Summary of Workshop Outcomes

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THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

Disclaimer

- This presentation includes a preliminary summary of workshop outcomes. These outcomes were discussed with the workshop participants and many have been edited after such discussion. Final workshop outcomes are contained in the formal workshop summary report.

Reminder of Workshop Goals

1. Solidify recommendations for marine **BC measurement approaches**
2. Identify effective technological and operational **strategies to control BC** from marine engines

Takeaways: Measuring Marine BC

- Goal and approach
  - Measure to control at source; focus measurement approaches first on a test stand e.g. engines.
  - On-board measurement will be important for aftertreatment, conformity, and compliance etc.
- Conclusions on instruments
  - Cannot recommend ambient measurement techniques as fit for purpose.
  - Limitations seen in some thermo-optical methods, with EC/OC fractions varying across labs and even approaches within a lab for a given sample.
  - Good correlation seen between some thermo-optical methods (EC/OC), PAS, FSN (e.g. AVL 415-SE) on engine/fuel combinations where BC fraction of PM is not very low. Less data available on LII but pending from U of Rostock consortium.
  - High dilution ratios for instruments designed for ambient measurement (MAAP, aethalometers) introduces considerable uncertainty in measurement.
- Conclusions on protocol
  - Clear value seen in instrument calibration
  - Need for sample conditioning (thermal denuding and/or catalytic stripping) is more ambiguous and introduces high losses to deal with.
  - Value in having a reference fuel to allow comparative testing across engines, recognizing that it will not be representative of all marine fuel types needed for a good inventory.

Takeaways: Measuring Marine BC (next steps)

- Reporting protocol is great starting point, but need to develop a recommended measurement method and then a uniform standard. Neither is IMO's job.
- Ad hoc technical committee can play this role. Unlikely to see IMO recognize an external process formally but ICCT may be able to continue facilitating role.
- Existing reporting protocol is great, detailed project reports should also be written and ideally data collated and made available to interested parties.
- More thought needed on how the ad hoc group might prioritize standardizing the measurement reporting protocol.
  - Hardware should be a focus (losses, sampling, errors, needed dilution ratios) but a reference fuel likely also needed.

Takeaways: Marine Fuels and BC

- Specific findings on fuels:
  - Chemical composition of fuels influence physical properties and BC formation. Aromatic and olefin content drives BC formation.
  - Evidence suggests that shifting from conventional HFO to distillate fuels such as MGO reduces black carbon, but lower sulfur hybrid fuels created by blending residual and light fraction blends may not. More research is needed on those fuels.
  - Some interaction seen between engine load and relative BC emissions of fuels. At lower loads (e.g 25%) metallic impurities in HFO may promote more complete combustion compared to blends.
- Simple metrics need to be developed to link fuel chemical properties directly to black carbon emissions (e.g. hydrogen/carbon ratio).

Takeaways: BC Control Strategies

- Some existing technologies to control BC from OGVs, but none being directly promoted by standards and deployment rates remain low
- Three buckets of control strategies:
  - Additional "hardware" include: NG engines, SCR, scrubbers (~20% reduction seen), shorepower, engine timing and fuel injection changes at low loads.
  - Fuels: LNG, hydrogen, electricity
  - Other technologies like slide valves and sac volume minimization also reduce BC but are in general use for market reasons
- Conclusions regarding DPFs:
  - DPFs are a well-established technology for on-road engines but there are significant challenges for use on marine vessels: space, fuel quality, back pressure, filter maintenance, etc.
  - Standards in place in the US and Europe for smaller vessels with heavy-duty or locomotive derivative engines (C1/C2) that could drive DPF adoption in those vessels.

Takeaways: BC Control Policies

- Options exist for BC control in and outside the Arctic include MARPOL Annex VI standards, Polar Code requirements, PSSA, routing restrictions, and "Club-like Approaches"
- Existing policies (e.g. ECAs) to control NOx, SOx, and PM are unlikely to reduce BC emissions on an absolute basis given projected traffic growth.
  - Cobenefits of existing PM policies that can be built upon for BC
- Value in thinking short-term and concrete, but also need to consider holistic impacts (OC/EC ratios and not just BC emissions), knock-on effects of regional rather than global regulation, and wider approaches (e.g. ABC)
- Further research is on emission factors by engine and fuel type, load, etc. is needed. Reporting of co-pollutants is desirable.

Thank you!

Thanks to:

- You, the participants!
- Environment and Climate Change Canada
- CCAC
- MARAD

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