Cold Ironing at Ports as an Emissions Reduction Option

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Presentation Outline

- Background
  - A brief history of Cold Ironing
  - Motivation for electricity
- Current Status and prospects
  - USA vs EU
  - Challenges and opportunities
- Methodology
  - Quantifying environmental impacts
  - Basic economics
  - Formulating the economics
- Simplified case studies
- Further Work

Background

- Maritime shipping is considered the most fuel-efficient mode of transport
- Moves 90% of world trade (UNCTAD, 2017), accounts for <3% of CO_2
- In SOx terms, estimated at 5-8% (Eyring et al., 2005)
  - Update based on OECD countries at 3.45% (all transport) in 2015
- in NOx around 15% (Corbett et al., 2007)
- Regulatory pressure is increasing both at local and global level

Background ii

- The issue of ship emissions near ports is also important
- To reduce ship emissions near ports:
- Operational Measures
  - Speed Reduction Programmes
  - Virtual Arrival
  - Fuel switch to cleaner types
- Technological Measures
  - Newer/ more efficient vessels
  - Cold Ironing

MailOnline

How 16 ships create as much pollution as all the cars in the world

By FRED PEARCE
UPDATED: 22:13, 21 November 2009

GAS2
a Technorati top 10 car blog.

Hybrid / EV Biofuels Car Hacks / DIY 2 Wheels

One Container Ship Pollutes As Much As 50 Million Cars

Increasing pressure

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

California Environmental Protection Agency
AIR RESOURCES BOARD

ESPO

From Kyoto to Paris

The Kyoto Protocol was adopted on 11 December 1997. Owing to a complex ratification process, it entered into force on 16 February 2005. Currently, there are 192 Parties to the Kyoto Protocol.

In short, the Kyoto Protocol operationalizes the United Nations Framework Convention on Climate Change by committing industrialized countries and economies in transition to limit and reduce greenhouse gases (GHG) emissions in accordance with agreed individual targets. The Convention itself only asks those countries to adopt policies and measures on mitigation and to report periodically.

PARIS2015
UN CLIMATE CHANGE CONFERENCE
COP21·CMP11

The Paris Agreement is a **legally binding international treaty on climate change**. It was adopted by 196 Parties at COP 21 in Paris, on 12 December 2015 and entered into force on 4 November 2016.

Its goal is to **limit global warming** to well below 2, **preferably to 1.5 degrees Celsius**, compared to pre-industrial levels.

To achieve this long-term temperature goal, countries aim to **reach global peaking of greenhouse gas emissions as soon as possible** to achieve a climate neutral world by mid-century.

Ambitious goals

2050 long-term strategy

The EU aims to be climate-neutral by 2050 – an economy with net-zero greenhouse gas emissions. This objective is at the heart of the European Green Deal EN ••• and in line with the EU's commitment to global climate action under the Paris Agreement EN •••.

April 20, 2021
10:23 PM CEST
Last Updated 6 months ago

Environment

U.S. to join effort to curb climate-warming emissions from shipping

2 minute read

By Valerie Volcovici

WASHINGTON, April 20 (Reuters) - The United States will join an international effort to achieve zero emissions by 2050 in the global shipping industry, climate envoy John Kerry announced ahead of a summit of world leaders President Joe Biden will host this week.

"We're going to look to the ocean to continue to help reduce pollution," he told a conference hosted by the Ocean Conservancy on Tuesday.

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UN body adopts climate change strategy for shipping

The Initial IMO Strategy

MEPC 72/17/Add.1
Annex 11, page 1

ANNEX 11

RESOLUTION MEPC.304(72)
(adopted on 13 April 2018)

INITIAL IMO STRATEGY ON REDUCTION OF GHG EMISSIONS FROM SHIPS

.1 ***carbon intensity of the ship to decline through implementation of further phases of the energy efficiency design index (EEDI) for new ships***

.2 ***carbon intensity of international shipping to decline***

.3 ***GHG emissions from international shipping to peak and decline***

- Carbon intensity reduction: 40% by 2030, aim for 70% by 2050
- Absolute emissions reduction: 50% by 2050
- Ongoing discussion
- Various proposals currently under consideration
  - Speed limits
  - Power limits
  - EEXI
  - Goal-based measures

Pressure for port sector

Reducing Emissions?

- Q: How do we go about reducing emissions from vessels?

A: A series of Measures..

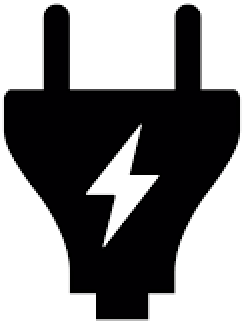
- *Operational*
- *Technological*
- *Regulatory*

- Find a Win-Win solution?

Measures contemplated

- Operational – Logistics based
  - Speed reduction
  - Optimized routing
  - Weather routing
  - Fleet management

- Technological
  - More efficient (energy-saving) engines and propulsion
  - More efficient vehicle designs
  - Cleaner fuels (low sulphur content)
  - Alternative fuels (fuel cells, biofuels, etc)
  - Devices to trap exhaust emissions (scrubbers, etc)
  - Energy recuperation devices
  - "Cold ironing" in ports



- Market-based or Regulatory measures
  - Emissions Trading Scheme (ETS)
  - Carbon Tax/Levy on Fuel
  - Speed limits
  - Others

Funding avenues

Press release | 17 September 2020 | Brussels

European Green Deal Call: €1 billion investment to boost the green and digital transition

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Press contact

The European Commission has decided today to launch a €1 billion call for research and innovation projects that respond to the climate crisis and help protect Europe's unique ecosystems and biodiversity. The Horizon 2020-funded European Green Deal Call, which will open tomorrow for registration, will spur Europe's recovery from the coronavirus crisis by turning green challenges into innovation opportunities.

Funding avenues ii

European Commission | Funding & tender opportunities
Single Electronic Data Interchange Area (SEDIA)

English EN

Register Login

SEARCH FUNDING & TENDERS | HOW TO PARTICIPATE | PROJECTS & RESULTS | WORK AS AN EXPERT | SUPPORT

Green airports and ports as multimodal hubs for sustainable and smart mobility

TOPIC ID: LC-GD-5-1-2020

Hyper powered vessel battery charging system (ZEWT Partnership)

TOPIC ID: HORIZON-CL5-2021-D5-01-11

Some basic terminology

- Cold Ironing
  - or Alternative Marine Power –AMP
  - or OnShore Power Supply – OPS

- The process of providing electrical power

To cover requirements of hotelling activities

- Essentially it allows shutting down auxiliary engines

A brief history on Cold Ironing

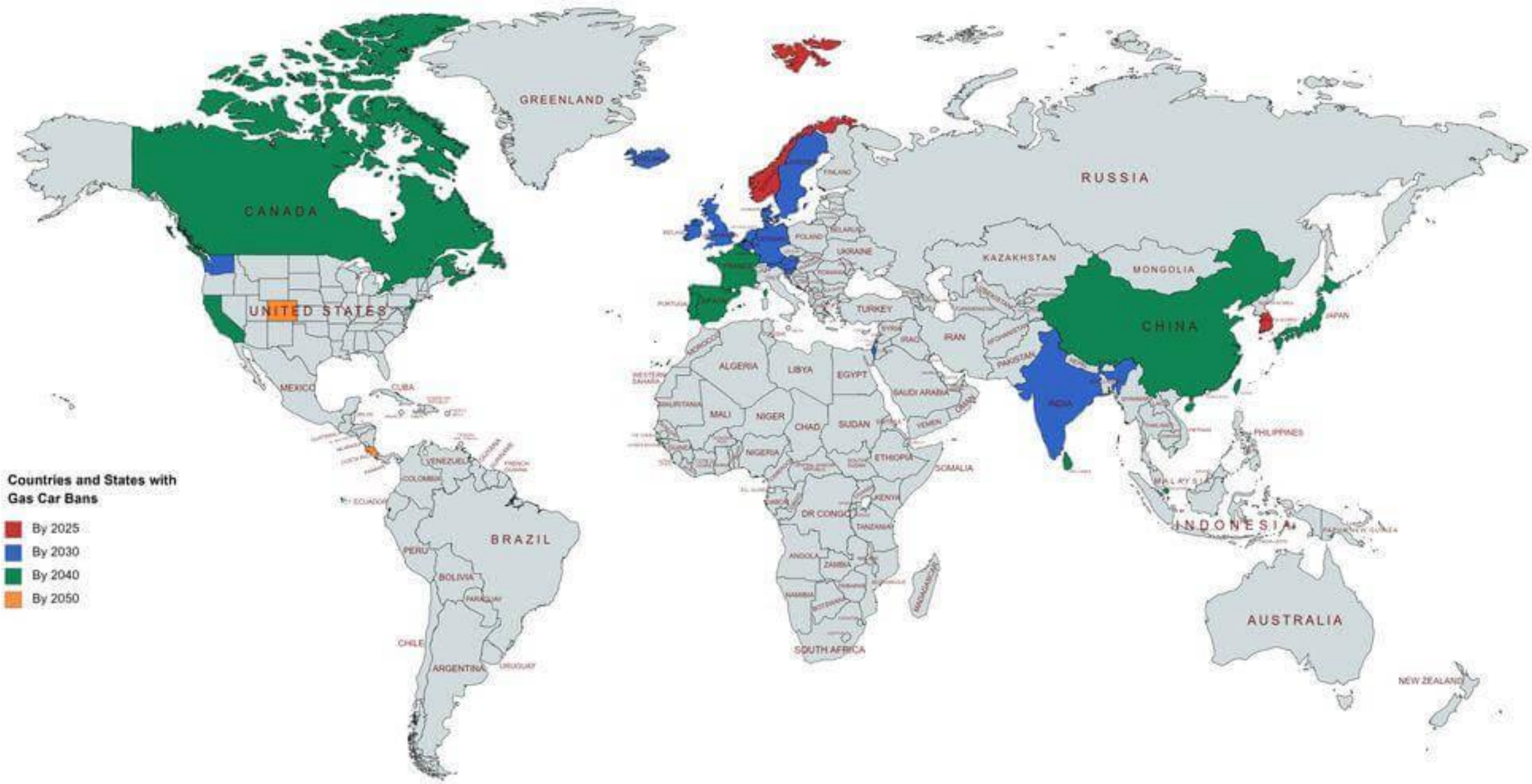
- Term stems from old iron coal-fired engines ”cooling down” when at port
- Nowadays, only main engines are switched off at the port
- Cold ironing could be used to receive power from other ships
- Normally Auxiliary engines and auxiliary boilers are still running at berth
- With Cold Ironing, only boilers will be running to maintain temperatures

Motivation for electricity

- Environmental benefits – so called zero emissions
  - No emissions from auxiliary engines at port
  - Global benefit when using a clean grid in carbon terms
  - Less PM emissions where it matters
  - Reduced noise and vibration

- Economic motivation
  - fuel costs higher than electricity
  - Provision of subsidies
  - Adhere to regulation

Motivation for electricity
Countries and US states with Gas Car Bans



Source: https://www.chargedfuture.com/countries-and-states-with-gas-car-bans/

Partial motivation

- Sulphur emission control areas and relevant sulphur limits
- EU Directive

European Union ports

The maximum allowable sulphur content of marine fuel used by ships at berth in Union ports is

- 0.10 % by mass

The fuel changeover operation should be as soon as possible after arrival at berth and as late as possible before departure.

The sulphur limit does not apply if:

- Ships are due to be at berth for less than two hours, according to published timetables; or
- Ships switch off all engines and use shore-side electricity while at berth in ports.

Current status – ports using CI

Europe		North America		Asia		Oceania	
Antwerp (container, barges)	Belgium	Halifax (cruise)	Canada	Baku (container) *planned*	Azerbaijan	Auckland (cruise) *planned*	New Zealand
Zeebrugge (Ro-Ro)		Montreal (cruise)		Shangai (cruise)	China		
Helsinki (Ro-Ro)	Finland	Vancouver (container, cruise)					
Kemi (Ro-Ro)		Prince Rupert (container)		Qingdao (container)			
Kotka (Ro-Ro)		Los Angeles (Ocean Going Vessels/OGV)	U.S.A.	V.O.Chidambaranar (bulk)	India		
Oulu (Ro-Ro)		Long Beach (OGV)		Tokyo (cargo ships and ferries)	Japan		
		Oakland (container)					
Le Havre	France	San Francisco (OGV)		Busan	S. Korea		
Marseille (ferries)		San Diego (reefer ships)		Incheon			
Lübeck (Ro-Ro)	Germany	Seatlle (cruise)		Ulsan			
Hamburg (Cruise) *power by LNG barges*		Juneau (cruise)		Yeosu Gqangyang			
Amsterdam (river boats)	Netherlands	Pittsburg (bulk)		Taipei	Taiwan		
Rotterdam (barges)							
Oslo (Ro-Pax)	Norway						
Bergen (supply vessels)							
Goteborg (Ro-Ro)	Sweden						
Helsingborg (ferry)							
Piteå							
Stockholm (Ro-Pax)							
Milford Haven (tugs)	UK						

Current status - regulation

- California: At-Berth Regulation (progressive limits)
  - 2014: 50% of fleet's visit aux. engines to operate less than three hours
    Total onboard aux. engine generation reduced by at least 50%
  - 2017: 70%
  - 2020: 80%

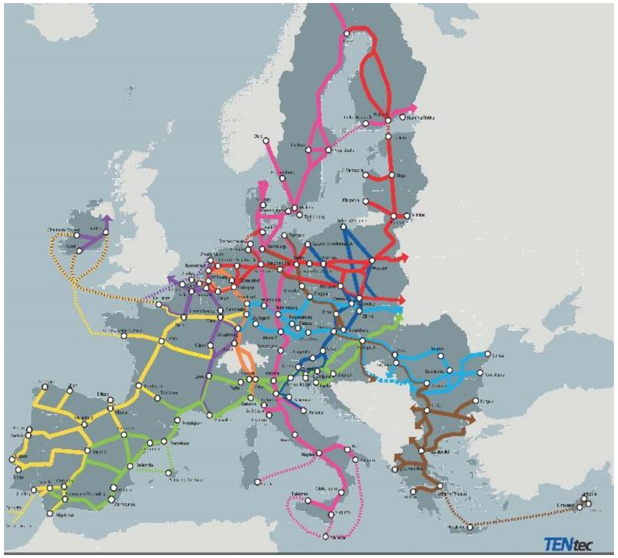
- European Union
  - EU(2005/33/EC) sulphur directive - 0.1% vessels at berth (>2 hours)
  - Before SECA that could promote cold ironing
  - After SECA questionable

- New EU requirement:
  - Ports will be required in the short-term future (by 2025) to be able to provide shore power (EU 2014/94/EU)

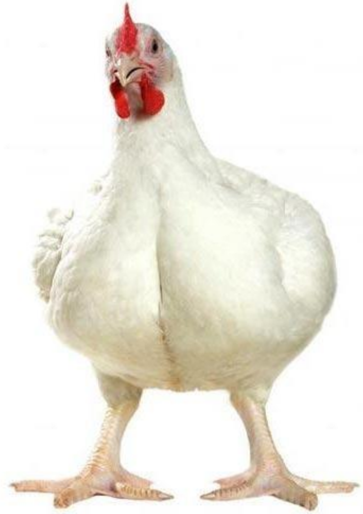
Ports in TEN-T corridors will have to provide shorepower as priority (unless)

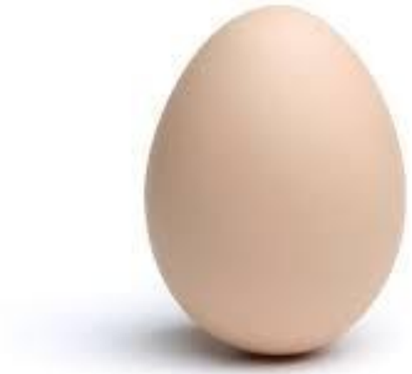
"Member States shall ensure that the need for shore-side electricity supply for inland waterway vessels and seagoing ships in maritime and inland ports is assessed in their national policy frameworks. Such shore-side electricity supply shall be installed as a priority in ports of the TEN-T Core Network, and in other ports, by 31 December 2025, unless there is no demand and the costs are disproportionate to the benefits, including environmental benefits."

Directive 2014/94/EU of the European Parliament and of the Council of 22 October 2014 on the deployment of alternative fuels infrastructure



Main challenge





Main Challenge

- Power Requirement during peak demands
  - One thing to power a small feeder/Ro-Ro vessel (between 1000-2000kW)
  - Completely different to power a ULCV or a large Cruiseship (up to 9500kW)

- Other (minor in comparison) challenges include:
  - Difference in voltage around the world
  - Vessel lay-up times
  - Berth availability

About ports..

- The most cliché quotation about ports:

When you have seen one port....

...you have seen one port

Opportunities

- Technology will mature due to regulation forcing it in important ports
  - New builds may come Cold Ironing ready
- Subsidies offered to ports for infrastructure
- Subsidies offered from ports
  - Stockholm provides up to 0.5million SEK for each vessel (mainly Ro-Ro) that gets retrofit (subject to a 3-year visiting commitment)
  - Antwerp was considering to offer power for free
- Time will help through fleet replacement

Opportunities ii

- Intermediate solutions
  - Hamburg LNG-barge cold ironing option

  - Container instead of retrofit

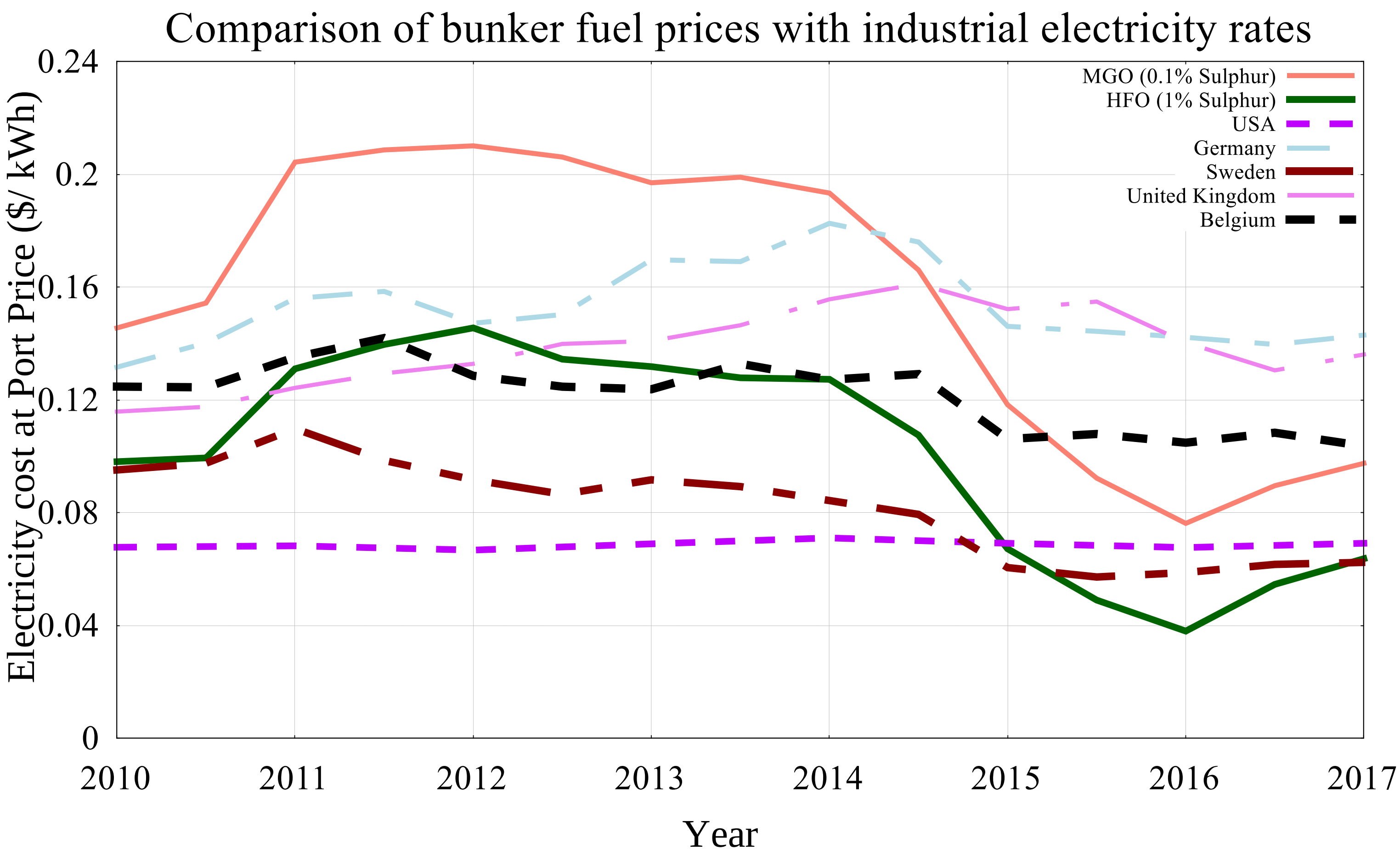
- Uncertainty on fuel costs following global sulphur CAP

- Potential of internalizing external costs may lead to rise in Cold Ironing

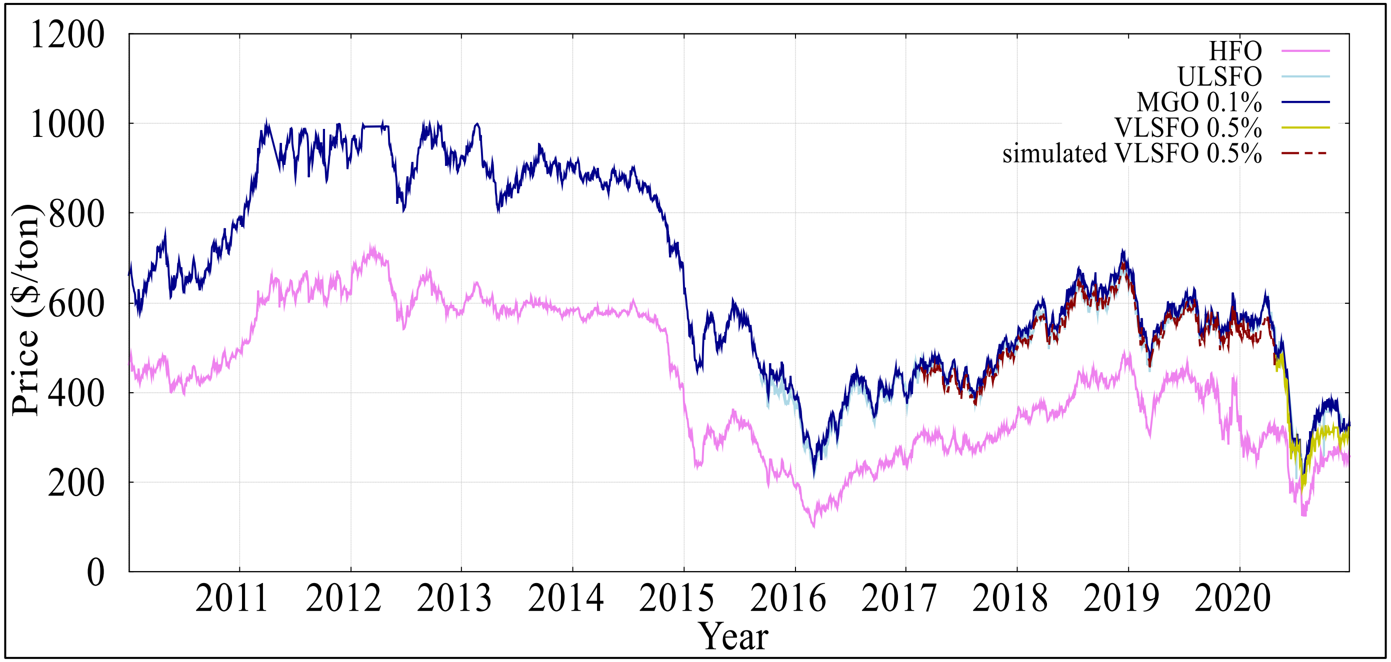
External Costs of Emissions in Seas in EU. Source: Ricardo – AEA (2014)

Pollutant	Unit Values for Main pollutants in sea areas (€/ton)			
	CO_2	SO_2	NO_x	$PM_{2.5}$
Baltic Sea	90	5250	4700	13800
Black Sea		7950	4200	22550
Mediterranean		6700	1850	18500
North Sea		7600	5950	25800

Fuel Price vs Electricity



Fuel price volatility



Enter MBMs

- A bunker levy or Emissions Trading System can further promote technological solutions


MENU

VERIFAVIA shipping

Verify, Comply, Navigate

Inclusion of Shipping in the EU Emissions Trading System

08/02/2021

Contact the author

HFW

The European Parliament has approved draft legislation to include emissions from ships in the EU Emissions Trading System (ETS) from 1 January 2022. Simultaneously, the EU Commission has launched an initiative to renew the ETS and extend its scope to the shipping industry. The initiative is currently in the public consultation phase, which closes on 5 February 2021.

The proposed legislation (which includes amendments to the EU Monitoring, Reporting and Verification (MRV) Regulation1 and the ETS Directive2) is now awaiting approval from the EU Council, and absent further proposals or amendments, could be adopted in early 2021.

Estimating Emissions with and without AMP

- fuel consumption $FC_{B,k}$ (tons) at berth (B) of a ship k relying on aux. engines

$$FC_{B,k}(ton) = 10^{-6} \cdot (SFOC_{a,k} \cdot EL_{a,k} \cdot EP_{a,k} + SFOC_{b,k} \cdot EL_{b,k} \cdot EP_{b,k}) \cdot t_{B,k}$$

- Where
  - *SFOC*(g/kWh) is the specific fuel oil consumption,
  - *EL*(%) the fractional load of the nominal power
  - *EP*(kW) of the auxiliary engines (*a*) and boilers (*b*),
  - $t_{B,k}$ (hours) is the duration of berth

- With AMP:

$$FC_{B,k}(ton) = 10^{-6} \cdot (\cancel{SFOC_{a,k} \cdot EL_{a,k} \cdot EP_{a,k}} + SFOC_{b,k} \cdot EL_{b,k} \cdot EP_{b,k}) \cdot t_{B,k}$$

- At the energy source it depends on energy mixture, and total transmission/conversion losses

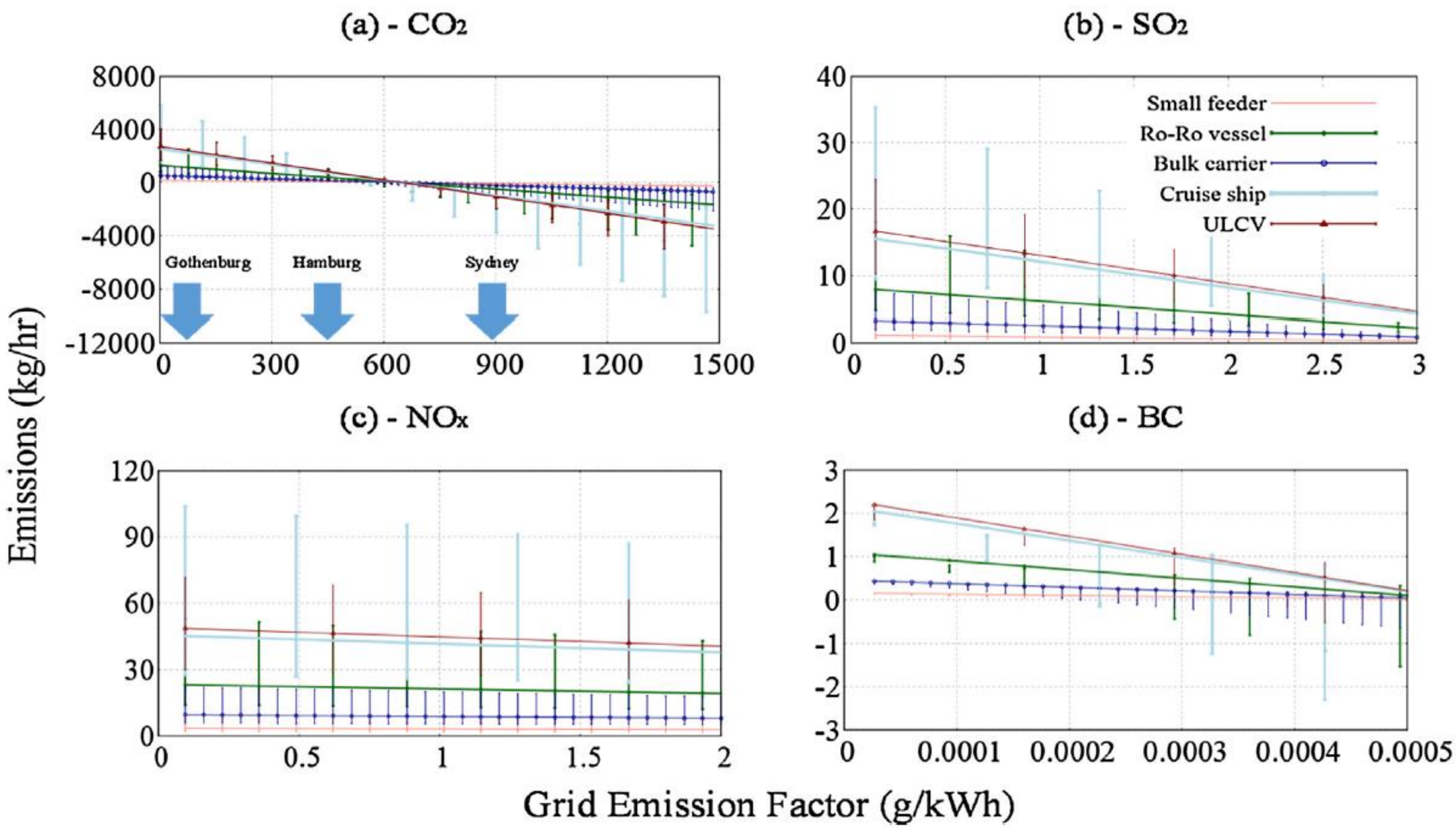
Variability of emissions per energy mix

- In comparison, typical Aux. engine results in 650-720 g/CO2 per kWh

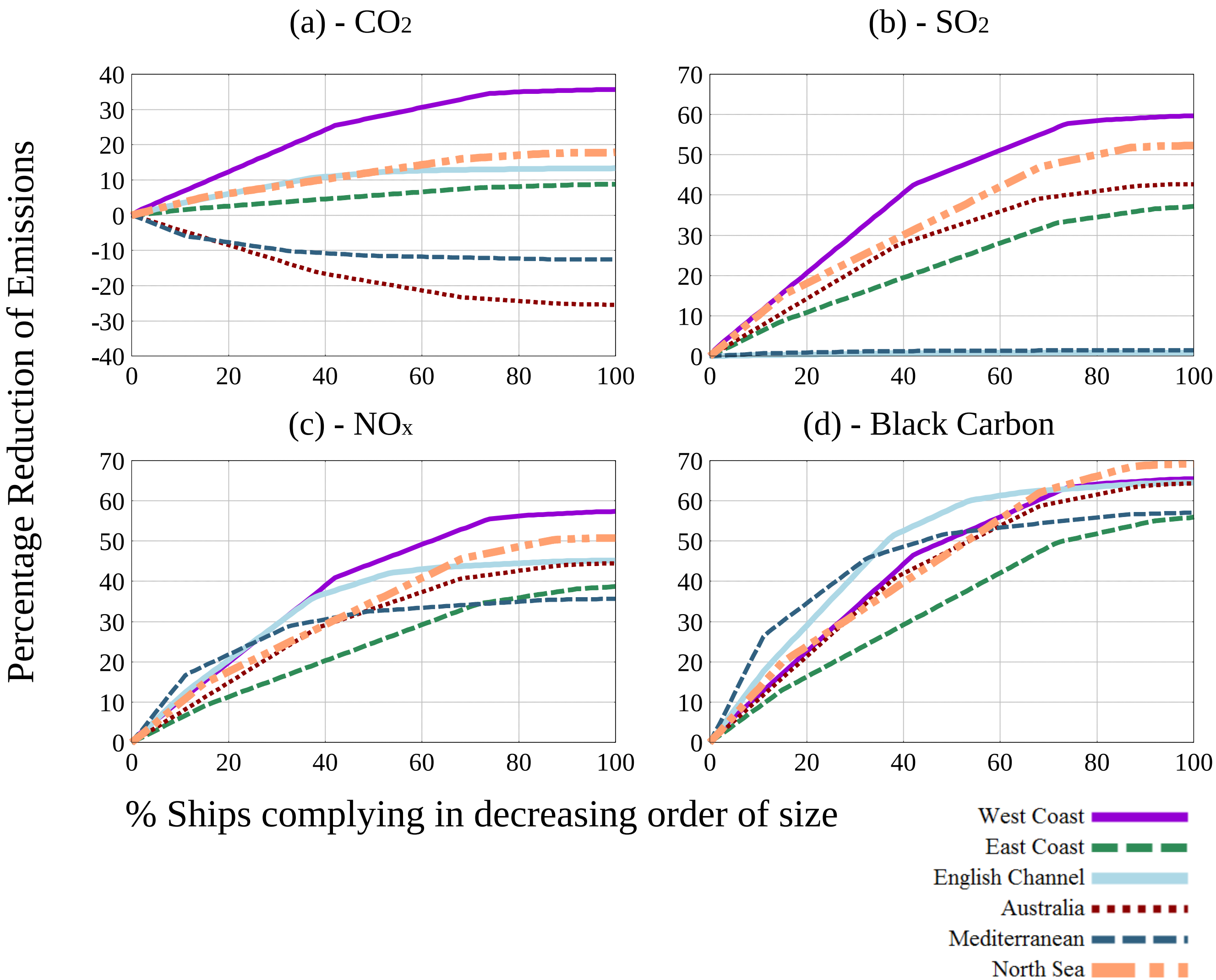
source: Zis et al., 2014

Port	*Country*	*Coal*	*Fuel and LNG*	*Nuclear*	*RES (including Hydro)*	*Others (including imports)*	*EFgrid*[1]			
							CO_2 (kg/kWh)	*SO_2 (g/kWh)*	*NO_x (g/kWh)*	*BC (g/kWh)*
Los Angeles	USA	7.3	54.6	14.9	22.9	0.3	0.299	0	0.41	0.002
Virginia	USA	45.1	9.6	41.4	3.7	0.2	0.507	0.96	0.31	0.003
Felixstowe	UK	28.9	44.2	17.3	7.9	1.7	0.474	0.36	0.76	0.003
Sydney	Australia	77.9	13.8	0	7.3	0	0.901	2.1	1.3	0.003
Piraeus	Greece	55.7	30.5	0	13.8	0	0.797	0.18	1.28	0.003
Hamburg	Germany	43.4	14.9	22.8	17.8	1.1	0.441	0.52	0.72	0.003

Global emissions as a function of grid



Environmental Trade-offs with Cold Ironing



Basic costs

- Ship operator:
  - Range between 0.3-2 million $ per ship depending on size, type, requirement for transformers
  - As with most abatement technologies (e.g. scrubbers), cost is higher for retrofit than new-build (150-200% according to IAPH)
  - Cost per kWh which depends on port providing power

- Port operator:
  - Range between 0.4-4 million $ per berth depending on size, location, types of visiting vessels, and energy demands
  - Cost per kWh which depends on energy source

Formulating the Economics

- Ship Operator
  - Economic balance (cost or benefit) of ship *k* calling $N_{c,k}$ times at ports with cold ironing capability (*c*)

Cost of energy Cost of fuel aux. engine

$$\Delta C_{AMP,k} = \frac{C_{R,k} - S_{R,k}}{(1 + r_k)^y} + N_{c,k} \cdot (t_{L,AMP,k} \cdot C_{t,k} + P_{AMP} \cdot E_{AMP,k} - FC_{a,B,k} \cdot P_{f,c} - R_{AMP,P,k})$$

  - where:
  - $C_{R,k}$ cost of retrofitting the vessel
  - $S_{R,k}$ is a potential subsidy towards retrofit
  - $t_{L,AMP,k}$ time lost during plugging/unplugging (value of time $C_{t,k}$)
  - $R_{AMP,P,k}$ incentive per call using AMP

Formulating the Economics ii

- Port Operator
  - Economic balance (cost or benefit) of port opting to invest in AMP berth

$$C_{AMP,P} = N_B \cdot \frac{C_{AMP,I,P} + C_{AMP,O,P}}{(1+r_P)^t} + \sum_{k=1}^{n} \left(\frac{S_{R,k}}{(1+r_P)^t} + R_{AMP,k} + P_{grid} \cdot E_{grid,k} - P_{AMP,k} \cdot E_{AMP,k} \right)$$

Cost of energy

Revenue from selling to ship

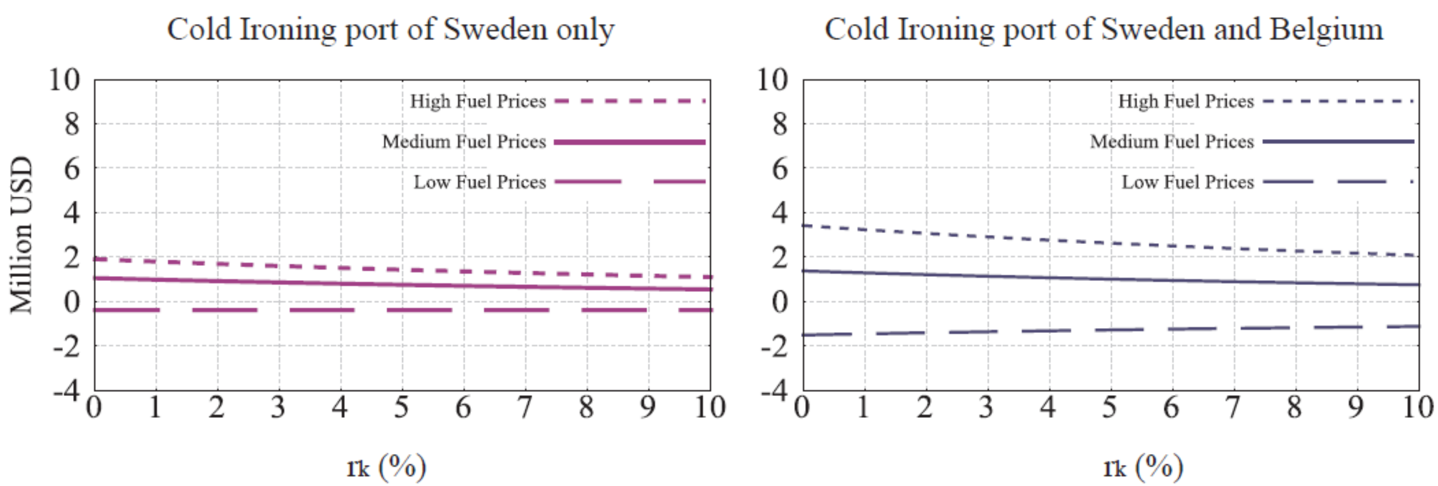
where:

- $C_{AMP,I,P}$ cost of installing AMP berth
- $C_{AMP,I,P}$ operating costs of AMP berth (maintenance, staff etc.)
- $t_{L,AMP,k}$ time lost during plugging/unplugging (value of time $C_{t,k}$)
- $R_{AMP,P,k}$ incentive per call using AMP

A simplified Case Study

Ship Operator

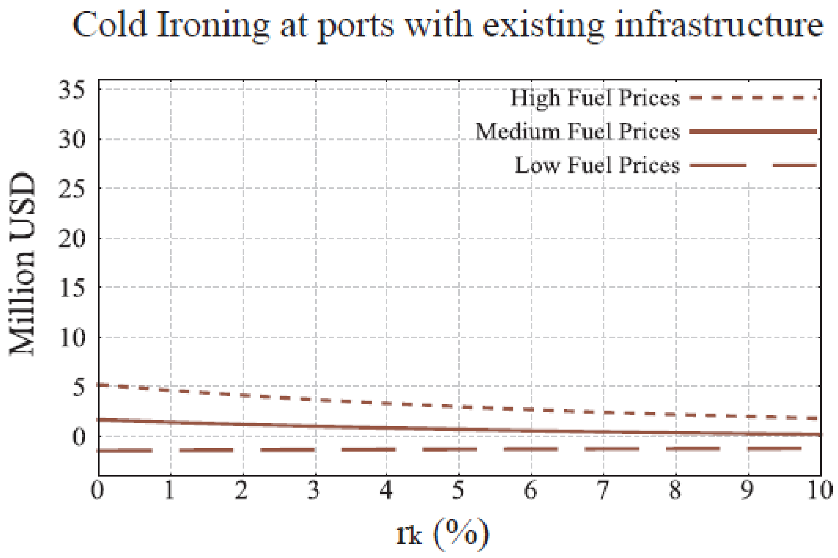
- A Ro-Ro operator with auxiliary power of 6000 kW and 30% at berth requirements
- Sailing 4 times a week between two ports, average berth stay at 8 hours

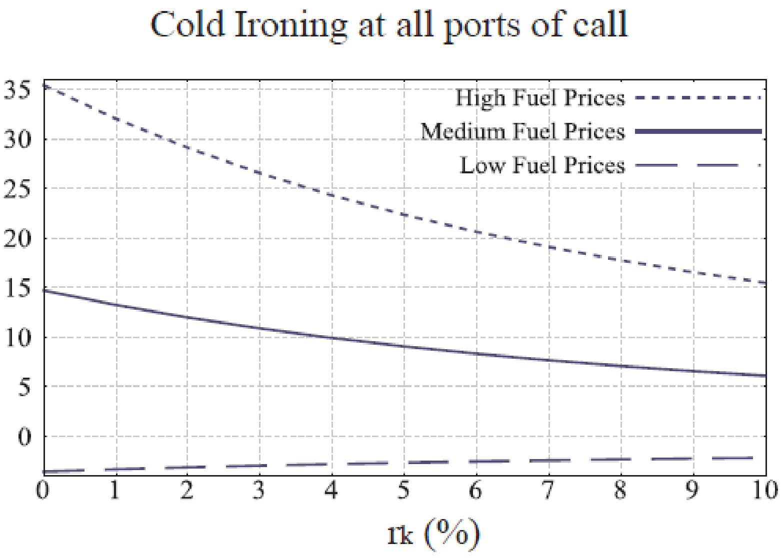


- At high fuel prices the payback period is reduced. SECA limits improve cost-effectiveness of cold ironing
- But!! With SECA limits, compliance is required at sailing, so maybe invest in different technology with same money (e.g. scrubbers)

A simplified case study ii

- Large Cruise ship

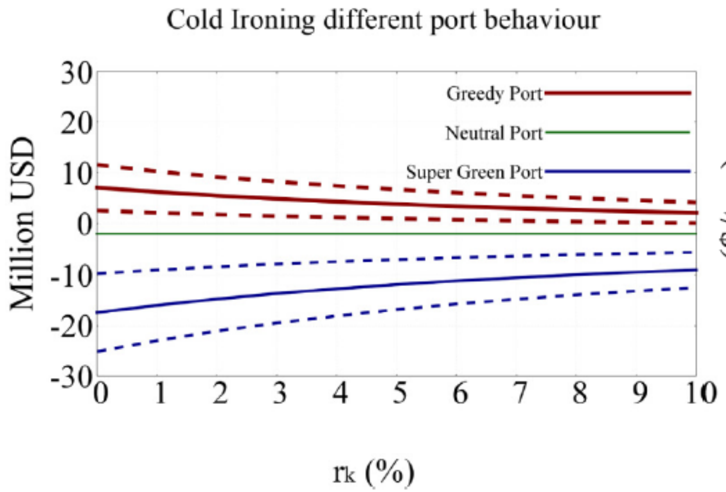


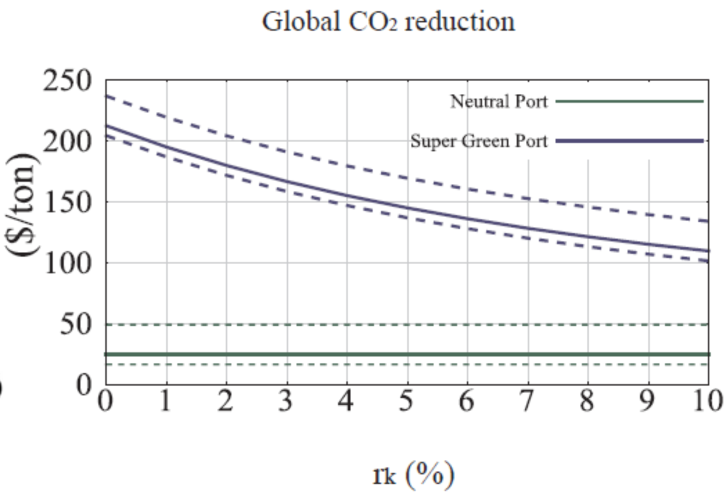


A simplified Case Study iii

<u>Port Operator</u>

- Terminal invests in AMP, but does not make profit from selling energy
- Also using Vessel Speed Reduction Programme (VSRP)
- Berth cost at 1.5 million $, assumed at 0.105 M$ per year
- 10% of Vessels can use AMP





- Tight budgets only use AMP
- As penetration rate is increasing, cost will drop
- AMP + VSRP can be cost effective when targeting large vessels

Conclusion

- Cold ironing is here to stay, and may become the norm in the future
- A chicken and egg problem (who will invest first) may be solved due to regulation requiring use of technology
- It shows good cost effectiveness during high fuel price periods (as electro-mobility)
- While SECA regulation increases cost-effectiveness, it also benefits more other abatement options
- Requirement for examination of subsidies towards participating stakeholders

Further Work

- Challenges for port operators
  - Berth scheduling
  - How many berths to convert
  - Pricing policy per kWh

- Challenges for ship operators
  - ”Break-even” hours of operation per ship type
  - CBA vs alternative abatement options
  - Implications of Cold Ironing Ports on Network Design

- Can an MBM break the deadlock?

Thank you - Questions?

More academic <u>info</u>:

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ELSEVIER

Prospects of cold ironing as an emissions reduction option

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Check for updates

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