# Approaches to control air pollution from ports and ships

*Green Ports: New Front for China's War on Pollution and Climate Change Mitigation*

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# Outline

- Why should we care?
- Case study:  Shore power and fuel switching in Shenzhen
- Next up:  Emission control areas
- Looking forward
- Conclusions

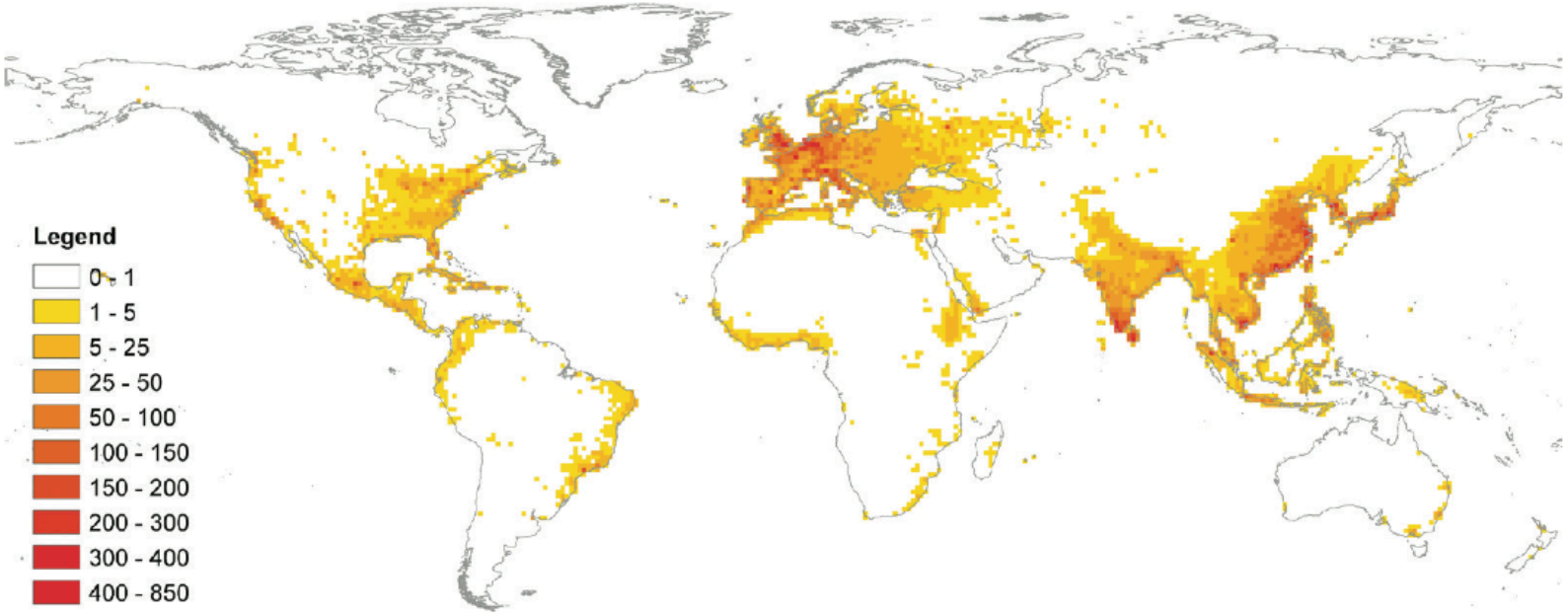
# Approaches to control air pollution from ports and ships

## Why should we care?

# Air pollution from ports and vessels pose a serious public health challenge

- Three quarter of the world's major cities and 50% of the global population lives on the coast exposed to pollution from shipping and ports
- Estimated 60,000 premature cardiopulmonary and lung cancer deaths in 2002 related to particulate emissions from shipping.

Annual premature mortality from ship emissions




*Winebrake, J., Corbett, J., Green, E., Lauer, A., & Eyring, V. (2009). Mitigating the Health Impacts of Pollution from Oceangoing Shipping: An Assessment of Low-Sulfur Fuel Mandates. Environmental Science and Technology, 43(13), 4776*

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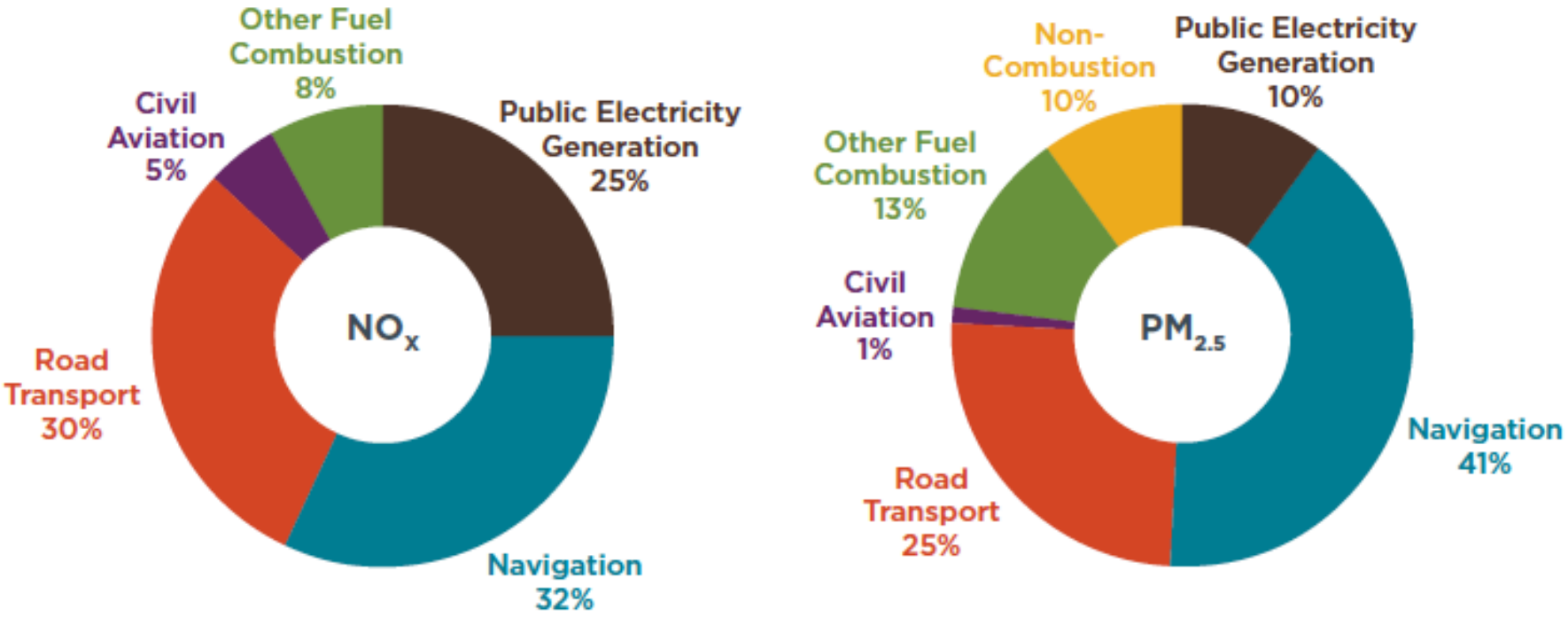
# Ships air pollution become relatively more important as cities clean up

Emissions by source in Hong Kong, 2010




*Source: Hong Kong Environmental Protection Department*

# Shipping is also important for black carbon control

- Shipping responsible for 8~13% of diesel-related black carbon emissions in 2010, with 80% of those emissions in the Northern Hemisphere.
- Interest in Arctic shipping via Russia's Northern Sea Route is high.
- Increased vessel traffic through the Bering Strait could increase air pollution 150 to 600% in the US High Arctic by 2025 using today's fuels.


Wall Street Journal, 29 October 2015.

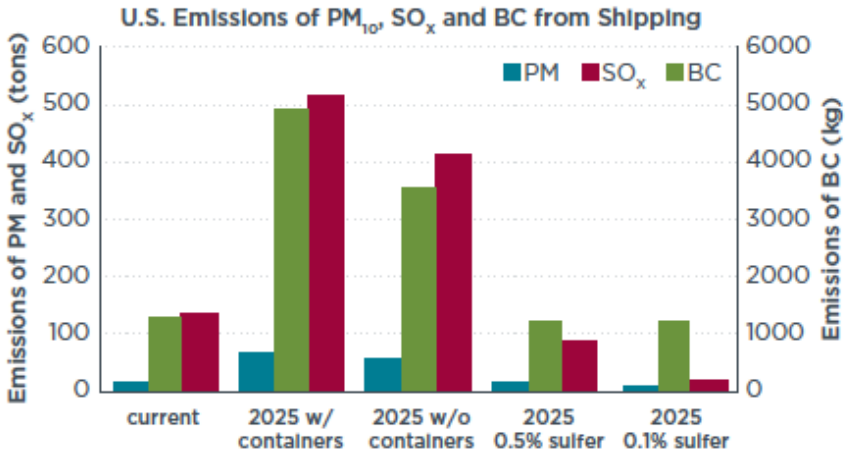



**Figure 1.** Comparison of the potential reduction in emissions with the application of 0.5% and 0.1% fuel for Arctic vessels assuming the low growth scenario.

http://www.theicct.org/air-pollution-marine-vessels-us-high-arctic-2025

# Approaches to control air pollution from ports and ships

## Shore power and fuel switching at the Port of Shenzhen

# Assessment of shore power and fuel switching at the Port of Shenzhen

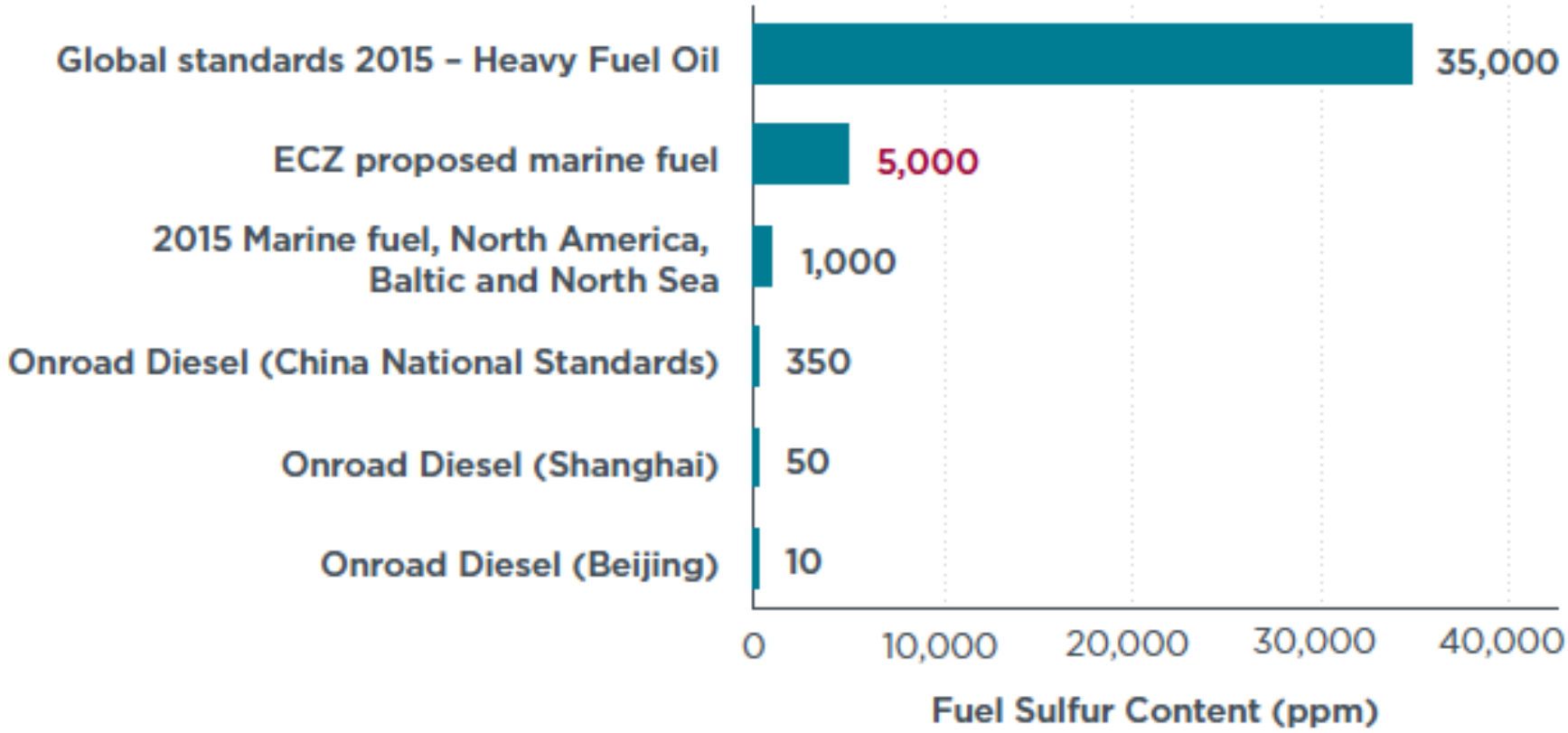
- SOx and PM emissions are of great concern in China
- Shenzhen is a key port linking PRD feeder routes to many international container routes
- August 2015 MoT action plan for port and ship emissions
- Mature technologies technologies with existing infrastructure/ regulatory support
  - Fuel switching subsidies
  - California shore power mandate

# Shore power background

- Port electrification strategy to replace ship auxiliary engine use at berth
- Requires shoreside and shipside capital investments
  - Shoreside (~$5,000,000/berth): distribution switchgear, circuit breakers, safety grounding, underground cable conduits, electrical vaults, power and communications receptacles and plugs.
  - Shipside retrofits ($300,000 to $2,000,000/ship): power cable receptacles plus electrical management system
- International, although not uniform, standard: ISO 80005-1

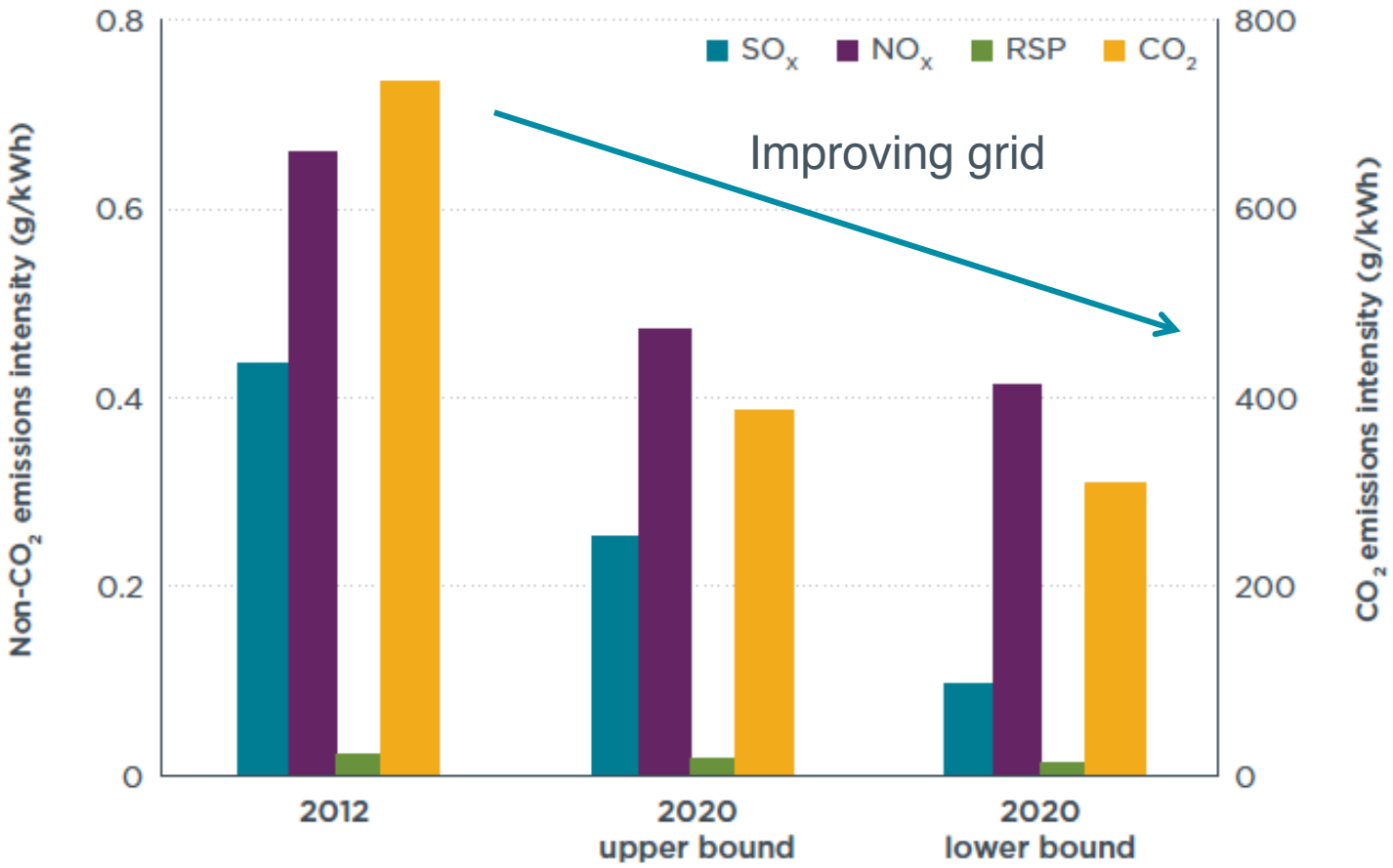
Shore power infrastructure in Shekou, Shenzhen

# Examples of fuel switching requirements




http://adi-analytics.com/wp-content/uploads/2015/06/World-ECA-Map.png

# Emission factors for Shenzhen shore power

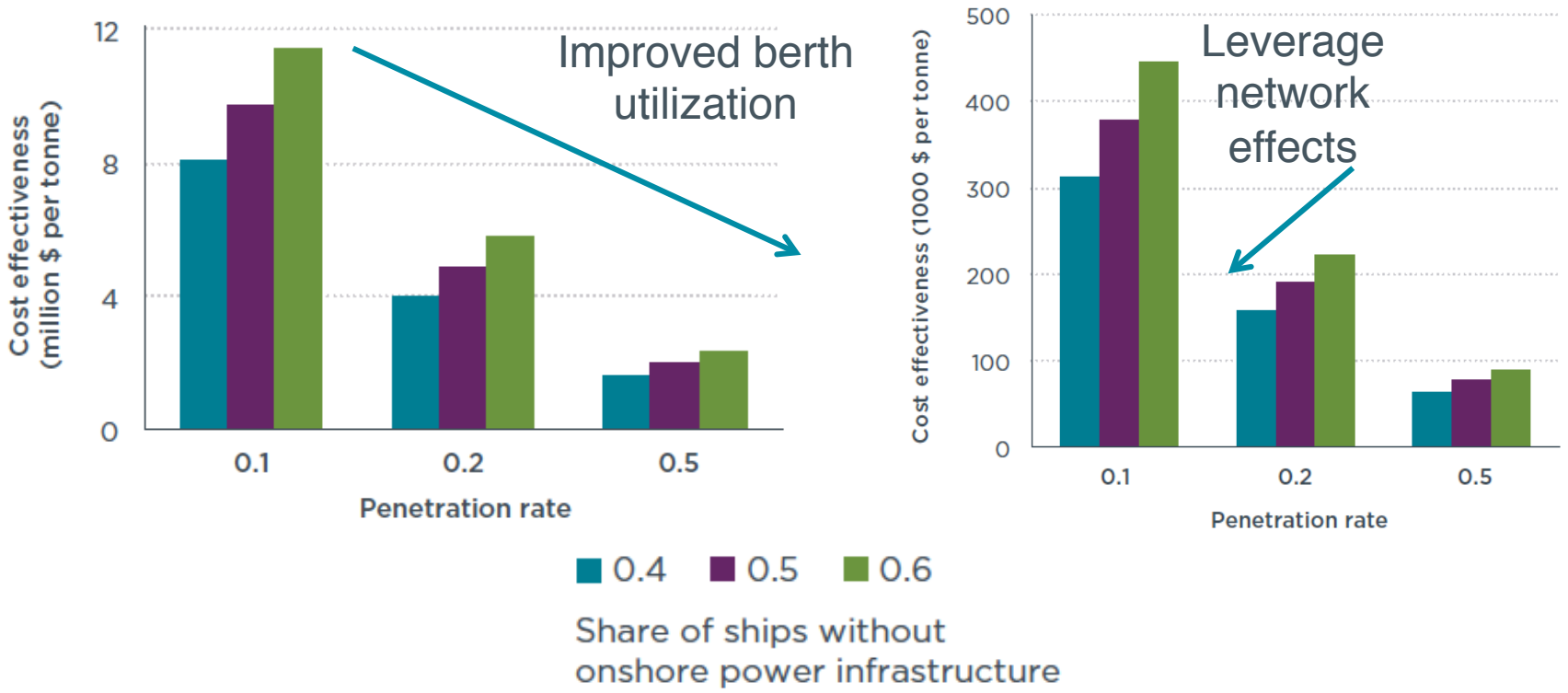



Source: Costs and benefits of shore power at the Port of Shenzhen, ICCT and WWC, 2015.

# Cost effectiveness of Shenzhen shore power

Particulate matter

NOx




Source: Costs and benefits of shore power at the Port of Shenzhen, ICCT and WWC, 2015.

# Case study conclusions

- Shore power is an effective means of reducing air pollution at berth, providing 88%, 94%, 95%, and 37% reductions in SOx, NOx, RSP, and $CO_2$ respectively in 2020.
- Relatively expensive compared to at berth fuel switching ($13,000/tonne SOx, $310,000/tonne PM)
- Cost effectiveness improves as utilization rate increases, through network effects and with greater incorporation into new build ships
- Policy recommendations
  - Prioritize 0.5% to 0.1% sulfur fuel switching
  - Consider incentives to attract shore power capable ships
  - Work with other Pacific Rim ports to take advantage of network effects

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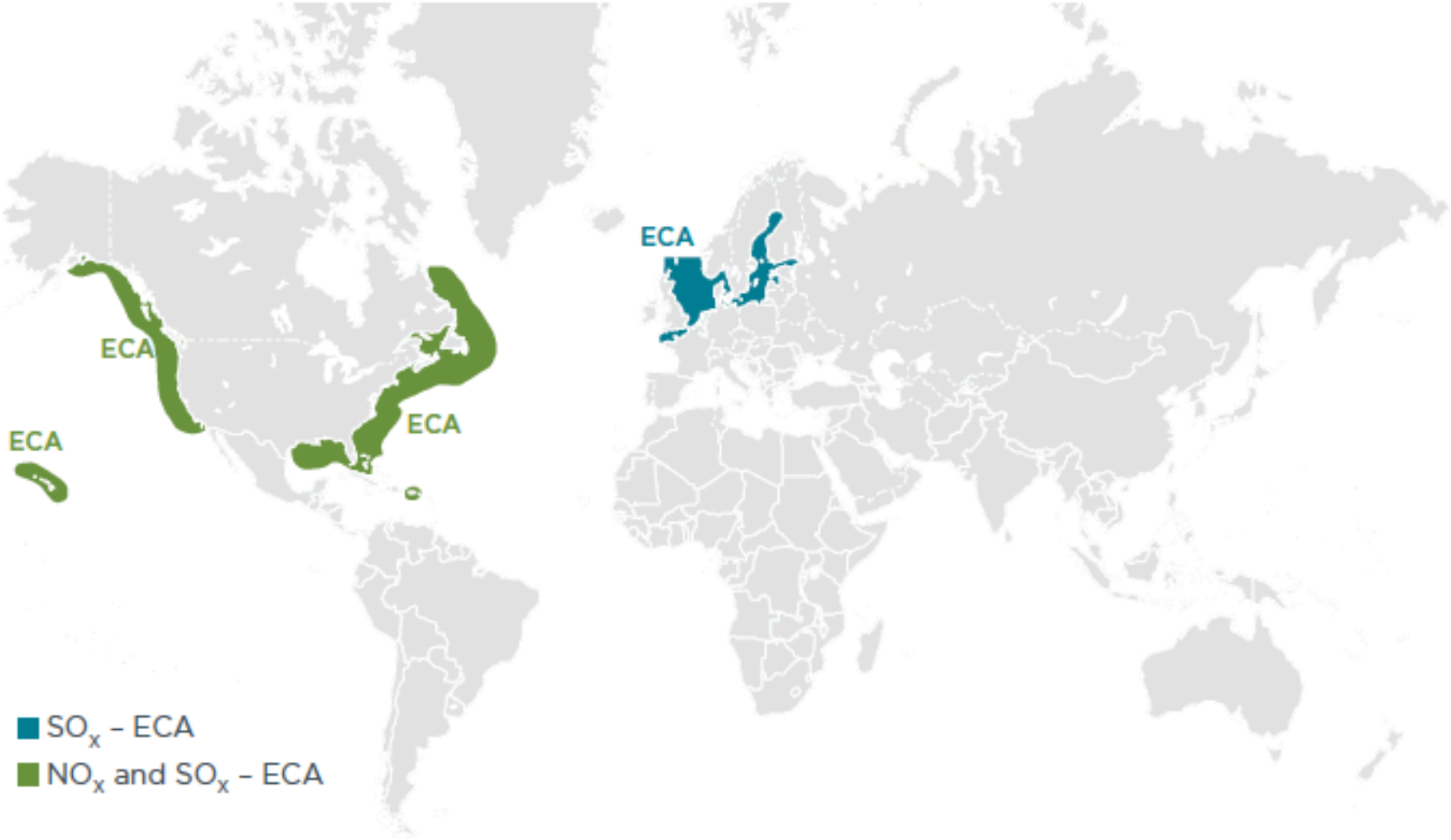
## Emission Control Areas

# Existing Emission Control Areas (ECAs)




http://adl-analytics.com/wp-content/uploads/2015/06/World-ECA-Map.png

# Domestic Emission Control Areas (D-ECA)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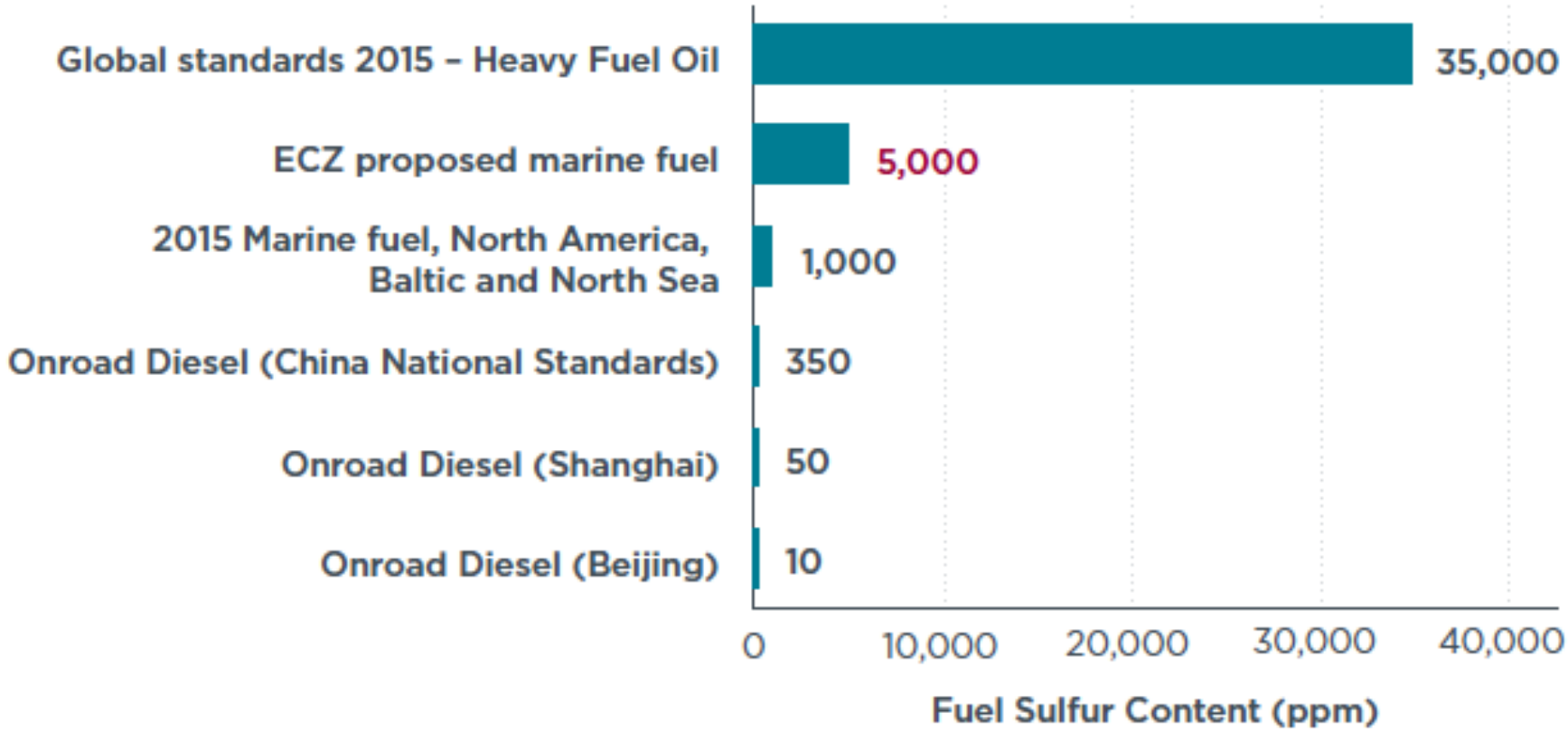
# Comparison of ECA requirements




http://adi-analytics.com/wp-content/uploads/2015/06/World-ECA-Map.png

# Benefits of going the extra step

- Greater geographic coverage:
  - <200 nm coverage, vs. 12 nm for D-ECAs
  - Full coast, rather than current D-ECAs only
- Greater emission reductions:
  - Additional, cost effective SOx and PM reductions
  - Potential for NOx control as well
- Leverage international experience with compliance and enforcement
- Accelerated investments in control technology could stimulate international competitiveness

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## Looking forward

# The flow of policy and technology


# What will we be discussing in 5 to 10 years?

- Exacting fuel quality standards as a key enabling strategy
- Near-zero emission standards for engines
- Soot free goods movement
- Where possible, alternative and sustainable fuels (including electrification)
- Managing the impacts of Arctic shipping
- Integrating environmental considerations into supply chain management
- Compliance and enforcement!

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## Conclusions

# Conclusions

- Shore power is an effective means of reducing air pollution in Shenzhen
  - Additional (MDO to MGO) fuel switching could be prioritized
  - Additional measures to increase shore power utilization and leverage existing investments are recommended
- IMO ECA system provides a potential vehicle for expanded air quality benefits
- Studying other modes may provide clues as to where future work will lead us

# Thank You

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