From: Miranda Marti
To: Commission-Public-Records; stacy@350seattle.org
Subject: [EXTERNAL] Written public comment for the 10/26 Commission Meeting
Date: Monday, October 25, 2021 2:50:55 PM
Attachments: Maritime Solutions Team 10_26 Written Testimony.pdf

Good afternoon,

I have attached a pdf of the written public comment that the 350 Seattle Maritime Solutions team would like to submit for the October 26th Port Commission meeting.

Please let me know if you have any questions or if you have any difficulty accessing the attached document.

Sincerely,

Miranda Marti

October 25, 2021

Re: Public Comment for the 10/26 Port of Seattle Commissioner Meeting

Dear Port of Seattle Executive Director & Commissioners,

The 350 Seattle Maritime Solutions team is providing the following written public comment regarding the accelerated climate targets and the first reading of the Maritime Clean Air Action Plan (MCAAP).

We support the Executive Director adopting the recommended accelerated GHG targets & timelines AND also note the following regarding the MCAAP plans to meet these targets:

1. The Scope 3 emission reduction plans rely on advocacy for policies, regulations and technology that are not yet available. We support the Port of Seattle investing in advocacy, and also recognize that the port needs to consider alternate plans if advocacy and industry do not yield the necessary results to meet these targets.
2. Within the MCAAP Clean Air Action Plans' common accountability framework, we view the commitment to review and update implementation plans as critical to the credibility of the MCAAP. Accelerating targets and timelines is only meaningful if there is a realistic path to meet them. As a contingency if advocacy and technology do not yield the necessary outcomes to meet climate goals, we would also like to see alternate plans to:
    - Reduce cruise calls to zero as quickly as possible until zero carbon cruise ships run under ethical business practices are available.
    - Rethink business as usual. Given the Port of Seattle is one of the largest landholders in King County, it is reasonable that we expect new ideas for revenue in a green economy vs. business as usual accommodation of difficult to decarbonize transportation sectors & the fossil fuel industry.

We expect to see the port demonstrate that these bold climate goals are achievable under the current state charter for economic growth. If they are not, we expect the Port of Seattle to work to align the state charter for port districts with climate realities & environmental justice.

In solidarity with the Duwamish River Cleanup Coalition, we would like to amplify the demands and concerns that they have raised in written comments to the Port of Seattle and the Northwest Seaport Alliance, including that the Port of Seattle:

- Prioritize the health of the Duwamish Valley (DV) residents, taking actions to reduce GHG and air pollution for DV communities first
- Articulate the specific actions or steps the Port will take to "support" real time air monitoring. DRCC has been fighting for years for the port to conduct real time air monitoring at port sites and in the DV community, and for the port to pair diesel particulate matter reductions with a health indicator as part of their accountability plan.

- Expand and develop more areas for carbon sequestration in the DV and ensure that any plans for the purchase of carbon credits mentioned in the MCAAP benefit the DV.

With regards to the final point above about carbon credits and offsets: we also stand by the objections to the use of carbon offsets that we raised in our April 8, 2021 comments to the Port of Seattle regarding the 2021 MCAAP Draft[1]. We do not support the use of carbon offsets to achieve climate goals. If the port does move forward with a plan for carbon offsets, however, we stand in solidarity with the Duwamish River Cleanup Coalition's demand that any such plan benefit Duwamish Valley communities.

Thank you for your time and attention. If you would like to follow up with us regarding any of these comments, please reach out to Miranda Marti (mirandahmarti@gmail.com) or Stacy Oaks (stacy@350seattle.org).

Sincerely,

Miranda Marti and Stacy Oaks, co-leads
350 Seattle Maritime Solutions Team

https://350seattle.org/solutions-port

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[1] **OGV3 "**Regarding the action to evaluate an optional carbon offset or "Good Traveler" type program for Seattle's homeport cruise passengers in coordination with cruise lines, our note on XS3 objecting to Cap & Trade programs on the grounds of environmental justice applies here as well. We advocate for the expansion of carbon sequestration areas, but not as a trade off for the climate and public health harms associated with cruise ship emissions."

From: JOHN A BIRNEL
To: Commission-Public-Records
Subject: [EXTERNAL] Public testimony for Oct 26th Port meeting
Date: Monday, October 25, 2021 6:23:20 PM

Thank you for the work you are doing in Scope 1 and 2 to reduce carbon pollution at the Port. Scope 3 emissions related to the Port are, of course, more complicated. I would urge you to "bit the bullet" and initiate a public campaign for the flying public, including business customers, to drastically reduce their flying. I believe this would be consistent with your mission to promote the common good, help in your efforts to realistically reduce Scope 3 emissions, and reduce the need for further airport expansion. If you seriously question whether your mission could encompass such a campaign, I would request that you advocate an appropriate broadening of the enabling RCW 53 law.

John Birnel, a resident of Seattle and a volunteer of the Aviation Team of 350 Seattle, a group that works for climate justice.

From: Robin Briggs
To: Commission-Public-Records
Subject: [EXTERNAL] Scope 3 emissions MIA in Port GHG Inventory
Date: Tuesday, October 26, 2021 8:01:19 AM

I am writing to ask for improvements in how the Port of Seattle calculates its greenhouse gas emissions, specifically its scope 3 emissions. Scope 3 emissions for maritime counts only emissions within the immediate area – only as far as Point No Point. The emissions should include half the round trip, so it should count either the trip from the home port to Seattle, or from Seattle back to the home port. Counting only what is emitted in the Sound ignores the bulk of the emissions. It's like sweeping it under the rug.

The Scope 3 emissions for aviation are in a more dire strait -- "*Coming Soon!*" according to your website. It's been coming soon for quite awhile. Somehow King County managed to count the emissions from SeaTac Airport, why can't the Port of Seattle? If the Port wants to be a trusted entity, it needs to engage in an open, transparent process, and report the emissions, how the emissions were calculated, and what steps the Port can take to reduce them.

I appreciate the work the Port has done to reduce its scope 1 and 2 emissions. The Port needs to step up to the plate and address the scope 3 emissions as well. I have grown children, and I am concerned about the climate not just for their sake, but for my own. Climate change is happening now, it is coming faster than anticipated, and the consequences are more severe. Please don't pretend the Port doesn't have scope 3 emissions. Report them, and then together as a community we can figure out what to do next.

Thanks very much for your attention to this matter, and for your public service.

Robin Briggs

From:	Elizabeth Burton
To:	Commission-Public-Records
Subject:	[EXTERNAL] Re: Public Comment
Date:	Tuesday, October 26, 2021 1:21:37 PM

Hello, Clerk,

I was at the check-in to give public comment this morning, and waited from 11:30 until 1:16 pm to deliver my public comment at today's commission meeting. I pressed *6 multiple times when my name was called, but despite this, you apparently couldn't hear me. I am extremely disappointed that I could not deliver the comments during the meeting, due to technical problems beyond my control. Therefore, I am asking to submit my comments in written form.

Thank you,
Elizabeth Burton

Good afternoon, Commissioners and Port Staff. My name is Elizabeth Burton.

For the last year and a half, the Port's website, spokespeople, and commissioners have repeatedly claimed that the Port has met its climate goals ten years early. This claim is based on projects that reduce scope 1 & 2 emissions; it ignores entirely the fact that scope 3 emissions dwarf scopes 1 & 2, and that the Port is not at all on track to meet its scope 3 climate goals. Claiming that you've met your climate goals 10 years early, with no acknowledgement that there are larger, more significant climate goals you're not meeting, keeps both the media and the public in the dark about the magnitude of your runaway scope 3 emissions: it hides the harm that they do, and shields you from pressure to reduce them. It is also the opposite of transparency and accountability, two values that are enshrined in your Century Agenda. Going forward, I ask that you be more honest about your climate work, and refrain from this kind of misleading spin.

I also ask that you take responsibility for the 90% of scope 3 emissions that you are currently ignoring: those emitted outside our airshed. A recent legal analysis of the Paris Agreement shows that, contrary to industry claims, there is no legal basis for excluding international shipping and aviation emissions from parties' obligation to reduce emissions.

The analysis found that no state should discharge responsibility for monitoring or controlling international shipping or aviation emissions to the IMO or the ICAO.

Under the Paris Agreement, emission reduction plans must be economy-wide, and must serve the central aim of the Agreement, which is to limit global temperature increase. Therefore, action must be taken on *all* emissions that affect climate.

Thank you.

On Oct 26, 2021, at 8:41 AM, Commission-Public-Records <commission-public-records@portseattle.org> wrote:

Thank you Elizabeth Burton,

Join us via your mobile or laptop device on through Teams or call into the number provided below at **11:30 a.m. PST** on Tuesday October 26, 2021 in order to be marked present and ready to speak. A member of port staff will join the call to take a roll call of the names we have listed and go over the procedure. Please plan to call from a location with as little background noise as possible.

You should expect to be on the line for between 30-60 minutes as we dispose of preliminary business on the agenda and we hear from other public commenters. While it's not possible for us to predict how many people will comment on October 26, we expect individual comment time to be limited to two minutes and all rules of order and decorum will apply as usual.

If you have any questions please let us know. We appreciate your dedication to public health and your interest in participating in the Port of Seattle Commission meeting.

Microsoft Teams meeting

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Best Regards,

Commission Public Records

From:	Sharla Dodd
To:	Commission-Public-Records
Subject:	[EXTERNAL] Public Comment Port Meeting 10/26/21
Date:	Monday, October 25, 2021 9:11:03 PM

Dear Port of Seattle Commissioners,

I want to commend your acknowledgement of aviation's impact on climate change through the strengthening of the Port's emissions targets. Though the reduction of Scope 3 emissions is undoubtedly the biggest challenge, the Port's ambitious plans to reduce Scope 1 and 2 emissions are an important step in the right direction.

Unfortunately your goal of Scope 3 carbon neutrality does nothing to require any emissions reductions and as such is inadequate. Carbon offset programs haven't proven to result in significant emissions reductions and are mostly located in the developing world which often leads to land grabbing and local conflict (not to mention lack of oversight and corruption, making a true accounting difficult). Using carbon neutrality as a goal only serves to allow the wealthy of the world to avoid personally reckoning with the environmental damage they cause while they greenwash away their guilt.

Additionally, Sustainable Aviation Fuels (SAFs) are the not panacea that they are purported to be as they barely reduce CO2 per mile flown and (as you recognize) there is limited capacity for biofuel production. SAF production does not, at this time nor predicted in the near future, have the capacity to fulfill the rapidly growing thirst for aviation in any meaningful way.

Rather than claiming that Scope 3 emissions are outside of your immediate control and waiting for technological advances in airplanes to materialize, the Port could instead take decisive action and lead our state and nation in the right direction in the fight to mitigate climate change. The Port needs to acknowledge that flight reduction (the opposite of the anticipated doubling of flight demand within mere years) is what is required and the SAMP must be altered to reflect our current climate reality. I fear for our future if our liberal, environmentally-conscious city's leaders aren't able to take the necessary steps to stave off the ever-worsening consequences of climate collapse in a timely manner.

Thank you for your time,

Sharla Dodd, Seattle resident

From:	Alexa Fay
To:	Commission-Public-Records
Subject:	[EXTERNAL] Citations on Health Impacts of SAFs
Date:	Tuesday, October 26, 2021 6:04:25 PM
Attachments:	laiti aircraft soot conventional and biofuels 2019.pdf

Greetings,

I wanted to follow up with Commissioner Felleman's request for citations on the health impacts of Sustainable Aviation Fuels (SAF). This article discusses health impacts of different fuels including kerosene and biofuels and can be found here.
I'm highlighting the area on biofuels below:
"Evidence of increased cell membrane damage and oxidative stress in the cell cultures was identified. Oxidative stress accelerates ageing of cells and can be a trigger for cancer or immune system diseases. The particles turned out to cause different degrees of damage depending on the turbine thrust level and type of fuel: the highest values were recorded for conventional fuel at ground idling, and for biofuel in climb mode. These results were surprising. The cell reactions in the tests with conventional kerosene fuel at full engine thrust -- comparable with takeoff and climb- in particular, were weaker than expected. "These results can be partly explained by the very small dimensions and the structure of these particles," says Anthi Liati, specialized in the nanostructure of combustion aerosols at Empa. Moreover, the cells responded to biofuel exposure by increasing the secretion of inflammatory cytokines, which play a central role in our immune system. "This reaction reduces the ability of airway epithelial cells to react appropriately to any subsequent viral or bacterial infections," explains Marianne Geiser."

Another article which I have attached to the email discusses soot reactivity from traditional and biofuels from aircraft use.
I've highlighted a key point from the paper's conclusion below:
"At climb-out conditions the HEFA blend soot shows higher reactivity thus potentially bearing higher health risk compared to Jet A-1 produced soot at this thrust level. However, HEFA blending produces lower soot amounts than Jet A-1 and this needs to be taken into account besides soot reactivity, in order to obtain the net effect"

I'd be happy to share more on the health impacts of aviation and maritime emissions, as well as the economic benefits that would come from reducing emissions-related health disparities and issues.

Thank you,
Alexa Fay

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Aircraft soot from conventional fuels and biofuels during ground idle and climb-out conditions: Electron microscopy and X-ray micro-spectroscopy☆

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ABSTRACT

Aircraft soot has a significant impact on global and local air pollution and is of particular concern for the population working at airports and living nearby. The morphology and chemistry of soot are related to its reactivity and depend mainly on engine operating conditions and fuel-type. We investigated the morphology (by transmission electron microscopy) and chemistry (by X-ray micro-spectroscopy) of soot from the exhaust of a CFM 56-7B26 turbofan engine, currently the most common engine in aviation fleet, operated in the test cell of SR Technics, Zurich airport. Standard kerosene (Jet A-1) and a biofuel blend (Jet A-1 with 32% HEFA) were used at ground idle and climb-out engine thrust, as these conditions highly influence air quality at airport areas. The results indicate that soot reactivity decreases from ground idle to climb-out conditions for both fuel types. Nearly one third of the primary soot particles generated by the blended fuel at climb-out engine thrust bear an outer amorphous shell implying higher reactivity. This characteristic referring to soot reactivity needs to be taken into account when evaluating the advantage of HEFA blending at high engine thrust. The soot type that is most prone to react with its surrounding is generated by Jet A-1 fuel at ground idle. Biofuel blending slightly lowers soot reactivity at ground idle but does the opposite at climb-out conditions. As far as soot reactivity is concerned, biofuels can prove beneficial for airports where ground idle is a common situation; the benefit of biofuels for climb-out conditions is uncertain.

1. Introduction

Aviation affects global and local air quality, and influences climate, the environment and human health. Air traffic has a global annual growth of ~5% (Leahy, 2017) and is expected to rise in the future thus increasing the environmental and human health concerns and posing new challenges for further research on aircraft emissions. Aircraft emissions include gaseous components such as CO_2, NOx, CO and SOx, volatile organic compounds, as well as solid particulate matter (PM). Solid PM comprises mainly soot and to a small extent ash (metal particles). Soot generated by road transport is known to have adverse effects on human health while studies concerning the health impacts of jet exhaust soot are limited (Touri et al., 2013).

Introduction of biofuels in road transport has proven successful for soot reduction (e.g. (Boot et al., 2009; Klein-DouwelDonkerbroek et al., 2009; Westbrook et al., 2006),). Biofuels have been tested recently also in aviation in form of blends with standard aviation fuel. Note that aviation fuels contain only trace levels of oxygen (ASTM D7566-18, 2018) but the use of oxygenated biofuels in aviation is a topic of scientific discussion (Llamas et al., 2013). Common biofuels with beneficial

☆ This paper has been recommended for acceptance by Bernd Nowack.
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environmental potential are hydro-processed esters and fatty acids (HEFA), as well as those produced by a Fischer-Tropsch synthesis (FT) (Rojo et al., 2015). The few studies dealing with aircraft engine exhaust characterization with biofuel blends (Rojo et al., 2015; Beyersdorf et al., 2014; Timko et al., 2010) conclude that biofuel blending reduces soot emissions.

A key issue that can elucidate the impact of soot on health and the environment is the knowledge of physical and chemical properties in the micro- and nano-scale. Physical properties refer to the morphology of soot particles (size and internal nano-structure, i.e. degree of atomic order). These properties vary depending on type of the fuel used and the engine operating conditions, i.e. the fuel/air ratio during combustion, as well as flame temperature and residence time of the particles in the flame (Timko et al., 2010; Braun, 2005; Kinsey et al., 2011; Lobo et al., 2012; Petzold et al., 1999; Vander Wal et al., 2014). Soot morphology and chemistry reflect its reactivity, important for determining the oxidation capacity of soot and/or its capacity to react with the surrounding, in general. The formation of ice clouds from soot has also been related to soot morphology and chemical composition (KulkarniChina et al., 2016; Knopf et al., 2018). Moreover, the hydrophilic character of soot, in combination with the active particle number (particles serving as condensation nuclei versus total particles) are properties used in recent models on contrail and cirrus formation (Hendricks et al., 2011).

A series of studies have been devoted to the oxidation reactivity of soot in road transport and showed that soot with small particle size (large surface to volume ratio) and amorphous internal nano-structure (low thermodynamic stability) favor oxidation reactivity, in contrast to large particle sizes and well-ordered nano-structures (e.g. (Pahalagedara et al., 2012; Yehliu et al., 2012)). Whether the size weighs more than the internal nano-structure in determining the degree of soot reactivity is unclear but there are indications that the size is rather the more important parameter (Lapuerta et al., 2012). Regarding the chemical composition of soot versus oxidation reactivity, different studies (Lamharess et al., 2011; Song et al., 2006; Yehliu et al., 2011) arrive at different conclusions but show a trend for high reactivity when soot has high oxygen content. Although not adequately researched and established, soot reactivity can be considered, in a more general sense, as referring to the availability of atoms on the particle surface and bulk for reaction, not strictly with oxygen only.

Soot particles resulting from different fuel types, engine operating conditions and/or ambient temperatures have comparable but not identical morphologies. The primary particle constituents of the agglomerates all share a nearly spherical shape and consist of generally concentric, carbon-dominated layers (approaching the graphene structure) of variable length, separation distances and periodicity. The nano-structure of soot is well demonstrated on high resolution transmission electron microscopy (HRTEM) images. With increasing degree of structural order, carbon lamellae length increases (less edge atoms are exposed), separation distances between carbon lamellae decreases and reactivity is reduced. In addition to the primary particle morphology, the morphological characteristics of soot agglomerates may also influence reactivity.

While numerous studies use TEM to determine morphological characteristics of soot generated in road-traffic, only few publications are available on aircraft soot morphology. Popovicheva et al. (Popovitcheva et al., 2000) studied nano-structural parameters of soot and report significant water adsorption on soot generated by a typical aircraft engine compared to non-polar gases. Detailed TEM characterization of aircraft soot was presented by (Vander Wal et al., 2014) and (Parent et al., 2016) reporting a clear variation in the degree of soot crystallinity with engine thrust level, the lower thrust soot exhibiting a lower structural order than at high thrust. The same conclusion was reached in a more general study on aircraft PM emissions including TEM characterization (LiatiBrem et al., 2014). In addition, Vander Wal et al. (Vander Wal et al., 2014) reported significant oxygen content on soot surfaces which may influence the hydrophilic properties of soot.

Regarding biofuel use in road transport, soot morphology shows a lower degree of structural order, and thus higher reactivity, than diesel soot (Lapuerta et al., 2012; Song et al., 2006; Yehliu et al., 2011; Liati et al., 2012; Vander Wal and Tomasek, 2003). To our knowledge, TEM studies on soot from alternative fuels in aviation are lacking.

The chemical composition of soot can also provide important information on the degree of reactivity. Carbonyl or carboxyl groups, for instance, can increase soot reactivity with respect to pure carbon since the energy needed to remove oxygen is lower than the one needed to remove elemental carbon. A previous study reported that surface bound carboxyl functional groups tend to decarboxylate in the presence of ozone, sunlight and adsorbed water (Smith and Chughtai, 1995). Soot in the ambient atmosphere has been extensively characterized using scanning transmission X-ray microscopy coupled to near edge X-Ray absorption fine structure (STXM/NEXAFS) spectroscopy (Liati et al., 2013; Moffet et al., 2016; TakahamaGilardoni et al., 2007). STXM/NEXAFS yields X-ray absorption peaks at particular X-ray energies quantifying the molecular bonding environment of carbon atoms. Ground based particle sampling shows that soot is typically found at the center of particles mixed with organic and inorganic matter as its atmospheric residence time increases (Moffet et al., 2016; TakahamaGilardoni et al., 2007). To date, only a single study using NEXAFS (in electron yield mode, as opposed to transmission mode in STXM) spectroscopy on soot from an aircraft engine using conventional fuel is available and revealed that soot surfaces can be more oxidized than the soot core, on average (Parent et al., 2016).

Within the framework of the present paper, the morphology (by TEM) and chemistry (by NEXAFS spectroscopy) of soot generated by a CFM 56-7B26 turbofan engine, currently the most common engine in aviation fleet, operated with standard aviation conventional kerosene (Jet A-1) and an alternative fuel (HEFA) blend at ground idle and climb-out conditions were investigated. These engine thrust conditions were chosen as they are crucial for the population working at airports and leaving in the surrounding. The turbofan engine was operated in the test cell of SR Technics, Zurich airport. The aim of the paper was to investigate and inter-compare the morphological and chemical characteristics of soot generated by the different fuel types and thrust levels, evaluate soot reactivity for each condition and examine the environmental benefits from the use of alternative fuels from the soot reactivity point of view.

2. Experimental

2.1. Sampling setup and procedures

The experiments were carried out in the engine test cell of SR Technics at Zurich airport, within the framework of the project EMPAIREX. An in-service CFM 56-7B26 hi-bypass turbofan engine was used, popular in the current aircraft fleet and used on the Boeing 737 short-to medium-range twinjet narrow-body airliner. This particular engine had 15'200 flight cycles (32'000 h wing time) and a stable performance during the entire campaign. The engine thrust levels were controlled according to the engine combustor inlet temperature (T3, proprietary value) for which the corresponding thrust levels are known for standard atmospheric conditions (15 °C, 1013.25 hPa). Idling thrust is affected by ambient conditions. In this work it corresponded to 3–4% of the maximum sea level thrust output. During the experiments two different fuel types were used: i) Jet A-1 and ii) a blend consisting of Jet A-1 with 32% HEFA (Supplementary Table S2). HEFA fuel has many of the properties of petroleum derived jet fuels the main difference from Jet A-1 being the lower total aromatics and the sulfur contents (18.1% v/v and 490 ppm for Jet A-1, respectively and 11.3% v/v and 350 ppm for the HEFA- Jet A-1 blend, respectively).

PM was collected during climb-out (~85% engine thrust; P85) and ground idle conditions, directly on TEM grids (for soot morphology) and on silicon nitride (Si_3N_4) membranes (for NEXAFS analyses). For each engine thrust condition, both Jet A-1 and HEFA blend were used. An additional experiment applying Jet-A1 fuel doped with 4% HEFA at nearly 100% thrust conditions ('Maximum Continuous') was conducted and used in STXM/NEXAFS analysis. Supplementary Table S1 summarizes the conditions during sampling, including online measurements. Details on the sampling setup and procedure and a schematic of the sampling equipment are given in the supplementary information (section S1).

2.2. Transmission electron microscopy – image processing

TEM studies were performed with a JEOL 2200FS TEM/STEM microscope equipped with an Omega filter, a Schottky field emission gun at 200 kV, and a point to point resolution of 0.23 nm (Electron Microscopy Center of Empa). The TEM instrument is equipped with an EDX detector (JEOL EDX detector: EX-24065JGT) for elemental analysis. Images were taken in bright field (BF) and dark field (DF) STEM mode, as well as in TEM and HRTEM mode. For optimum contrast and distinction of nano-structural features, particles located in holes of the carbon film were chosen.

Image processing of five representative soot particles per thrust condition and fuel type was carried out in order to quantify and compare the fringe length. For the quantification of the fringe length we used MATLAB following a procedure suggested in different recent papers (e.g. (Song et al., 2006; La Rocca et al., 2015)) including the following steps: image cropping, negative transformation, image histogram equalization, Gaussian low-pass filter; top hat transformation, binarization and skeletonization. Removal of artifacts (branch points removal) was most efficient by marking the fringes by hand onto the HRTEM image of the soot particles. The binary image was processed using MATLAB by applying the built-in skeletonization function. The analysis was then automated and standardized.

2.3. X-ray micro-spectroscopy (NEXAFS)

Carbon functionalities in single particles were investigated with STXM/NEXAFS. A detailed overview of this technique can be found in (RaabeTzvetkov et al., 2008). Focused single energy X-rays irradiated particles deposited either on silicon nitride, Si_3N_4, membranes or TEM grids as sample substrates. Substrates were transported under a N_2 atmosphere to the PolLux beamline (X07DA) of the Swiss Light Source at the Paul Scherrer Institute. STXM/NEXAFS analysis was conducted on a total of 44 particles and classified as either soot (10 particles), mixtures of organic and soot (13 particles) or organic only (21 particles). Scanning X-ray energies were 278–320 eV; absorption was measured with a high spatial resolution of 35×35 nm to observe carbon bonding. This energy range covers electron binding energies for ground state electron orbitals of the carbon atom (carbon K-edge). Absorption spectra were converted to optical density (OD) over the 2-D projected particle area as a function of X-ray energy where $OD = -\ln(I/I_0)$, and I and I_0 are the transmitted and initial X-ray light intensities, respectively. Energy calibration was performed by comparing the measured lowest energy peak of polystyrene with its literature value (Dhez et al., 2003). Series of particle OD images at closely spaced energy steps were taken and processed with publically available software for automated X-ray image analysis (Moffet et al., 2010). Spectra reported here were background subtracted by the OD at the carbon pre-edge (278–280 eV) and normalized to the spectral area at the carbon post-edge (305–320 eV) (Takahama et al., 2010).

3. TEM results

3.1. Size of agglomerates and primary particles

The size of soot agglomerates and their primary particle constituents was determined from TEM images using the measuring tool of the software 'Digital Micrograph'. The size of the agglomerates is taken here as their maximum length, that of the nearly spherical primary particles by the diameter of their circular projection. For the measurements we took into consideration isolated, freestanding agglomerates. Thus the agglomerate size expressed as maximum length would be a representative and consistent figure allowing comparison between different thrust conditions. We have no indication for agglomeration on the TEM grid during sampling. The geometric mean diameters of the agglomerates, as obtained by simultaneous online measurements are also listed in Supplementary Table S1.

Based on 300–400 measurements, ground idle conditions result in significantly smaller agglomerates than climb-out. We determined a modal size range of soot agglomerates and primary particles. For both Jet A-1 and HEFA blend fuel types, ~80% of soot agglomerates generated at ground idle conditions fall within the size mode <40 nm (Fig. 1a). At 85% engine load, a modal size of 40–80 nm was observed accounting for ~35% of the particles, while another ~20% were between 80 and 120 nm. Inside the smallest size range (<40 nm), idle Jet A-1 agglomerates are considerably smaller than idle HEFA blend ones (Fig. 1b; Jet A1: ~45% are <20 nm versus HEFA blend: only ~15% are <20 nm). The increasing trend from low to high thrust level identified for agglomerates is also observed for the primary soot particles (Fig. 1c): the big majority (~75–85%) at ground idle conditions for both fuel types was between 5 and 10 nm; at P85 the maximum (~30%) lies between 15 and 20 nm; ~60% of them are 10–25 nm in diameter (Fig. 1c). HEFA blend at idle conditions produces the highest percentage of the smallest primary particles (~20% are 3–5 nm large in contrast to 2% of the Jet A-1 ones).

The TEM images of Fig. 2 depict a representative view of the size and relative amount of soot agglomerates under P85 and ground idle conditions. The described differences between low and high thrust conditions were also found in a previous TEM study of aircraft soot emissions (LiatiBrem et al., 2014), where ~60% of the primary particle sizes during taxiing (~7% thrust) were 10–15 nm (mode 13 nm) and ~60% of primary particles under full thrust (~100% thrust) were 10–25 nm (mode 24 nm). Moreover, the results of simultaneous online measurements of the size of soot agglomerates show the same trend as the TEM results (Supplementary Table S1). Taking into account only the size of soot agglomerates and primary particles, i.e. not considering internal nanostructures and internal arrangement of primary particles within the agglomerate, our results indicate higher reactivity for ground idle particles of both fuel types compared to P85 particles. It is reminded that small primary soot particles and small agglomerates tend to be more reactive than large ones (see earlier, Introduction).

3.2. Internal nano-structure of primary soot particles

Primary soot particles from both investigated fuel types and engine thrust conditions consist of discontinuous carbon lamellae (fringes) (Fig. 3). Discontinuities in carbon lamellae are marked by grey areas on the images where no fringes can be distinguished and correspond to regions of highly disordered arrangements, likely due to irregular and episodic incorporation of organic compounds during particle growth.

Representative HRTEM images are given in Fig. 3. Amorphous cores usually constitute a very small part of the particle volume; particles with strongly bent carbon lamellae are observed almost to the particle's center. Abundance of curved lamellae at particle interiors indicates a relatively high functionality and therefore high reactivity of soot at this stage of particle development. More or less planar, slightly deformed lamellae of various length form packages of different thickness and orientation overlying the particle interior and resulting in an approximately concentric arrangement.

A peculiarity in soot nanostructure is identified for the P85 soot of the HEFA blend: a considerable part of the examined particles show a highly disordered, nearly amorphous outer shell 2–8 nm thick (Fig. 3C). We estimate the percentage of the particles bearing this type of amorphous shell to about 30–40% of the totally observed particles. Note that this observation requires high resolution imaging which cannot go along with solid statistics. Thus the 30–40% estimation is only a rough approximation. Note also that no expansion and, in general, no deformation of this amorphous shell was observed under the electron beam. The outer shell described above has been identified also in P85 soot generated with HEFA-doped fuel (4% HEFA), but was not observed in soot produced with Jet A-1. An amorphous outer shell has been reported by La Roca et al. (La Rocca et al., 2015) for primary particles of soot from engine oil of a modern direct injection gasoline engine. In our case, an origin of this soot type from engine oil cannot be completely excluded but the fact that it has been found only when using HEFA fuel and only at high thrust conditions favors its formation in connection with the use of HEFA fuel type. Finally, in a few P85 soot particles produced by both Jet A-1 fuel and HEFA blend ash particles are observed either inside the particle or attached on it. It is recalled that ash (or metal PM), represents the non-carbonaceous inorganic fraction of solid PM at the aircraft exhaust originating mainly from lubricating oil and to a small degree from fuel additives. Depending on the saturation level, ash may occur as separate particles attached onto soot or inside soot particles. Ash may also include fragments detached from various engine components (engine wear).

3.2.1. Carbon lamellae (fringe) length - image processing

HRTEM images of primary soot particles qualitatively reveal that ground idle particles (Fig. 3A) have a lower degree of order with respect to carbon lamella length and arrangement than the P85 particles (Fig. 3B). Carbon lamella length is the continuous linear distance of an atomic carbon layer plane uninterrupted by any amorphous interference.

Fig. 4 shows histograms of fringe length frequency. It is noteworthy that each individual soot particle used for the quantification of the fringe length gave consistent results for each thrust condition and fuel type examined. Data is presented for the same engine thrust with different fuel types (Fig. 4a and b), and again for the same fuel type and different engine thrust (Fig. 4c and d). It is noted that Fig. 4e comparing P85 soot particles with and without the outer amorphous shell was determined by excluding the amorphous shell. The results indicate that soot particles with the shortest graphene lamellae, which are the most reactive, are produced by Jet A-1 fuel at ground idle conditions (Fig. 4a). The second most reactive particle type in terms of graphene length is idle soot generated by HEFA blend. The least reactive soot, i.e. the one with the highest amount of long graphene lamellae is the one produced by HEFA blend at P85 conditions. However, taking into account that around 30–40% of P85 HEFA blend soot particles are enveloped by a ~2–8 nm thick amorphous (highly reactive) shell (Fig. 3C), it is quite likely that P85 HEFA blend soot is overall more reactive than P85 Jet A-1- soot. Moreover, the P85 HEFA blend particles with an

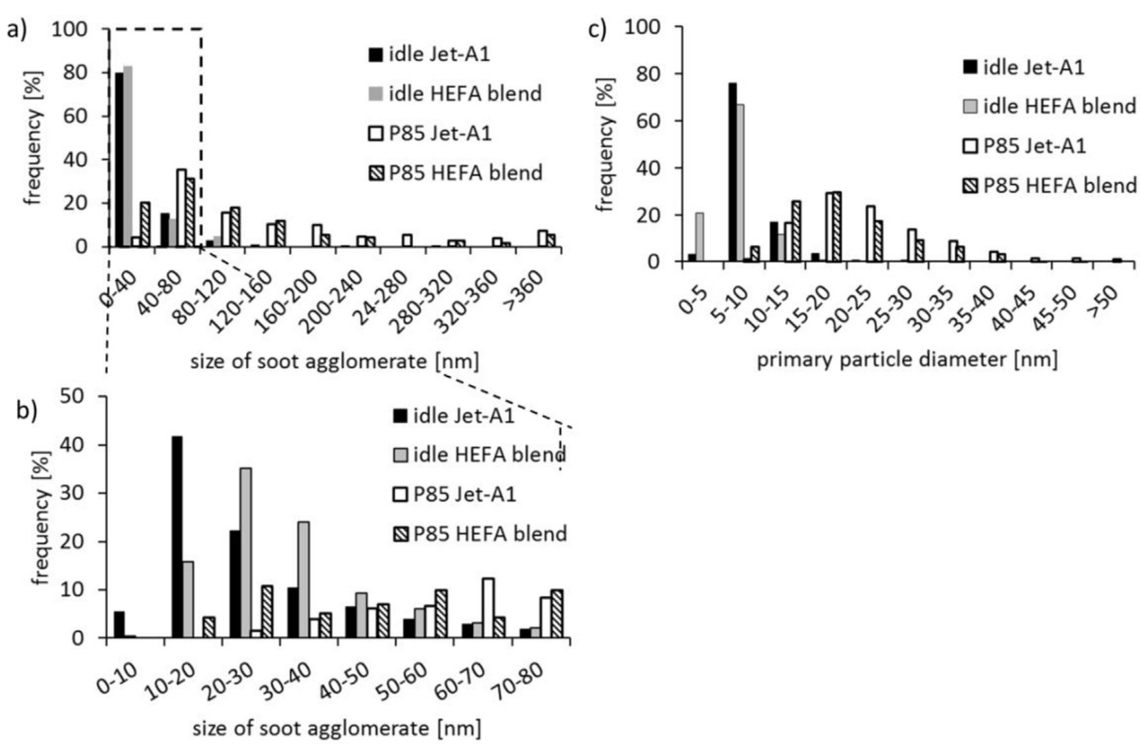

Fig. 1. Size distribution of soot agglomerates (a, b) and primary particles (c) for ground idle and P85 thrust conditions with Jet A-1 and HEFA blend showing significantly lower sizes for idle conditions.

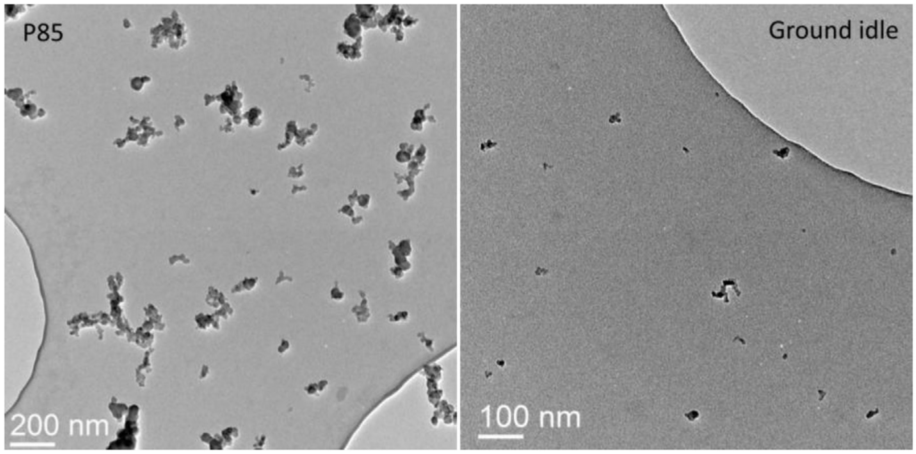

Fig. 2. TEM images demonstrating the higher abundance and larger agglomerate sizes of P85 (left panel) versus ground idle conditions (right panel). The P85 image was taken with a 10′000 magnification, the ground idle one with 20′000x to make particles distinguishable. The images are representative for both fuel types.

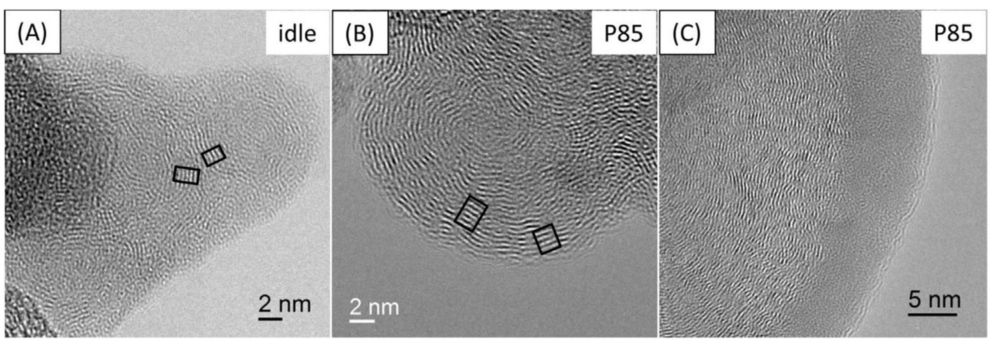

Fig. 3. HRTEM images of soot particles depicting their internal nanostructure. (A) ground idle conditions; (B): P85 thrust; (C) P85 thrust with HEFA blend showing an amorphous external shell (greyish) around the carbon lamellae-bearing part. Black squares in (A) and (B) mark examples of crystallites: Images (A and B) are representative for both fuel types.

outer amorphous shell have more abundant short fringes in the inner (non-amorphous) part than the particles without this shell. Finally, differences in fringe length distribution between the two fuel types are less pronounced for ground idle particles.

3.2.2. Separation distances (d_{002}) and periodicity of carbon lamellae

The separation distance between adjacent carbon lamellae, d_{002} is equivalent to the distance between individual graphene planes in the crystal lattice of graphite. As a result of randomly folded carbon lamellae slipped out of alignment, known as turbostratic stacking, irregular separation distances are common in soot particles, also in the examined ones. The carbon lamellae pattern of soot particles imaged on the HRTEM images is an interference pattern between non-diffracted and diffracted electrons in the beam and is depicted in form of different degrees of brightness. For a quantification of the separation distances between carbon lamellae, the profile line plot of Digital Micrograph was applied. This tool can depict variations of the brightness across successive carbon lamellae and can be transformed to numerical data thus providing the spacing between dark and bright fringes, as well as the periodicity. Various fields of view were selected on HRTEM images where adjacent carbon lamellae were nearly straight and formed crystallites (see earlier, section 3.2). d_{002} was measured from totally 155 to 180 carbon lamellae per particle type.

Fig. 5 presents histograms of d_{002} comparing the different fuel types (Fig. 5a and b) and engine thrust levels (Fig. 5c and d). Panel e) shows d_{002} for HEFA blend soot with and without the amorphous shell (section 3.2; Fig. 3C). The particles with the highest d_{002} percentage deviating most from that of graphite (0.335 nm), i.e. the most reactive ones, are those generated at ground idle conditions using Jet A-1 fuel. At P85 (Fig. 5b), the HEFA blend soot produced particles with d_{002} closer to that of graphite compared to Jet A-1 fuel. In general, both fuel types at P85 thrust produce soot with d_{002} closer to graphite than at ground idle. This difference is more pronounced for the HEFA blend (compare Fig. 5c and d). The HEFA blend P85 soot particles show comparable d_{002} distribution patterns irrespective of the presence of an outermost amorphous shell (Fig. 5e). In Fig. 5f, the mean d_{002} values (with the standard deviation), as well as the median values have been plotted, indicating a tendency of increasing crystallinity (decreasing d_{002}) from ground idle to P85 conditions for both fuel-types, as well as from Jet A-1 soot to HEFA blend soot. As for the periodicity, maximum values of 4 and 5 were measured for idle and P85 soot, respectively, for both fuel types. The width and amount of the crystallites is higher for P85 soot than for idle one, for both fuels.

Conclusively, d_{002} values and periodicity indicate a trend of increasing crystallinity from ground idle to 85% engine thrust and from Jet A-1 fuel to HEFA blend. The presence of an amorphous rim in HEFA blend P85 particles may, however, inverse this trend for the P85 conditions, possibly rendering the HEFA blend P85 soot overall more reactive than the Jet A-1 P85 one. Table 1 summarizes the morphological features of soot for the different engine thrust levels and fuel types.

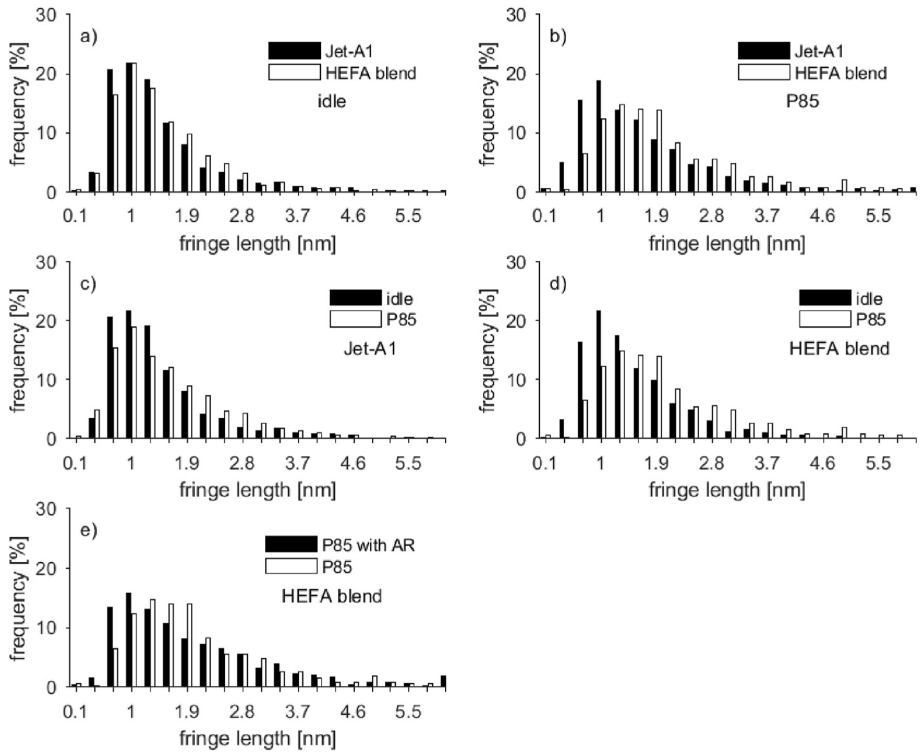

Fig. 4. Distribution of graphene sheet length of primary soot particles generated under idle and P85 engine thrust with Jet A-1 and HEFA blend fuel types. Bin size is 0.3 nm. AR: amorphous rim.

3.3. X-ray micro-spectroscopy (NEXAFS)

NEXAFS spectroscopy was applied on a series of samples collected under the following engine thrust and fuel types: (i) ground idle with Jet A-1, (ii) 85% with Jet A-1, (iii) 85% with Jet A-1/32% HEFA blend and (iv) ~100% engine thrust with 4% HEFA doped Jet A-1 fuel.

Fig. 6 shows average NEXAFS spectra of analyzed material. Those which are ascribed exclusively to soot are shown in Fig. 6a and have a characteristic X-ray absorption peak at about 285.4 eV corresponding to carbon-carbon double bonding with a similar OD compared with the carbon post-edge between 305 and 320 eV (MoffetTivanski and Gilles, 2011). These spectra were additionally identified as soot, based on the observed OD at 288.6 eV being less than or equal to the peak at 285.4 eV. The peak position and height found in the analyzed spectra are qualitatively in agreement with previous literature (Braun, 2005; Parent et al., 2016; Moffet et al., 2010). Parent et al. (2016) investigated soot generated from an aircraft engine operating with common kerosene fuel at 85% load using electron yield NEXAFS spectroscopy (black dashed line in Fig. 6a). The spectrum from bulk primary soot particles is similar to the ones obtained here for HEFA blend soot and for soot doped with 4% HEFA at high thrust and shown as the red and green lines, respectively. Similar spectra of soot in atmospheric samples depicting carbon-carbon double bonding peak position (285.4 eV) are reported by (Moffet et al., 2010).

In addition to soot, organic matter was also found on some of the analyzed particles from all run conditions and fuel-types indicated by a peak at 288.6 eV corresponding to the carboxyl functionality (Fig. 6b (Moffet et al., 2010). We suggest that this organic matter is mixed with soot, as both 285.4 (carbon-carbon double bonding) and 288.6 eV peaks are always observed together. Most peak positions for organic matter are found at 288.6 eV with one exception at 286.0 eV seen for ~100% engine load with 4% HEFA-doped fuel, indicating phenolic (C-OH) bonding (MoffetTivanski and Gilles, 2011). We do not report on precise proportions of particles that are either soot or organic-type using NEXAFS, as this would require investigation of a very large amount of particles and is beyond the scope of our work. The exact organic-type could not be clearly identified using STXM/NEXAFS. Some theoretical possibilities include deposited particles of engine lubrication oil or particles nucleated from semi-volatile organics in the exhaust as it cools after leaving the engine or condensation of organic vapor to buildup organic matter on the substrate during impaction. However, we do not consider these possibilities as likely because we never observed spherical shaped particles (droplets) indicative of condensation on a substrate. Furthermore, the sampling strategy (heating and prompt dilution) minimizes the potential for homogenous nucleation. It is also unlikely, that the signal is from uniform condensation of organic matter because NEXAFS spectra are normalized to the substrate signal exactly adjacent to particles. Organic matter with a characteristic peak at 288.6 eV has been observed to be always associated with ambient soot (Moffet et al., 2016; Moffet et al., 2010; MoffetTivanski and Gilles, 2011; Takahama and Russell, 2010; Moffet et al., 2013; Takahama et al., 2007). Diesel soot (Braun, 2005) also has both carbon-carbon double bonding and organic matter, however, peak positions differ slightly from ours and other previous literature.

Braun et al. (2006) investigated how X-ray exposure can chemically transform or damage organic matter associated with diesel soot and observed that increasing X-ray exposure would decrease absorption at 288.6 eV while increasing absorption at 290.2 eV attributable to CO_3 production. We did investigate damage due to X-ray exposure of the samples collected at 85% load with a 32% HEFA blend and found that even doubling the X-ray dose does not alter X-ray absorption spectra (Supplementary Fig. S3).

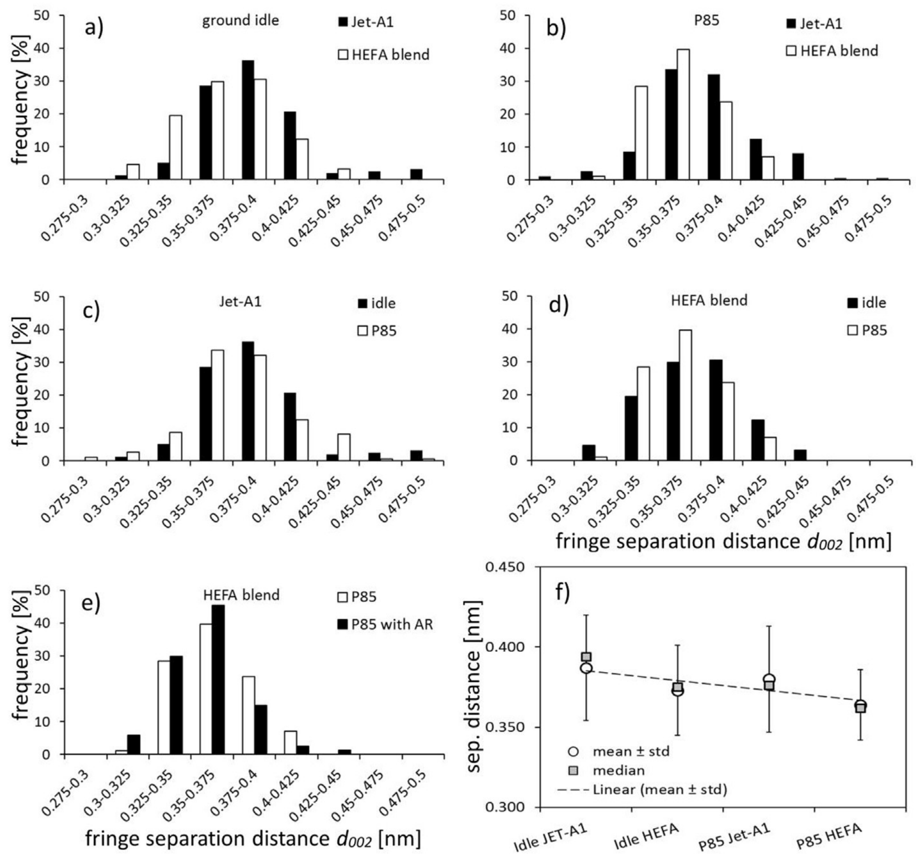

Fig. 5. (a–e): distribution of separation distances d_{002} between carbon lamellae measured from crystallites of primary soot particles generated at ground idle and P85 engine thrust with Jet A-1 and HEFA blend fuel types. Bin size is 0.025 nm; (f) mean/median d_{002} values vs. thrust level/fuel type exhibiting decrease of crystallinity from ground idle to P85 and from Jet-A1 to HEFA blend. AR: amorphous rim.

Table 1
Summary of morphological characteristics of soot.

	Ground idle		P85		P100
	Jet A-1	*HEFA blend*	*Jet A-1*	*HEFA blend*	*4% HEFA doping*
Agglomerate size (nm)	9-40 (80%)	10-40 (80%)	40-80 (35%) 80-120 (20%)	40-80 (35%) 80-120 (20%)	–
Primary particle size (nm)	5-10 (75–85%)	5-10 (75–85%)	10-25 (60%)	10-25 (60%)	–
Fringe length (nm)	0.7–1 (~45%)	0.7–1 (~40%)	0.7–1 (~35%)	0.7–1 (~20%)	–
Inter-fringe distance d_{002} mean ± std dev./median	0.387 ± 0.033/0.394	0.373 ± 0.028/0.375	0.380 ± 0.033/0.376	0.364 ± 0.022/0.362	–
Periodicity (max)	4	4	5	5	–
Degree of graphitization (based on NEXAFS)	0.62	–	–	0.76	0.71

Furthermore, all spectra did not have clearly discernable peaks at 290.2 eV with the exception of a single particle from samples collected at ~100% engine load doped with 4% HEFA fuel (Supplementary Fig. S2). Therefore, we claim the vast majority of particles may not have been susceptible to the beam damage as observed by Braun et al. implying a different organic composition despite a qualitatively similar spectral appearance. Finally, we investigated oxygen NEXAFS spectroscopy on organic matter from the same sample and found similar spectra compared to organic matter associated with soot from Moffet et al. (MoffetTivanski and Gilles, 2011) (Supplementary Fig. S2). We note that quantification of soot in atmospheric aerosol particles and how they are mixed with organic and inorganic material has proved highly useful, especially for predictions of direct radiative effects (Moffet et al., 2016; Fierce et al., 2016). We conclude that those particles emitted from aircraft engine run on both conventional and alternative fuels can be identified using existing methods.

The degree of graphitization in soot particles is an indicator of soot reactivity, i.e. the more graphite-like particles tend to have less reactivity (e.g. (Pahalagedara et al., 2012; Yehliu et al., 2012)). In terms of NEXAFS related observables, the degree of graphitization in carbonaceous material can be defined as the ratio, $r = OD_{C=C}/OD_{Cedge}$, where $OD_{C=C}$ and OD_{Cedge} is the pre-edge subtracted OD at the carbon-carbon double bonding peak (285.3 eV) and the C-edge step at 292 eV (Liati et al., 2013; di Stasio and Braun, 2006; Jäger et al., 1999). Compared to graphite in which r = 1.55 (di Stasio and Braun, 2006), our soot samples (Fig. 6a) have r = 0.76, 0.71 and 0.62 when the engine was operated with 85% load and HEFA blend, ~100% load and 4% HEFA-doped Jet A-1 fuel and ground idle with Jet A-1 fuel, respectively (Table 1). We note that (Parent et al., 2016) using 85% load and conventional fuel had r = 0.74. This implies that the HEFA blend used in our study at climb-out conditions

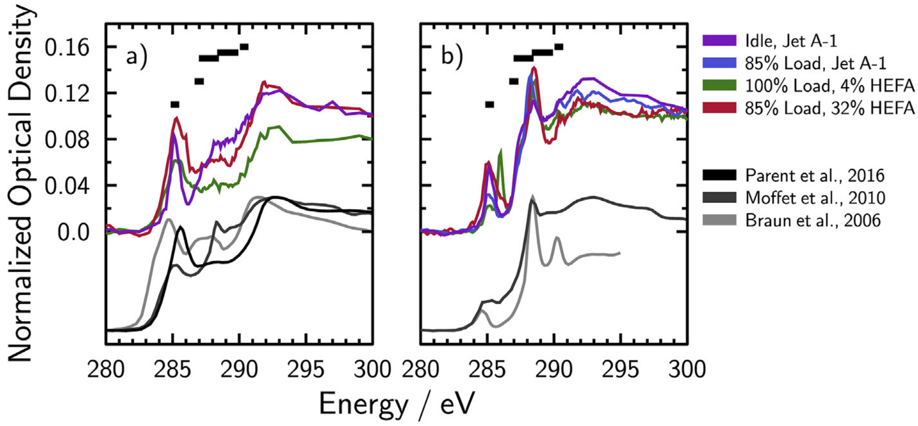

Fig. 6. NEXAFS spectra of soot (a) and soot with organic matter (b) on substrates for particles collected under different engine thrust conditions and fuel combinations. Spectra from previous studies on soot and associated organic matter (if present) are shown vertically shifted downwards for clarity for 85% engine thrust with unblended fuel (black) (Parent et al., 2016), ambient soot particles (dark grey) (Moffet et al., 2010) and diesel exhaust (light grey) (Braun et al., 2006). The black horizontal lines above the spectra mark energy ranges from 284.9 to 285.5eV, 286.7–287.3 eV, 287.0–288.5 eV, 288.3–290.0 eV and 290.0–290.7 eV corresponding to functionalities R(C=C)R, R(C-OH), R(C=O)R, R(C=O)OH and CO_3, respectively.

has almost no impact on the degree of graphitization expressed in the NEXAFS spectra. It is important to note the spatial scale of the STXM/NEXAFS technique is not capable of resolving amorphous carbon layers at soot surfaces with a thickness of a few nanometers, as seen on the HRTEM images (Fig. 3). Thus, we cannot claim this amorphous rim was not an organic carbon coating on the surface of primary soot particles.

4. Discussion

The smaller size of ground idle soot agglomerates and primary particles compared to that of P85 soot, for both fuel types investigated implies that ground idle soot is the more reactive one in this respect. The smaller size of ground idle primary particles can be attributed to soot inception and oxidation mechanisms in the engine combustor, which depend on air to fuel ratio, temperature and residence time. However, the exact formation mechanisms of soot are highly complex and it is hard to distinguish which parameter(s) are responsible for the observed differences. More research is needed to clarify these issues.

The lower degree of crystallinity of ground idle soot compared to P85 soot implies also higher reactivity and indicates that idle particles are richer in organic carbon relative to elemental carbon. This inference is in line with the findings of (Wey et al., 2007) and (Timko et al., 2010), who reported that the elemental carbon to organic carbon ratio increases with engine thrust level. An increase in the degree of crystallinity of soot with engine power is reported also by (Vander Wal et al., 2014), in a TEM study of soot generated by a CFM-56-3 engine aboard a DC-8 aircraft fueled by a kerosene fuel type JP-8. On the other hand, Parent et al. (2016), who studied the nanostructure of soot produced by a different engine (PowerJet, SaM146-1S17) burning Jet A-1 fuel and operated on a test facility (SNECMA, Villaroche, France) found no significant variations in soot nanostructure with engine operating regimes. The above authors comment that different engines and fuels complicate a direct comparison of soot generated under similar engine operating regimes and that the engine technology probably influences the combustion conditions and the soot characteristics.

As already mentioned in the Introduction, one parameter that can influence the degree of crystallinity is temperature. Temperature which favors graphitization (de-hydrogenation) increases with engine thrust level. This would explain our results as to why the P85 soot is more crystalline than the idle one. In this respect, Vander Wal et al. (Vander Wal et al., 2014) suggest that the change in soot nanostructure from idle (more disordered) to P85 (better ordered) is driven by changing species contributing to soot surface growth (PAHs, likely fuel-borne at low temperature and acetylene at higher temperatures).

A trend towards increasing degree of soot crystallinity was observed in the present study for ground idle conditions when Jet A-1 was blended with HEFA fuel. At 85% thrust, the situation becomes more complicated due to the presence of a disordered 2–8 nm broad outermost particle shell in a considerable part of soot particles studied. The fraction of P85 HEFA blend soot without the amorphous outermost shell shows a slightly more graphitized nanostructure than P85 Jet A-1 soot. Moreover, the inner (crystalline) part of the P85 HEFA blend particles with the amorphous shell have shorter fringe length (indicating lower crystallinity) but slightly lower inter-fringe distances (indicating higher crystallinity) than the HEFA blend soot particles without this shell. It cannot be judged which of the above opposing characteristics (fringe length or inter-fringe distance) weighs more for ascribing a net result on the degree of crystallinity.

The experiments of the present study indicate that the addition of HEFA favors the formation of slightly more graphitized soot. In this case, temperature can be considered as an influencing factor promoting graphitization of HEFA blend soot, as there are indications that the addition of purely aliphatic species, such as HEFA fuel, increases slightly the local flame temperature in the rich section of the combustor. The pure HEFA component used in this study had a slightly higher specific energy content of 44.2 MJ/kg versus Jet A-1 used which had 43.3 MJ/kg). However, considering the partial and relatively extended (30–40%) presence of soot with a nearly amorphous shell when using P85 HEFA blended (and 4% HEFA-doped) Jet A-1 fuel, the soot generated with HEFA (blending and doping) at high thrust is overall less crystalline, i.e. more reactive than the Jet A-1 one. Moore et al. (2017) investigated HEFA blended Jet A-1 fuel (50/50) at in-flight cruise conditions and mention that the greatest effect of the HEFA blend on emissions is associated with a reduction in black-carbon-equivalent mass. The finding of these authors is in line with the overall less crystalline P85 HEFA blend soot particles identified in the present study. The crystalline part of the soot particles generated by burning HEFA blend can be ascribed to dehydrogenation (graphitization) and reactions related to fuel pyrolysis (mainly production of C_2H_2 species) of Jet A-1 components of the blend, possibly promoted by HEFA-induced higher temperatures. As a result, C=C chains are formed leading to a graphitized structure of soot particles. The amorphous shell of soot particles could potentially be attributed to an insufficient quenching and oxidation of soot precursors within the combustor which is probably favored for the HEFA blend. Further research is needed to understand the precise mechanism (or mechanisms) involved in the formation of such an amorphous shell at the outermost part of soot particles.

As stated in the Introduction, studies on soot reactivity refer strictly to its oxidation capacity. However, it is plausible to hypothesize that soot reactivity cannot be limited to its capacity for oxidation only, but refers generally to the presence of atoms on the particle surface and bulk available for reaction. Such reactions may occur when soot comes into contact with its surrounding, i.e. atmospheric components or cells. Aircraft soot emissions generated at ground level (ground idle) and close to ground level (climb out) contribute to an increase of local air pollution and bear the risk to cause health damage. On the other hand, soot at altitude has an effect mainly on tropospheric chemistry and global warming. The generation of aircraft soot with high reactivity at and close to ground level can be considered as having both benefits and disadvantages: the beneficial part is related to the stage of soot formation in the engine where it can still react with oxygen and be partly or totally eliminated, i.e. before reaching the exhaust. As soon as it reaches the ambient air and can be inhaled, highly reactive soot can prove more harmful than less reactive one, as it has a higher capacity to react with its surrounding, also with cells. The results of the present study indicate that the soot type with the highest reactivity and thus the most prone to react with oxygen and probably also when it comes into contact with cells is the one generated at ground idle conditions with the Jet-A-1 fuel, due to the small particle size and defected nanostructure. This finding is of high significance for the people working at airports and/or living in the surrounding areas as these conditions at airports are prevalent. The HEFA blend ground idle (small size), as well as the P85 soot (amorphous shell) can be also considered as highly reactive. Whether the particle size or the presence of the amorphous shell is the more decisive parameter for rendering soot more reactive cannot be evaluated at this stage of research. Thus it cannot be predicted, based on soot morphology, which soot type shows higher reactivity. It is also not known how soot chemistry influences cell dysfunction and damage. Despite these shortcomings, ample work has shown that soot can generate reactive oxygen species (ROS) in lung epithelial cells (Garza et al., 2008) which is known to cause adverse health effects in humans (Fuzzi et al., 2015). To our knowledge, any link between an amorphous rim on primary soot particles and generation of ROS species has not been investigated in previous literature. The lack of crystallinity may allow for greater reaction pathways and generation of more ROS exacerbating any health impacts of soot exposure beyond what is already expected. Interestingly, a study on health effects of aircraft exhaust carried out within the framework of the same research project revealed that among ground idle and P85 soot with Jet A-1 and HEFA blend, ground idle soot with Jet A-1 is the one with the highest impact on bronchial cells (Jonsdottir et al. Nature Comm. Biology; in revision). These results are in line with the detailed soot morphology results obtained here, as the idle Jet A-1 soot was shown to possess a combination of morphological characteristics indicating very high reactivity. One should, however, consider that HEFA blend produces lower amounts of soot as compared to conventional, Jet A-1 kerosene (both particle number and mass; Table S1 in Supplementary Information). The net effect among the roles of soot reactivity versus soot amount with respect to potential health risk needs still to be evaluated and should be taken into consideration in order to assess the benefit of biofuels.

From the environmental point of view, the apparent nanostructural defects of the ground idle soot, as well as the ones of the P85 soot from HEFA blend (or HEFA-doped Jet A-1) with the outermost amorphous shell imply the presence of numerous reactive sites at the soot surface, such as unsaturated organics or hydroxyl groups, for instance. Indeed, oxygenated functional groups were always observed on all samples from STXM/NEXAFS analysis. These oxygenated groups have a variety of functional forms due to the various carbon K-edge absorption peaks (Fig. 6b). We also note that identified soot spectra in Fig. 6a further suggest reactive sites due to the observed oxygenated groups. Of course, the common and main feature in soot spectra is the C=C peak which occurs at a consistent X-ray energy (285.3 eV) in agreement with previous studies (Parent et al., 2016; MoffetTivanski and Gilles, 2011). These soot types with numerous defected sites may have a different behavior towards atmospheric components compared to more graphitized soot. The surface of the more defected particles may have, for instance, a higher ability to attract or repulse water favoring or not the formation of contrails but this effect is related to soot present at altitude and is beyond the goal of the present paper.

5. Conclusions

Based on both the physical and chemical characterization of aircraft soot, the following conclusions can be drawn from this study.

1. The soot type that shows the highest reactivity is the one produced with Jet A-1 fuel at ground idle conditions. Assuming that reactivity is related to the presence of atoms on the particle surface and bulk available for reaction, this soot type has the potential to react most with oxygen and be eliminated during and immediately after its generation. It is also the soot type that would be most prone to react with the atmospheric environment and probably also with cells, when inhaled.
2. At ground idle conditions, blending of HEFA with Jet A-1 fuel decreases slightly the reactivity of the generated soot. Thus, as far as health risks are concerned, mixing of Jet A-1 with HEFA could possibly prove beneficial at airport areas where ground idle conditions are prevalent.
3. At climb-out conditions the HEFA blend soot shows higher reactivity thus potentially bearing higher health risk compared to Jet A-1 produced soot at this thrust level. However, HEFA blending produces lower soot amounts than Jet A-1 and this needs to be taken into account besides soot reactivity, in order to obtain the net effect.
4. The reactivity of soot decreases with increasing engine thrust level (from ground idle to climb-out conditions). HEFA blending may result in a more moderate reactivity decrease at climb-out conditions, as inferred from the presence of a reactive outermost shell in nearly one third of the investigated soot particles.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.envpol.2019.01.078.

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From:	Laureen France
To:	Commission-Public-Records
Subject:	[EXTERNAL] Public Comment -- Carbon Emissions and Accelerating Century Agenda Objectives
Date:	Monday, October 25, 2021 10:21:07 AM

Commissioners,

Thank you for recognizing the serious impact of aviation on climate change, and proposing actions to strengthening the Port's emissions targets. I'm relieved and encouraged by your ambitious plans to reduce Scope 1 and 2 emissions, and I agree that reducing Scope 3 emissions is challenging.

The Scope 3 goal for carbon neutrality is an inadequate standard, because it does not require emissions reductions. The problems with offset programs are well-documented, with few projects resulting in actual emissions reduction.

Offsetting projects are largely located in the Global South and often lead to local conflicts or land grabbing. Ultimately, offsetting is a form of carbon colonialism. It enables a small share of the world population, often the wealthiest, to fly while ignoring the costs that are imposed on others. And those who bear the greatest environmental and economic costs are people whose historic contribution to climate change is negligible. For these reasons, I urge you not to use "carbon neutral" as a goal.

Promotion of "Sustainable" Aviation Fuel is not a credible or acceptable policy to address aviation's climate problem; it results in slight CO_2 reductions per mile flown. I am glad you recognize the limited capacity for biofuel production. "Sustainable" Aviation Fuel is simply not capable of reducing CO_2 to 2007 levels by 2050, especially given the anticipated increases in flying.

While you suggest that Scope 3 emissions are "outside the Port's direct control," there is something that the Port can, and should do.

Instead of wishfully thinking that electric or hydrogen-powered aircraft will provide the answer, though neither option is viable for long haul trips, you could change the "Sustainable" Airport Master Plan to reflect the necessity to reduce flying. Planning for a massive increase in flying should not be a fait accompli. If the Port Commissioners believe they have no power to reduce flights into and out of our region, then perhaps they should advocate an update in the law to reflect the current massive climate crisis that may, in time, render all discussions of travel, moot. Just yesterday, the World Meteorological Organization reported that greenhouse gas concentrations hit a new record high last year and increased at a faster rate than the annual average for the last decade despite a temporary reduction during pandemic-related lockdowns. The "business as usual" approach to an unprecedented threat is disturbing.

Thank you for your consideration,

Laureen France

From:	laura gibbons
To:	Commission-Public-Records
Subject:	[EXTERNAL] Written version of the comments I just made
Date:	Tuesday, October 26, 2021 12:50:27 PM

WARNING: External email. Links or attachments may be unsafe.

Commissioners,

I want to thank you for recognizing the seriousness of the impact of aviation on climate change by strengthening the Port's emissions targets. I'm impressed by your ambitious plans to reduce Scope 1 and 2 emissions, and I agree that reducing Scope 3 emissions is challenging.

Promotion of "Sustainable" Aviation Fuel isn't going to get us there. It does not represent a credible policy to address aviation's climate problem, because its use results in only slight CO_2 reductions per mile flown. I am glad you recognize the limited capacity for biofuel production. "Sustainable" Aviation Fuel is just not capable of reducing us to 2007 levels by 2050, especially given anticipated increases in flying.

Also, the Scope 3 goal for carbon neutrality is an inadequate standard, because it doesn't require ANY reductions in aviation emissions. Problems with offset programs are well-documented, and ultimately offsetting is a form of **carbon colonialism**. To enable a small share of the world population to fly with a clear environmental conscience, others bear the costs: people whose historical contribution to climate change is negligible, and who are already experiencing the impacts of the climate crisis. For these reasons, I urge you not to use "carbon neutral" as a goal.

You talk about Scope 3 emissions as "outside the Port's direct control", but actually there ***is*** something you can do. Instead of hoping for electric or hydrogen-powered plans, make the "Sustainable" Airport Master Plan truly sustainably by reflecting the necessary ***reduction*** in flying, rather than a massive increase. If you feel you cannot do that under RCW53, the Port must advocate for updating the law to reflect the current climate crisis.

Sincerely,

Laura Gibbons

Seattle

From:	David Goebel
To:	Commission-Public-Records
Cc:	Felleman, Fred
Subject:	[EXTERNAL] Alaska Airlines reference to "FAA upcoming redesign of the region"s airspace"
Date:	Tuesday, October 26, 2021 3:42:49 PM
Attachments:	SeePage5-AlaskaAirSAMPComment_27Sep2018_ShaneJones.pdf

WARNING: External email. Links or attachments may be unsafe.

As promised today, attached is the Alaska Airlines SAMP comment I found to include in the record. See highlighted text on page 5.

If this is news to you, then Alaska may know something you don't, or perhaps they're just off base. In any case worth checking out it seems to avoid being blind sighted by airspace changes like what happened with the automatic 270 degree turns on Northflow turbo-prop departures, which led to litigation with the City of Burien. Twice. Stan had to tap TRACON spies to get the bottom of that one.

Thanks,

David

From: Commission-Public-Records <commission-public-records@portseattle.org>
Sent: Tuesday, October 26, 2021 8:28 AM
To: david@vifs.org
Subject: RE: [EXTERNAL] I wish to make a public comment at tomorrow's commission meeting.

Thank you David Goebel,

Join us via your mobile or laptop device on through Teams or call into the number provided below at **11:30 a.m. PST** on Tuesday October 26, 2021 in order to be marked present and ready to speak. A member of port staff will join the call to take a roll call of the names we have listed and go over the procedure. Please plan to call from a location with as little background noise as possible.

You should expect to be on the line for between 30-60 minutes as we dispose of preliminary business on the agenda and we hear from other public commenters. While it's not possible for us to predict how many people will comment on October 26, we expect individual comment time to be limited to two minutes and all rules of order and decorum will apply as usual.

If you have any questions please let us know. We appreciate your dedication to public health and your interest in participating in the Port of Seattle Commission meeting.

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Best Regards,

Commission Public Records

From: David Goebel <david@vifs.org>
Sent: Monday, October 25, 2021 11:19 PM
To: Commission-Public-Records <commission-public-records@portseattle.org>
Subject: [EXTERNAL] I wish to make a public comment at tomorrow's commission meeting.

WARNING: External email. Links or attachments may be unsafe.

Hi,

The topics will be the new GAO report on PBN implementation, the SAMP, and more if time allows.

Thanks,

David

Alaska

September 27, 2018

Mr. Steve Rybolt
Port of Seattle
Aviation Environmental and Sustainability
P.O. Box 68727
Seattle, WA 98168

Re: Scope of Seattle-Tacoma Airport Sustainable Airport Master Plan proposed environmental assessment

Alaska Airlines submits these comments in response to the Port of Seattle's ("the Port") request for public comment during the scoping process for the proposed actions contained in the Sustainable Airport Master Plan ("SAMP").

Alaska Airlines appreciates this opportunity to participate in the scoping phase of the Seattle-Tacoma ("Sea-Tac") Airport's proposed implementation of the SAMP. Our comments fall into three categories: *how* the Port should proceed with the environmental analysis of the SAMP; *what* that environmental review should include with respect to alternatives; and, *whether* some of the action items are needed so urgently they should be approved while the environmental review of the SAMP is underway.

Alaska Airlines is headquartered at Sea-Tac, and the airline along with its wholly-owned subsidiary Horizon Airlines has more operations at Sea-Tac than any other carrier. Alaska Airlines is firmly rooted in this community and fully committed to the success of Sea-Tac. We are also committed to staying engaged in this process to its conclusion. As the Puget Sound region continues to expand, and projections for airline traffic continue to grow, a smoothly functioning, properly equipped, operationally efficient and environmentally sustainable Sea-Tac Airport is critical for our community, area residents, and the regional economy.

First, Alaska Airlines asks the Port to reconsider *how* these proposals should be examined in order to ensure compliance with all applicable environmental statutes. We believe the scoping phase of the SAMP is a step in the right direction in preparing Sea-Tac for the implementation of this ambitious program. At the same time, we are concerned that the Port and the Federal Aviation Administration ("FAA") may be jeopardizing the SAMP's implementation by proposing to meet the rigorous requirements of the National Environmental Policy Act ("NEPA") with an environmental assessment ("EA") rather than an environmental impact statement ("EIS"). Alaska Airlines believes this is a mistake and strongly encourages the Port to reconsider. Instead, we believe it is in the best interest of the SAMP, the community, the environment, and all stakeholders concerned about the future of this airport for the Port to meet its legal requirements under NEPA with an EIS, rather than an EA. Anticipating the heightened scrutiny this project will likely face, we believe that the Port should take the time and effort to develop a full EIS. Making this decision now will help ensure the most rigorous standard of environmental review, and be more cost-effective and efficient over the long term.

AA-1

While preparing an EIS may require more upfront time and effort than if the Port were to develop an EA, Alaska Airlines believes this additional time would ultimately be an effort well spent. Preparing an EIS eliminates the need to make a finding of no significant impact (FONSI) which in a project of this magnitude could be more difficult than demonstrating procedural compliance with the EIS process. In addition, preparing an EIS could produce more substantive stakeholder feedback and fully effectuate the stated goals of the SAMP projects. As a result, an EIS may ultimately be more cost-effective than generating an EA, as any major litigation delay will almost certainly drive up the total cost of the project as construction deadlines are impacted.

What is more, if the Port decides to proceed with an EA, there may be a strong likelihood that the Port may only be able to justify a finding of no significant impact if it straps a host of massive mitigation projects to the FONSI. Such mitigation proposals could have the potential to saddle the Port and Sea-Tac operations with numerous, potentially onerous obligations that may never have been contemplated within the SAMP. These obligations may not end with approval of the proposed actions. If project opponents conclude at some point in the future that there has been a failure to continue to honor ongoing mitigation commitments, they could initiate additional litigation risk assailing the effectiveness of mitigation measures adopted in the FONSI. This uncertainty could continue years after project approval, for as long as mitigation measures remain in place. As a result, an EA/FONSI that requires extreme mitigation may well be more difficult to implement than taking the time to prepare an EIS, which would not require such mitigation proposals.

AA-1

Second, Alaska Airlines urges the Port to expand *what* the forthcoming environmental analysis should consider. At present, the range of alternatives slated for detailed consideration is inadequate. In NEPA analysis, if an alternative satisfies the project's Purpose and Need and is feasible, that alternative warrants close scrutiny in the EIS or EA. Here, the Port has stated that the Purpose and Need for the projects identified in the SAMP is to address concerns that are applicable to the entire airport. As a result, the Port's decision to address future airport-wide demands by considering only North Terminal alternatives is both ill-advised and legally inadequate, especially when another feasible alternative is available.

AA-2

Alaska Airlines has demonstrated that an alternative involving extensions and/or modifications to existing concourses in the Main Terminal is a viable, feasible alternative that can satisfy the SAMP's Purpose and Need when paired with certain roadway and other improvements considered in the SAMP – and others in the main terminal and transportation access that would be ancillary to this work. The alternative proposed by Alaska Airlines would address inefficiencies in the existing terminal, inadequacies which would be unaffected by the proposals in the SAMP. Alaska Airlines' alternative merits detailed consideration in the NEPA process.

AA-2

There are at least several benefits that could result if the alternative proposed by Alaska Airlines is given detailed consideration in the NEPA process. Alaska Airlines has shown that the proposal advanced in the SAMP poses a substantial risk of overbuilding. The SAMP ignores already approved construction projects, including the North Satellite Modernization Project, the International Arrival Facility, and Concourse D Annex project. These projects will add approximately 25% more aircraft parking positions by 2022 than existed in 2017. Even with conservative utilization of these additional facilities, this added capacity will accommodate the 2027 demand forecast.

Also, detailed consideration of a more modest alternative would provide the Port and stakeholders with beneficial flexibility in selecting an alternative that meets the SAMP's Purpose and Need without overbuilding. If the concerns of Alaska Airlines are validated and the Port concludes at the conclusion of the NEPA process that the actions proposed by the SAMP are not needed, failure to consider a more modest alternative now would require beginning the NEPA process anew, which would be an unfortunate waste of time and resources.

AA-3 Additionally, and separate from the SAMP environmental assessment, the Port plans to conduct an in depth study of the most significant factor contributing to delay at the airport: the limitations on current airspace capacity. Clearly, the overall impact of significant improvement in the region's airspace can play a role in addressing airport delay. The failure to make adequate airspace revisions could compromise the expected benefits of the SAMP. Therefore, it is unclear how the proposed environmental analysis could objectively evaluate the SAMP without incorporating the findings of an airspace study or why the two are not part of the same work stream.

Notably, the timing for conducting the airspace study will preclude its consideration in the SAMP environmental review. This makes no sense. Authorizing the SAMP without linkage to and coordination with the FAA upcoming redesign of the region's airspace is akin to substantially expanding a railroad station without addressing the need for additional train tracks. The Port should not commit to building the proposed terminal facilities for projected growth without some credible plan to make room in the sky for those additional aircraft.

AA-2 Respectfully, Alaska Airlines suggests that when confronted with projections of future growth at Sea-Tac, the Port and the many stakeholders should not be tempted to pursue an overly ambitious response when that response is likely to impose severe operational, customer experience, and financial constraints upon the Port, air carriers, and passengers. It would be especially unfortunate if the burdens of implementing these audacious projects had the effect of precluding needed improvements to the Main Terminal where 80% of the airport's passengers will continue to transit, even with a fully-operational new North Terminal. Indeed, using the Port's own data from Leigh Fisher on forecast delay, it is possible that implementation of the SAMP actions could adversely affect the airport's ability to compete with other airports in attracting new carriers and new service.

AA-2

Finally, Alaska Airlines requests that the Port examine *whether* some of the proposed actions in the SAMP could be implemented in the immediate future rather than waiting for the completion of the NEPA analysis. The FAA has adopted procedures in FAA Order 1050.1F that allow for documented categorical exclusions.[1] Alaska Airlines believes that certain proposed actions, such as the high-speed taxiway for Runway 34L as identified as an airport improvement in the SAMP, has independent utility and could be reviewed through the mechanism of a documented categorical exclusion. Importantly, swift approval of these measures could provide important environmental, customer, and operation benefits, and may not need to be subject to detailed environmental scrutiny.

AA-4

Thank you for your consideration of these comments.

Sincerely,

Shane Jones
Vice President – Airport Real Estate and Development

[1] FAA, Order 1050.1F, at 1-6 (July 16, 2015), https://www.faa.gov/documentLibrary/media/Order/FAA_Order_1050_1F.pdf.

From:	Anne Kroeker
To:	Commission-Public-Records
Cc:	Richard Leeds
Subject:	[EXTERNAL] Written Public Comments for 10/26/21 Commission Meeting
Date:	Tuesday, October 26, 2021 8:54:55 AM

WARNING: External email. Links or attachments may be unsafe.

Dear Port of Seattle Commissioners and Staff,

Thank you for addressing the dire need to reduce carbon emissions from all port-related activities. Please consider identifying only quantifiable standards, away from ideologic ones, such as the ones you have outlined as *carbon neutral* or *net zero*, as you determine the Port's GHG emissions goals. The methods to achieve these goals either include offsets, which is an inequitable way to allow the privileged to continue to produce emissions, or are energy-intensive and haven't been proven to pencil out. In both cases, other noxious emissions are continued to be produced at the tailpipe.

As you present, Scope 3 emissions are outside the Port's direct control, but they are within the Port's indirect control. It is the latter category which must be emphasized as critically important to attack more vigorously, if our society is to make any progress in reducing our growing carbon emissions. It is the direct aircraft usage by the public which allow emissions to be produced and if the Port were to shutdown, so would these emissions coming to and from this airport. This is an extreme example but it does illustrate the power that the Port does hold. To date, no Commissioners nor Port staff have been willing to look at the potential of reducing the "need" to fly, which is why all reduction goals continue to be unattainable.

Promotion of biofuel production for jet fuel replacement is a good idea in that it does lower the carbon emissions production cycle, if implemented properly, but it does not represent a credible or acceptable policy to address aviation's climate problem, as the reductions are slight and inconsequential next to aviation growth. In addition, asking all taxpayers to pay for the development of alternative aviation fuels is inequitable when only a small percent of the population reap the benefits. The argument that aviation is good for our whole economic balance is still trickle-down theory, which has been disproven time and again.

Thank you for accepting the above comments and I hope that you may consider them in your review as you create stronger GHG emissions goals, for all of the Port's sanctioned activities.

Sincerely,

Anne Kroeker and Richard Leeds

Scope 1 & 2 emissions (these are emissions generated by direct operations, or by electricity generation that buildings use)

- Current goals:
  - 50% below 2005 levels by 2030
  - Carbon neutral by 2050
- New scope 1 & 2 goals:
  - Net zero by 2040

Scope 3 emissions: (these include emissions from planes and ships; these dwarf the others in magnitude)

- Current goals:
  - 50% below 2007 levels by 2030
  - 80% below 2007 levels by 2050
- New scope 3 goals:
  - 50% below 2007 by 2030
  - Carbon neutral by 2050

From: Laura Loe
To: Commission-Public-Records
Subject: [EXTERNAL] Cruise Ships - Laura Loe 10/26
Date: Monday, October 25, 2021 11:45:17 PM

I'd like to provide public comment for the 10/26 meeting.
—-

Please halt all expansion of fossil fuel infrastructure, especially related to cruise ships.

Cruise ships are not good for air, water, climate change, or labor rights.

I'm a renter in 98119 and lead a nonprofit called Share The Cities Action Fund and I am very worried about the Port doing more to fight climate change and take a lead on this issue.

Please educate members of the public about the health and climate impacts of all decisions that you are making, not just short term economic perceived benefits.

The long term harm to our economy from global warming is far more serious than losing money from fewer or no cruise ships.

Thanks for supporting other advocates also pushing for safer communities in the Duwamish and SeaTac.

Listen to the environmental justice demands of local communities … we elected you to help protect us from global systems focused on profit over people's health.

--
Laura Loe
She/Her
Executive Director, Share The Cities Action Fund

From:	Bernedine Lund
To:	Commission-Public-Records
Subject:	[EXTERNAL] Tuesday Oct 26 POS COmmissioner public comments
Date:	Monday, October 25, 2021 10:02:25 PM
Attachments:	public comments 10-26-21.pdf

WARNING: External email. Links or attachments may be unsafe.

Hi, attached is a file with my public comments for item 10c on the agenda - Carbon emissions etc.

I will try to be on the call by phone to give the public comment in person. I may be under the kitchen sink mopping up and fixing a water leak, and could take a break to give the public comment. In this case I would rather be doing the public comment than laying on my back under the sink - maybe the store won't have a faucet we need!

Have a good week.

Bernedine Lund
253-829-3729

Public Comment, PoS Commissioner's meeting 10-26-2021, Agenda Item 10c – Carbon Emissions and Accelerating Century Agenda Objectives; Bernedine Lund, resident of Federal Way and volunteer for 350 Seattle Aviation Group

Hello, Commissioners,

Thank you for allowing me to comment on your plans for resetting the PoS's emissions goals. I was very happy to see that the proposal is to reduce emissions to 0 by 2040, 10 years early.

My other comments are on the presentation for Agenda item 10c - Carbon Emissions and Accelerate Century Agenda Objectives, slide 14. Slide 14 shows that for Scope 3, the Port proposes to reach the goal of 0 emissions by 2040 using the two strategies 1) Net-Zero strategy and 2) Carbon neutral/negative strategy as needed, while at the same time increasing the number of flights.

Both strategies have serious negative issues and may not give the results of reducing CO2 you expect. The Net-zero strategy proposal is to remove CO2 from air; however the process currently is highly energy intensive, has not been tried in large scale efforts, and does not address other emissions. The carbon neutral/negative strategy uses offsets and has been highly criticized because it moves the responsibility of carbon reduction to other entities, such as third world countries, and is most likely to create other problems along with no CO2 reductions.

It seems unconsciousable (unwise, ill-advised, etc.) for the PoS to still plan an expansion as outlined in the SAMP. By planning to greatly increase the number of flights means you also need to greatly decrease aircraft emissions using strategies you hope work. Not to reduce the emissions means you will not meet the Scope 3 goals, one of which is to make flying equitable to both flyers and non-flyers.

The proposal also still includes using biofuels. You must be aware of the increasing number of concerns about using biofuels and the negative impact it is having on poorer countries. It also seems unwise to rely on a strategy that has yet to be proven at scale.

Not expanding flights is still the best known way to meet the emissions goals. This is the only way that it will be equitable for both flyers and non-flyers. This strategy is being pursued in places that are saying "No" to airport expansions due to pressure from local residents. Not expanding also gives time to airline and other industries to develop technologies that will not produce emissions.

From:	Rosemary Moore
To:	Commission-Public-Records
Subject:	[EXTERNAL] AMENDED Written Comment for Port Commission meeting 10/26/21 Topic: Revised Emission Goals
Date:	Monday, October 25, 2021 3:18:30 PM

UPDATED Comments:

Commissioners,

Thank you for recognizing the seriousness of the impact of aviation on climate change by strengthening the Port's emissions targets, in particular to reduce Scope 1 and 2 emissions.

While I agree that reducing Scope 3 emissions is challenging I believe that the Port Commission's proposed Scope 3 goals are inadequate and far too passive. Until or unless there is an actual and realizable method of zero/very low-emission flying, the Port must require and work for a **reduction** in flying. If you feel that a change in the law is necessary to accomplish this, then you must advocate to update the law accordingly.

The Port Commission also has contracting powers that can be used to impose adequate standards on third parties.

The Scope 3 goal for carbon neutrality is an inadequate standard, because it doesn't require ANY reductions in emissions. I urge you not to use "carbon neutral" as a goal.
Problems with offset programs are well-documented, with few projects resulting in additional emissions reduction. To enable a small share of the world population to fly with a clear environmental conscience, others bear the costs.

Your goal of achieving "Net-zero" by removing CO2 from the air is **highly energy intensive,** has not been tried or shown to work in large scale efforts, and does not address other emissions.

Promotion of "Sustainable" Aviation Fuel, hydrogen, biofuel, electric planes do not at present represent a credible or acceptable policy to address aviation's climate problem, because they result in only slight CO_2 reductions per mile flown, if any. I am glad you recognize the limited capacity for biofuel production. "Sustainable" Aviation Fuel is just not capable of reducing us to 2007 levels by 2050, especially given anticipated increases in flying. As our commissioners you cannot merely cross your fingers and hope there will be a technological solution, be it hydrogen, electric or something else.

As our commissioners, you need to make firm decisions based on what we know and can be certain of **now. We face a crisis it cannot simply be business as usual.**

I urge you to change the "Sustainable" Airport Master Plan to reflect the necessary reduction in flying, not a massive increase.

Thank you,

Rosemary Moore
6230 East Mercer Way
Mercer Island
WA 98040
Cell: (1) 206 251 7009

From: Rosemary Moore
Sent: Monday, October 25, 2021 2:53 PM
To: commission-public-records@portseattle.org
Subject: Written Comment for Port Commission meeting 10/26/21 Topic: Revised Emission Goals

Commissioners,

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As our commissioners, you need to make firm decisions based on what we know and can be certain of **now. We face a crisis it cannot simply be business as usual.**

I urge you to change the “Sustainable” Airport Master Plan to reflect the necessary reduction in flying, not a massive increase.

Thank you,

Rosemary Moore
6230 East Mercer Way
Mercer Island
WA 98040
Cell: (1) 206 251 7009

From:	Eric Ross
To:	Commission-Public-Records
Subject:	[EXTERNAL] Requested Link to Study on Public Health Impacts from Port activities
Date:	Tuesday, October 26, 2021 3:12:13 PM

WARNING: External email. Links or attachments may be unsafe.

Dear Port of Seattle,

Thank you for listening to the concerns of community members and reflecting those concerns in the accelerated timeline towards zero emissions in the Maritime Clean Air Action Plan.

Here is the study I (Eric Ross) and commissioner Fred Felleman referenced concerning health impacts of air pollution from port operations and the shipping sector.

Commissioner Fred Fellerman asked if there was a study that linked impacts of air pollution on public health to operations at ports. This study by the International Council on Clean Transportation does just that. The study found that "the areas of Seattle and San Francisco lead in terms of early deaths per 100,000 residents (1.8 and 1.6), or more than double the global average, due to air pollution from the ports of Seattle, Tacoma, Oakland, and San Francisco."

Link to Study: https://theicct.org/sites/default/files/publications/Global_health_impacts_transport_emissions_2010-2015_20190226.pdf

On the ICCT website they summarized some of methodologies and metrics, and findings:

A group of researchers from the ICCT, The George Washington University Milken Institute School of Public Health, and the University of Colorado Boulder released a new study assessing premature mortality associated with air pollution from transportation. The study found that fine particulate matter (PM2.5) and ozone from on-road vehicles, non-road engines, and oceangoing vessels was linked to an estimated 385,000 * premature deaths in 2015 worldwide. About half of these deaths were attributed to air pollution from diesel cars, trucks and buses. But **a surprisingly large fraction of the early mortality—approximately 15%, or 60,000 deaths—were due to air pollution from the 70,000 international ships that ply the world's oceans. That equates to about 160 billion dollars of health damages annually.**

The study assessed health impacts using methods from the Global Burden of Disease (GBD) 2017. The methodology used can be considered conservative* in the number of deaths estimated. As a result, the estimates of air pollution health impacts are lower than other studies, and could be revised upward if any of these assumptions are relaxed.

Still, the study highlights the uneven distribution of premature mortality due to air pollution from international shipping. It provides the raw data, which allows anyone to run their own secondary analysis. We put together a follow-up analysis of shipping impacts using that data, and found some interesting results, namely that many of these deaths occur in places one might not expect.

Despite recent adoption of more stringent vehicle emission regulations in some major vehicle markets, the transportation sector remains a major contributor to the air pollution disease burden globally. This points to the need for reducing emissions from the transportation sector to be a central element of national and local management plans aimed at reducing ambient air pollution and its burden on public health.

Longer term, eventually we'll need completely carbon-free ships powered by electricity, hydrogen...

Thank you for your work,

-Eric Ross

860-605-0776

From: Jordan Van Voast
To: Commission-Public-Records
Subject: Re: [EXTERNAL] public comment
Date: Tuesday, October 26, 2021 7:33:57 AM
Attachments: 10.26.21.emailed to council version.docx

Thank you. Please share a slightly longer version of my oral comments with the Commission (attached).

On Mon, Oct 25, 2021 at 8:57 AM Commission-Public-Records <commission-public-records@portseattle.org> wrote:

> Thank you Jordan Van Voast,
>
> Join us via your mobile or laptop device on through Teams or call into the number provided below at **11:30 a.m. PST** on Tuesday October 26, 2021 in order to be marked present and ready to speak. A member of port staff will join the call to take a roll call of the names we have listed and go over the procedure. Please plan to call from a location with as little background noise as possible.
>
> You should expect to be on the line for between 30-60 minutes as we dispose of preliminary business on the agenda and we hear from other public commenters. While it's not possible for us to predict how many people will comment on October 26, we expect individual comment time to be limited to two minutes and all rules of order and decorum will apply as usual.
>
> If you have any questions please let us know. We appreciate your dedication to public health and your interest in participating in the Port of Seattle Commission meeting.
>
> ---
>
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Good afternoon Port Commissioners and Director Metruck, my name is Jordan Van Voast. I am here to speak about the Port of Seattle's new climate goals. In short, these goals woefully fail to address the scope of the climate emergency. Whether it's achieving "Net Zero on Scope 1 and 2 by 2040" or , "Carbon Neutral" on Scope 3 by 2050, these targets out 20 and 30 years are not going to prevent emissions from continuing to rise now and that's what we need a plan for. With every bunker fuel burning cruise ship pulling away from Seattle's harbor and the hundreds of thousands of air travelers who come here to board a cruise, any hope of limiting global warming to 1.5 degrees above pre-industrial baseline slips further over the horizon. The lives of millions of people and billions of animals and marine species are on the line. And it gets exponentially worse every moment we delay with false solutions[1]. Days ago, hundreds died in India and Nepal due to record breaking late monsoon rains and flooding. Does anyone even remember the heat dome of 2021?[2] Yesterday's "bomb cyclone" making it's way across the U.S. to the East Coast was reportedly the largest storm ever to hit the west coast with severe flooding, mudslides, and loss of life. What next?

While net zero is still a better goal than carbon neutral, both are rooted in a deep denial of the severity of the crisis we are in and the apocalyptic future that our children may face. To avert this crisis, we need to confront our denial, reign in our magical thinking and reduce all non-essential emissions now, not setting targets for 30 years away that depend upon technologies that aren't available. Cruising is a non-essential business with a gigantic emissions and ecological footprint and it needs to end. Thank you.

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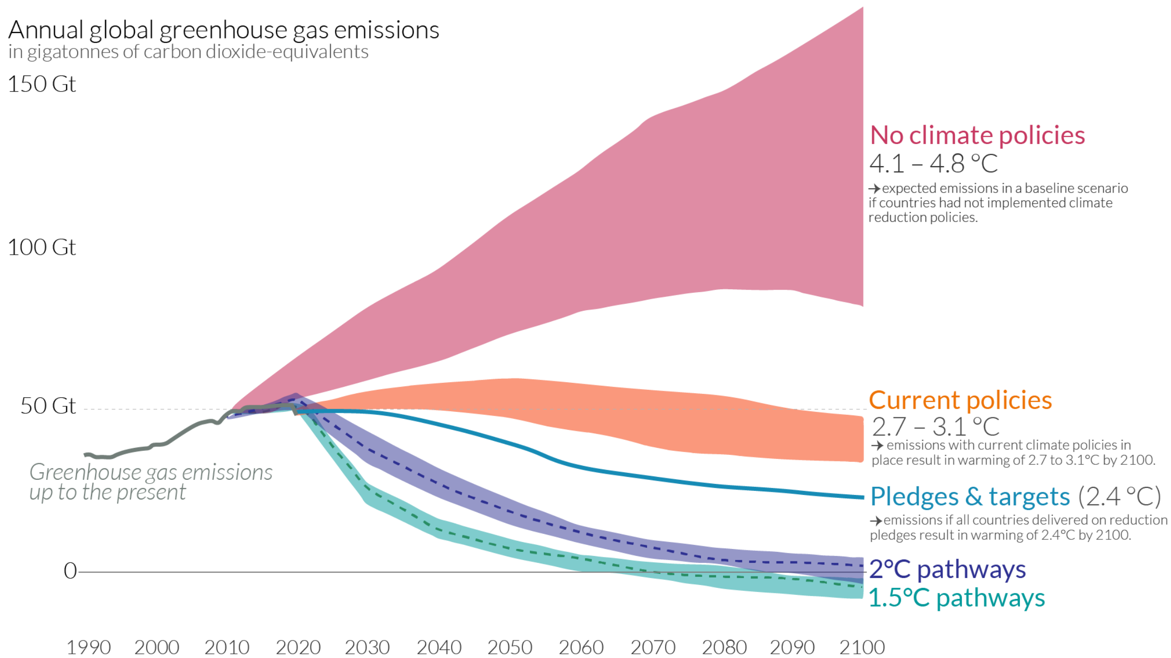
[1] https://stevemaclellan.com/two-fatal-flaws-with-net-zero-by-2050-net-zero-and-by-2050/

[2] https://www.theguardian.com/environment/2021/jul/08/heat-dome-canada-pacific-northwest-animal-deaths

Global greenhouse gas emissions and warming scenarios

– Each pathway comes with uncertainty, marked by the shading from low to high emissions under each scenario.
– Warming refers to the expected global temperature rise by 2100, relative to pre-industrial temperatures.



Data source: Climate Action Tracker (based on national policies and pledges as of May 2021).
OurWorldinData.org – Research and data to make progress against the world's largest problems.

Last updated: July 2021.