Review of Black Carbon (BC) and Polycyclic Aromatic Hydrocarbon (PAH) Emission Reductions

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Introduction

Context and Purpose:

- BC: A short-lived climate pollutant with significant warming potential.
- PAHs: Toxic organic compounds with adverse health impacts

Scope:

- Investigate the impact of PM abatement on BC and PAH emissions across key sectors.

Review on Black Carbon (BC) and Polycyclic Aromatic Hydrocarbons (PAHs) emission reductions induced by PM emission abatement techniques

TFTEI background informal technical document
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BC and PAH Sources and Impacts

Sources:

- Key sources: Fossil fuel and biomass burning

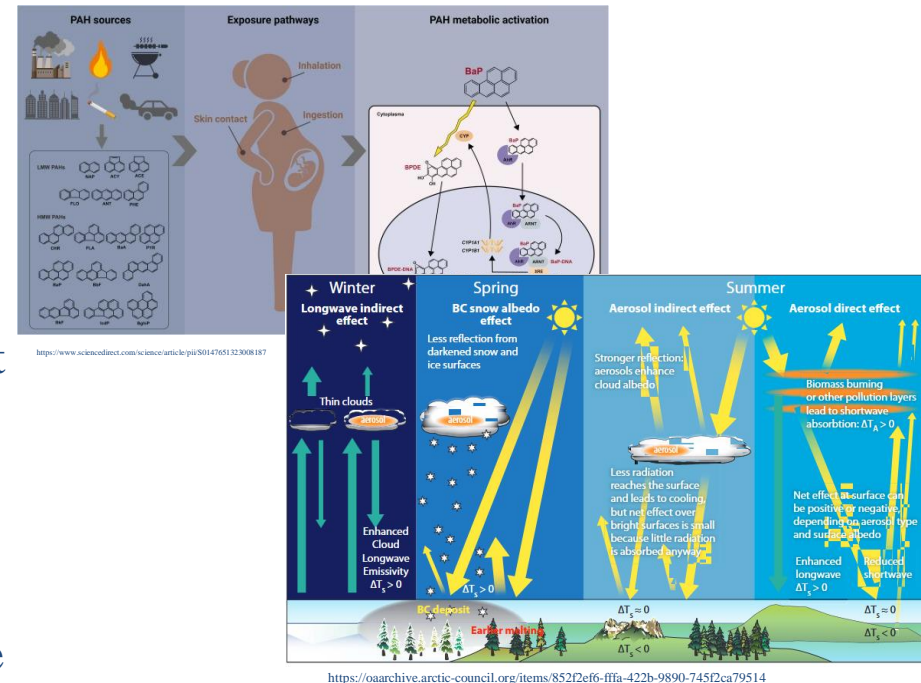- Gas Flaring is an important source of pollutants for both air quality and climate impact in the Artic regions

https://metalmininginfo.kz/archives/3227

https://liting.uz/

Impacts:

BC:

- Health impacts: Cardiovascular and respiratory diseases

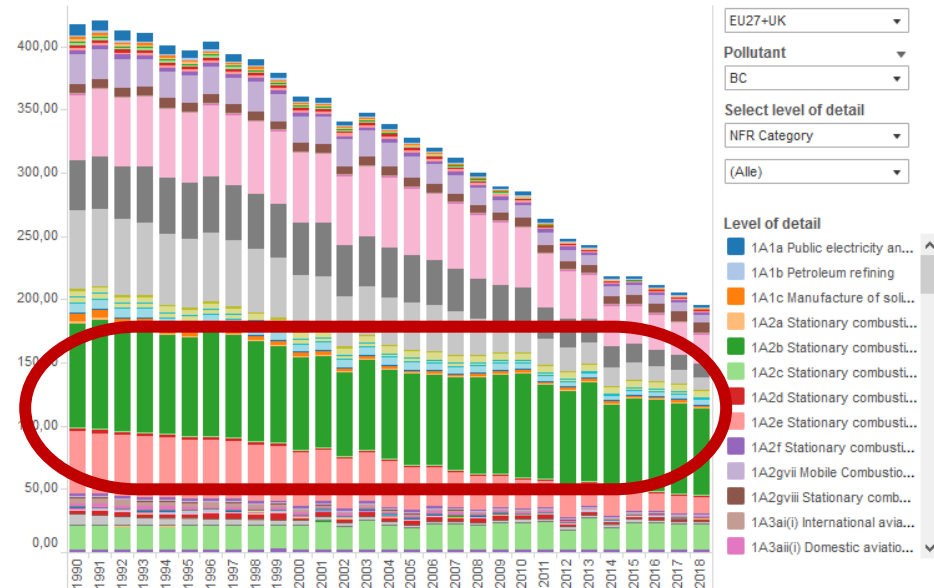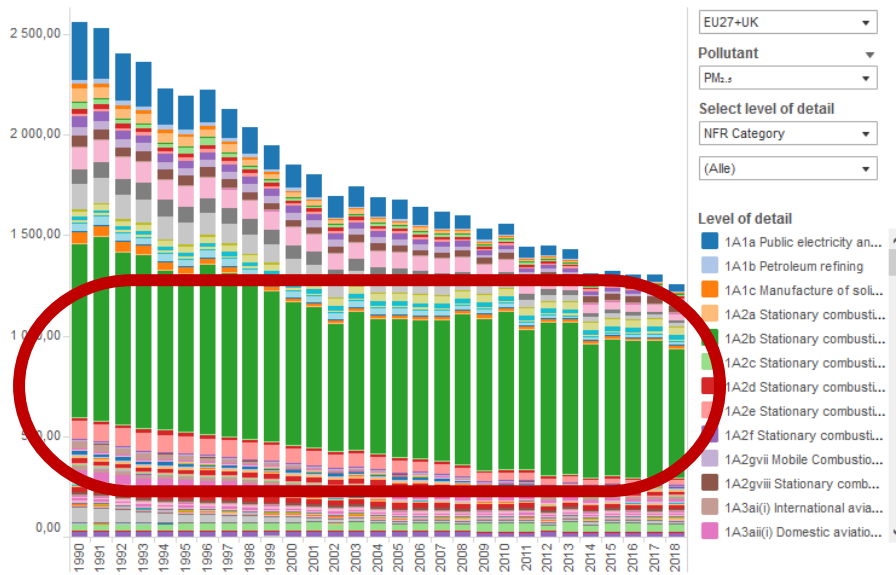- Climate effects: Absorption of solar radiation, accelerating Arctic ice melt

PAH:

- Carcinogenic and mutagenic properties

- Long-term environmental persistence

https://www.sciencedirect.com/science/article/pii/S0147651323008187

https://oaarchive.arctic-council.org/items/852f2ef6-fffa-422b-9890-745f2ca79514

Key Pollutants and Their Impacts

BC and PAH main target sectors for EU27+UK

https://www.ceip.at/data-viewer

Sectoral Analysis and Emission Reductions

Key Sectors:

- *Residential wood combustion*: Largest contributor globally

Recommended limit values for dust emissions released from new solid fuel combustion installations with a rated thermal input < 500 kWth to be used with product standards

	Dust (mg/m³)
Open/closed fireplaces and stoves using wood	75
Log wood boilers (with heat storage tank)	40
Pellet stoves and boilers	50
Stoves and boilers using other solid fuels than wood	50
Automatic combustion installations	50

(Note: O$_2$ reference content: 13%)

- *Gas flaring*: Significant Arctic impact, mitigation through steam-assisted flares

- *Road transport*: Effective reductions via particulate filters (e.g., DPF, GPF)

Euro 6 emission limits for passenger cars and light-commercial vehicles, table from (Rodríguez et al., 2019)

	LDVs, LCVs Class 1[a]		LCVs Class 2		LCVs Class 3	
	Gasoline[b]	Diesel[c]	Gasoline	Diesel	Gasoline	Diesel
NMHC*	68	-	90	-	108	-
THC*	100	-	130	-	160	-
NOx*	60	80	75	105	82	125
THC+NOx*	-	170	-	195	-	215
CO*	1000	500	1810	630	2270	740
PM*	4.5[d]	4.5[d]	4.5[d]	4.5	4.5[d]	4.5
PN**	6×10^{11}[d]	6×10^{11}[d]	6×10^{11}[d]	6×10^{11}	6×10^{11}[d]	6×10^{11}

Notes: (a) Classes 1 through 3 are weight classes. (b) Gasoline is used as a proxy term for positive ignition (PI) engines. (c) Diesel is used as a proxy term for compression ignition (CI) engines. (d) Applicable to direct injection engines. * unit in mg km^{-1}, ** unit in # km^{-1}.

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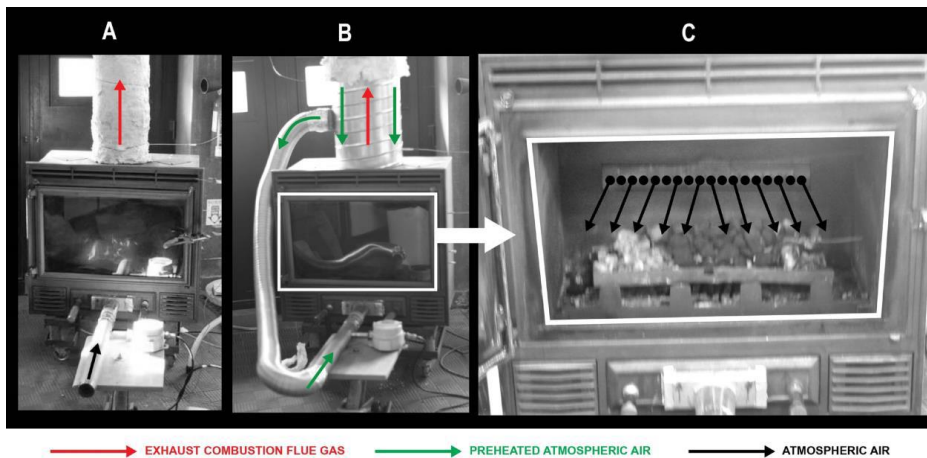
Sectoral Analysis and Emission Reductions

Techniques for Reduction:

- Residential combustion: Eco-labeled stoves, dry wood, air staging

- Road transport: Adoption of Euro VI standards, DPFs, and GPFs

- Gas flaring: Steam-assisted flares, optimized designs using AI

https://oaarchive.arctic-council.org/server/api/core/bitstreams/f5c94fa8-bc2c-4320-a421-f9241f7fa984/content

EXHAUST COMBUSTION FLUE GAS → PREHEATED ATMOSPHERIC AIR → ATMOSPHERIC AIR

Wood stove and the retrofitting interventions: A – Wood stove as sold in the market (WSref); B – Wood stove with annular chimney (WSMC1); C – Combustion chamber of the wood stove with component of secondary air-inlets (18 nozzles) (WSMC2) (Carvalho et al., 2018)

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Challenges and Opportunities

Challenges:

- High initial costs for retrofitting stoves and vehicles.

- Lack of standardized emission factor measurements.

- Knowledge gaps in PAH chemical transformations.

Opportunities:

- Co-benefits for health and climate from targeted reductions.

- Integration of modern monitoring systems for better compliance

Conclusion and Recommendations

Key Takeaways:

- BC and PAH reductions are critical for climate and health benefits.

- PM abatement technologies are effective but require broader adoption.

Recommendations:

- Promote eco-design standards and retrofitting.

- Strengthen regulations on gas flaring and vehicular emissions.

- Develop harmonized methods for emission measurements.

Thank you very much

Questions?