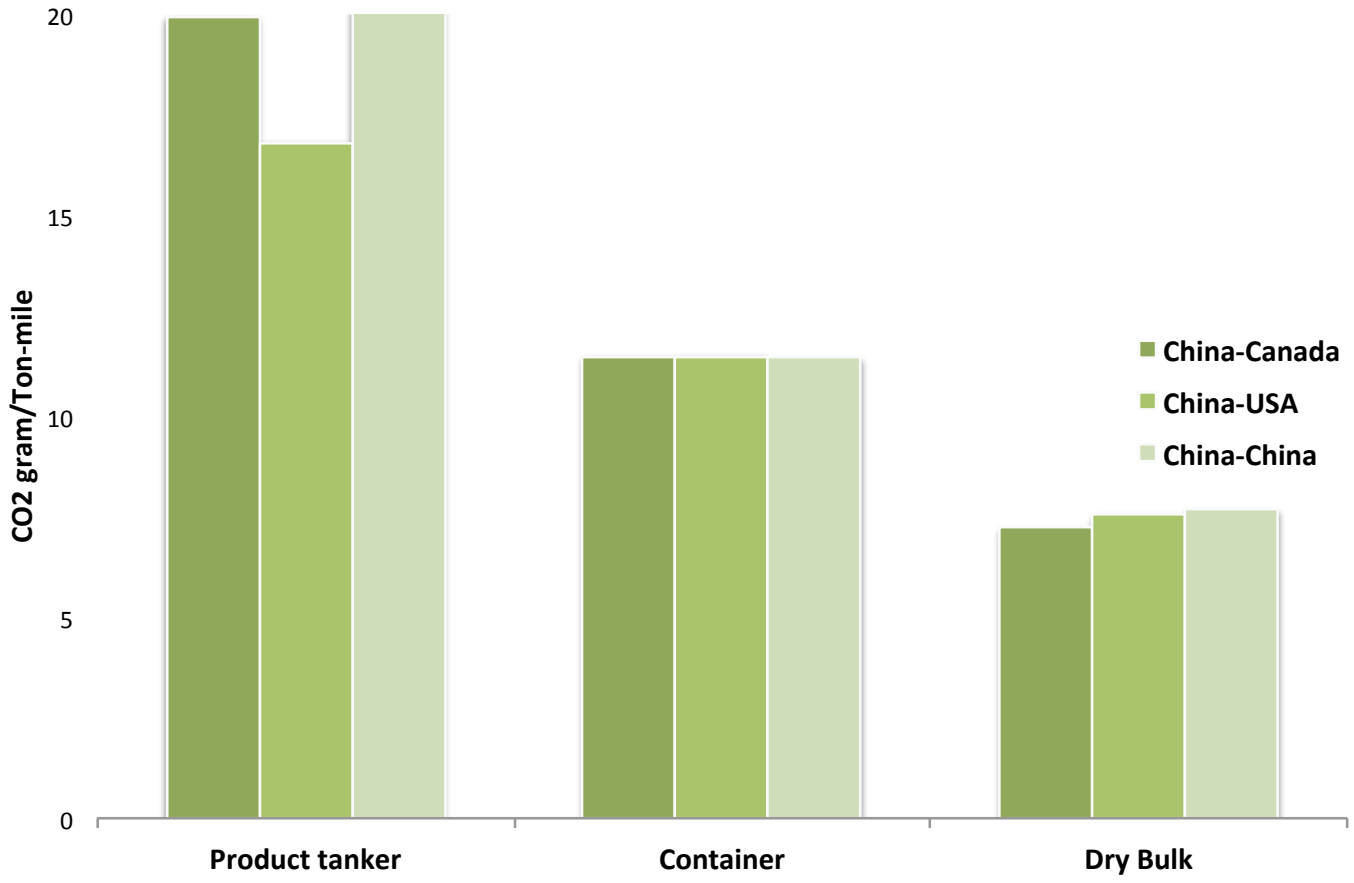
使用AIS数据建立排放清单
Using AIS data to compile shipping inventory

- 利用AIS数据提供的及时数据可以更好的估算船舶排放
- AIS is better equipped to calculate shipping inventory



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北美港口和船舶排放清单的前沿问题
Emerging Issues in port and shipping inventory

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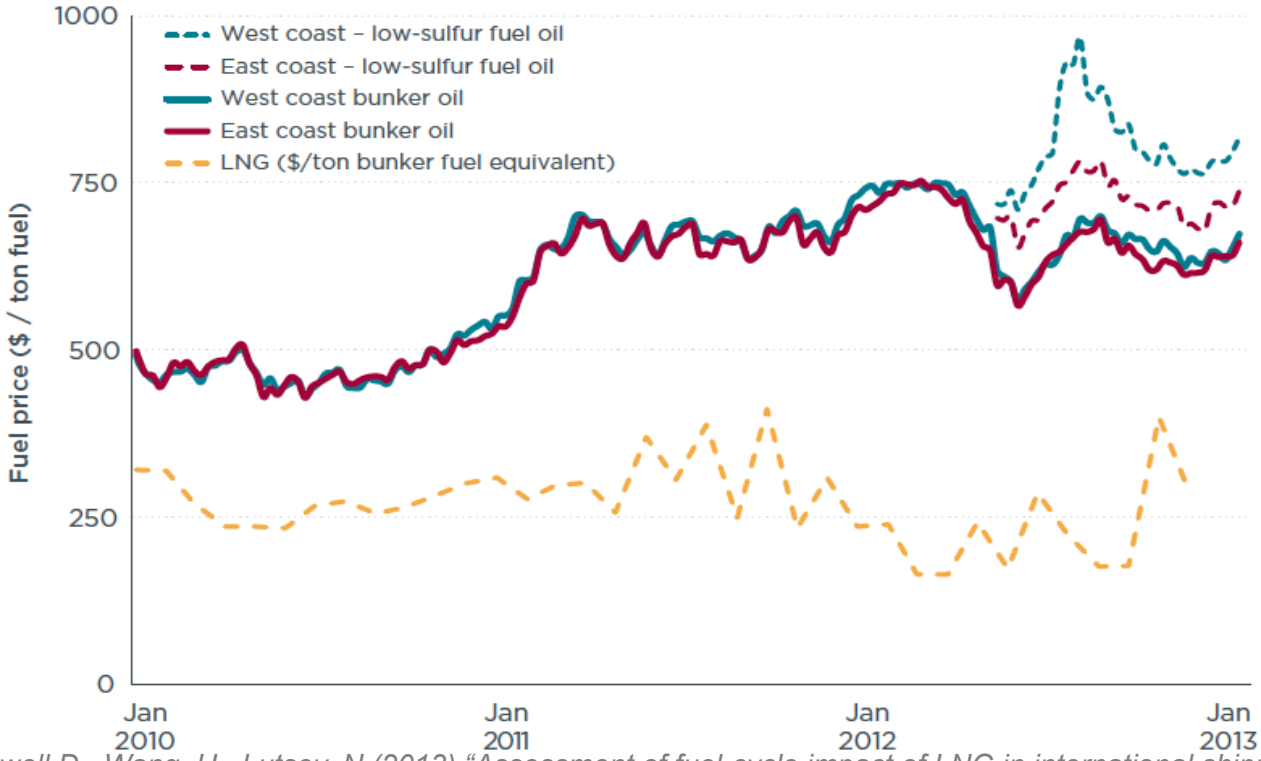
使用液化天然气作为船用油
LNG as a marine fuel

- 液化天然气作为船用燃料降低运行成本并降低常规污染物排放
- LNG as a marine fuel reduces cost and conventional pollutants



Lowell D., Wang, H., Lutsey, N (2013) "Assessment of fuel-cycle impact of LNG in international shipping, available at http://www.theicct.org/assessment-fuel-cycle-impact-lng-international-shipping

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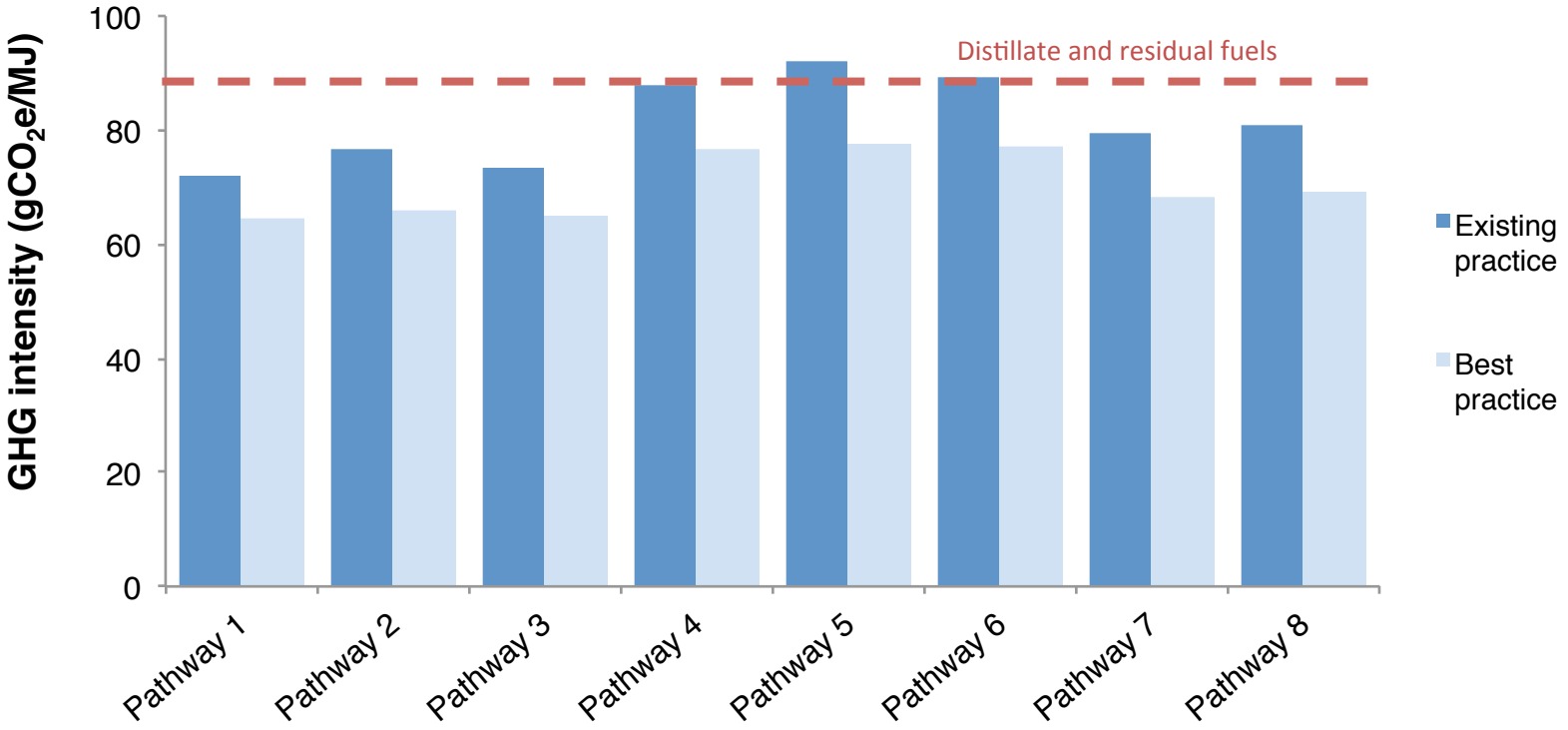
液化天然气作为船用油的生命周期温室气体排放
Lifecycle GHG emission from LNG as a marine fuel

- 使用液化天然气作为船用油的生命周期温室气体排放取决于不同路径
- Lifecycle GHG benefits from using LNG as marine fuel varies by pathways



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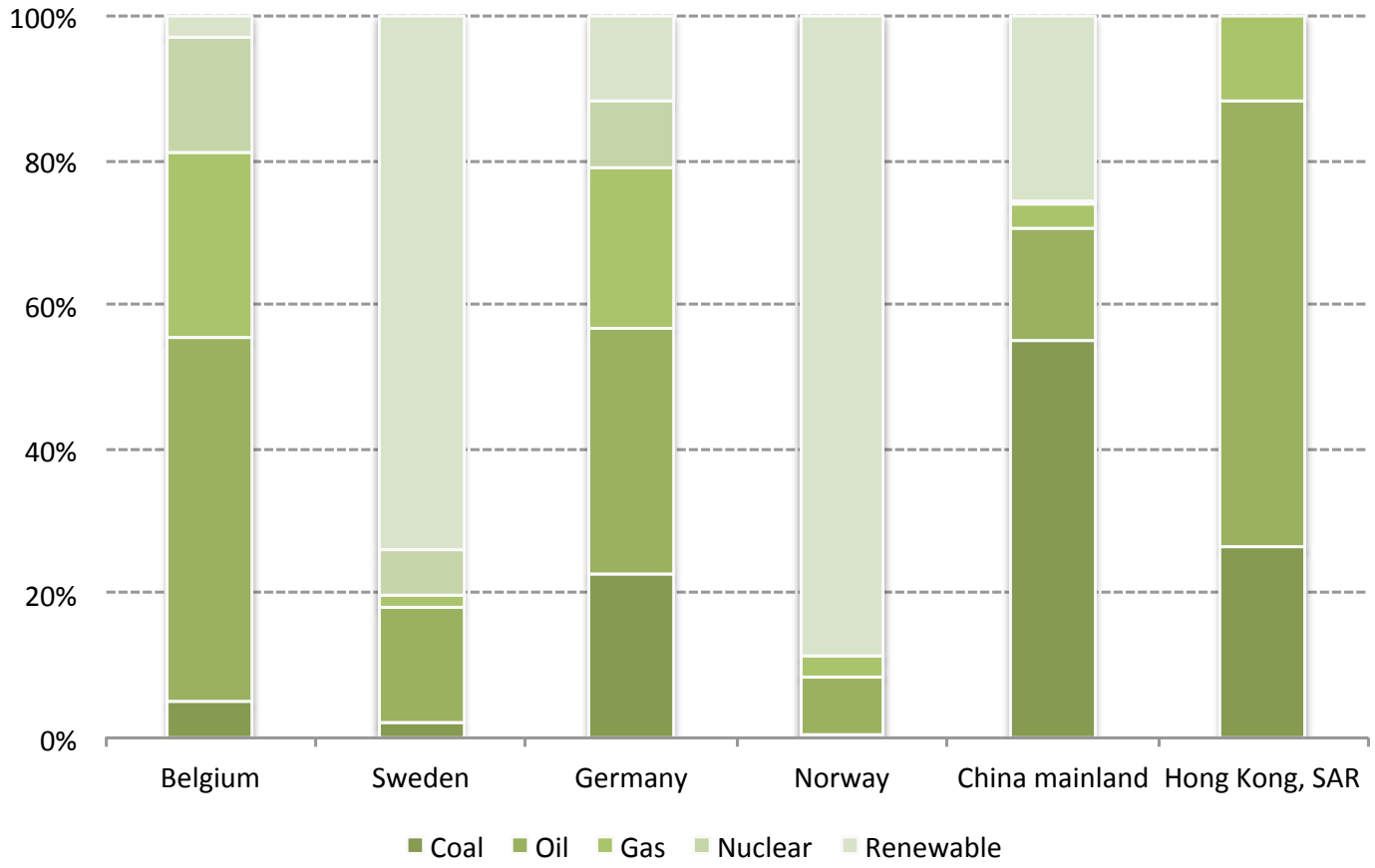
其他关于生命周期排放的分析
Other Lifecycle analysis

- 以岸电为例：岸电的发展也要考虑生命周期排放
- Use shore power as an example: the development of shore power also needs to consider lifecycle emissions



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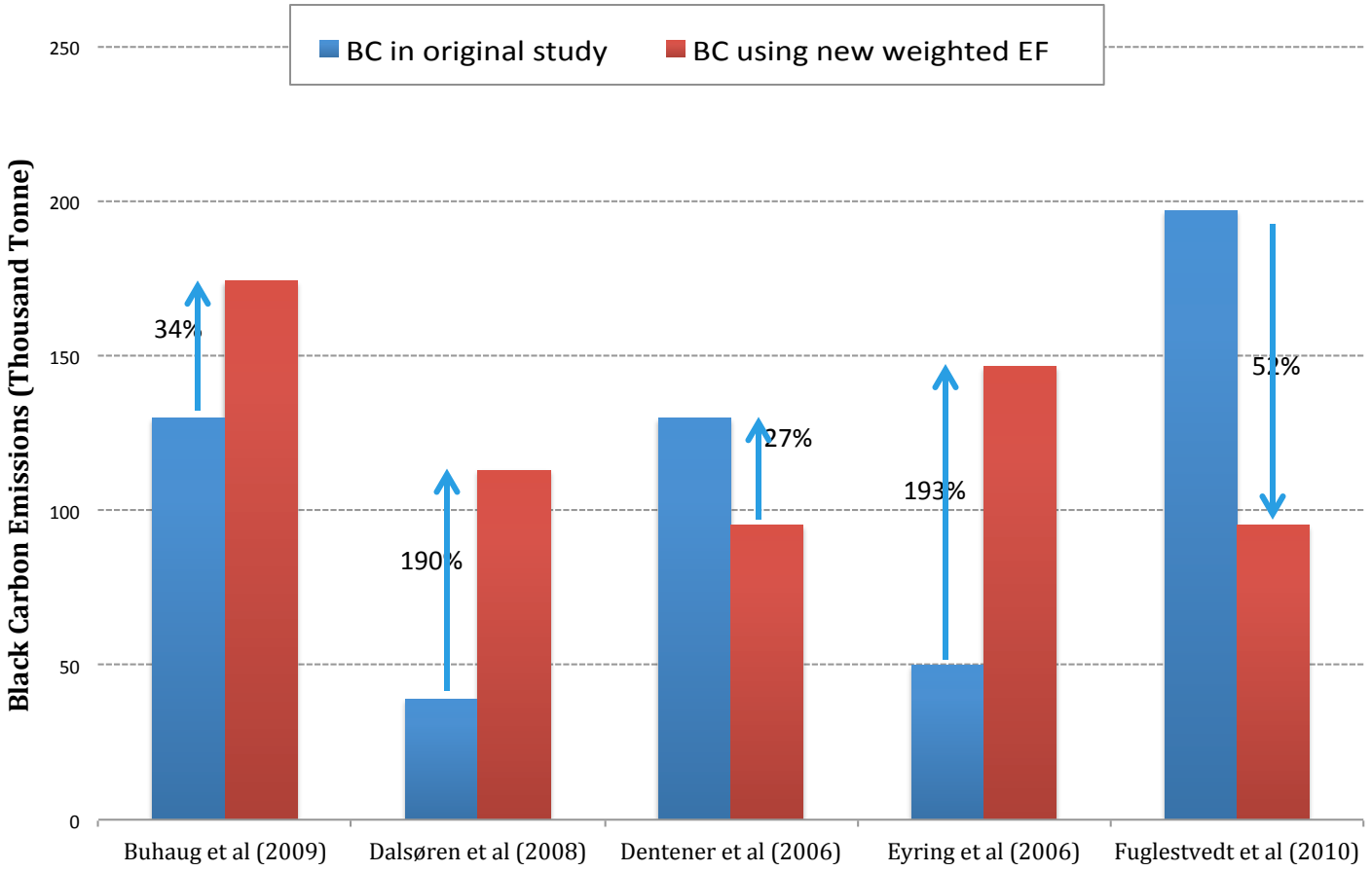
排放因子是影响黑炭排放清单的最重要因素
Emission factor is the single most important variable in BC inventory

- 黑炭排放清单在使用重新衡量的排放因子后差别很大
- The marine BC inventory estimates differ significantly when a different EF is used while keeping fuel consumption unchanged



Wang, H., Minjares, R (2012) Global emissions of marine black carbon: Critical review and revised assessment. Submitted to 92nd Transportation Research Board.

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确定黑炭排放因子的船舶测试
Ship testing to determine BC_{EF}

- 元素碳使用NIOSH方法相较使用IMPROVE方法更高
- The Elemental Carbon (EC) was higher for the NIOSH method as compared to the IMPROVE method
- 可吸入颗粒物构成：45%硫酸盐，45%有机碳和10%元素碳
- The total PM composition is approximately 45% sulfate, 45% organic and a small fraction of EC (10%).
- 黑炭排放因子随功率降低而增加
- BC_{EF} increase as load decreases

					NIOSH		IMPROVE			
Nominal Load	eLoad [4] e_kW	Load %	$PM_{2.5}$ mg/kWh	PA-soot [1] mg/kWh	EC mg/kWh	OC mg/kWh	EC mg/kWh	OC mg/kWh	MAAP [2] mg/kWh	Aeth [3] mg/kWh
Post M1	1689	58.2%	206.2	5.6	3.68	79.6	8.35	74.8	n/a	n/a
Post M2	1279	44.1%	199.5	22.2	14.13	82.6	27.55	74.6	n/a	n/a
Post M3	595	20.5%	294.4	88.2	99.09	126.9	133.15	95.5	n/a	n/a
Pre M1	1602	55.2%	407.6	28.6	29.69	257.8	35.21	166.8	n/a	n/a
Pre M2	1243	42.9%	373.3	32.5	27.98	183.0	40.71	158.1	n/a	n/a
Pre M3	603	20.8%	491.1	90.5	n/a	295.8	n/a	173.2	n/a	n/a

美国环保局港口计划
EPA Port Initiative

- 与港口合作降低港口污染
- Work with ports to reduce air emissions
- 协调和其他利益相关方的工作
- Collaborate with other stakeholders
- 复制Smartway的成功经验
- Replicate the success story of Smartway

SmartWay℠
Transport Partner
Getting There With Cleaner Air

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

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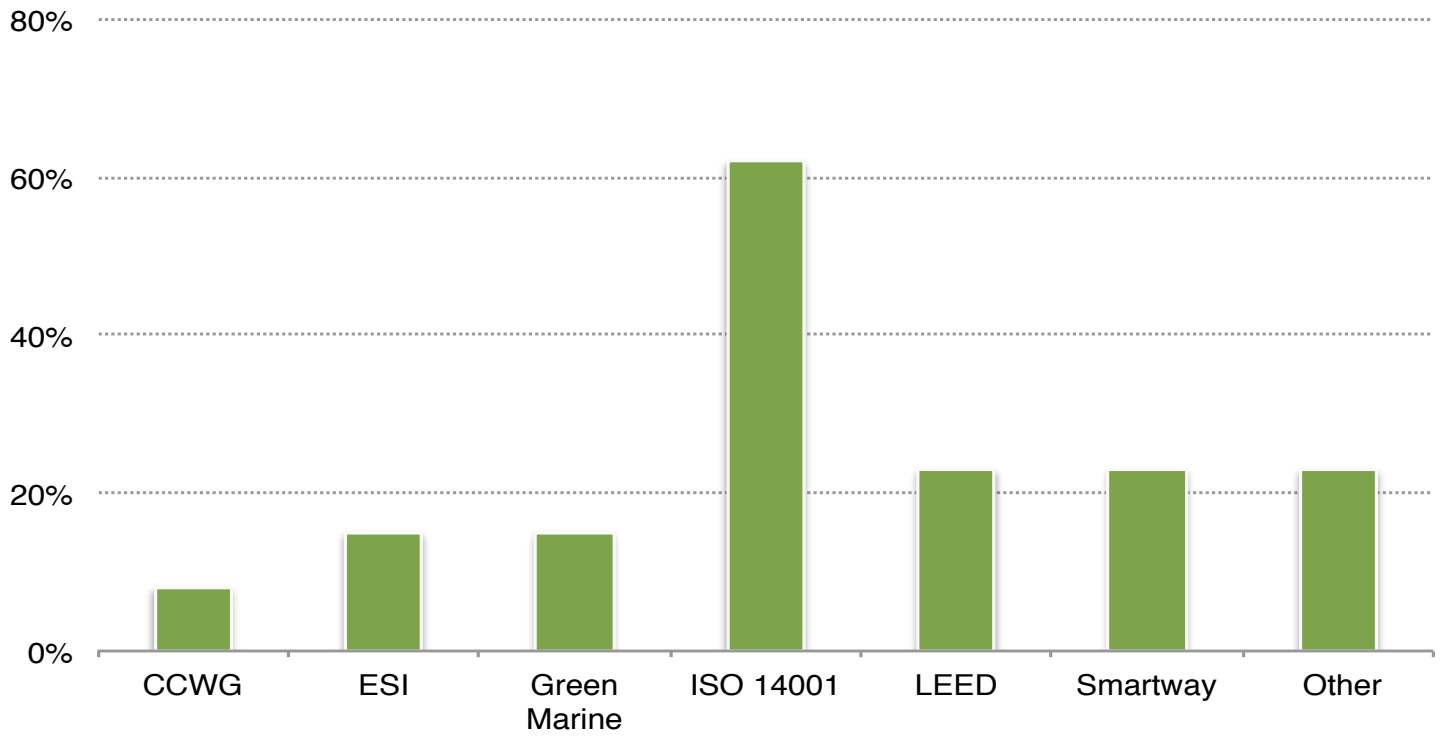
港口认可项目
Port Recognition Program

- 与EDF合作，ICCT对美国主要港口进行了问卷调查，并推荐建立港口识别项目的标准
- Working with EDF, ICCT surveyed ports on their environmental programs and provided recommendations on port recognition metrics



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结论
Conclusion

- 排放清单建立方法业已成型，数据是关键
- Methodology has been establish and proven; data is key
- 港口船和内河船排放清单更有不确定性
- Compiling inventory for harbor crafts and inland ships is more challenging
- 黑炭和液化天然气的排放清单会是新的课题
- LNG and BC have become new focuses

谢谢

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