Discussion: Brainstorming potential policies to reduce BC emissions from ships

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13 Appropriate BC control measures according to 5th ICCT workshop participants

Fuels	Exhaust Gas Treatment	Engine Tuning, Propulsion System Design, and other measures
LNG (>99% ↓) Distillate (33% ↓) Biodiesel (75% ↓) Methanol (55%-75%+ ↓)	Diesel Particulate Filters (DPFs) + distillates (>96% ↓) DPF + SCR + distillates (>96% ↓) Electrostatic Precipitators (>91% ↓)	Engine tuning to low BC (BC ↓ varies) Engine control technologies (BC ↓ varies) Hybrid propulsion (BC ↓ varies) Full battery electric vessel (100% ↓) Fuel cells powered by hydrogen, ammonia, or other zero-carbon fuels (100% ↓) Shore power (100% ↓)

Scrubbers are not very effective at removing BC (0-30%)

Slow steaming usually reduces BC but not linearly: BC/kWh increases as speed decreases, but BC/km does go down in most cases.

Potential policies to reduce BC from ships (1/3)

Target	Type	Description	Scope	Compliance	BC measurement needed?
New ships	Emissions limit	BC/kWh limit	New ships (would take a long time and "pre-buy" issue)? Geographic scope TBD	At or below limit	Yes, parent engine of an engine group or engine family (worst emitter) certification in test bed and on-board confirmation
	BCECA (not fast; needs new reg framework)	Distillate /methanol use with filter	New ships; PC Arctic	Use approved fuel/device combination	Yes, [aftertreatment certification in lab]

Potential policies to reduce BC from ships (2/3)

Target	Type	Description	Scope	Compliance	BC measurement needed?
All ships	Emissions limit	BC/kWh limit	All ships – retrofits Geographic scope TBD	At or below limit	Yes, retrofit is certified to prove compliance, with the on-board certification
	Arctic ECA	SECA but no scrubbers	New + all ships; PC Arctic	Use compliant fuel	No
	Modern ship requirement	Only [2011+] ships allowed in the Arctic	PC Arctic	NOx compliance (it's a way to promote modern vessels)	No
	Shore power	SP mandate	TBD	Plug in at near Arctic berths	No

Potential policies to reduce BC from ships (3/3)

Target	Type	Description	Scope	Compliance	BC measurement needed?
Fuels	Fuel quality	HFO ban	All ships; PC Arctic	No HFO in fuel tanks	No
	Fuel Quality (e.g. aromatic limit)	Promotion of cleaner fuels	All ships; PC Arctic? Global?		Not at vessel level

Discussion: Considerations for appropriate BC control policies

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Potential considerations to identify appropriate BC control policies

Considerations	Definition
Effectiveness	Magnitude of potential BC emission reductions that can be demonstrated consistently
Feasibility	Can be applied without unduly impacting operational performance, cost, or safety
Availability	Can be used in the maritime shipping sector in the short or mid-term[1]
Applicability	The set of engine types and duty cycles where the policy could apply to
Co-emitted pollutants	Impact on other air, liquid, and solid waste pollution from the ship
Measurement	Whether black carbon must be measured to demonstrate compliance
Enforceability	Can be enforced in a way that ensures compliance
Other	Other considerations

[1]Short-term could mean before 2023, mid-term from 2023 to 2030. Other control measures could become available in the future.

Discussion: Control Policies and Consideration Cross-walk

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Control policies were not evaluated against the gray considerations because they relate to BC control measures. As such, the participants evaluated polices against measurement, enforceability and other considerations. BC control measures were evaluated against the grayed out considerations at the 5th workshop.

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Control policies vs. considerations (1 of 3)

Target	Policy	Measurement	Enforceability[5]	Other	Decision
New ships	Global Standard: Emissions limit (eBC/kWh limit) Global	Yes	Medium to High: EIAPP certificate for engine and/or IAPP for ship	Enforceability medium if a new test cycle needs to be defined; High if it's the same as NOx procedure	Appropriate
	Regional Standard: BCECA which is basically a regional emissions limit, similar to Tier 3 for NOx	Yes	Low to High: depends on means of compliance. If it's always operating on a compliant fuel it's simple; if it usually runs on non-BCECA fuel, then enforcement is harder	not fast; requires a new regulatory framework	Appropriate

[5] Qualitative scale where High means a policy can be enforced by using or modifying existing verification methods; Medium means that it could be enforced but new verification methods would be needed; Low means that it is difficult to ensure compliance

Control policies vs. considerations (2 of 3)

Target	Policy	Measurement	Enforceability[5]	Other	Decision
All ships	Emissions limit (eBC/kWh)	Yes	Medium to High: Similar process as new ship emissions limit but need to develop a regional and retrofit verification scheme	Related to retrofit difficulty; paired with incentives (?)	Appropriate
	Arctic ECA	No	High	If it's just a new SECA it's easier than also prohibiting scrubbers unless there is an HFO ban. Could it happen given that one criterion for ECA is health benefits? Could be effective if paired w/ aromatic limit for fuel.	Not appropriate* *Not appropriate with existing ECA criteria which limits sulfur content of marine fuels for all ships and NO_x emissions for new ships. Black carbon would fall under the broader category of particulate matter, but PM is controlled indirectly by sulfur content and other fuel characteristics, such as aromatic content, control BC emissions, not sulfur content.
	Modern ship requirement	No	High	Need to consider keel laid date pre-buy issue	Appropriate
	Shore power	No	High	Few ports in the Arctic, effectiveness depends on power generation source and grid capacity. Has health co-benefits.	Appropriate

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Control policies vs. considerations (3 of 3)

Target	Policy	Measurement	Enforceability[5]	Other	Decision
Fuels	HFO ban	No	High (bunker delivery note and fuel log inspection)	Really no residual fuels! (Above and beyond 0.5% fuels)	Appropriate
	Fuel Quality Standard (e.g. aromatic limit)	No	Unclear	Potential areas of investigation: aromatic/hydrogen content linked to BC; "no carbon" fuels; ISO 8217 revision	More work needed

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Workshop consensus on appropriate BC control policies

Appropriate	Not appropriate	More work needed	Not evaluated
Emissions limit (new ships, global) Emissions limit (new ship, regional) Emissions limit (all ships regional) Shore power Modern ship requirement HFO ban	Arctic ECA*	Fuel quality standard	Integration with existing policies (e.g. EEDI)

* Not appropriate with existing ECA criteria, which limits sulfur content of marine fuels for all ships and NO_x emissions for new ships. Black carbon would fall under the broader category of particulate matter, but PM is controlled indirectly by sulfur content and other fuel characteristics, such as aromatic content, control BC emissions, not sulfur content.

Summary of Workshop Outcomes

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Goal and outputs for this workshop

- Goals:
  - Identify appropriate black carbon control policies
  - Discuss potential standardized sampling, conditioning, and measurement protocols, including a traceable reference method
- Anticipated Outputs:
  - Workshop summary report
  - PPR 7 INF paper containing the workshop summary report
  - PPR 7 member state submission(s) on appropriate BC control policies, noting which need BC to be measured
  - PPR 7 member state submission(s) on potential measurement protocols and how they relate to potential BC control policies

Key themes from Day 1 presentations (General)

- Near the finish line! PPR to report back to MEPC 77 (2021) on:
  1. How to regulate or otherwise control BC
  2. Standardized measurement protocols
- BC measurement protocols will benefit from knowing what policies we might pursue (engine only? engine plus aftertreatment? on-board testing?)
- Building blocks for regulation exist
  1. Technical expertise on BC sampling and measurement is available
  2. Appropriate BC measuring instruments are available.
  3. A test procedure for measurement of BC emissions from marine engines (on test-bed as well as on-board) is possible!
- Shipping is one of the few emission sources in the high Arctic
- Better understanding of link between BC and climate/health/air quality would help set standard limit
- BC or close proxy like PN is already regulated in other sectors, e.g. aviation, L/HDVs, rail, and small marine engines

Key themes from Day 1 presentations (control technologies)

- Currently no regulatory driver for direct BC control e.g. cosmetics, not climate, driving DPFs in yachts.
- DPFs: 97% or greater BC reductions, applicable to high speed and MSD engines on MDO/MGO, work starting on medium-speed engines + HFO.
- ESP: can achieve 80% collection efficiency with continuous operation, minimal maintenance, and small power demand
- SECA fuels: BC reductions in moving from HFO to MGO and for some hybrid fuels
- Co-benefits of upstream BC removal for aftertreatment generally (SCR and scrubbers)

Key themes from Day 1 presentations (control policies)

- Policymakers (IMO, Arctic Council) and others need state of the art science-based information to design smart policies to regulate emissions.
- New Digital Technologies (IoT, DLTs, AI, Big Data) interact with one another and could help record, track, and report emissions from ships and help with enforcement. But watch out for GIGO.
- Baltic plume studies support SECAs as a BC control measure: 50% reduction in nvPM; <65% reduction in BC
- Benefits of an HFO ban: reduces BC, residual oil spill risk, enables the use of filters, cost-effective way of controlling BC deposition in the Arctic

Key themes from Day 1 presentations (measurement protocols)

- Standardized measurement approach would enable a flexible, progressive control policy that pushes technology forward
- Proper sampling, calibration, adjustment, and traceable reference methods are important for accurate and reproducible measurement of marine BC.
- Correlations of different instruments can/have been developed under reference conditions (fuel and test bed), robust to different fuel types
- General trend: The larger the engine, the lower the BC emissions (g eBC/kg fuel)
- Much larger variation in emission factors across engines (3 orders overall, 1 order within an engine family across test conditions) than across measurement approaches

Key themes from Day 1 presentations (measurement protocols)

- Fuel standard may be needed on aromatic content to control BC from blended fuels
- We need traceability of measurements, comparability between instruments, metrics and climate and health impact, in order to set a good emission limit.
- Pay attention to the building blocks of measurement uncertainty: every time you deviate from the raw exhaust, you introduce more uncertainty
- Key issues for standardization
  - Takes all variables into account: fuels, technology, engine size, etc.
  - Get a truly comparable measured values regardless of the conditions of the emissions
  - Good repeatability and reproducibility
  - Know the uncertainty of the measurement precisely
- Could be value in an international technical working group to coordinate efforts to standardize the approach

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Closing Remarks

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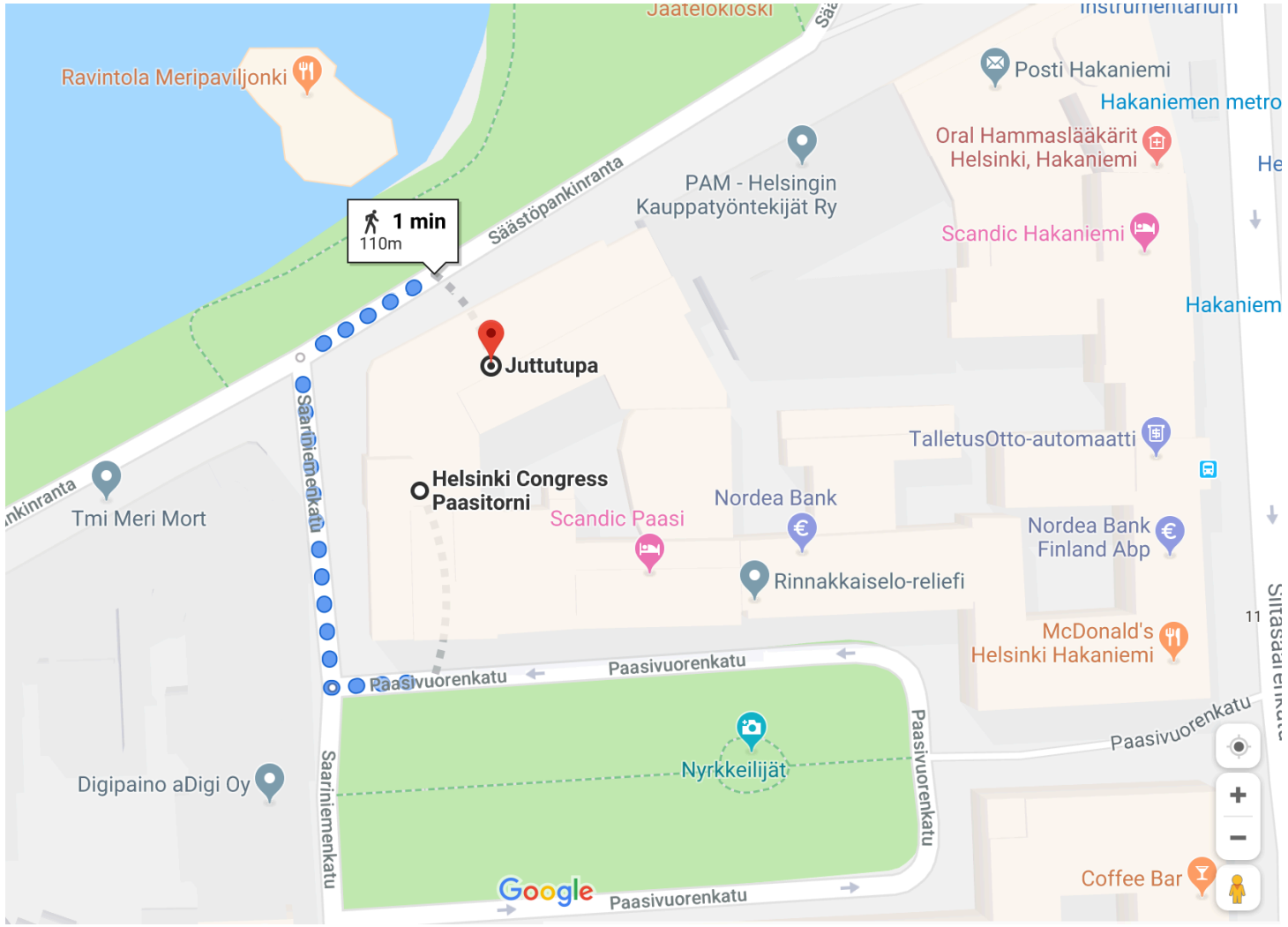
Next steps

- ICCT will prepare a workshop summary document and send it around to workshop participants for review and comments.
- ICCT will post workshop materials to our website and we will send you a link.
- ICCT will work with IMO Member States and International Organizations as they prepare PPR 7 submissions on appropriate BC control policies and standardized measurement protocols.
- 7th workshop same time next year?? Topic and Location TBD.

Join us for Happy Hour!
Juttutupa Pub, Säästöpankinranta 3, 00530 Helsinki



Thank you!

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All of you!