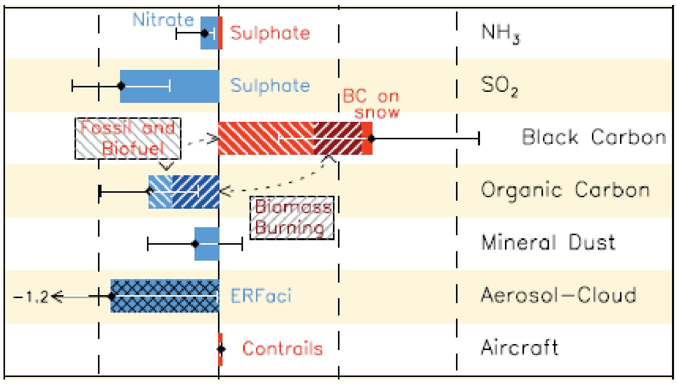
Joint Actions for Air Quality and Climate Mitigation in Europe



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European Topic Centre on Air Pollution and Climate Change Mitigation

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Front page picture:
IPCC Fifth Assessment Report: Radiative forcing bar-chart comparing the climate impact of various forcers over the period 1750-2011 (Myhre et al., 2013b).

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Abstract

Air quality improvement and climate change mitigation constitute two of the most pressing environmental challenges. Even if the atmospheric compounds concerned differ (air pollutants versus greenhouse gases), they are in the majority of cases emitted by the same sources. There is thus scope to join efforts and benefit from mutual leverage in triggering action.

Combined action for air and climate can be undertaken by (i) targeting atmospheric compounds that happen to have detrimental impacts on health, ecosystem and climate at the same time, (ii) targeting emission sources that emit a cocktail of pollutants and greenhouse gases.

Under item (i), we find the theme of Short-Lived-Climate-Pollutant mitigation. Several atmospheric constituents can be considered as both climate forcer and pollutants. It is chiefly the case of black carbon and methane. There is a growing concern that a putting the priority on such species could mutualise benefits for air and climate.

Under item (ii), considering that the vast majority of anthropogenic activities would emit at the same time pollutants and greenhouse gases, we find a long list of measures that can yield cobenefits (synergies) or trade-off for air and climate.

The present document aims at assessing the level of awareness in Europe about joint actions to improve air quality and mitigate climate change. Background information on SLCP is provided, as well as a detailed list of measures offering cobenefits or trade-off for air quality and climate mitigation. An analysis of the situation in European countries is also performed together with selected case studies for Nordic countries.

We conclude that there is a solid body of evidence for opportunities for joint action on air quality and climate change (either through SLCP mitigation or acting on synergetic sources). There are a number of international activities to foster action on SLCP, but at present only Norway has developed a concrete national action plan. The level of awareness on synergies is higher and it should be noted that most countries have identified potential synergies for air quality in their greenhouse gas mitigation plans.

1 Introduction

Black carbon, methane, tropospheric ozone (O_3) and hydrofluorocarbons (HFCs) are responsible for 40-45% of the historical anthropogenic radiative forcing (Forster et al., 2007). These chemical species have lifetimes from hours to about 15 years in the atmosphere and are therefore referred to as short-lived climate forcers (SLCFs). Contrary to carbon dioxide (CO_2), reducing SLCFs emissions may prevent as much as 90% of their predicted warming effect within decades, the final 10% would be delayed for hundreds of years due to thermal inertia of the climate system (Zaelke and Borgford-Parnell, 2013).

In order to emphasise their detrimental impact on human health and ecosystems, the term Short Lived Climate Pollutants is also found in the literature (SLCPs). Black carbon, as any other aerosols contributing to particulate matter, have detrimental impacts on human health, in particular cardiovascular mortality and cardiopulmonary hospital admissions (WHO, 2013). Short term exposure to ozone pollution has also adverse impacts on health (WHO, 2013), and ozone is detrimental for crops and ecosystems too (Simpson et al., 2014). Methane is also considered as a SLCP, rather for its role as precursor of tropospheric ozone than for direct impact on human health and ecosystems. HFCs were introduced in industrial processes to replace chlorofluorocarbons (CFCs) banned after the Montreal Protocol because of their adverse impact on the stratospheric ozone layer, and therefore on human health through UV radiation. On the contrary to CFCs, HFCs have no impact on stratospheric ozone and cannot be considered as pollutants or precursors, they are however considered as SLCF because of their short lifetime and strong warming potential.

Reducing emission of SLCPs would lead to benefits in terms of both climate mitigation and air quality. In addition, it is expected that such benefits would be felt on the short term. SLCP mitigation became therefore quite legitimaly a topic of science and policy discussions since the publication of a joint report by UNEP (United Nations Environment Programme) and WMO (World Meteorological Organisation) on the topic in 2011 (UNEP and WMO, 2011) and the subsequent launch in 2012 of the Climate and Clean Air Coalition (see later section on International Initiatives, Section 2.4.3). An additional interest was raised by Countries of the Arctic Council because global warming is particularly fast at high latitudes. The threat of an irreversible melting of the Arctic fosters the need for fast action at these latitudes.

It should be noted that, besides SLCPs, there are also vast opportunities to reduce simultaneously greenhouse gases and air pollutant emissions (e.g. the cobenefits of improving energy efficiency), such measures will also be discussed in the present report.

After a decade of discussion in the science community, and 3-5 years in policy forums, it is now timely to propose an overview of the level of awareness on joint air and climate action in Europe. It is the aim of the present report that includes: general background information on SLCPs in Section 2 (definition, impacts, inventories, existing policy instruments as well as a compilation of existing mitigation measures that can affect air quality and climate change at the same time), a list of mitigation measures offering synergies or trade-off for joint action on air quality and climate mitigation beyond specific SLCP actions (Section 3), two detailed case studies on Nordic Countries (Section4) and the Netherlands (Section 5), and a general overview of overlaps between air and climate action plans in all other European countries (6).

2 Background Information on SLCPs

The main atmospheric chemical compounds of interest in relation with short term air quality and climate change interactions are **methane** and **black carbon** because of the clear cobenefits of reducing their emissions for climate change as well as human health and direct impacts on ecosystem and crops. Although less often pointed out, **HFCs, Ozone, NOx** (nitrogen oxides), **NMVOCs** (non-methane volatile organic compounds), **organic aerosol** (OA) as well as **sulphate** and **nitrate secondary inorganic aerosol** are also sometimes mentioned in this context. The present section includes a few definitions and background information on their impact on air quality and climate change. We also propose here an overview where SLCP are dealt with in existing international agreements and initiatives.

2.1 Definitions

2.1.1 Methane

Methane (CH_4) is a strong greenhouse gas and a precursor of ozone. About 60% of methane emissions at the global scale come from anthropogenic activities (CCAC, 2014). In North America and Europe the main activity sectors responsible for CH_4 emissions are fossil fuel extraction and distribution, waste/landfill, and agriculture, in approximately equal proportions (UNEP, 2011).

The absolute global warming potential of methane per unit mass emitted is 28 times larger than that of CO_2 but it's lifetime is much shorter, with 12.4 years (Myhre et al., 2013b). In 2000, Europe was responsible for about 15% of global anthropogenic emissions according to the Representative Concentration Pathways of IPCC (HTAP, 2010). CH_4 has no direct impact on health and ecosystem but it is a very important ozone precursor, to such extent that it was found to have a similar impact on ozone change since the 1960s in Europe than all other local or global precursors (Wild et al., 2012).

2.1.2 Tropospheric Ozone

Ozone is an atmospheric oxidant not emitted directly by human activities, but formed in the atmosphere because of emissions of NOx, NMVOCs, CH_4, and CO. It is responsible for 25,000 premature death per year in Europe (IIASA, 2013) as well as substantial negative impacts on crops yields. It has a radiative forcing of about 15% that of well mixed greenhouse gases (Myhre et al., 2013b).

2.1.3 Nitrogen oxides

In the context of air quality and climate interactions, nitrogen oxides are only relevant because of their role of precursors of ozone and aerosols, as well as their impact on methane. NOx contribute to the (i) formation of tropospheric ozone and (ii) ammonium nitrate aerosol, but they tend to (iii) decrease CH_4 lifetime, henceforth concentrations. Because tropospheric ozone and CH_4 are warming agent, and ammonium nitrate is mainly cooling, reducing NOx emission would have a cooling effect because of (i), but a warming effect because of (ii) and (iii).

2.1.4 Carbonaceous and organic aerosols

Black Carbon is a type of aerosol singled out for its property to interact with light (hence the reference as *black*) and therefore its importance in the climate context.

Black carbon is emitted as a result of incomplete combustion. In Europe about half of BC emissions are due to traffic sources, followed by heating and agricultural burning totalling about 10% of global emissions (Bond et al., 2013). Carbonaceous aerosols were historically referred to as soot, today the terms “black” or “elemental” carbon (BC or EC) are found. Both of them are based on an idealized view of carbonaceous aerosols that would be ideally absorbing light (as a black body for BC), or considered as an atom of carbon not bounded to any other chemical element (EC)(Petzold et al., 2013).

Black carbon is generally co-emitted with a fraction of primary organic carbon or NMVOCs that can ultimately lead to the formation of secondary organic carbon. This co-emission challenges the identification of mitigation measures that would be unequivocally leading to warming reductions (Unger et al., 2010), looking for high BC/OA ratios (Stohl et al., 2015).

Whereas black carbon contributes to warming through absorption of sunlight and reducing the surface albedo when deposited on snow, organic aerosols tend to scatter light and therefore have a cooling effect. Both type of carbonaceous aerosol (and any other aerosol) have an indirect impact on climate through the formation of clouds which, although still uncertain, likely also contribute to a cooling effect (Boucher et al., 2013).

2.1.5 Inorganic aerosols

Ammonium nitrate and sulphate aerosols fall in the category of secondary inorganic aerosols. They are formed in the atmosphere as a result of emissions of sulphur dioxide and ammonia in the presence of nitrogen oxides and contribute to the mix referred to as “particulate matter” (PM). Sulphate aerosol are very efficient at scattering light, and exert as such a cooling effect on climate. Nitrate is also mainly cooling the climate, but to a lesser extent. Similarly to BC, they also have an indirect cooling impact on climate through perturbation on clouds.

2.1.6 HydroFluoroCarbons

HFCs is a family of compounds with an atmospheric lifetime of days to several decades, and a global warming potential (GWP100) reaching the thousands, making them very important short-lived climate forcers. They don’t have any impact on air quality and can therefore not be considered as pollutants. They were introduced as a substitute for ozone depleting substances (such as chlorofluorocarbons – CFCs – and hydrochlorofluorocarbons – HCFCs) and the rapid growth of their emissions is such that they became a topic of interest under the SLCF umbrella, even though no cobenefits for air quality are expected.

2.2 *Climate Impacts*

While all the atmospheric compounds (but HFCs) listed in 2.1 have negative impacts on health and ecosystem, their contribution to climate change is intricate because cooling and warming compensations that occur across various timescales must be compared. To achieve this comparison, various techniques and metrics were proposed in the literature.

The most widespread comparison is based on the concept of **radiative forcing** used in IPCC Assessment Reports (Myhre et al., 2013b), reported in Figure 1. It allows putting in perspective the relative importance of various constituents of the climate-chemistry system combining (i) their warming/cooling effect and (ii) their net abundance. Both direct and indirect (through cloud interactions) effects of aerosols are displayed. And the issue of co-emitted species for BC/OC is highlighted for fossil and biomass combustion. Secondary organic aerosols are ignored from this graph because of insufficient confidence in their representation in climate-chemistry models.

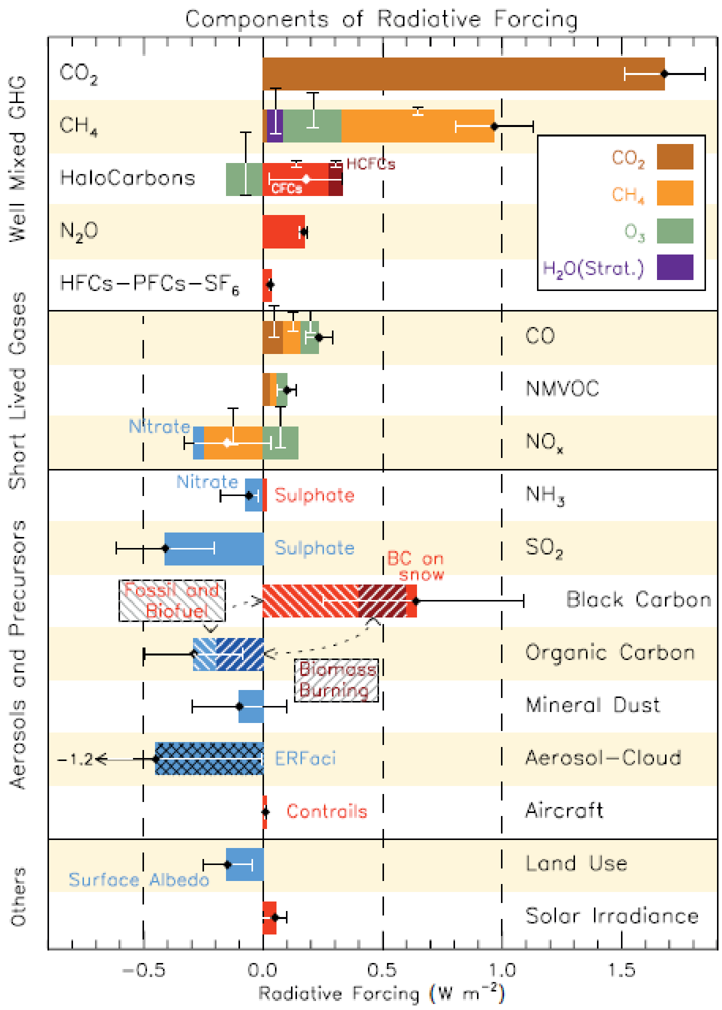

Figure 1: Radiative forcing bar-chart comparing the climate impact of various forcers over the period 1750-2011 (Myhre et al., 2013b) Figure 8.17.

It is important to note that Radiative Forcing is a backward looking perspective that requires the knowledge of the relative abundance (atmospheric concentration) of the relevant compounds. When it comes to support to policy making, metrics designed to quantify the effect of a given mitigation measure (therefore related to emissions rather than concentrations) are needed. That is why the global warming potential (GWP) was designed and adopted in climate agreements for long-lived greenhouses gases. Unfortunately, the GWP concept does not apply to short lived climate forcers that violate hypotheses on the atmospheric mixing and lack of interactions formulated in the definition of GWP (Colette et al., 2014). That is why alternative metrics were introduced such as the Global Temperature Potential (GTP) and its regional declination: the Absolute Regional Temperature Potential (ARTP) (Shindell et al., 2008;Shindell, 2012;Collins et al., 2013).

The absolute global temperature potential is the atmospheric temperature response (in K) for a given time horizon (e.g. 10, 20, or 100 years) that is expected from a pulse emission of a given short lived climate forcer. Similarly to the warming potential, it is generally expressed as GTP, i.e. normalised by the AGTP of CO_2. It is computed using numeric chemistry-climate models as described in detail in the IPCC AR5. The recent European Research Project ECLIPSE proposed an update of the GTP20 of the main SLCFs (Stohl et al., 2015).

These estimations of GTP20 (Figure 2) confirm the clear benefit of mitigating CH_4 and BC to act on global warming in the short term. It also reminds that there might be trade-offs brought about by reduction of SO_2 and NOx as these compounds have a predominant cooling impact. Sulphate aerosol are indeed efficiently scattering light in addition to the indirect cloud effect. Reducing NOx emission will contribute to reduce ozone concentration, and therefore limits its warming impact. But on the contrary, reducing NOx emissions will increase the lifetime of CH_4 and therefore yield a warming. Reducing NOx will also reduce nitrate aerosol concentration that have a cooling effect. These later two effects appear to dominate so that NOx mitigation will lead to a warming effect in the short term.

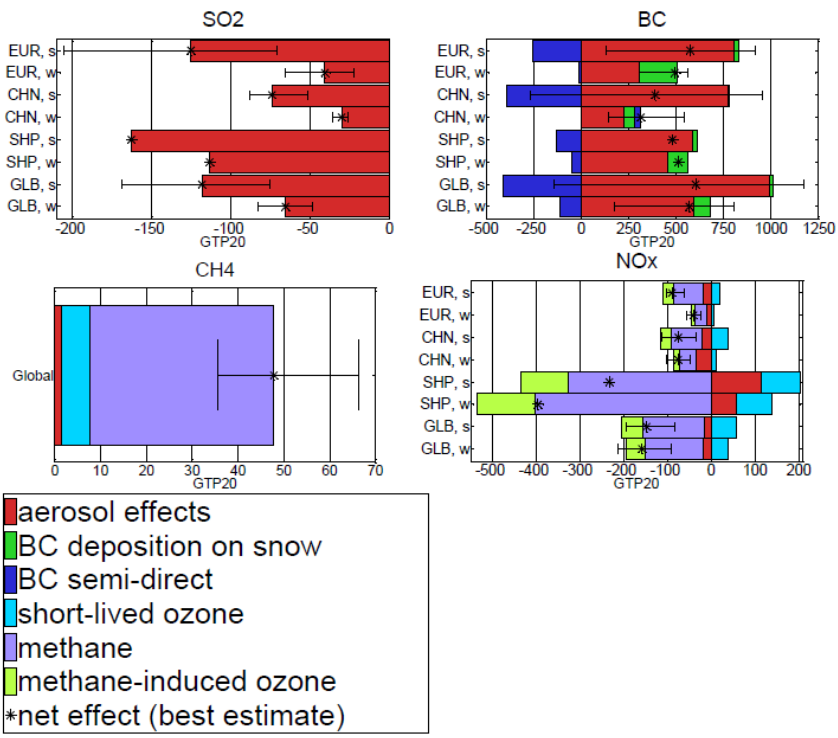

Figure 2: GTP20 of SLCPs for Europe (EUR), China (CHN), global (GLB) and the shipping sector (SHP) for both Northern Hemisphere summer (s) and winter (w), from (Stohl et al., 2015).

Such trade-offs have not been quantified in details in the existing literature, for instance by assessing the climate penalty that could yield an ambitious air quality legislation targeting NOx reductions. On the contrary, cobenefits have been assessed in details by proposing packages of measures that would optimise the health and climate cobenefits that can be expected from SLCP mitigation.

Besides the 2011 Ozone and Black Carbon Assessment (UNEP and WMO, 2011), a recent update was proposed as part of the ECLIPSE project, where a basket of 17 mitigation measures were identified as beneficial for both climate and air quality(Stohl et al., 2015). These measures targeted primarily CH_4 and BC mitigation, avoiding measures devoted to SO_2 and NOx mitigation, and favouring high BC/OA ratios. For both CH_4 and BC, the first priority was a measure relevant for the oil and gas industry in relation to reducing gas venting and flaring. Many of the other CH_4 mitigation measures were related to waste management, while most BC measures were not relevant for the European situation (high emitters elimination, replacement of cooking stoves and of kerosene wick lamps). A substantial air quality benefit can be expected from this SLCP mitigation package, with 0.9 month gain in life expectancy in Europe in 2030 compared to a "current legislation" (CLE) scenario (and much larger gains in the rest of the world). The climate benefit is also important with 0.45 +/- 0.04 K less warming in the SLCP scenario compared to the CLE, about 90% of which is due to CH_4 mitigation. The relatively small climate forcing attributed to black carbon was not originally expected (Baker et al., 2015), and further sensitivity studies with state of the art earth system models (with coupled ocean circulation and sea-ice dynamics) showed that, unlike the warming impact of reducing SO_2 emission, removing black and organic carbon emissions did not necessarily lead to a discernible climate response (Figure 3), which raises important scientific questions for future SLCP studies.

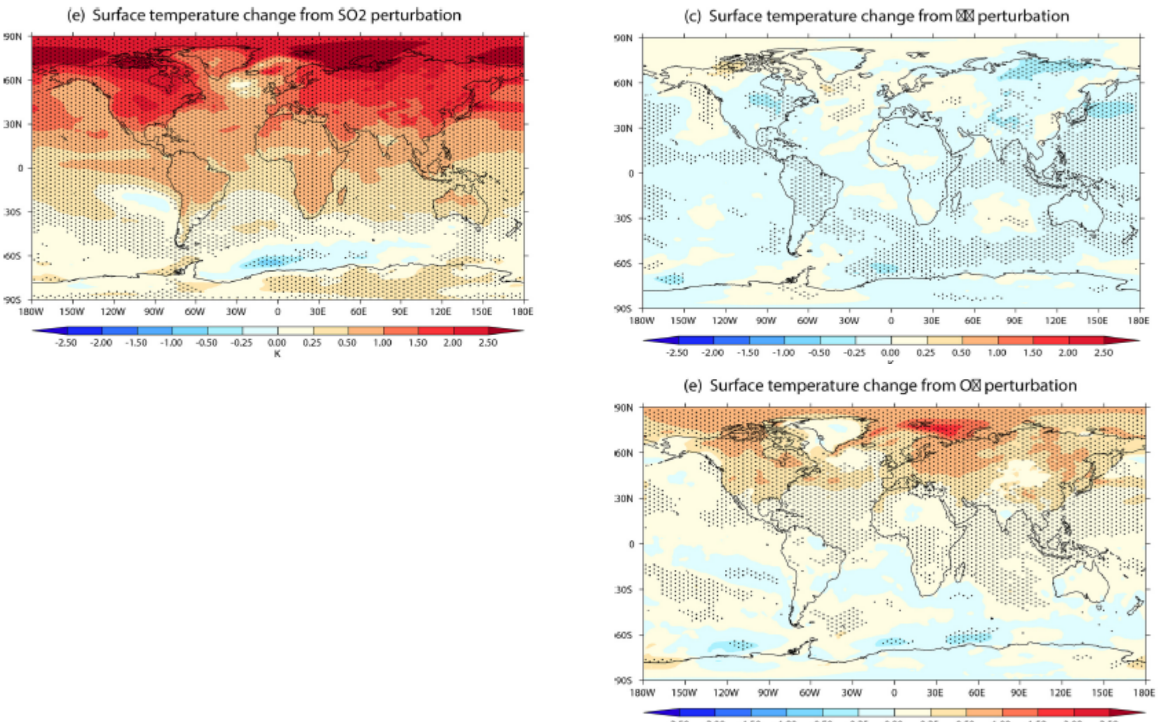

Figure 3: Temperature response (K) resulting from the removal of SO2 (top left), Black Carbon (top right) and Organic Carbon (bottom right) in the ECLIPSE four Earth System Model ensemble, from (Baker et al., 2015)

2.3 *Inventories*

All countries concerned by the present report have reported emission for methane in the past, but black carbon emissions are an emerging issue, and the first reports were completed in 2014 as part of the Convention on Long-range Transboundary Air Pollution convention. The list of countries having reported BC emission data to the EMEP Centre for Emission Inventory and Projection is given in Table 1.

Countries	BC inventory
Austria	NO
Belgium	YES
Bulgaria	YES, Only for road transport
Croatia	NO
Cyprus	YES but not for all sectors.
Czech Republic	YES Only for waste
Denmark	YES
Estonia	YES
Finland	YES
France	YES
Germany	NO
Greece	NO
Hungary	YES
Ireland	YES
Italy	YES
Latvia	YES
Lithuania	YES but not for all sectors.
Luxembourg	NO
Malta	YES only for Waste and Public Power
Netherlands	YES
Norway	YES
Poland	NO
Portugal	YES
Romania	YES but not for all sectors.
Slovakia	NO
Slovenia	NO
Spain	NO
Sweden	YES
Switzerland	YES
United Kingdom	YES

Table 1: List of EU28 countries having delivered Black Carbon emission data to the LRTAP Convention by 2015.

2.4 *International Policy Instruments and Initiatives*

SLCP mitigation overlaps a number of existing Conventions, Organisations, and Forums. In this section we list the various instruments involving European countries where SLCP are, or could become, relevant.

To date, methane (CH_4) emission reduction is only addressed in the Kyoto Protocol although there are discussions to account for CH_4 emission in the ongoing revision of the European Directive on National Emission Ceilings (NECD). Black carbon is not specifically targeted in any currently enforced agreement, although it is indirectly included in measures devoted to PM mitigation (for instance in the ongoing revision of the NECD and the revised Gothenburg Protocol, as supported for instance by the European Parliament[1]).

2.4.1 Global Conventions and Protocols

Montreal Protocol: The MP is an international treaty that became effective in 1989. It was designed to protect the ozone layer by phasing out the production of substances responsible for stratospheric ozone depletion (chiefly chlorofluorocarbons – CFCs - and hydrochlorofluorocarbons, HCFCs). These substances are sometime replaced by alternatives (HFCs) whose very high GWP is a concern in the context of climate change. In the last submission the MP was discussed as an option to also reduce other short lived climate pollutants[2].

The **Kyoto Protocol**, signed under the UNFCCC, sets targets for six greenhouse gases: carbon dioxide (CO_2), CH_4, nitrous oxide (N_2O), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs) and sulfur hexafluoride (SF6).

The **MARPOL Convention** is a global agreement under the International Maritime Organiation that includes measures to regulate air pollution from ships. The Marpol convention targets shipping emission of sulphur dioxide (SO_2), nitrogen oxides (NOx), and particulate matter (PM). There is no specific mention to black carbon (BC), but with the development of shipping in the Arctic region it is feared that ships would constitute a significant contribution to SLCP emissions in the future, making the MARPOL Convention a legitimate forum to address that concern.

2.4.2 Regional Convention and Protocols

The Convention on Long Range Transboundary Air Pollution (CLRTAP) was signed in 1979 and entered into force in 1983, it has 51 parties with a geographic coverage extending in the UNECE region from North America to Europe. Six protocols were signed under the Convention, notably the Gothenburg Protocol to Abate Acidification, Eutrophication and

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[1] UNEP: Near-term climate protection and clean air benefits: Actions for controlling short-lived climate forcers, UNEP, Nairobi, Kenya, 2011. referring to European Parliament resolution of 20 January 2011 on a sustainable EU policy for the High North (2009/2214(INI)) available at http://www.europarl.europa.eu/sides/getDoc.do?type=REPORT&reference=A7-2010-0377&language=EN

[2] From http://unfccc.int/focus/mitigation/items/7907.php

Ground level ozone, in 1999. After the recent revision adopted in 2012 but not yet enforced, the proposed Protocol now covers Particulate Matter. Black Carbon is not included in the negotiation of emission ceilings under CLRTAP, although the Convention started in 2015 to collect emission data from State Parties, thereby constituting a first step towards the possible definition of such ceilings.

The European Union Directive on National Emission Ceilings (2001/81/EC, NECD) sets targets for Member States in terms of Sulphur Dioxide, Nitrogen oxides, volatile organic compounds, ammonia. Its revision is currently ongoing as part of the EU Clean Air Package, and the Directive will likely be extended to include objectives on PM emissions, but also possibly on CH_4.

2.4.3 International Cooperative Initiatives

The **Climate and Clean Air Coalition** (CCAC) to Reduce Short-Lived Climate Pollutants was launched in 2012 by the UNEP with the aim (i) to raise awareness of short lived climate pollutant impacts and mitigation strategies, (ii) enhancing and developing new national and regional actions, including by identifying and overcoming barriers, (iii) enhancing capacity, and mobilizing support and promoting best practices and (iv) showcasing successful efforts.

UNEP has had a long lasting interest in SLCP mitigation, developed in the lee of the Atmospheric Brown Cloud project in the year 2000s (Ramanathan and al., 2008) and the Integrated Assessment of Black Carbon and Tropospheric Ozone published with WMO in 2011 (UNEP and WMO, 2011). UNEP also published in 2011 a Synthesis Report on existing actions for controlling SLCP (UNEP, 2011). Besides International agreements, the 2011 Synthesis also mentions a number of multilateral initiatives that could offer an interesting forum to foster the discussions on SLCP mitigation options. Such initiatives include:

- The International Civil Aviation Organization that regulates at present PM and O3 precursors;
- the Global Alliance for Clan Cookstoves a public private partnership under the UN Foundation;
- the Global Gas Flaring Reduction Partnership launched at the World Summit on Sustainable Development in Johannesburg in 2002;
- the Global Methane Initiative (GMI) (established in 2010) is a multilateral initiative that unites public- and private-sector interests to advance the recovery and use of methane as a clean energy source. GMI builds on the existing structure and success of the Methane to Markets Partnership.

The **Arctic Council** is a regional high-level intergovernmental forum involving all eight countries directly neighbouring the Arctic Region. It has a strong interest in SLCP issues, in particular through its Arctic Monitoring and Assessment Programme (See also Section 4.2). The Arctic Council, at the Ministerial Meeting that took place in Iqaluit in 2015[3], committed to take enhanced and collective actions to significantly reduce black carbon and methane emissions. The Arctic Council Framework committed to:

- provide black carbon inventories starting in 2015;

[3] https://oaarchive.arctic-council.org/handle/11374/610

- establish an aggregate summary of black carbon and methane emissions;
- adopt an ambitious and quantitative collective goal on black carbon.

All these commitments would be fulfilled by the next Arctic Council Ministerial meeting in 2017. In addition, the Arctic Council committed to enhance the sharing of national reports and policies to reduce emissions.

3 Air Quality and Climate Mitigation Measures

In order to propose specific examples of options to improve air quality and mitigate climate change simultaneously, we provide in this section a list of measures and instruments that will have an impact on both air pollutant and greenhouse gases emissions.

Regarding SLCP mitigation, one can refer for instance to the measures identified by IIASA with the GAINS model in the framework of the ECLIPSE project (Stohl et al., 2015). A total of 17 BC and CH_4 mitigation measures were found to deliver more than 80% of total the climate benefit. Although the focus of this selection of measures was worldwide, it should be noted that a few of these measures are also relevant for European countries. If we focus on BC alone (as the most relevant for health impacts), the following measures were found to deliver 33% of the climate benefit:

- Oil and gas industry: improving efficiency and reducing gas flaring;
- Transport: eliminating high-emitting vehicles (super-emitters);
- Residential–commercial: clean biomass cooking stoves;
- Residential–commercial: replacement of kerosene wick lamps with LED lamps;
- Transport: widespread Euro VI emission standards (incl. particle filters) on diesel vehicles;
- Industrial processes: modernised (mechanised) coke ovens;
- Agriculture: effective ban of open-field burning of agricultural residues.

Besides SLCPs, many, if not most, measures targeting reduction of any greenhouse gases will also have an impact on emissions of a few air pollutants (that are not necessarily SLCP themselves). This is because most sources co-emit a cocktail of greenhouse gases and air pollutants. If the measure acts unambiguously to improve air quality and climate, one will talk about synergies, in the opposite case, a trade-off is found[4].

We will present below various measures and instruments applicable to specific activity sectors and directed at air quality improvement and/or climate change mitigation. For each sector, the measures are pointed out as offering a clear synergy or trade-off, or if the net impact would require further, more quantitative, assessment (note that it was beyond the ambition of the present report to give quantitative information on attainable emission reductions). More details on the reason for which a measure would be listed in a given category can be found in the more extensive table in Annex 2.

These lists result from the measures reported by countries in the EEA GHG PaM Database and from earlier work collecting information from international literature (studies, but also BREF documents[5]) and French policy plans and presented in (Bessagnet et al., 2009).

[4] Note that an identified trade-off does not necessarily mean that the measure is undesirable in every case
[5] http://eippcb.jrc.ec.europa.eu/reference/

Table 2: List of measures offering clear cobenefit (green), trade-off (red), or uncertain (yellow) outcome for air quality and climate mitigation in the Energy Sector

	Energy sector
	Develop use of hydro energy
	Use of geothermal energy
	Use of photovoltaic energy
	Use of solar thermal energy
	Electricity from wind turbines/wind parks (on-shore/off-shore)
	Fuel substitution – from coal to natural gas
	Modernisation of electricity transmission and distribution grid
	IGCC - Integrated gasification combined cycle plant
	Use of circulating fluidized bed combustion in oil shale boilers
	Replacement of old by new power plants
	Improvement of production efficiency in existing coal-fired power plants
	Reduced consumption of electrical household appliances
	Ecodesign
	Improvement in energy efficiency
	Energy efficiency in district heating plants
	Interconnection of islands to mainland's/European electrical grid
	Energy certificates
	Green and/or CHP certificates
	ETS - Emission Trading Scheme
	End of tax exemption on coal and heavy fuel
	Tax on NOx emissions
	Taxation on energy for electricity generation
	Facilitators services for RES and CHP promotion
	Energy planning by electricity producers
	CO_2 Capture
	Low NOx burners
	Flue gas recirculation
	Fuel staging (reburning)
	Renewable energy use
	Biomethanisation
	CHP - Combined Heat and Power
	Electricity produced from renewable energy sources
	Reduced VAT for subscriptions to district heating
	Flue gas desulphurisation (FGD)
	Selective Catalytic Reduction (SCR)
	Selective non catalytic reduction (SNCR)
	Reduced air preheat
	Use of biomass

Red	Electricity production from biomass, biogas, renewable MSW
Red	Use of fuel wood
Red	Use of fuel wood by municipalities
Red	Energy tax based on carbon content/CO2 tax

Table 3: List of measures offering clear cobenefit (green), trade-off (red), or uncertain (yellow) outcome for air quality and climate mitigation in the Transport Sector

Transport	
Road/non-road	
Green	European Emission Standards
Green	Connecting coaches to the electric grid during prolonged stops
Green	Electric mobility
Green	Increase of the share of public transport or non-motorized transport in urban travel
Green	Densification of the city
Green	Implementation of bike-sharing in cities
Green	Securing / separation of non-motorized transport modes
Green	Use of lighter, less powerful vehicles ('downsizing')
Green	Eco-driving
Green	Fluidifying traffic through speed regulation
Green	Improve freight transport efficiency
Green	Free public transport for commuters
Green	Promotion of car sharing
Green	Promotion of public transport through employer financial contribution
Green	Taxes based on the vehicles' environmental impacts (GES and AP)
Green	Fuel tax increase (possibly based on fuel type)
Green	Best Available Technology for public transport
Green	Non-road mobile machinery: Emission limit values imposing the implementation of emission reduction technologies for diesel
Green	Non-road mobile machinery: Emission limit values imposing the implementation of emission reduction technologies for gasoline
Green	Non-road mobile machinery: substitution of fuel oil by diesel containing a fraction of biofuel
Yellow	New road-vehicle engines
Yellow	Engine oils with low viscosity
Yellow	CO2 emissions label
Yellow	Increase of technical inspections for cars
Yellow	Increased number of filling stations equipped with petrol vapour recovery
Yellow	Low Emission Zones
Yellow	Reduction of vehicle speed/speed limits
Yellow	Motorway lanes in urban and peri-urban areas dedicated to public transport and sufficiently occupied private vehicles (car-sharing)
Yellow	Modulation of motorway tolls based on the vehicles' AP and / or CO2 emissions
Yellow	Truck road charge

	European CO2 trading in the automotive industry
	City tolls
	Bonus/Surcharge for CO2 (or "Greening of consumption tax")
	Tax on company cars as a function of CO2 emissions
	Incentives for fleet renewal
	Non-road mobile machinery: use of fuels with lower sulphur content
	Non-road mobile machinery: fleet renewal incentive
	Reduction of sulphur content in fuels
	Development of renewable energy: biofuels
	Phase out of fuel oil use by local transport, substitution by biofuel
Aviation	
	Electricity for APU (auxiliary power unit) on airports
	Air passenger taxes /EU-ETS aviation
	Reducing energy consumption of aircraft
	Aircraft taxiing on one engine
	Adaptation of the paths to the available airspace enlargement in Europe
	Modal shift Air => Rail
	Reducing the fuel consumption of reactors
Shipping	
	Supplying energy in form of electricity to docked ships
	Development of coastal navigation
	Wide gauge canal Seine-North-Europe
	SCR
	Scrubbers for stacks of ships
	Recovery of hydrocarbon and VOC vapours from vessels docked during loading / unloading and refuelling
	Improving the competitiveness of sea ports
	Reduction in the sulphur content of fuels
Rail	
	Electrification and modernization of railway lines and engines
	Increase in the share of rail freight transport
	Phase-out of heavy fuel oil used by rail transport
	Development of the High speed train network
Non specified mode	
	Modal change

Table 4: List of measures offering clear cobenefit (green), trade-off (red), or uncertain (yellow) outcome for air quality and climate mitigation in the Agriculture Sector

Agriculture & livestock	
Fertilizer use	
	Reducing fertilizer inputs
	Limitation of use of fertilizers with high volatilization rates (urea, nitrogen fertilizers)
	Reduction in the use of mineral fertilizers
	Rational use of organic and nitrogen based fertilizers
	Nearby ground band spreading of liquid manure
	Replacement of nitrogen fertilizers by liquid manure spreading
	Replacement of nitrogen fertilizer by urea
	Replacement of nitrogen fertilizers by incorporation of manure into the soil
	Replacement of spreading by manure injection / incorporation into the soil
Treatment and storage of animal excretions	
	Development of agricultural methanisation (new plants)
	Recovery of biogas from animal storage system
	Construction of manure storage facilities
	Coverage of slurry storages
	For cattle livestock: Covered manure storage or ventilation
Animal feed	
	Reduction of nitrogen supply of livestock feed
	Multiphase feeding of mono-gastric animals
Livestock numbers and livestock management	
	Reduction of livestock numbers
	Decoupling of premiums for suckling cows
	Promotion of grazing for cows and suckling cows
	Increase in the proportion of grazed animals
	Efficient animal production
Adaptation of agricultural and farming approaches	
	New crops (leguminous vegetables)
	Organic farming
Agricultural waste burning	
	Stubble management
	Ban on burning straw on fields
Road/off-road machinery	
	Engine setting for tractors

Table 5: List of measures offering clear cobenefit (green), trade-off (red), or uncertain (yellow) outcome for air quality and climate mitigation in the Industry Sector

Industry	
Industry - general	
	Increase in energy efficiency
	Eco-design
	Energy efficient buildings
	Use of highly efficient electric motors and inverters
	CHP (combined heat and power)
	Use of natural gas
	Use of biomass
	Eco-design Directive
	Ban low-efficiency products from market
	BAT for energy efficiency
	Subsidy for investment in energy savings/efficiency by industry
	Electricity certificates
	EU ETS
	Tax on CO2 emissions
	Fossil fuel tax
	Energy audits
	Subsidised energy audits for SMEs
	Voluntary agreements for energy efficiency
	Use of thermal energy (renewable)
Industry - combustion	
	Low NOx burners
	Flue gas recirculation
	Fuel staging (reburning)
	Reduced air preheat
	Selective Catalytic Reduction (SCR)
	Selective non catalytic reduction (SNCR)
	Use of low sulphur fuel oil
Industry - Chemistry, petro-chemistry	
	Reduction of diffuse VOC emissions (from leaks, loading, treatment basins)
	NOx from refineries: SCR
	NOx from efineries: SNCR
	NOx from refineries: hydrotreatment of petroleum feedstocks
Industry - metallurgy	
	Reduction of SF6 emissions from magnesium foundries
Industry - industrial processes	
	Limited VOC content in paints and varnishes
	Limitation of VOC emissions by organic solvents in industrial installations
	Reduce N2O emissions from nitric acid production

Table 6: List of measures offering clear cobenefit (green), trade-off (red), or uncertain (yellow) outcome for air quality and climate mitigation in the Residential Sector

Residential, commercial, tertiary sector	
green	Energy performance of residential and non-residential buildings (new and modernization of existing buildings)
green	Inspection of boilers
green	Efficient domestic lighting
green	Use of low-NOx boilers, low temperature boilers, condensing boilers
green	Use of non-biomass renewables
green	Increase use of natural gas substituting diesel
green	Energy efficiency in end-use appliances
green	Use of efficient and low emission boilers, stoves and HVAC systems
green	Improved heating management
green	Limitation of air conditioning
green	Solar water heaters
green	Micro wind turbines
green	Display of the energy performance of buildings
green	Zero-tax credits or tax deductions for building energy efficiency investments
green	Thermal minimum requirements for buildings
green	Eco-design Directive
green	Energy efficiency requirements for appliances and products such as white goods, lighting, televisions, heating and cooling systems and electric motors
green	Energy efficiency/performance requirements for Heat Generators for Space Heating and the Production of Hot Water
green	Distribution of energy saving lamps in the domestic sector
green	Rebates on energy efficient domestic appliances
green	Minimum energy efficiency standards for heating equipment in the residential buildings
green	Tax allowances for energy reduction from heating
green	Encouraging the construction of "low energy" and "passive" new residential buildings
green	Grants/financial support for buildings energy audits
green	Energy labelling
green	Public procurement of energy-efficient products
green	Common procurement of energy-efficient products
green	Smart Metering
green	CO2 tax
yellow	Increased natural gas use
yellow	Increased use of renewable energy
yellow	Use of biomass boilers and wood stoves
yellow	Increasing the share of wood in construction
yellow	Economic incentives (for individuals, private and public sector & services) or the purchase of efficient equipment
yellow	Economic incentives for energy efficiency improvements

	Economic incentives for energy efficiency projects (public and private sector)

Table 7: List of measures offering clear cobenefit (green), trade-off (red), or uncertain (yellow) outcome for air quality and climate mitigation in the Waste Sector

Waste treatment	
	Application of ELVs for waste incinerators to all installations incinerating waste
	Minimisation of waste quantities going to landfills
	Emission limit values (ELVs) for TOC, N2O for mechanical biological treatment plants
	Landfill gas flaring and recovery
	Reduction of organic material destined to landfill: composting

4 Case Study on SLCP Action Plans in Nordic Countries

4.1 Introduction

This chapter summarizes the available information regarding existing plans to reduce emissions of SLCPs in the Nordic countries. Information about existing plans, level of implementation, quantification of mitigation, or activities in general associated with reduction of SLCP will be presented when available. Moreover, general information regarding national and international activities carried out in each Nordic country will be presented to provide a general overview of the level of national priority.

Plans and abatement measures taken by the different Nordic countries target sectors such as agriculture (CH_4), waste management (CH_4), residential heating by biomass (BC) and road traffic (BC). These sectors have been pointed out as the main sources of CH_4 and BC, based on the emission inventories.

4.2 Science and Policy Background

Reducing all four SLCPs has the potential to avoid 0.6° C global warming by 2050 and up to 1.5°C of warming by 2100 (Hu et al., 2013). Reducing black carbon, methane and tropospheric ozone has the potential to avoid more than 0.84 °C of warming in the Arctic by 2070, which can cut the rate of global warming by half and the rate of Arctic warming by two thirds (UNEP and WMO, 2011). The rate of global warming has been about 0.13 °C per decade the last 50 years (IPCC, 2007) and the rate of warming in the Arctic is currently at least twice the global average (AMAP, 2011). Black carbon is estimated to be responsible for 50% of Arctic warming, or almost 1°C of the total 1.9°C increase between 1890 and 2007 (Jacobson, 2010). In addition, the climate impact of some of the SLCPs is greater in the regions where they are emitted (Myhre et al., 2013a), calling for special mitigation of emissions close to the Arctic.

Warming in the Arctic may lead to dangerous climate feedbacks that cause warming to accelerate past tipping points. As the reflective ice and snow is replaced with darker heat-absorbing land and ocean, warming amplifies (Flanner et al., 2011) reducing ice and snow cover faster, and creating a dangerous feedback loop (Lenton, 2011). Over the past thirty years the minimum extent of Arctic summer sea ice has decreased by 13% per decade, reaching a new record minimum in 2012, nearly 50% less than the 1979 to 2000 average (AchutaRao K. M., 2013).

Cutting SLCPs is therefore recognised as a critical climate strategy for slowing the rate of climate change over the next several decades and for protecting the people and regions most vulnerable to near-term climate impacts through the end of the century. This is of particular importance in regions most vulnerable to climate change as the Arctic region, as well as for offsetting the near-term warming that results from reductions of cooling aerosols such as sulphates, done to protect human health and ecosystems.

Due to their (and their emissions') proximity to the Arctic, abating SLCP emissions is of especial relevance for the Nordic Countries. In 2012, the Environment ministers of Denmark, Finland, the Faroe Islands, Iceland, Norway, Sweden and Åland met to discuss actions to cut Nordic and Global emissions of SLCP. As a result, the Nordic countries adopted the Svalbard Declaration on SLCP by which:

> *"We, the environment ministers of Denmark, Finland, the Faroe Islands, Iceland, Norway, Sweden and Åland, discussed what we can do to cut global and Nordic emissions of short-lived climate forcers, such as black carbon and methane…*
>
> *Based on our close co-operation and shared values, we, the Nordic environment ministers, will intensify our efforts to reduce emissions of SLCFs at national, regional and global level. We will act as a driving force and work more closely together in international fora to advocate more ambitious international regulation of emissions of greenhouse gases and SLCFs."*

In the Svalbard Declaration, the ministers of the Nordic countries expressed willingness to 1) develop and strength the SLCP national emissions inventories; 2) identify cost-effective initiative to reduce emissions; and 3) evaluate the need for national and Nordic actions plans for emission reductions. This initiative is moreover in synergy with existing regulations that apply to some SLCP, such methane (CH_4) and hydrofluorocarbons (HFCs), which are regulated under the Kyoto Protocol.

At international level, the Nordic countries signed a joint statement with the United States of America (The White House, 2013) by which:

> *"Recognizing the rapid growth of the Climate and Clean Air Coalition over its first 18 months, we note the potential of the Coalition to catalyze significant global reductions of short-lived climate pollutants, which have major impacts on climate change and public health. The U.S. and Nordic members of the Coalition agree to intensify our efforts and invite others to join to take full advantage of the Coalition's potential."*

At international level, the Climate and Clean Air Coalition (CCAC) to reduce SLCP was launched in 2012 by the United Nations Environment Programme (UNEP) and founded by six countries (Bangladesh, Canada, Ghana, Mexico, Sweden and the United States). The aim of CCAC is to catalyse rapid reductions in SLCP to protect human health, agriculture and the environment. All Nordic countries, except Iceland, are partners of the CCAC and, as indicated before, Sweden is one of the founders.

Nordic financial instruments are essential for working forward on the reduction of SLCP. For instance, the Nordic Environment Finance Corporation (NEFCO) is an institution whose main purpose is generate positive environmental effect of interest to the Nordic region by funding projects in Central and Eastern European countries. Among the existing initiatives, a fund is available to finance Russian projects that reduce SLCF emissions, including black carbon. Another Nordic instrument, is the Ecolabel "The Swan", which promotes the purchase of more efficient and lower emission wood and pellets stoves.

The Nordic policy community has strengthened their effort to reduce SLCP such as methane. In 2014 a catalogue of best practises to abate methane emission was published (Norden, 2014). A series of measures were selected taking into account different criteria, for instance; the measure represents one of the sectors considered a major source; it is an actual implemented measure; it is technical (not financial or political instruments); among other criteria. Table 8 shows the selected measures in the best practice catalogue. The specific reason for including each measure in the catalogue and further assessment can be found in the report, along with specific information about the estimated emission reduction (Table 8), and the cost estimates.

Arctic Council created a Task Force for Action on Black Carbon and Methane to develop arrangements on actions to achieve enhanced black carbon and methane emission reductions in the Arctic. The IQALUIT Declaration (2015), signed in April 2015 during the Ministerial Meeting of the Arctic Council, declares that the ministers representing the eight Arctic States:

> *"23. Welcome the assessments and conclusions on black carbon, tropospheric ozone and methane which provide a clear and compelling basis for further action on short-lived climate forcers in the Arctic and beyond, as well as the successful work related to reducing black carbon emissions from diesel and residential wood combustion,*
>
> *24. Decide to implement the Framework for Action on Enhanced Black Carbon and Methane Emissions reductions, establish an expert group reporting to Senior Arctic Officials to report on our collective progress, and call upon observer states to join us in these actions given the global nature of the challenge,…"*

Table 8: Measures to reduce methane presented in the Nordic best practise catalogue (Norden, 2014). [1] reduction due to less diesel use. [2] Reduction due to amount reduce from CH_4 leakage.

Sector	Measure	Country (Location/Plant)	Emission reduction
Ruminant livestock	Production of milk and meat with high productivity combined with high environmental awareness	Sweden (Wapnö Farm)	28.8 tonnes CH_4/yr (10%)
Manure Management	Large-scale biogas production from manure, organic waste and sewage sludge for electricity and heat production	Denmark (Måjberg Biorefinery)	64 tonnes CH_4/yr
	Small-scale biogas production from manure, potatoes and flour for electricity and heat production	Sweden (Lövstad SLU)	0.351 tonnes CH_4/yr
	Full-scale try-outs with biogas production from solid horse manure	Sweden (Sötåsen and JTI)	24 kg CH_4/yr
	Small scale local biogas production with gas distribution pipelines to collective upgrading plants	Sweden (Biogas Brålanda)	
Landfill	Landfill gas collection system and upgrading	Iceland (Alfsnes, SORPA)	2.4 tonnes CH_4/yr[1] 5 305 tonnes CO_2/y 2 506 tonnes CH_4/yr[2]
	Low-Tech biocover system	Denmark (Klintholm losseplads)	76–129 tonnes CH_4/yr (88% - 94%)
	Micro-meteorological methods for efficient recovery of landfill gas and control of emissions	Finland (Päijät-Häme Waste Disposal Ltd., Lathi)	
	Using landfill gas with low methane content to a further extent with an stirling engine	Norway (Yggeset landfill)	90 tonnes CH_4/yr
Wastewater treatment	Increased biogas production through thermal hydrolysis of sludge for digestion	Denmark (Fredericia Spildevand A/S)	
	Sealed tanks for digested sludge	Sweden (Ryaverket, Gryaab)	81 tonnes CH_4/yr
Waste management	Pre-treatment and anaerobic digestion of	Sweden (Uppsala Biogas	3 tonnes CH_4/yr

	organic waste	Plant)
	Voluntary agreement for biogas and upgrading plants	Sweden (Several locations)
Oil and gas	Hydrocarbon blanketing to eliminate VOC emissions	Norway

4.3 Denmark

There is no specific plan to reduce emissions of SLCP in Denmark, and the existing actions to reduce greenhouse gases and air pollutant emissions are in accordance with European legislation and the Danish Climate Policy Plan (DEA, 2013b).

A new Energy Agreement was reached in Denmark in 2012, by which several initiatives were taken to reach a 100% renewable energy in the energy and transport sectors by 2050. Several of these initiatives will contribute to reductions of SLCP.

The Danish Climate Policy Plan is accompanied by a catalogue of mitigation actions (DEA, 2013a). It is worth pointing out that this catalogue includes details about the expected costs and monetized benefits for each measure. Even more relevant to the present context, is the fact that benefits explicitly refer, when appropriate, to external co-benefits beyond climate mitigation.

Denmark has regulatory, economic and information instruments addressing biomass burning for domestic heating in the context of air quality legislation. These instruments are relevant for the reduction of BC. They were originally designed to reduce particulate matter (PM) emissions, and will contribute to the reductions of BC. The maximum allowed PM emissions from new wood stoves is regulated at national level since 2008. The regulation establishes that stoves with and without boilers shall, as a minimum, comply with one of the following emission requirements for particles: 1) 10 g/kg, and maximum emission of 20 g/kg in the individual testing intervals, or 2) 75 mg/normal m3 at 13% of O_2. Moreover and from 2007, subsidies for the development of new technologies are available. Several dissemination campaigns have been carried out since 2006 for a correct use of stoves, with information about the impact of wood burning on heath and the environment.

Measures targeting CH_4 are part of the Danish Climate Policy Objective within Kyoto Protocol and progress was evaluated in 2005 (DME, 2005).

Very little cobenefits are explicitly identified between air pollution and climate change mitigation in the Danish Climate Policy Plan. The only example is given for measures acting to reduce nitrogen leaching and ammonia emission, while reduced nitrous oxide (N_2O) as a greenhouse gas at the same time. No cobenefits is mentioned for ozone pollution from methane emission reduction. The only cobenefits associated to reducing emissions in the transportation sector are associated to reducing congestion and travel time as well as accident under the rationale that “air pollution from new petrol and diesel cars in 2016-2018 will be limited.”

In addition, in the EEA PaM, Energy efficiency is reported to benefit to SOx and NOx emission reduction, but it is warned that development of biogas in the WST sector could increase NOx emissions.

To sum up, even if CH4 and BC emission reductions are indeed part of existing plans in Denmark, their combined impact as SLCP on air quality and climate change is not explicitly mentioned and other cobenefits of GHG mitigation for AP emissions are considered marginal.

4.4 Finland

There is no specific plan to abate emissions of for instance BC and the actions to support reductions of SLCP are based on European Legislation (e.g. for PM). Accordingly, BC is targeted under particulate emission measures such as the EU vehicle emission standards, and more stringent emission limits for non-road mobile machinery are expected.

Some specific national policies on BC have been formulated based on the national research projects on particulate matter, BC and their health effects. Table 9 shows the regulatory instruments existing in Finland to reduce emissions of BC. These instruments were originally implemented for the protection of human health, welfare and the environment. The measures apply to the residential heating sector, and specifically to the use of biomass burning. In addition to the regulatory instruments, information campaigns were carried out in 2007, 2008 and 2012 to promote efficient and environmentally friendly way of using fireplaces and stoves, as well as disseminating health issues related with wood combustion.

Table 9: Regulatory Instruments for reducing BC emissions in Finland.

Instrument	Timeframe	Level	Measure
Regulatory	2000 →	National	The Neighbourhood Act; households shall not be used in a way that causes excessive stress to the neighbourhood with harmful substance like soot, filth, dust, smell, etc.
Regulatory	1994	National	The Heath Protection Act: preventing, reducing and removing factors in the environment that might present health hazards, including among others smell, dust and smoke. The person in charge is obligated to rectify the situation.
Regulatory		National	The Environmental Protection Act (86/2000) and the Waste Act (1072/1993): Municipalities can issue their own regulations concerning small scale combustion. Municipal authority can regulate the use of a stove or even prohibit its use.
Regulatory		National	The Public Order Act (612/2003) authorises the municipalities to regulate the use of solid fuels in specific areas.

Finland updated their energy and climate strategy in 2013 (Finish National Energy and Climate Strategy, 2013), where specific measures and initiatives are formulated for emission reductions of greenhouse gases, therefore including methane and HFCs. Most of these measures apply to the waste sector aiming at 1) reducing the quantity and harmfulness of waste, 2) increasing the recycling and recovery of waste, and 3) reducing the waste disposal in landfills. Subsequently, the placement in landfill of organic and other biodegradable waste will be restricted by 2016, reducing methane emissions and increased waste incineration. For organic waste, strict limits will be imposed on its disposal in landfill and the recovery will be improved. For instance, the utilization of waste as fuel is considered a better option, allowing limiting methane emissions through incineration. As a summary, and according to the Finish National Energy and Climate Strategy (2013):

- The disposal of biodegradable and other organic waste in landfills for conventional waste will be further restricted.
- Implementation of new waste legislation will enhance the prevention of waste generation; promote recycling and the use of waste as recycled material; promote the energy use of waste unsuitable for recycling; and material recovery through an increase in incineration and the production of biogas.
- Emission factors for waste will be examined to determine whether they are up-to-date and whether any review is required.
- Increasing waste recovery must be included as part of regional planning.
- Peat and pulp production, as well as agricultural production have resulted in large amounts of organic sludge at the bottom of water bodies, and continuously releasing methane into the atmosphere. Studies will be launched to investigate the amount of such emissions and possible measures to limit them.

In terms of combined air quality and climate impacts explicitly mentioned in existing policies, efficiency gains in the ENE and improvement of TRA sector are expected to indirectly help improving air quality. On the contrary, the potential increase of PM emission resulting from the development of solid biomass use is small scale combustion devices is identified. In the AGR sector, GHG mitigation is only reported to have cobenefits for water quality and no impact on CH4 or NH3 emission is mentioned.

The situation is therefore similar to other European countries, where BC and CH4 emission reduction are indeed planned, but not explicitly because of their SLCP characteristics. Other co-benefits of climate change mitigation for the general reduction of air pollutant emissions are reported in the EEA Policies and Measure Database.

4.5 Iceland

Iceland does not have specific plans to abate emissions of SLCP. New policy initiatives on environmental issues may be of relevance for the abatement of SLCP, specially the National Action Plan for the Management of solid waste (2013), which is relevant for CH_4 emissions. The Iceland Climate Change Strategy (2007) includes measures that are relevant to reduce SLCP. Accordingly, it establishes that "it is a matter of high priority to reduce the use of fossil fuels in transport and in fisheries to the maximum extent possible and to use electricity or climate friendly fuels such as hydrogen, methane, or biodiesel instead. It is difficult to predict what the technological development will be in this respect, but it is worth pointing out that Iceland's 2002 sustainable development strategy, Welfare for the Future, sets forth the aim that Iceland's use of fossil fuels will be insignificant by the year 2030".

Some of the relevant measures are:

- It is necessary to continue to use economic incentives in order to encourage the purchase of climate-friendly motor vehicles and the use of climate-friendly fuels.

- Ships purchased by the government should be furnished with fuel-saving equipment aiming at increasing efficiency of shipping operations.
- A Study shall be made of the possibility of substituting ammonia for HFCs in the refrigeration system of ships.
- A national plan for waste handling should be implemented, and the resulting reduction in emissions should be assessed.
- Attempts should be made to increase the number of methane-driven automobiles through economic measures and/or government purchases of methane vehicles.
- Methane should be processed for fuel use or combustion in more locations in Iceland if possible.

4.6 Norway

To our knowledge, Norway is the only Nordic country that has developed a complete and specific action plan for the abatement of SLCP up to 2030. The Norwegian Environment Agency performed an integrated assessment of climate, health and environmental effects of Norwegian emissions of SLCP, proposing measures and instruments for reducing such effects by 2030 (NEA, 2013). The Norwegian plan for SLCP does not include measures to reduce CO_2 emissions, which are published elsewhere (NEA, 2010), even though these measures will also reduce SLCP. The purpose of the plan for SLCP is to identify emission reductions that will come in addition to the CO_2 measures.

The SLCP included in the Norwegian plan are BC, tropospheric ozone (O_3), methane (CH_4) and some hydrofluorocarbons (HFCs). Organic carbon (OC) and sulphur dioxide (SO_2) are also included as they are co-emitted with SLCP from some emission sources and they contribute to cooling effects. The climate effects of the Norwegian emissions of these pollutants is shown Figure 4. BC and CH_4 emissions are the highest contributors to warming effects, and the warming effect of HFCs emissions and indirect warming effects of NMVOC and CO as tropospheric ozone precursors are considerably lower. On the other hand, NO_x, SO_2 and OC have cooling effects in the evaluated 10 years perspective.

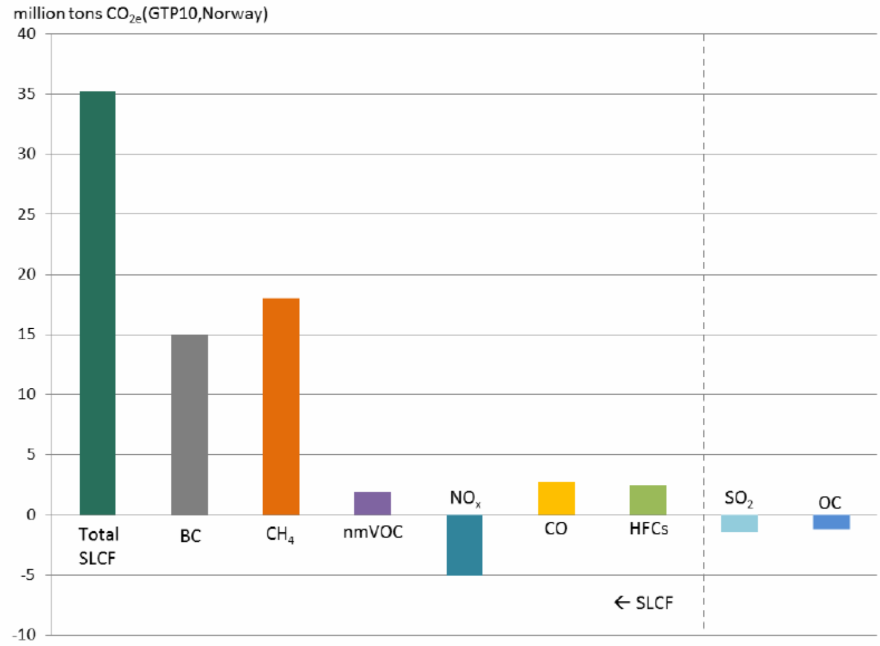

Figure 4: Climate effect (2011) for Norwegian emissions of SLCP, SO_2 and OC expressed as $CO_{2e\ (GTP10,\ Norway)}$ (million tons), (NEA, 2013).

The integrated assessment is carried out taking into account the impacts on; 1) Climate, defined as global atmospheric warming or cooling potential; 2) Health, defined as effects on public health at given pollutant concentrations; and 3) Environment, defined by the effects on crops and forest as consequence of exposure to certain pollutant levels.

Table 10 shows the 18 non-overlapping measures included and assessed in the Norwegian plan to reduce emissions of SLCP, the target compounds and type of instruments. The targeted sectors are agriculture, residential heating, industry, petroleum and HFCs in products. Based on the evaluation of the (NEA, 2013), the transition from red to white meat consumption will involve the highest climate effect (781 ktonnes CO_{2e}/yr), followed by monitored leak control and containment of HFCs (445 ktonnes CO_{2e}/yr). Eight out of the 18 measures have a health effect, and all of them are measures targeting BC emissions. The measure with the highest health effects is the accelerated introduction of new stoves and pellet burners (number 2 in Table 10). Emission reduction effectiveness was evaluated from a qualitative point of view, considering for instance that regulatory instruments are effective, raising awareness are less effective and that the combination of instruments contribute to the effective implementation of measures.

Different reduction strategies have been evaluated. Each strategy takes into account a group of measures from Table 10 that satisfy the selection criteria:

- cost effectiveness as the only selection criteria;
- cost effective measures that has in addition moderate/high emission reduction effectiveness;
- cost/emission reduction effective measures that in addition have moderate or high climate effect;
- cost/emission reduction effective measures that in addition have moderate or high health effect;

- cost/emission reduction effective measures that in addition have moderate/high climate and health effects.

Table 10: Non overlapping measures included in the Norwegian plan to reduce SLCP

#	SECTOR	MEASURE	TARGET COMPOUND	INSTRUMENT
1	Agriculture	Reduced food waste	CH_4	Information, outreach
2	Household Heating	Accelerated introduction of new stoves and pellet burners	BC, OC	Financial support, information, outreach
3	Industry	Energy efficiency in parts of industry	BC, OC	Financial support, information and outreach
4	Agriculture	Transition from red to white meat	CH_4	Financial support (in the production), information (consumer), outreach (consumer)
5	Industry	Improved combustion practices, inspection and maintenance	BC, OC	Inspection, information and outreach
6	HFCs in products	Reducing the filling need and use of HFCs with low climate effects	HFCs	Regulation
7	Transport	Retrofitting of diesel particulate filters (DPFs) on construction machinery	BC	Regulation, Low emission zones
8	Oil Industry	Increase recycling of nmVOCs and methane when loading crude oil offshore	nmVOC, CH4	Regulation, possible financial start-up support
9	Transport	Retrofitting and phasing in of DPFs on coastal vessels	BC	Regulation, financial support
10	Transport	Phasing in and retrofitting DPFs on fishing boats	BC	Regulation, financial support
11	HFCs in products	Monitoring leak control and containment of HFCs	HFCs	Inspection, supervision
12	Oil Industry	Retrofitting and phasing in of DPFs on mobile rigs	BC	Regulation and financial support
13	Industry	Conversion to Freiland process in the silicon carbide industry	CO	Regulation and financial support
14	Transport	Retrofitting of DPFs on light vehicles	BC	Regulation, financial support, low-emission zones
15	Agriculture	Phasing in biogas from manure on buses	BC, CH4	Financial support
16	Transport	Retrofitting of DPFs on tractors	BC	Regulation, financial support
17	Transport	Phasing in biogas from food waste on buses	BC, CH4	Financial support
18	Transport	Retrofitting of DPFs on heavy buses	BC	Regulation, financial support, low-emission zones

Table 11 shows the five different strategies for reducing SLCP, the reduction potential concerning climate change, the health benefit and the reduction in 2030 scenario regarding reference scenario (i.e. $CO_{2e(GTP10,\ Norway)}$ = 31 million tonnes). The first strategy, based on the cost effectiveness as the only criteria, includes 14 out of the 18 non-overlapping measures, all of them under 600 NOK per tonne of $CO_{2e(GTP10,\ Norway)}$. The four measures that are too expensive to be implemented are those regarding biogas and retrofitting of diesel particulate filters (DPFs) on heavy duty vehicles, measures 14 to 18 in Table 10. The strategy only based on the cost effectiveness shows the highest reduction potential (i.e. 3.7 million tonnes/yr;

Table 11), whereas the strategy that only takes into account measures with highest synergies or win-win situations (i.e. measures that are cost effective, and emission reduction effective, and in addition have moderate/high climate effect and have moderate/high health effects) has the lowest reduction potential (i.e. 0.9 million tonnes/yr; Table 11).

To our knowledge, the study carried out by the (NEA, 2013) is the only available assessment in Nordic countries for of different strategies, including both qualitative and quantitative estimates of potential reductions of SLCP and health benefit.

Table 11: Reduction strategies and corresponding effects. The numbers in brackets represent the measures included in each strategy, and indicated in Table 10.

Reduction strategy	Number of measures	Reduction Potential $CO_{2e\ (GTP10,\ Norway)}$ (million tonnes / yr)	SLCP Reduction 2030 scenario	Health Benefit (billion NOK / yr)
Cost effective measures	14	3.7	12%	1.4
Cost and emission reduction effective measures	12 [*2-3, 5-18*]	2.6	8%	1.4
Cost and emission reduction effective measure w/ moderate/high climate effect	5 [*2,7,9,11,14*]	1.7	5%	1.1
Cost and emission reduction effective measure with moderate/high health effect	5 [2,3,5,7,14]	1.1	4%	1.4
Cost and emission reduction effective measure with moderate/high climate and moderate/high health effects	3 [2,7,14]	0.9	3%	1.2

Some of the measures included in Table 10 are already implemented. For instance the accelerated introduction of new stove for wood burning is supported by the emission limit for new stove already introduced in 1998 at national level and the economic support to resident to replace old stove for new ones which is at municipality level. According to Norwegian regulation all stoves to be sold must be tested according to the Norwegian wood stove-testing standard (NS 3058/3059), and prove that their particle emissions are below 10 g/kg dry wood. The emission limit is expected to be changed as a result of ongoing European work on energy-labelling and Eco-design regulations.

Moreover, the Norwegian Environment Agency provides information to the public, especially in the winter season, on best practices for how to operate wood stoves, different technologies, and the health and climate effect of particles and BC. The main dissemination tools have been webpages, films, pamphlets and other media in general.

Another measure that is already implemented in some municipalities is the phasing in biogas from food waste on buses. In Oslo for instance, a plant for producing biomethane from household food waste opened in February 2014 aiming at producing biogas for fuelling 135 buses. Additional domestic regulations and actions currently implemented in Norway to reduce SLCP are:

- Tax on import and production of HFCs; introduced in 2003 and refund scheme in 2004;
- Ban certain uses of HFCs and enforce strict rules to prevent emissions;
- Approvals have to be given for flaring activities in the Petroleum industry by Pollution Control Act and the Petroleum Act.

- Waste management regulation; e.g. prohibition of depositing biodegradable waste, requirements to extract landfill gas and tax on the final treatment of waste.

4.7 Sweden

Sweden is actively working to reduce emissions of SLCP at both national and international level. For instance, Sweden is one of the founding members of the Climate and Clean Air Coalition (CCAC) to reduce SLCP, being actively involved in several of the initiatives.

The Swedish government, through the Ministry of Environment and Energy, has a specific webpage dedicated to SLCP (http://www.regeringen.se/sb/d/16243). The Swedish Meteorological and Hydrological Institute (SMHI) has been commissioned to coordinate Swedish actions on SLCP. The activities are also summarized in a specific webpage with general information regarding SCLP, national and international actions, research projects and contact details (http://www.smhi.se/slcp/det-svenska-slcp-arbetet).

A strategy to reduce emissions of SLCP is available in Sweden and has been recently updated (Miljödepartementet, 2013). The overall objective of the strategy is to reduce the incidence of SLCP, and to disseminate the knowledge about effects of SLCP on climate, health and ecosystem. The strategy aims at: 1) Reducing global and regional warming and the impact on vulnerable regions, particularly the Arctic; 2) Improve global public health by improving air quality; 3) Contribute to improved individual living conditions, particularly for women and children; 4) Reduce ozone negative impact on ecosystems and thus improve food security and economic productivity.

The national and international Swedish efforts to reduce the incidence of SLCP is in synergy with existing environmental targets in the field of air quality[6], reduce climate impact[7] and on sustainable forest[8]. At national level, the Swedish strategy aim at implementing measures to reduce the incidence of SLCP and to support: 1) achieving national environmental objectives, 2) reducing health costs, 3) reducing damage to forests and crops and 4) to lead for increasing international ambitions regarding reduction of SLCP.

The Swedish strategy (Miljödepartementet, 2013) defines measures at national level, plans in the context of Nordic cooperation and initiatives or actions worldwide. The national plan includes:

- Development of better emission inventories for SLCP. Part of the work is to establish a Swedish emission inventory for BC and to improve the emission inventory regarding ozone precursors and methane. This work is also carried out as part of Nordic cooperation.
- Establishing intermediate targets for SLCP under environmental initiatives when relevant.

[6] http://www.miljomal.se/Miljomalen/2-Frisk-luft/Nar-vi-miljokvalitetsmalet/
[7] http://www.miljomal.se/sv/Miljomalen/1-Begransad-klimatpaverkan/
[8] http://www.miljomal.se/sv/Miljomalen/12-Levande-skogar/

- Accomplish the "no-regrets measures", for instance requiring that newly installed wood stoves for domestic heating meet the environmental requirements for the best available technology.
- Identify further concrete mitigation measures based on more accurate assessment of cost effectiveness.

The activities defined as part of Nordic cooperation include:
- Sweden will work to consolidate the Nordic platform and seek Nordic consensus for political involvement to increase efforts to address the reduction of SLCP within EU, CCAC and the Arctic Council.
- Sweden will work on ensuring that knowledge from projects about emission inventories of BC are disseminated within the Nordic cooperation and contribute to increase knowledge of sources outside the Nordic region.

The Swedish strategy defines international activities in the context of Climate and Clean Air Coalition (CCAC):
- Sweden will actively work for that CCAC remains action -oriented, and continues contributing to reduce emissions of and increase knowledge about SLCP in all regions.
- Sweden will keep working to emphasize the importance of national actions.
- A resource group with representatives of authorities will be created to support Sweden's work in CCACs board. The most relevant authorities are the Environmental Protection Agency, Energy Agency, The Swedish International Development Cooperation Agency (Sida), Swedish Meteorological and Hydrological Institute (SMHI), Transport Agency and the Swedish Transport Administration.
- Sweden will initially focus efforts on programs to 1) Reduce SLCP from the municipal waste sector and 2) Reduce BC emissions from heavy diesel vehicles and engines.
- Contribute to the development of new clean stoves.
- Actively participate in outreach activities and information. Continue bilateral dialogue with key countries to increase interest in reducing SLCP emissions.

The specific work in the context of Arctic Council to reduce emission includes:
- Continue the work in the Arctic Council for an agreement to limit emissions SLCP and specifically BC. Sweden should take a leading role in the process of reducing the presence of SLCP and BC in the Arctic, building on international commitments under CLRTAP.
- Continue the work that aims at the Arctic Council and its member countries take measures to reduce the incidence of SLCP.
- Work for that the Arctic Council further examines the effects of SLCP.
- Continued supporting projects in Russia to reduce emissions of BC (e.g. burning of agricultural residues). Support for SLCP - related projects through supporting instruments.

Specific instruments for reducing BC emissions in Sweden are in place. Regulations at national level comprise the Swedish Environmental Code by which anyone using a solid fuel stove is required to ensure that it causes the least amount of pollution by using the best available technology. Moreover, building regulations drawn by the Swedish National Board of Housing apply to solid fuel boilers and comply with European Standard (NS-EN 303-5, 2012). In addition, information at national level regarding wood burning, the use of stoves and health is disseminated through the Swedish Energy Agency website, or through brochures. Economic instruments are not available.

Specific example of SLCP mitigation measures that are already in place in Swedish policies include:

- A landfill tax in place since 2000 in order to reduce the amount of waste disposed of to landfill (SFS 1999:673), which indirectly lead to methane emission reductions;
- Further ordinance on landfilling of waste (2001:512) was introduced in 2002 to ban landfilling of combustible materials and a similar ban was imposed on organic material in 2005. The ordinance also regulates collection and disposal of methane gas from landfills. The aim of the ordinance is to prevent and reduce landfilling adverse effects on human health and the environment. The ordinance reduces emissions of CH4.
- The Swedish Government decided on a new Rural Development Program for the period 2014-2020. The new programme, includes support for investments, for young entrepreneurs, capacity building, cooperation and innovation, support to areas with natural constraints, animal welfare payments, ecological farming and environmental and climate actions. One area of focus is to reduce agricultural emissions of greenhouse gases such as CH4. The programme budget amounts to a total of 36 billion Swedish crowns, of which 59 percent is financed by Sweden and the remaining 41 percent by EU. This instrument helps reducing emissions of CH4.
- Support to biogas production: On 1 January 2015, a support to biogas production from manure was established. The support aims to compensate for the double climate benefit obtained when manure is digested; namely benefit in reduced spontaneous methane emissions from manure and increased production of biogas that can replace fossil fuels. Production of biogas by anaerobic digestion of manure mobilizing a maximum of 20 cents/kWh produced biogas. The measure aims at reducing emissions of CH4.
- Voluntary commitment: In 2007 the Swedish Waste Management and Recycling association introduced a voluntary commitment where facilities included undertake to actively work with mapping and measures to reduce emissions of CH4. This commitment helps reducing emissions of CH4.

5 Case study on air quality and climate cobenefits in the Netherlands

Science institutions in the Netherlands have a long history in bringing the climate change and air pollution fields closer together and try to harvest some of the opportunity to harvest co-benefits of combined policies. The Netherlands are involved in a number of science and policy international cooperation initiatives focussing on SLCP, but at the domestic level, priority is given to cobenefits of climate and air policies in reducing classical greenhouse gases and air pollutants (through, e.g. energy efficiency measures).

The Netherlands hosts institutions that have the capacity to invest on SLCP issues. Research institutes such as RIVM (National Institute for Public Health and the Environment), PBL (Netherlands Environmental Assessment Agency) and KNMI (Royal Netherlands Meteorological Institute) are able to monitoring SLCPs, analysing and modelling policy measures and sharing data with international databases (and vice versa). Continuous measurement of air composition at ground level and by satellite, as well as climate modelling, play an important role in improving our understanding of the impact of policy and measures on air quality and the climate.

On the policy side, The Netherlands support actively the recently started Climate and Clean Air Coalition (CCAC), aimed to reduce SLCP and was launched in 2012 by the United Nations Environment Programme (UNEP). It is also considering developing specific international public-private partnership projects on cutting SLCPs, with a view to creating a snowball effect in regard and setting examples to new initiatives. One of the main international SLCP initiatives in which the Netherlands is involved is a project promoting cleaner cooking stoves, resulting in lower emissions of black carbon and improving public health. Furthermore, the Netherlands contributes to projects promoting biomass and other renewable fuels as alternatives to fuels with higher SLCP emissions.

At the domestic level, there are however no dedicated SLCP action. Nevertheless, it should be emphasized that, beyond SLCPs, air quality and climate mitigation co-impacts are very well identified in the Netherlands. In 2008 a first study to the potential for a combined climate change-air pollution approach was presented as the BOLK-1 study. In the follow-up study, finalized in 2013(Hammingh et al., 2013), the impact of proposed technologies was assessed using a number of scenario's up to 2050. The conclusion of these studies was that climate policies also often lead to less air pollution as well and that these co-benefits for air polluting emissions originate mostly from energy savings, improved energy efficiency, a switch from coal to gas, and use of renewable energy such as wind, solar and hydropower. However, there are also a number of climate measures of which little is known about the co-benefits or disbenefits, together referred to as co-impacts. These measures include use of biofuels in transport, use of biomass, biofuels and biogas in (small scale) stationary installations, combined heat and power generation, and CO2 capture and storage (CCS). National co-impacts of climate policies on air polluting emissions are also influenced by the amount of climate measures that countries might take in another country, through the flexible mechanisms. Any co-impacts associated with these climate measures also occur elsewhere.

Such science-based findings are being gradually transferred into policy. The Dutch methodology used to assess the national effects and costs of new climate and air pollution policies also integrates the synergies and trade-offs between climate policies and air pollutant emissions. It consists of different elements and steps. The first element is formed by the Dutch baseline projections for energy use, agricultural activities and GHGs and air polluting emissions. These baseline projections focus on 2020-2030 and include current climate, energy and air pollution polices. The second element in the Dutch methodology is the Dutch Options Document for Energy and Emissions 2020-2030. It consists of a large number of option descriptions (measures) and an Analysis Tool (Daniëls and Farla, 2006). Most of the options are technical such as CCS at new pulverised coal-fired power plants, but there are also various non-technical options, such as reduction in the maximum speed on motorways. The current option descriptions provide the reduction potentials in 2030 for more than 150 climate, energy and air pollution options. All options are inputs in the Analysis Tool which is the third element in the Dutch methodology. The Analysis Tool (Smekens et al., 2011) uses these options to produce cost optimal option packages towards a set of user-defined targets for CO2, other GHG and the air pollutants - SO2, NOx, NH3, particular matter (PM) and NMVOC. In the BOLK-2 study it was concluded that Climate policies in 2020, may lead to net cost savings for new air quality policy of up to 100 million euros per year. These cost savings are a few percent of the indicated costs in 2020 of current Dutch air quality policies (around 3 billion euros in 2020) or the additional Dutch climate packages (3-9 billion euros in 2020).

6 Overview of integration air quality and climate action plans in other European countries

The present section proposes an overview of Action Plans where cobenefits between air quality and climate were identified for the countries not covered by the Nordic and Netherlands case studies (Sections 0 and 5). A European-wide synthesis will be proposed in Section 7.

The compounds explicitly mentioned in the EEA Plans and Measures Database, or in the ETC survey, as targeted jointly by climate and air quality policies are listed for all countries. The type of mitigation measures discussed by broad activity sectors are: agriculture (AGR), energy supply and use in all sectors (ENE), industry (IND), traffic source (TRA), waste (WST).

Following the scope of the present report to assess the level of awareness and concern about climate and air quality interactions, only **cobenefits or trade-offs explicitly mentioned as such in the EEA database and the ETC survey are included below**.

6.1 Methodology for the overview of SLCP Action Plans

In order to review existing SLCP plans in Europe, a combination of sources at national and international levels were used. The present report includes detailed focus on (i) Nordic countries, and (ii) the Netherlands. For both these countries, relevant information was gather in published material quoted in the corresponding chapters.

For the rest of Europe, an overview of the situation was obtained analysing the EEA Greenhouse Gases Policies and Measure Database, and circulating a specific survey to appropriate stakeholders.

The EEA maintains a database of Policies and Measure (PAM) implemented or planned by European countries to reduce greenhouse gas emissions. Most of these PAMs have been reported to the European Commission, the United Framework Convention on Climate Change (UNFCCC) or the EEA. The search engine gives access to detailed information for each of these PAMs including, in some cases, the expected reductions in greenhouse gas emissions resulting from the implementation of these PAMs, as estimated by countries. The catalogue of measures is available at http://pam.apps.eea.europa.eu/ and the database is available at http://www.eea.europa.eu/data-and-maps/data/climate-change-mitigation-policies-and-measures-1. The version of the database used here is dates 2014-10-28 and includes 1600+ entries. The specific information assessed for the purposed of the present report was included under the fields: (i) Interaction with other policies and measures at the national or EU level, (ii) Details on policy interactions, (iii) Non GHG mitigation benefits.

The survey, entitled “Combined strategies to control climate change and air pollution” was distributed to national experts and environment protection agencies. Recipients included participants to the Workshop on “Improving Black Carbon Emission Estimates and

Abatement" organised jointly by the LRTAP Convention and the Air Quality EIONET network in Milan, May 2015. The list was augmented with selected contacts, in particular for countries not represented at the above workshop. The survey was also relayed by the CCAC Secretariat to selected countries (Finland, France, Germany, Ireland, Italy, The Netherlands, Norway, Poland, Sweden, Switzerland) in order to maximise the response rate.

The specific question asked in this survey are given in Annex A.

It is important to emphasise that the **results analysed in the present report only refer to air pollution and climate mitigation cobenefits explicitly mentioned in the available sources,** whereas such cobenefits could occur without having been identified/highlighted before. To some extent, this synthesis partly reflects the level of awareness of overlaps between air quality and climate mitigation measures in Member States rather than the actual expected efficiency of such measures.

6.2 Austria

Whereas GHG mitigation measures for AGR target CO_2, CH_4 and N_2O, the only cobenefits mentioned regards NH_3 in the context of ecosystem soil and ground water quality, there is no specific mention of co-benefits for air quality. Efficiency measures in the ENE and TRA sectors will yield a general benefit for air pollution. For IND a cobenefit is identified for surface ozone through NMVOC mitigation. In the WST sector, NMVOC reductions are expected to benefit to air quality but there is no explicit mention to CH4.

6.3 Belgium

For AGR, a cobenefit is identified through NH3 emission reductions. Reductions in emissions of SOx, NOx, and PM are expected as a result of energy efficiency and switch to cleaner fuels in the ENE sector. However, potential trade-offs are also pointed out for SOx in agricultural facilities resulting from the development of biomethanisation. For the residential sector, the shift from coal to gas will be beneficial (less PM and SO2 emissions) but a shift from fuel oil to gas leading to less GHG emission might also lead to an increase of NOx emission (because the combustion occurs at higher temperature). But the main trade-off in the residential sector regards PM emissions resulting from residential wood burning that must be considered with care. For TRA, GHG mitigation will largely be beneficial to air quality, except for biofuel promotion which needs to be examined, and also for the promotion of multimodal freight transport which is not so beneficial for NOx and SO2 if old ship engines are used. A potential trade-off is also identified for home working where the balance between emissions by travel to work and emissions due to heating the dwelling during home working ours has to be examined. For WST, a benefit for VOC is pointed out, but there is no specific reference to air quality benefit of reducing CH4. A possible increase in SO2 emissions is identified if biogas from landfill is not treated ahead.

6.4 Bulgaria

GHG mitigation in the AGR sector is expected benefits to environmental protection in general, and CH4 improvement is also explicitly mentioned. ENE efficiency measures and renewable sources such as hydropower are expected to benefit to air quality in general. Moving away from coal will contribute to reduce SOx and PM emissions. Development of

TRA standards will lead to AQ improvement. And CH4 reduction in the WST sector is identified as a generic environmental benefit.

6.5 Cyprus

There is no relevant mention to air quality cobenefits of GHG mitigation in the PaM Database of EEA.

6.6 Czech Republic

The only cobenefits of GHG in the AGR sector regard increasing biodiversity, nature, water and soil protection. There is no specific mention of benefits for air quality from CH4 or NH3 mitigation. Energy savings, improvement of fuel quality and moving to renewable sources will be beneficial to air quality in general, while coal phasing out will help in reducing SOx and PM emissions. TRA improvements are also expected to carry general cobenefits for air pollutant emissions in general (AP). While no such benefit is mentioned for WST.

6.7 Estonia

There is no specific action plan targeting methane mitigation, even if it is included in the annual GHG inventory. In the framework of the Rural Development Plan, investment support is provided for the production of bioenergy, including biogas collection equipment and biogas plants, which will benefit to CH4 emission reductions.

In addition to implementing the regulation (EU) No 517/2014 of the European Parliament and of the council on fluorinated greenhouse gases, Estonia plans to reduce the usage of HFCs in refrigeration sector by promoting use of low GWP and natural alternatives. The Estonian Environmental Ministry has launched project which will have the following outcomes:

- raising the public knowledge of low GWP and natural alternatives (website, seminar for interested companies, analysis of implementation costs and profitability and etc);
- reviewing and improving the certification and training programs for persons involved with refrigeration, air conditioning, heat pumps and other equipment containing fluorinated greenhouse gases

In addition, in the EEA PaM, a general cobenefit in terms of emission of air pollutants (SOx, NOx, NH3, NMVOC and PMs) is expected from improvement in energy efficiency and use of renewable sources.

6.8 France

Two mains type of AGR measures are identified. Some aim to reduce atmospheric nitrogen emission with the co-benefit to also reduce N_2O as a GHG. The others focus on reducing CH4 emissions because of its GHG nature but the co-benefit in terms of AQ is identified. Efficiency gains and further control of maintenance of small scale combustion is expected to improve air quality in general provided that stringent criteria are used for the performance of domestic wood burning appliances. Similarly, further GHG mitigation in the TRA sector is expected to benefit to air quality except measure in favour of bio-methanol use that increase emissions of air pollutant from the AGR sectors.

6.9 Germany

In the AGR sector, cobenefits of the nitrate directive are expected for CO2, CH4, N2O but also for NOx, NH3, and PM. Development of renewable and energy efficiency are expected to yield emission reductions for SOx, NOx and PM. TRA regulation will carry air quality cobenefits in general. While for WST, the main cobenefits are expected for NOx and persistent organic pollutants (POPs).

6.10 Greece

Improvements in the ENE sector will yield indirect benefits for SOx, NOx, NH3, NMVOC and PM emission.

6.11 Hungary

The only reported cobenefits of GHG mitigation in the AGR sector regards water quality. Increase the surface of forested areas will contribute to improve air quality as well as improvement in the TRA and WST sector.

6.12 Ireland

The Irish government aims to develop in 2015 a Clean Air Strategy, which will look at sources of air pollution nationally and how clean air can be achieved. The strategy will include local, regional, transboundary air quality impacts and include climate and air quality interactions. The Department of Environment Community and Local Government (DECLG) is currently drafting a "Clean Air Issues" paper which is intended for public consultation in late 2015.

Beyond Ireland, in relation with its involvement in the CCAC, DECLG and the Irish EPA initiated a small scale research project to review how the existing policy framework and activities with developing countries can trigger SLCP action.

There is no specific Methane action plan even if it will be included as part of several national sectoral mitigation plans (e.g. agriculture, waste) which are a requirement under the recently published Climate Action and Low Carbon Development Bill[9].

The main way in which HFCs are managed in Ireland follows implementation of the European regulation No 517/2014. The Environmental Protection Agency (EPA) is the competent Authority for the F Gas Regulations in Ireland[10].

Under the EU regulation it is required to phase down HFCs, control emissions by mandatory leak checking of equipment over certain thresholds (Article 4), and implementing the bans as outlined in Annex III of the EU Regulation. The HFC phase out will reduce the HFCs on the EU market by 79% based on a 2009 – 2012 baseline.

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[9] http://www.environ.ie/en/Environment/Atmosphere/ClimateChange/News/MainBody,40045,en.htm
[10] http://www.epa.ie/air/airenforcement/ozone/fluorinatedgreenhousegases

In addition, in the EEA PaM, a general benefit for air quality is expected from GHG mitigation in the ENE, TRA and WST sectors, despite a warning on potential increases in PM emission that could result from the use of solid biomass in small scale residential appliances.

6.13 Italy

The only SLCP being mitigated as such is methane, for instance by working on biogas collection from manure management waste management (e.g. recycling, pre-treatment of biodegradable waste, ...). Expected benefits on both air quality and climate change have been taken into account.

In the PaM Database, further benefits in NH3 mitigation for the NEC directive are expected from GHG mitigation in the AGR sector. Improvement for SOx, NOx, PM emission would result from efforts in the ENE sector, and all air pollutant emission would improve under TRA GHG mitigation measures. The only identified trade-off would regard potential increases in PM emission following the development of renewable (wood) in the residential sector.

6.14 Latvia

General cobenefits for air quality are mentioned for the majority of the measures taken under the AGR, ENE and TRA sectors, with no precise reference to a given compound, except for NOx emissions reduction due to Nitrate directive implementation.

6.15 Lithuania

Cobenefits of GHG mitigation are expected for SOx, NOx and PM emissions in the ENE sector related to co-generation and renewable energy promotion, as well as energy efficiency measures. Reduction of NOx emissions in the TRA sector is also identified as a co-benefit of bio-fuel promotion.

6.16 Luxemburg

Cobenefits of GHG mitigation in the ENE sector is expected to benefit to all air pollutant emissions, while in the TRA sector, improvement would occur for NOx and PM emissions.

6.17 Malta

The switch from coal to gas (ENE) will help reducing SOx and PM emissions, while other energy efficiency measures and development of renewable will be benefit to air pollution in general. For TRA a general improvement of air pollutant emissions is also expected. In the WST sector, GHG mitigation will indirectly help improving POP emissions such as dioxins and furans.

6.18 Poland

There is no clear overlap between climate and air quality policies in the answer to the survey or in the EEA PaM. Only air pollutant emission reduction cobenefits are expected from gains in energy efficiency and the development of combined heat and power generation.

6.19 Portugal

There is no relevant mention to air quality cobenefits of GHG mitigation in the PaM Database of EEA.

6.20 Romania

There is no relevant mention to air quality cobenefits of GHG mitigation in the PaM Database of EEA.

6.21 Slovakia

Reduction of NOx, SO2 and PM are expected from gains in energy efficiency promoted in the context of GHG mitigation. Increase of wood combustion in the residential sector is also expected to reduce SO2 emissions and no specific warning is issued for PM emissions in that context. Developments in the TRA sector are expected to contribute to reduction in NOx and PM emissions.

6.22 Slovenia

Benefits in terms of NH3 emission are expected from GHG mitigation in the AGR sector. Cobenefits for air pollution will be obtained thanks to efforts in ENE and IND sectors (especially on SOx, NOx and PM). In the WST sector, methanisation will also contribute to capture landfill gas and reduce emission of SOx and NOx.

6.23 Spain

In the AGR sector, regulation of open air burning will contribute to reduce emissions of SOx, NH3, NOx and NMVOCs. All air pollutants (NOx, SO2, NMVOC, PM, Cd, Hg, Pb) are expected to benefit from energy efficiency measures. Some increases in PM, NOx and NMVOCs could result from the development of renewable. There are large cobenefits for air pollution in the TRA sector, including for aircraft emissions. In the WST sector, NH3 emission could increase because of composting. CH4 would decrease as a result of uptake in landfills, however its burning for the generation of heat or power would generate NOx emissions. In the IND sector, co-benefices are identified from a measured aiming to reduce VOC that also reduce CO2 emissions.

6.24 Switzerland

There is no identified overlap between air quality and climate mitigation plans. BC mitigation is mainly motivated by health protection and therefore considered exclusively as part of air quality plans (with particulate matter in general).

An action plan has been adopted by the federal government in 2006 to introduce diesel particle filter for all diesel engines (stationary and mobile) and to control emissions from wood burning. Measures are currently under implementation for vehicles and stationary sources and partly under development with regard to wood burning.

CH_4 and HFCs emission control are mainly driven by the implementation of the Kyoto protocol and therefore covered under climate policies (e.g. manure management or from solid waste disposal sites).

In addition, in the PaM Database of EEA, general cobenefits in terms of air pollutant emissions are expected from GHG mitigation measures in the TRA sector.

6.25 United Kingdom

The benefits of mitigation action across greenhouse gases and air pollutants are taken into account when developing action plans, but there is no explicit SLCP plan.

For the case of black carbon, it is indirectly reduced because of actions to reduce exposure to particulate matter. Similarly, the main rationale for the large number of actions to reduce methane emission (in agriculture, waste management and heat generation, replacement of gas mains pipework) stems from the greenhouse potential of methane.

In addition, in the PaM of EEA, several cobenefits are mentioned for NH_3 emission in GHG mitigation for the AGR sector. General cobenefits for air pollution are also expected in the ENE sector but no explicit outcomes are reported under TRA and WST activities.

7 Synthesis

7.1 Overview

In this section, we provide a synthetic overview of the level of awareness and concern of EU countries plus Norway and Switzerland on SLCP issues and climate and air quality cobenefits and trade-offs. **It should be emphasised that we deliberately choose to include in the analysis only measures where climate and AQ interactions are explicitly mentioned in the EEA PaM. The only exception regards Norway for which we also included the 18 measures identified in the SLCP Action Plan** (Section 4.6).

Table 12 synthesises the interactions between air quality and climate policies that could be identified from the EEA Policies and Measures database (PaM) and the ETC survey for each EU country plus Norway and Switzerland.

The emitted compounds concerned by such interactions and explicitly mentioned are listed in the table, “AP” is indicated when a general impact on air pollutant emissions is expected from a given GHG measure (without further precision on the emitted species). It should be noticed that HFCs are not listed here as they have no direct impact on AQ. BC is not mentioned here either as it is not mentioned as itself in the PaM database. A difference is made between co-benefits, where air pollutant emission reductions are expected from a GHG mitigation measure (benefit), or on the contrary trade-offs (penalty). The main activity sectors selected for this synthesis are: (i) Agriculture (AGR), (ii) Energy Supply and Use (ENE) in the Industry, Construction, Residential, Commercial and Agricultural sectors altogether, (iii) Industry (IND), (iv) Transport (TRA), (v) Waste (WST).

Countries	Agriculture									Energy Supply & Use (inc RES)													Industry						Transport										Waste										
	Benefit								Penalty	Benefit								Penalty					Benefit					Penalty	Benefit							Penalty			Benefit							Penalty			
	AP	NH3	CH4	SOx	NOx	PM	COV	Others	AP	AP	NH3	CH4	SOx	NOx	PM	COV	Others	AP	SOx	NOx	PM	COV	AP	SOx	NOx	PM	COV	AP	AP	NH3	SOx	NOx	PM	COV	Others	AP	SOx	NOx	AP	NH3	CH4	SOx	NOx	COV	Others	AP	NH3	SOx	NOx
Austria																																																	
Belgium																																																	
Bulgaria																																																	
Croatia																																																	
Cyprus																																																	
Czech Republic																																																	
Denmark																																			C6H6														
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France																																																	
Germany																																													POP				
Greece																																																	
Hungary																																																	
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Sweden																																																	
Switzerland																																																	
United Kingdom																																																	

Table 12: Interactions between air quality and climate policies that could be identified from the EEA Policies and Measures database (PaM), the ETC survey, and available documents.

7.2 Quantitative Analysis

The information provided in the PaM database (1618 measures) plus the 18 measures detailed in the SLCP Action Plan of Norway (not included in the PaM itself) are analysed here to provide a more quantitative overview of (1) GHG/AQ interactions identified in the measures planned in the EU countries (2) the number of measures targeting SLCFs (CH4 and HFC, Black Carbon being absent of the PaM Database).

7.2.1 Identification of GHG/AQ Interactions in European countries

Over the 1618 measures identified as having an impact on GHG, 40% are identified as having also an impact on AQ. In a large majority these interactions constitute cobenefits, only about 3% of the measures are identified as trade-offs (positive impact on GHG mitigation but possible increase of air pollutant emissions).

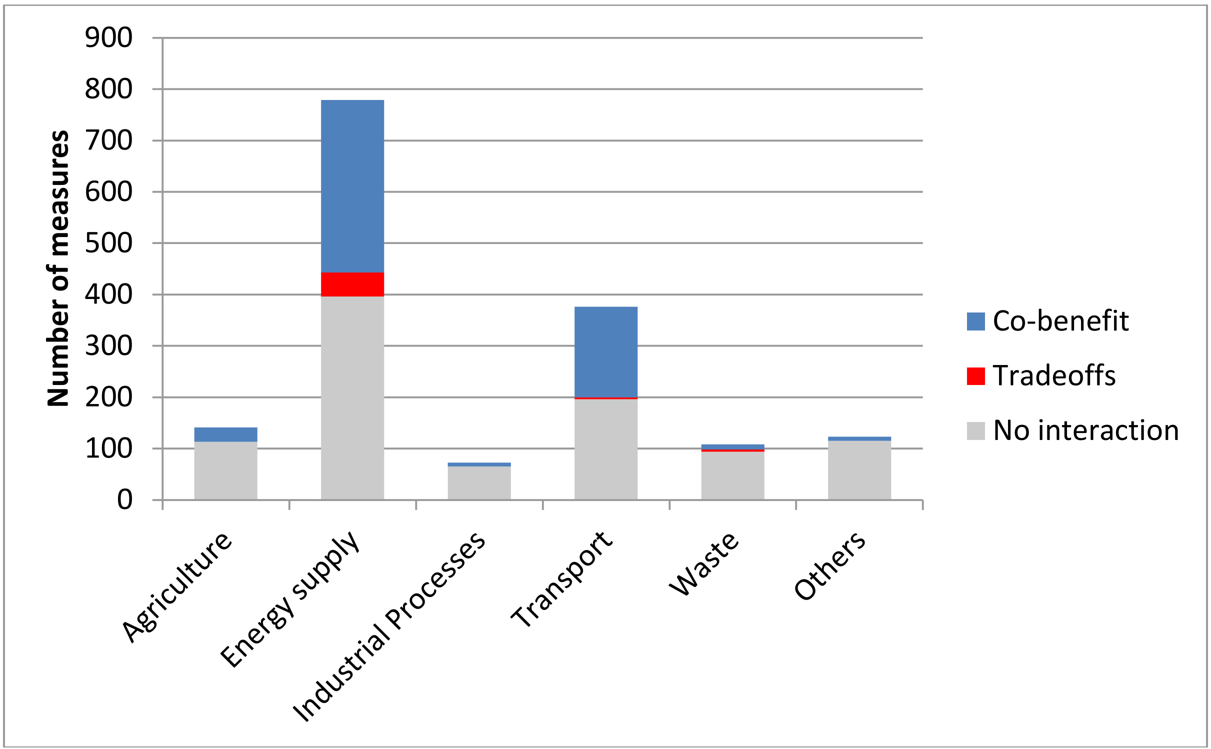

Figure 5: Interactions between AQ and GHG mitigation measures as identified in the PaM database

Such interactions are represented by activity sectors in (Figure 5). For the ENE and TRA sectors, interactions on air pollutants in general are identified in about half of the measures. In AGR, IND or WST, much less interactions are reported although reduction of CH4 is targeted in respectively 44% and 82% of the AGR and WST measures. This demonstrates that CH4 is not well identified as having an impact on air quality. Negative interactions are mainly identified in the ENE sectors, in relation with the development of wood burning as a renewable energy source.

Among the pollutants identified as co-benefit, NOx and PM represent both 27%, SOx 24% and VOC 11% (Figure 6). BC is not explicitly mentioned in the GHG PaM Database but is generally reduced through the reduction of PM emissions. NOx, SOx and VOC are O3 precursors. Indeed, even if O3 is only mentioned a very few times, reductions of its precursors should also reduce its concentration. Reduction of CH4 is almost never pointed out as a co-benefit for AQ even if it represents an important part of the GHG targeted by the measures of the database.

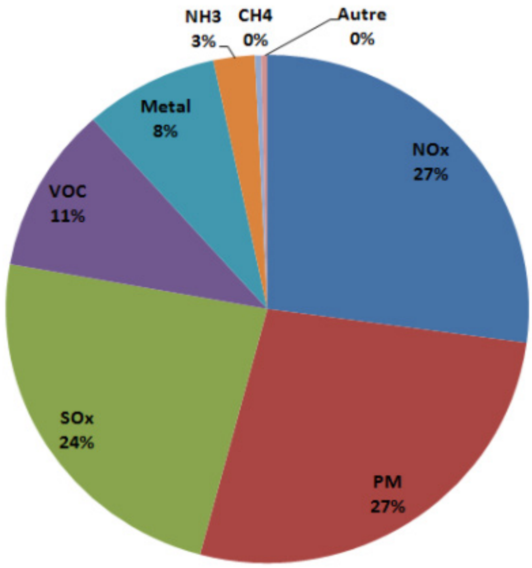

Figure 6: Distribution of the main air pollutant identified as benefiting from a GHG mitigation measure in the EEA PaM database

7.2.2 SLCF mitigation (CH4 and HFC)

Figure 7 gives the distribution of the GHG for which an emission reduction is expected from the different measures of the EEA PaM database. 19% and 6% of the measures aim to reduce the emission of respectively CH4 and HFC. HFC reduction is mainly expected from the IND sectors (Figure 8) with European regulation on F-gas and on HFCs in mobile air conditioning. The ENE sector also contributes, mainly through energy efficiency measures that would reduce the use of air conditioning. Measures from almost any sectors are expected to reduce CH4 emissions. However, the only sectors where CH4 is the main targeted GHG are AGR and WST.

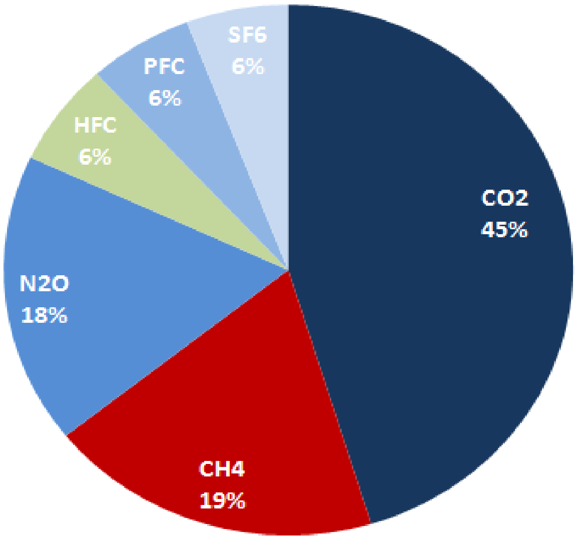

Figure 7: Distribution of the main greenhouse gases listed in the EEA PaM database

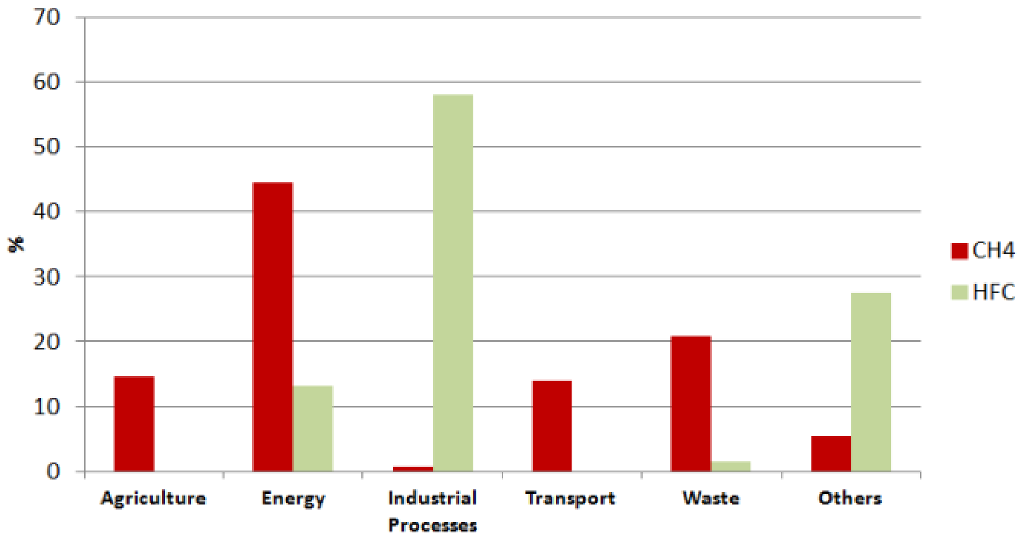

Figure 8: Sectoral distribution of the measures targetting CH4 and HFCs

There are also spatial in-homogeneities in the way SLCFs are accounted for in Europe. Table 13 summarizes for each European country the number of measures aiming to reduce CH4 or HFC emissions because of their GHG nature. Over Europe, only Luxembourg does not report any measure aiming to reduce CH4. Concerning HFC, 8 countries does not report any measure for HFC reduction.

Targeted GES	Austria	Belgium	Bulgaria	Cyprus	Czech Republic	Denmark	Estonia	Finland	France	Germany	Greece	Hungary	Ireland	Italy	Latvia
CH4	14	7	17	21	19	9	12	11	22	9	3	5	56	2	2
HFC	5	4	1	0	0	3	0	3	8	4	0	0	1	0	1

Targeted GES	Lithuania	Luxem-bourg	Malta	Nether-lands	Norway	Poland	Portugal	Romania	Slovakia	Slovenia	Spain	Sweden	Switzer-land	United Kingdom
CH4	2	0	51	3	7	7	3	13	22	5	42	5	2	47
HFC	0	0	1	2	1	1	2	1	0	4	4	2	2	2

Table 13: Number of measures targeting CH4 and HFC in European countries, as reported in the EEA GHG PaM database.

8 Annex 1: Web Survey on National SLCP Plans

This annex provides the list of question raised in the survey circulated to national experts and representatives to inquire about the state of concern about SLCP Action Plans in Europe.

Introduction

Some of the chemical species emitted in the atmosphere by human activities have both an impact on climate change and air quality. Such species include black carbon, methane and several hydrofluorocarbons and are referred to as Short-Lived Climate Pollutants.

The European Environment Agency would like to better understand the concern of European countries about short-lived climate pollutants. It has therefore asked the European Topic Centre on Air and Climate Mitigation to investigate:

- which European countries are considering SLCP mitigation,
- if yes, whether such initiative are conducted in dedicated plans or jointly with other environmental policies,
- what are the expected impacts.

The present survey is being sent to all EEA member countries, we would very much appreciate your input on the basis of your best knowledge of current status and plans in your country.

Indicate for which country you are filling this survey, and if you work for an official policy authority or as a national expert [open text answer]

Emission Inventory

Tick boxes if there is an emission inventory in your country for:

- Black carbon
- Methane
- Hydrofluorocarbons

SLCP Action Plan

Is there a dedicated Action Plan targetting specifically SLCPs because of their joint impact on climate change and air pollution in your country ? or is such a plan currently being drafted ? [yes/no]

If a SLCP Action Plan exists

Which SLCP are included in the plan? [Black Carbon, Methane, Hydrofluorocarbons, Other]
What is the list of planned measures per pollutant ?
What is the level of implementation of the plan (city, national,...) ?

Have you quantified the emission reduction potential of implementing the action plan or individual measures ?
Have you quantified the expected impact for climate change ?
Have you quantified the expected impact for air quality ?
Have you performed a cost-benefit analysis of the plan ?
Does this plan overlap with any other Action Plan (e.g. on air quality, climate change...)?

If a SLCP Action Plan does not exists

Is the development of such a plan considered in the near future?
Is black carbon included in any other action plan (e.g. on air quality, climate change...)?
Is methane included in any other action plan (e.g. on air quality, climate change...)?
Are hydrofluorocarbons included in any other action plan (e.g. on air quality, climate change...)?

Conclusion

Thank you for your contribution, please provide your contact details and links to any relevant reference. Additional material can be sent via email to augustin.colette@ineris.fr

Results

Responses to the survey were kindly provided by the following experts, whose participation to this initiative is gratefully acknowledged:

- Denmark: Ole-Kenneth Nielsen, from Aarhus University, responsible for the Official Emission Inventories and Projections Reporting;
- Estonia: Estonian Environment Agency, responsible for the national emission inventory compilation under LRTAP;
- Ireland: David Dodd, Science Policy Advisor at the Department of Environment Community and Local Government (DECLG) of the Ministry in charge of Environment;
- Italy Ricardo Delauretis from Ispra Ambiente, National Expert participating to LRTAP;
- Norway: Vigdis Vestreng and Maria Kvalevag from the Norvegian EPA;
- Poland: Bozen Adamska from the Ministry of Environment;
- The Netherlands: Anonymous answer;
- Sweden: Anna Forsgren from the Swedish EPA;
- Switzerland: Regine Röthlisberger, Beat Mueller, and Richard Ballaman, from the Federal Office for the Environment;
- United Kingdom: Chris Dore, National Expert under LRTAP.

9 Annex 2: List of measures with identified trade-off or benefit for air quality and climate mitigation

This annex presents the detailed results of the analysis of measures and instruments having an impact on both air quality and climate change as reported by countries in the EEA GHG PaM Database and from earlier work collecting information from international literature (studies, but also BREF documents[11]) and French policy plans and presented in (Bessagnet et al., 2009).

We have tried to be as comprehensive as possible, summarising where different countries reported comparable (although not identical) measures. Various policy instruments reported in the database aim at the implementation of several measures simultaneously (e.g. reduction in energy consumption plus use of renewable energy sources). Given that the reported impact on air pollutants (APs) and greenhouse gases (GHGs) is therefore a combined effect of several measures these instruments are not reported in the following tables.

While the initial aim was to identify measures (e.g. “increase energy efficiency of buildings”) aimed at emissions reductions, the EEA GHG PaM Database frequently focuses on policy instruments developed to reduce emissions (e.g. “Directive on energy performance of buildings”). In the following a specific focus was set on measures, but the tables also report examples of policy instruments, without however trying to be comprehensive. A main reason for this is that the implementation of a given measure can frequently be attained by a whole panel of different policy instruments (regulatory, economic, voluntary, information based ...) and that the exact design within each instrument type differs across countries (e.g. for economic instruments tax, subsidy, tax allowance/deduction, grants ...).

A number of further methodological issues need to be stated: In order to correctly qualify the degree of synergy of a given measure, it would be necessary to take into account the annual change of emissions (relative variation and absolute change), the stability of this effect over time and the impact on local air quality. This is outside the scope of the current work and only the information available on reductions or increases in emissions are taken into account. Furthermore, for a strict assessment of the impact of a given measure on air pollution and climate change the whole life cycle (from the cradle to the grave) would have to be taken into account. The lifecycle view is equally outside the scope of this report.

The assessment of measures presented hereafter relies primarily on the information provided by countries in the EEA GHG PaM Database. When assessments differ across countries, the different views are generally indicated. Different assessments by countries of an identical measure are either accounted for by directly indicating possible contradictory results or by reporting pollutants and greenhouse gases for which an effect is reported by some countries but not by others in brackets.

[11] http://eippcb.jrc.ec.europa.eu/reference/

In the detailed tables we classify measures according to different types, such as technical measures (differentiating where applicable between primary and end-of-pipe measures), structural measures or behavioural change measures... When presenting policy instruments, we also indicate the type of instruments (see above). Sometimes the distinction between measure and instrument is blurred, and this is also reflected in the tables.

9.1 Energy sector

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
CO_2 Capture	Technical / End-of-pipe measure	Post-combustion (extraction with solvents)	↓ SO_2 which is removed as an impurity by the post-combustion unit; ↑NOx possible due to energy efficiency penalty, ↑ NH_3 by solvent degradation	↓ CO_2 by definition despite efficiency penalties	Measure difficult to classify. Considered rather as win/win measure by some experts, despite the energy penalty and need for additional treatments (NOx, NH_3). Others put emphasis on trade-offs with APs. Its effectiveness would depend on the type of installation: the efficiency penalty is higher for coal plants than for gas plants. Future performance of oxy-combustion and pre-combustion processes unknown.
		Oxy-combustion (emerging technology)	↓ NOx and PM possible for the same reasons; ↑ NOx possible due to higher energy consumption for the process and the CO_2 transport		
		Pre-combustion (emerging technology, conversion of fuel into a synthesis gas)			
Flue gas desulphurisation (FGD)	Technical / End-of-pipe measure	SO_2 capture	↓ SO_2; ↓ PM	↑ CO_2 as increase in electricity consumption and net production of CO_2 for processes using wet/limestone scrubbers	Measure with trade-offs: reduction of air emissions at the expense of CO_2 emissions
Selective Catalytic Reduction (SCR)	Technical / End-of-pipe measure	NOx reduction by injection of ammonia	↓ NOx ; ↑ NH_3 by definition	↑ N_2O ; ↑ CO_2 due to increased electricity consumption	Measure with trade-offs. Nevertheless, according to the BREF "Economic and Cross Media Effects", the overall environmental balance of SCR can in some cases be positive,

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
					despite the trade-offs.
Selective non catalytic reduction (SNCR)	Technical / End-of-pipe measure	NOx reduction by injection of ammonia or urea	↓ NOx ; ↑ NH3 by definition	↑ N2O	Measure with trade-offs. Nevertheless, according to the BREF "Economic and Cross Media Effects", the overall environmental balance of SNCR can in some cases be positive, despite the trade-offs.
Low excess air	Technical / primary measure	Reduction of NOx emissions by reducing the amount of oxygen available in the combustion zone	↓ NOx, SO3; risk of incomplete combustion and increase of unburned carbon in the ash (e.g. carbon and carbonaceous particles) and of CO formation	No need for additional energy	Measure rather without trade-offs, but not synergetic either.
Low NOx burners	Technical / primary measure	Reduction of NOx by modifying the means of introducing air and fuel to delay the mixing, reduce the availability of oxygen, and reduce the peak flame temperature	↓ NOx ; Risk of unburned carbon in the ash and of CO formation	Possible ↑ CO2 due to increase in energy consumption for external recirculation of flue-gases	No real synergy. Trade-offs possible under certain conditions.

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
Flue gas recirculation	Technical / primary measure	Reduction of NOx through a reduction of the available oxygen in the combustion zone and decrease of flame temperature	↓ NOx	Risk of ↑ CO2 when excessive amounts of gas are being recirculated due to increased energy consumption for the ventilators	No real synergy. Trade-offs possible under certain conditions.
Fuel staging (reburning)	Technical / primary measure	Reduction of NOx emissions based on creation of different burning zones in the furnace by staged injection of fuel and air	↓ NOx; risk of hydrogen cyanide (HCN) and ammonia (NH3) formation, risk of incomplete combustion which can be reduced by using gas as fuel and by applying the measure in boilers having a long residence time	↑ CO2, possibility of higher consumption of reburning fuel	No real synergy. Trade-offs possible.
Reduced air preheat	Technical / primary measure	Reduction of NOx emissions due to reduced flame temperature in the combustion zone	↓ NOx	↑ CO2; risk of increased fuel consumption because a higher portion of the thermal energy contained in the flue-gas cannot be used and ends up escaping through the stack. This risk can be reduced by applying energy conservation methods.	Measure with potential trade-offs.

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
Use of biomass	Structural measure	Reduction of carbon emissions through substitution of fossil fuels by biomass energy	Mixed and often negative effects; ↑ PM proven and possibly ↑ of other air pollutants. The effects depend on the type and origin of the biomass and on the installations in which they are used.	↓ CO_2 (CH_4, N_2O)	Measure tending to involve trade-offs that can be reduced by the use of highly efficient and therefore expensive technologies
		Combined Combustion: replacement of coal	↓ SO_2 and of other air pollutants due to the sulphur content generally being lower than that of coal and when installations are equipped with sophisticated emission reduction systems		
		Combined Combustion: replacement of gas	↑ air pollution, assuming that emission reduction technologies installed on these types of facilities are less efficient		

Measure/instrument	**Type**	**Description**	**Effect on air pollutant emissions**	**Effect on greenhouse gas emissions**	**Conclusion / comment**
Electricity production from renewable energy sources	Structural measure	Promotion of electricity production from renewable energy sources by granting fixed feed-in tariffs for various forms of biomass transformation and power production by wind, water, geothermal energy and photovoltaic.	Improvement in AQ in general (however, for biomass this may depend on the energy carrier substituted for, for photovoltaic there may be relevant life cycle emissions)	↓ CO_2 (CH_4, N_2O)	Measure with potential for synergetic effects. Other effects: energy security, reduces import dependency, increases availability of power supply capacities, improves electricity supply diversification, increases share of electricity production from domestic sources.
Electricity production from biomass, biogas, renewable MSW	Structural measure	Increase power generation from biomass, biogas and renewable MSW to reduce fossil fuel consumption and improve self-sufficiency	↓ SO_2, ↑ PM, NO_x, NMVOC	↓ CO_2, CH_4, N_2O	Measure with trade-offs.
Renewable energy use	Structural measure	Objective: increase RES share.	Some state an improvement for AQ in general others a threat. Increased combustion of biomass will increase particulate matter emissions without proper abatement.	↓ CO_2 (CH_4, N_2O)	Measure with potential for synergetic effects, but not guaranteed at the minimum for PM emissions (biomass).

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
Use of fuel wood	Structural measure	Wood combustion in household appliances	↑ PM, PAHs, NMVOCs, NOx, dioxins and furans which depends on the type of installation and wood used	↓ CO_2 ; Carbon neutral if the wood chain is taken into account. However, the effect of increased VOC emissions, which are ozone precursors, is to be deducted from the GHG balance.	Measure involving trade-offs: reduction of CO_2 emissions at the expense of air pollutants. The degree of the trade-off depends on the fuel substituted, the wood type and the type of installation.
Use of fuel wood by municipalities	Structural measure	Increase use of wood energy installations (wood heat generators, gasification of wood chips, other valorisation techniques) in municipalities	↑ PM	↓ CO_2	Measure with trade-offs.
Use of hydro energy	Structural measure	Reduction in emissions due to hydro energy use	Improvement in AQ in general	↓ CO_2 (CH_4, N_2O)	Measure with synergetic effect.
Use of geothermal energy	Structural measure	Expansion of geothermal energy use for heat supply from district heating	↓ SOx, NOx, PM	↓ CO_2, CH_4, N_2O	Measure with synergetic effect.
Use of photovoltaic energy	Structural measure	Expansion of photovoltaic plants	↓ SOx, NOx, PM (improvement in AQ in general)	↓ CO_2 (CH_4, N_2O)	Measure with synergetic effect.

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
Use of solar thermal energy	Structural measure	Objective: Increase solar power generation to reduce fossil fuel consumption and improve self-sufficiency.	↓ NOx, SOx, VOC, PM, Cd, Hg, Pb	↓ CO2, CH4, N2O	Measure with synergetic effect.
Electricity from wind turbines/wind parks (on-shore/off-shore)	Structural measure	Reduction in emissions due to wind energy use	Improvement in AQ in general (↓ SOx, NOx)	↓ CO2 (CH4, N2O)	Measure with synergetic effect.
Low sulphur coal	Structural / technical measure	Reduction of SO2 emissions by fuel substitution	↓ SO2; If the low sulphur coal is imported from distant countries, the impact of additional transport could be negative	If the coal is imported from distant countries, the impact of additional transport could be negative	Measure a priori without synergistic effect; Other effects: possibility of ash modification for coals with sulphur content of less than 4%, which could affect the performance of electrostatic precipitators
Fuel substitution – from coal to natural gas	Structural measure	Reduction of emissions due to fuel substitution	↓ SOx, PM	↓ CO2 (CH4, NO2)	Measure with synergetic effect.
Reduction of emissions from gas networks	Technical measure	Emission reduction through a reduction of leaks from the natural gas distribution network	Negligible effect a priori	↓ GHG (especially CH4)	Measure a priori with neither significant synergies nor trade-offs

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
Reduction of emissions from electricity transmission and distribution	Technical measure	Emission reduction through decreasing of losses in the distribution and transmission networks	Improvement in AQ in general	↓ CO_2	Measure with synergetic effect.
Modernisation of electricity transmission and distribution grid	Technical measure	Reducing energy losses through the modernization of the national electricity transmission and distribution grid	↓ SO_x, NO_x, PM	↓ CO_2	Measure with synergetic effect.
Biomethanisation	Technical measure/Production technology	Develop biomethanisation in agricultural establishments	Impact on air pollutants has to be investigated. For instance, there could be risks of SO_x emissions.	↓ CO_2	Measure potentially entailing trade-offs.
CHP - Combined Heat and Power	Technical measure/Production technology	Highly efficient method for electricity and heat generation	Potential ↓ AP (SO_x, NO_x ; depends on the fuels used). Reduced energy demand will reduce emissions of air pollutants also. However increased combustion of biomass will increase particulate matter emissions.	↓ CO_2, (CH_4, N_2O)	Measure with synergetic potential, but not guaranteed. Requires local heat demand (closeness to industrial processes or residential areas)
IGCC - Integrated gasification combined cycle plant	Technical measure/Production technology	High efficiency coal combustion using a pressurized reactor	↓ SO_2 ; ↓ NO_x (compared to conventional coal-fired plants); ↓ PM	↓ CO_2	Measure with synergetic potential. Production of a synthesis gas (mixture of CO, H_2, CO_2).

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
Use of circulating fluidized bed combustion in oil shale boilers	Technical measure (production technology)	Replacing of oil shale boilers of conventional pulverized combustion technology with the ones utilizing the circulating fluidized bed combustion	↓ SOx	↓ CO2, N2O	Measure with synergetic effect.
Replacement of old by new power plants	Technical measure (production technology)	Gradual decommissioning of old inefficient thermal power units and commissioning of new ones	↓ SOx, NOx, PM, NH3, VOC	↓ CO2 (CH4, N2O)	Measure with synergetic effect.
Improvement of production efficiency in existing coal-fired power plants	Technical / energy efficiency measure		↓ SOx and PM	↓ CO2	Measure with synergetic effect.
Consumption of electrical household appliances	Technical / energy efficiency measure	Reduced consumption of the devices (exclude from the market the most energy consuming equipment, elimination of standby mode of devices, ...)	↓ air pollution (emissions avoided due to reduced electricity production and reduction in consumption)	↓ GHG (emissions avoided due to reduced electricity production and reduction in consumption)	Synergetic/win-win measure
Ecodesign	Technical measure	Reduction in emissions through improvement in energy efficiency	Improvement in AQ in general	↓ CO2	Measure with synergetic effect.
Improvement in energy efficiency	Technical measure	Reduction in emissions through improvement in energy efficiency	Improvement in AQ in general (less emissions through energy	↓ CO2	Measure with synergetic effect.

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
			savings)		
Energy efficiency in district heating plants	Technical measure	More effective use of fuel in the DH system, reducing energy loss and emissions	Improvement in AQ in general	↓ CO_2	Measure with synergetic effect.
Interconnection of islands to mainland's/European electrical grid	Technical measure		↓ SO_x, NO_x, NH_3, NMVOC and Particulates (especially ↓NO_x)	↓ CO_2 (CH_4, N_2O)	Measure with synergetic effect.
Energy certificates	Regulatory instrument (Technical / structural measure)	Obligation for energy suppliers to achieve energy savings (or to have them achieved by their clients) for which they obtain certificates	↓ air pollution from the production and use of energy owing to energy savings	↓ GHG from the production and use of energy owing to energy savings	Win-win measure to the extent that certificates lead to energy savings
		Certificates may also be obtained for substitution of a non-renewable energy source by a renewable source	↑ ↓ AP	A priori CO_2 ↓	Measure with potential trade-offs (e.g. in case of an increase in biomass / wood as energy source)

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
Green and/or CHP certificates	Regulatory/economic instrument	Green certificates allocated to producers of green electricity that avoid the emission of a fixed amount of CO_2 from a reference fossil fuel plant (natural gas CCGT). In case of failure, a penalty fee is due. Similar process for CHP. Creation of a market for green certificates for the benefit of green electricity producers. Share of electricity sales to be covered by RES and/or high efficiency CHP. Guaranteed minimum income for suppliers of green energy.	↓ NOx, SOx and PM emissions reduced as RES electricity production is substituted to fossil fuel combustion	↓ CO_2	Instrument with synergetic effects.
Electricity production from renewable energy sources and CHP	Economic instrument	Financial support for electricity generation from RES through subsidies	↓ NOx, SOx and PM emissions reduced as RES electricity production is substituted to fossil fuel combustion	↓ CO_2	Measure with synergetic effects
Electricity produced from renewable energy sources	Economic instrument	Preferential feed-in tariffs for electricity produced from renewable energy sources	↓ PM, SO_2 through replacement of fossil fuels, especially coal.	↓ CO_2	Instrument with potential for synergetic effects, especially when substitution for coal.

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
ETS - Emission Trading Scheme	Economic instrument	Limit the CO_2 emissions of large power plants and industrial plants through a trading mechanism for emission certificates (quotas)	Improvement AQ in General. ↓ NOx, SOx and PM emissions through energy savings that reduce the amount of fossil fuel combusted.	↓ CO_2, (CH_4)	Instrument with potential for synergetic effects.
Energy tax based on carbon content/CO_2 tax	Economic instrument	Taxation of energy according to its carbon content	↓ AP if the instrument encourages more efficient energy use; ↑ APs possible if the instrument encourages fuel substitutions (in particular biomass)	CO_2 ↓	Measure with potential trade-offs (e.g. if the instrument increases the use of biofuels or biomass)
End of tax exemption on coal and heavy fuel	Economic instrument	Objective to discourage the use of coal and heavy fuel in power plants	↓ NOx, SOx and PM emissions reduced as RES electricity production is substituted to fossil fuel combustion	↓ CO_2	Measure with synergetic effects
Tax on NOx emissions	Economic instrument	To provide economic incentives to reduce noxious air emissions (synergy with CO_2 reduction) by the use of more energy efficient and less polluting technologies	↓ AP in general	↓ CO_2	Measure with synergetic effects

Measure/instrument	**Type**	**Description**	**Effect on air pollutant emissions**	**Effect on greenhouse gas emissions**	**Conclusion / comment**
Taxation on energy for electricity generation	Economic instrument	Objective: reduce the tariff deficit from policies promoting cogeneration and electricity generation from renewable sources, although the effect is estimated to reduce the current net export of electricity, which will lower generation needs	↓ NOx, SOx, VOC, PM, Cd, Hg, Pb through reduced energy consumption/electricity generation	↓ CO_2, CH_4, N_2O	Measure with synergetic effects
Reduced VAT for subscriptions to district heating	Economic instrument	Reduce the VAT rate for urban heating to the same rate as for gas and electricity	Potential ↑ AP if the instrument contributes to the development of district heating based on wood depends also on the type of energy replaced for wood)	↓ CO_2 priori	Measure with potential trade-offs
		The reduced VAT rate also applies to heat supplies based at least to 50% on biomass, geothermal energy, waste energy and energy recovery	Potential ↑ AP to the extent that the reduction in the heating bill increases energy consumption (possible rebound effects)	Potential ↑ GHG to the extent that the reduction in the heating bill increases energy consumption (possible rebound effects)	

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
Facilitators services for RES and CHP promotion	Informational/ Educational instrument	Facilitators perform promotional actions and provide guidance and technical support to projects holders; exists for each RES technology (windmills, biomethanisation, wood energy, bio-fuels, mini hydro-electricity, PV electricity, ... as well as for CHP	↓ NOx, SOx and PM emissions reduced as energy savings reduce the amount of fossil fuel combusted	↓ CO2	Measure with synergetic effects
Energy planning by electricity producers	Regulatory/planning instrument	Energy efficiency improvement and GHG emission reductions in the electricity production sector.	↓ NOx, SOx and PM emissions reduced as energy savings reduce the amount of fossil fuel combusted	↓ CO2	Measure with synergetic effects
Energy labelling of household electrical appliances	Informational/ Educational instrument	Objective: Convincing consumers to buy more energy efficient household appliances through offering necessary information for decisions on purchases.	↓ AP emissions through decrease in energy consumption.	↓ CO2	Measure with synergetic effects

9.2 Transport

9.2.1 Transport: Road/non-road

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
New road-vehicle engines	Technical measure	Reduction of CO_2 emissions through progress of motorization	↑ ↓ AP depending on the type of technology adopted	CO_2 ↓	Synergistic effects not guaranteed and even potential trade-offs because the links between CO_2 and air pollutant emissions (PM, NO_x and NMVOC) are highly variable and complex for car and truck engines
European Emission Standards	Regulatory instrument	Implementation of European standards on car emission (EURO 5 and EURO 6 in particular)	↓ AP	↓ CO_2	Synergetic effects.
Engine oils with low viscosity	Technical measure	CO_2 reduction through reduction in fuel consumption	↓ AP linked to the reduction of fuel consumption	↓ CO_2	Potentially synergetic measure, but positive effect on AP emissions of vehicles not guaranteed; Reduction in AP linked to possible reduction in fuel consumption

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
CO_2 emissions label	Information instrument	Instrument (CO_2 label with different classes) to encourage consumers to purchase vehicles emitting less CO_2	↓ ↑ AP	↓ CO_2	Synergetic effect not guaranteed, potential of trade-offs. AP emissions of the vehicle (especially PM) may be affected in different ways and differ from the CO_2 emission trends. Possible counterproductive effect of labelling limited to GHGs, e.g. trend towards more diesel vehicles emitting more PM and NO_x. A differentiation of the label between diesel and petrol, or according to also AP emissions would be preferable.
Increase of technical inspections	Technical measure	Strengthening of technical inspections at the road side, especially with respect to measurement of pollutant emissions (the measure pre-supposes the establishment of control areas designed for this purpose)	Effects dependent on the criteria aimed at by the technical inspections	Effects dependent on the criteria aimed at by the technical inspections	Synergetic effects possible but not guaranteed. Synergies possibly achievable if the inspections focus on correct functioning of emission control measures and the right engine setting.

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
Connecting coaches to the electric grid during prolonged stops	Technical/fuel choice measure	Reducing emissions through engine shutdown while maintaining on-board services, especially air conditioning	↓ AP	↓ CO_2	Measure with synergetic effects for AP and GHGs the importance of which depends however on the energy mix used to produce electricity and on the fuel used by the coach (which is substituted during stops). Note that shutting down on board services (and thus of the motor) during long bus stops, especially of heating and air conditioning, would be more efficient.
Reduction of sulphur content in fuels	Technical/structural measure	Transposition of European fuel quality Directives	↓ SO_2, NO_x	CO_2 ↑ (these trade-offs are not identified by all countries)	Measure entailing trade-offs over the complete product chain; Reducing the sulphur content in fuels is an energy intensive process, increasing refinery emissions
Electric mobility	Technical/structural measure	Development and use of clean, and at least partly electrified vehicles for private, public and commercial traffic, as well as the intelligent integration of innovative mobility offers and services	↓ AP	↓ CO_2	Measure a priori with synergetic effects. Effects will depend on the energy sources from which electricity is generated (energy mix)

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
Increased number of filling stations equipped with petrol vapour recovery	Technical measure	Lowering the threshold for the petrol flow rate from which on a recovery of diffuse VOC emissions during refuelling of vehicles is implemented	VOC ↓	Difficult to assess, the effects of VOC emissions on climate are complex and may be positive or negative	Assessment of the measure requires an analysis of the radiative transfer properties of VOCs and of the pollutants for which VOCs are precursors (ozone, secondary organic aerosols)
Development of renewable energy: biofuels	Structural measure	Increase in the share of renewable energy in final energy demand to reduce CO_2 emissions: Biodiesel, Bioethanol	↑ PM10, NOx, NH_3 (↓ SO_2 possible) from exhaust	↑↓ CO_2, N_2O over the life cycle possible, ↓CO_2 from exhaust	Measure with important trade-offs, or even negative effects for air pollution and climate change (for the 1st generation biofuels). Measure with negative impact on pollutant emissions from agriculture also. Not all countries identify these trade-offs.
Phase out of fuel oil use by local transport	Structural measure	Replacement by Diester30 fuel (70% diesel and 30% Vegetable Oil Methyl Esther [FAME]); tests with Diester100 and with vehicles running on Ethanol 95 (E95)	↑ AP possible if the result is comparable to the use of biofuels in cars	↓ CO_2	Measure with potential trade-offs. Effects on AP might improve through an optimisation of the engines for the use of these fuels

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
Increase of the share of public transport or non-motorized transport in urban travel	Structural/behavioural change measure (modal change)	Reducing emissions through a reduction in the use of the most polluting transport modes (modal change)	↓ AP (potentially of PM, NOx, VOCs, CO)	↓ CO_2	Measure with a priori synergetic effects. Exact results of assessment will depend on the hypotheses made with respect to technologies and fuels used as well as on vehicle occupancy rates
Low Emission Zones	Regulatory instrument	The objective is generally to reduce local pollution through restrictions to access these areas to certain vehicles. Various criteria are possible, e.g. vehicle type, age or technology	↓ AP within the area but the effects need to be analysed over the entire agglomeration (transport may deviate to other areas)	↓ ↑ CO_2, possibly ↑N_2O (the effects need to be analysed over the entire agglomeration)	Measure with potentially synergetic effects, but not guaranteed. When this instrument leads to a) the retrofitting of vehicles (e.g. particulate filters, techniques for reducing NOx) small CO_2 penalties and additional N_2O emissions are possible; b) an accelerated replacement of vehicles by newer or less polluting vehicles, the effects may be synergistic. Other uncertainties: the effect of the instrument may be transitory until the vehicle fleet evolves, unless the severity of access restriction increases over time

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
Densification of the city	Urban planning measure	Reduction of CO_2 emissions by reducing urban travel	↓ air emissions from transport, however the impact of the city's overall emissions on air quality is uncertain	↓ CO_2 from transport	Measure with synergistic effects for emissions, but not necessarily for air quality. Air quality depends on the pollutant concentrations that are likely to be higher in a denser city
Implementation of bike-sharing in cities	Urban planning instrument/incentive instrument	Incentives to urban community for developing bike-sharing project	↓ AP	↓ CO_2	Win-win measure
Securing / separation of non-motorized transport modes	Urban planning measure	Allocation of space to pedestrians and cyclists	↓ of the impact of air quality on pedestrians and cyclists (through improved air quality and reduced exposure in these zones/paths dedicated to non-motorized travel modes); ↓ AP if modal shift to non-motorized transport modes takes place	↓ CO_2 if modal shift to non-motorized transport modes takes place	Measure with potential win-win effects in so far as a modal shift to non-motorized transport modes occurs. Positive effect on air quality for pedestrians and cyclists using separate paths.
Use of lighter, less powerful vehicles ('downsizing')	Behavioural measure	Reduction of CO_2 emissions by reducing vehicle fuel consumption	↓ AP ; Needs to be evaluated over the whole life cycle (including refineries)	↓ CO_2 due to the reduction in fuel consumption. A precise evaluation needs to take into account the whole	Win-win measure, but possibly more effective for GHGs than for APs

Measure/instrument	**Type**	**Description**	**Effect on air pollutant emissions**	**Effect on greenhouse gas emissions**	**Conclusion / comment**
				life cycle.	
Reduction of vehicle speed/speed limits	Regulatory instrument/traffic management	Reduction of CO2 emissions or improvement of local air quality through speed reductions.	↓ NOx, PM on motorways and fast roads, but ↑ possible in urban areas (areas limited to 30 km/h for example)	↓ CO2 on motorways and fast roads	Win-win measure for motorways and fast roads. However, win-win effect not guaranteed in cities. In cities it might be more useful to implement specifically dimensioned measures against congestion in order to reduce emissions.
Eco-driving	Behavioural measure	Reduction in CO2 emissions by reducing fuel consumption	↓ local air pollution (e.g. NOx, HC, CO)	↓ CO2	Win-win measure. Accompanying measures/instruments would be useful to assure that the behavioural change is stable over time.
Making traffic more fluid through speed regulation	Regulatory instrument/traffic management	Making traffic more fluid in regularly congested areas to obtain more optimal speeds	↓ AP	↓ CO2	Instruments with win-win effects provided the dynamic management reduces congestion and leads to more optimal speeds with respect to AP and CO2 emissions

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
Motorway lanes in urban and peri-urban areas dedicated to public transport and sufficiently occupied private vehicles (car-sharing)	Regulatory instrument/traffic management	Reduction of congestion and thus improvement in local air quality, speed optimization, reduction in travel time of the vehicles concerned, improvement of freight transport; Reduction in fuel consumption through reduced number of vehicles and less congestion; Improvement of and increase in more sustainable transport modes	↓ ↑ AP?	↓ ↑ CO2?	Potential win-win measure if overall congestion is reduced, as well as the number of vehicle-km and if speeds are optimized... However, risk of increased congestion on the other lanes (in particular if an existing lane is converted into a dedicated lane). Lack of studies on net effects from benefits in terms of emission reductions on dedicated lanes, and a potential increase in congestion on other lanes.
Improve freight transport efficiency	Behavioural/planning measure	Optimizing timetables, loading and unloading procedures and the logistics of freight transport by road.	↓ AP	↓ CO2	Win-win measure.
Free public transport for commuters	Economic/incentive instrument	Promote the use of public transport (modal change)	↓ AP	↓ CO2	Win-win effects, instrument with synergetic effects.
Promotion of car sharing	Economic/incentive instrument	Promotion of car-sharing: financial compensation by the employers, incentive taxes, creation of parking place etc …	↓ AP	↓ CO2	Reduction of traffic: Instrument with synergetic effects (win-win).

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
Promotion of public transport through employer financial contribution	Regulatory instrument (imposing financial incentive setting)	50% of the price for a public transport season ticket is paid by the employer	↓ AP	↓ CO_2	Instrument with win-win effect.
Modulation of motorway tolls based on the vehicles' AP and / or CO_2 emissions	Economic/incentive instrument		↓ ↑ AP?	↓ ↑ CO_2?	The effect of the instrument will depend on the environmental criteria according to which tolls are differentiated. Vehicle emissions can differ across different APs and be different from CO_2 emissions trends. If, for example, toll levels depend only on the level of CO_2 emissions, trade-offs for APs are possible (e.g. by favouring diesel vehicles)
Truck road charge	Economic/incentive instrument	Charging of heavy goods vehicles for road use as a differentiated according to vehicle weight or number of axles and according to kilometres travelled	↓ AP possible	↓ CO_2 possible	Win-win effect possible. The effects of the instrument on the carriers' behaviour, and thus on pollutant emissions will depend on the level of the charge (whether or not incentive) and on the specific design of this economic instrument. Changes in the behaviour in order to avoid the charge depend on charging criteria and the availability of alternatives to road transport.

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
European CO_2 trading in the automotive industry	Economic instrument	Obligation for manufacturers to comply with a limit for average emissions per new vehicle sold, but allowing for possible exchanges between manufacturers and / or retailers	↓ ↑ AP?	↓ CO_2	Instrument for which synergetic effects are not guaranteed. AP vehicle emissions may be different from CO_2 emission trends. Counterproductive effects for AP are possible, for example by favouring diesel vehicles. If the permit market leads to the construction of lighter vehicles, positive effects also on AP are possible.
City tolls	Economic/incentive instrument	Instrument introducing a toll for drivers of (certain) vehicles entering the zone concerned; instrument often primarily aimed at reducing congestion rather than pollution	↓ AP (NO_x, PM) in the toll zone; but potential ↑ outside	↓ CO_2 in the zone; but potential ↑ outside	Synergetic effects on AP and GHGs often observed in practice, at least in the zone concerned by the toll (through reduced congestion, a modal shift towards public transport, avoided trips). However, bypassing the zone is also frequently observed (potential increase in emissions outside the zone), but analyses on net effects are lacking. In the future the impact of city tolls on AP may be less important than on GHGs, owing to improvement of vehicles.

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
Bonus/Surcharge for CO_2 (or "Greening of consumption tax")	Economic/incentive instrument	Reduction of prices for a car when CO_2 emissions stay below a certain level, increase of prices for emissions above this level	↓ ↑ AP?	CO_2 ↓	Synergetic effect of instrument not guaranteed, and potential for trade-offs. The AP emissions of a vehicle (especially the PM emissions) may differ from the CO_2 emission trends. In addition, a trend towards diesel cars emitting more PM and NOx is possible. This counterproductive effect could be avoided by differentiating the bonus / surcharge between diesel and petrol cars.
Taxes based on the vehicles' environmental impacts (GES and PA)	Economic/incentive instrument	Environmental Impact Assessment of vehicles (GES and AP), taxes base on the fuel efficiency of the cars	↓ AP	CO_2 ↓	Instrument with synergetic effects (win-win)
Fuel tax increase (possibly based on fuel type)	Economic/incentive instrument	Reduction of individual motorised transport and a shift towards public transport	↓ AP	CO_2 ↓	The reduction of the use of individual motorised transport and the expected shift towards public transport should lead to synergetic effects.
Best Available Technology for public transport	Technical measure	Reduce emissions through the use of clean vehicles in public transport	↓ AP	CO_2 ↓	Measure with synergetic effect.

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
Tax on company cars as a function of CO2 emissions	Economic/incentive instrument	Annual tax payable by all companies owning or using cars the level of which depends on CO2 emissions (in some countries differentiated by fiscal power)	↓ ↑ AP?	↓ CO2	Synergetic effect of instrument not guaranteed, and potential for trade-offs. The AP emissions of a vehicle (especially the PM emissions) may differ from the CO2 emission trends. In addition, a trend towards diesel cars emitting more PM and NOx is possible.
Incentives for fleet renewal	Economic/incentive instrument	Unspecified instrument that aims to replace old vehicles by newer vehicles	↓ ↑ AP?	↓ ↑ CO2?	The use of more recent (equivalent) vehicles could reduce AP and CO2 (provided they respect more stringent Euro standards and consume less fuel). However, net effects for AP and GHGs depend on the life cycle impacts: a) related to end of life of replaced vehicles; b) related to the manufacture of additional vehicles (for combustion vehicles replacing combustion vehicles); The effect of such an instrument would be more positive if old vehicles were replaced by low-emission vehicles, such as hybrids.

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
Non-road mobile machinery: use of fuels with lower sulphur content	Technical/structural measure	Substitution of fuel oil by diesel	↓ SO_2, NO_x	A priori negligible effect	Measure a priori without synergetic effects. Trade-offs possible to the extent that low sulphur diesel is chosen, as reducing the sulphur content of fuels risks increasing refinery emissions
Non-road mobile machinery: fleet renewal incentive	Economic/incentive instrument	Objective of modernizing the fleet	↓ ↑ AP?	↓ ↑ CO_2?	Potential win-win measure for machinery use (if newer vehicles meet tighter limit values for air pollutants **and** if they consume less fuel). However, the net effects for AP and GHGs depend on the life cycle impacts: a) related to end of life from replaced vehicles, b) related to the manufacture of additional vehicles
Non-road mobile machinery: Emission limit values imposing the implementation of emission reduction technologies for diesel	Regulatory instrument	Adjusting the reference emission limits for gaseous pollutants emitted by diesel engines with Phase IIIB and IV technology installed in non-road mobile machinery	↓ NO_x, PM, VOC, CO	↓ CO_2	Instrument with synergetic effects.

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
Non-road mobile machinery: substitution of fuel oil by diesel containing a fraction of biofuel	Technical/structural change measure	Reduction in emissions of sulphur and unburned fractions using a fraction of biofuel; need for new motors equipped pollution reduction equipment	↓ SOx	↓ CO_2	Measure with synergetic effect.
Non-road mobile machinery: Emission limit values imposing the implementation of emission reduction technologies for gasoline	Regulatory instrument	Adjusting the reference emission limits for gaseous pollutants emitted by gasoline engines Phases I and II technology installed in non-road machinery	↓ NOx, PM, VOC, CO	↓ CH_4, N_2O	Instrument with synergetic effects.

9.2.2 Transport: Aviation

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
Reducing the fuel consumption of reactors	Technical measure	Improvement of fuel consumption efficiency (through improved engines plane design)	↓ AP, ↑ NOx	↓ CO_2	Trade-offs between AP and GHGs observed in the past. Increasing fuel efficiency increases the combustion temperature and hence NOx emissions.
Electricity for APU (auxiliary power unit) on airports	Technical / behavioural measure	The equipment of aircraft parking stands by power supply allows limiting the use of auxiliary power engines (APU)	↓ NOx	CO_2 ↓	Measure with synergetic effect, the extend of which depends on the energy mix in electricity generation
Air passenger taxes /EU-ETS aviation	Economic/incentive instrument	Tax applied for all departures. The amount depends on the destination country	↓ AP	↓ CO_2	Instrument with synergetic effect
Reducing energy consumption of aircraft	Behavioural change measure	Reduction of energy consumption, emissions and noise by developing manoeuvring aircraft approach up to the point of final approach (descent from the optimum position, staying longer at higher altitudes, and operating at a lower engine speed), by improving the load distribution of aircraft, adapting the speed of the aircraft	↓ AP	↓ CO_2	Measure with synergetic effect

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
Aircraft taxiing on one engine	Behavioural change measure	Reduction of energy consumption and emissions by the use of a single engine aircraft in the taxiing phase.	↓ AP	↓ CO_2	Measure with synergetic effect
Adaptation of the paths to the available airspace enlargement in Europe	Technical and behavioural change measure	Reducing energy consumption in air traffic by optimising the flight path	↓ AP	↓ CO_2	Measure with synergetic effect
Modal shift Air => Rail	Structural / behavioural change measure	Modal change: replacing short trips by plane by trips by (high speed) train	↓ NO_x, CO, VOC, SO_2, PM possible	CO_2 ↓	Exact effects depend on the energy mix for electricity production (underlying assumption: use of electrified railway)

9.2.3 Transport: Rail

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
Phase-out of heavy fuel oil used by rail transport	Technical/structural measure	Fuel mix measure. Tests using B30 (fuel containing 30% biofuel) in regional express trains and test runs with railway engines powered by B100 (fuel containing 100% biofuel)	↑ AP possible if the record is comparable to that of he use of biofuels in road vehicles	↓↑ CO_2? Effect uncertain for first generation biofuels	Measure potentially entailing trade-offs

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
Development of the High speed train network	Modal change measure	Induce more travel by train through increase of the high speed train network (modal shift)	↓ AP	CO_2 ↓	Measure with synergetic effects if the main effect is a modal shift from road and air to electrified train (and given the French energy mix). Less positive effects if the main effect is not a modal shift but additional travel.
Electrification and modernization of railway lines and engines	Technical/Structural measure	Electrification and modernization of railway lines; Procurement of new, energy efficient railway engines	↓ AP	CO_2 ↓	Win-win measure
Increase in the share of rail freight transport	Modal change measure	Objective to transfer road freight transport to rail	↓ AP	CO_2 ↓	Measure with potential for synergetic effects (assuming a modal shift of transport from trucks (road) to rail). Exact effects on emissions will depend on the fuel type used by the trains. Road PM emission reductions might be compensated by non-exhaust PM emissions from rail transport.

9.2.4 Transport: Shipping

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
SCR	Technical measure	Reducing emissions through the injection of urea in the presence of a catalyst	↓ NOx , and potentially SO2 and PM, ↑ NH3 possible	↑ N2O possible	Measure with potential trade-offs. Nonetheless, the increase in N2O could be compensated by the reduction of NOx (ozone precursor, which itself is a GHG)
Scrubbers for stacks of ships	Technical measure	Fuel gas scrubbing with sea water (emerging technology)	↓ SO2, PM		Measure a priori without synergetic effects
Recovery of hydrocarbon and VOC vapours from vessels docked during loading / unloading and refuelling	Technical measure				For an assessment of the measure's impact on climate change the energy efficiency of these systems needs to be evaluated.
Supplying energy in form of electricity to docked ships	Technical measure	Provide the necessary on board energy to ships docked in ports through a connection to the electricity network (thus replacing the use of auxiliary motors)	↓ AP (NOx, SO2, PM, VOC)	↓ CO2	Measure a priori with synergetic effects. Replacement of local air pollutant emissions by lower emissions (and generally emitted outside the city) from electricity production. The extent to which emissions are reduced depends on the energy mix for electricity production.
Reduction in the sulphur content of fuels	Technical measure	Reducing SO2 emissions by using fuels with low sulphur content	↓ SO2 from ships, ↑ from refineries	↑ CO2 from refineries, ↓ of secondary aerosols formation of (due to net effect on SO2	Measure with trade-offs: Net benefit for AP, but not for climate

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
				(↓))	
Development of coastal navigation	Territorial Planning/modal change measure	Development of motorways of the sea and modal shift from road to sea	↓ AP probable (although a reduction in all APs may not be guaranteed)	↓ CO_2 (provided that a massif transfer of traffic flows from road to ship is possible, and that the distance travelled is shorter by sea than by road)	Measure with potential synergetic effects
Wide gauge canal Seine-North-Europe	Territorial Planning/modal change measure	Modal shift of freight transport from road to sea	↓ AP probable (although a reduction in all APs may not be guaranteed)	CO_2 ↓	Measure with potential synergetic effects
Improving the competitiveness of sea ports	Technical measure	Offer better services for the transport of containers	Could lead to an increase in the truck traffic to ports and thus to a reduction in local air quality	↓ CO_2 (if modal shift from road to sea); ↑ CO_2 if increase of truck traffic	Assessment of measure requires further investigation

9.2.5 Transport: Non determined mode

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
Modal change	Structural/behavioural change measure (modal change)	Modification of the relative shares of different transport modes used	↓ ↑ AP	↑ ↓ CO_2	The effect of the measure (win-win or not) will depend on which transport mode is replaced by which. For example, for shipping, NO_x and SO_2 emissions may increase if ships are equipped with old engines.
		Example of win-win measure: switch from short distance air travel to high-speed train (usually electrified)	↓ CO, NO_x, VOC, SO_2, PM possible	↓ CO_2 possible	Effects will depend on the energy sources from which electricity is generated (energy mix)

9.3 Residential, commercial, tertiary sectors

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
Energy performance of residential and non residential buildings (new and modernization of existing buildings)	Technical measure	Objective: Improve energy efficiency of buildings	↓ SOx, NOx, PM, (NH3, VOC)	↓ CO2, CH4, N2O	Measure with synergetic effects
Improvement in energy efficiency	Technical measures	Energy efficiency measures focusing on non-ETS sectors (industry, residential and tertiary sector).	↓ SOx, NOx, PM, NH3, VOC	↓ CO2	Measure with synergetic effects
Inspection of boilers	Technical measure	Regular inspections to avoid performance degradation	↓ PA; Emissions of air pollutants from a boiler degrade over time and with lack of maintenance	↓ CO2 as boiler maintenance may lead to fuel savings	Measure with synergetic effects
Efficient domestic lighting	Technical measure	Increase the efficiency of domestic lighting	Improvement in AQ in general. Reduced emissions of air pollutants as a result of reduced primary energy input to electricity generation.	↓ CO2, CH4, N2O	Measure with synergetic effects

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
Use of low-NOx boilers, low temperature boilers, condensing boilers	Technical measure	Reduction of NOx through use of boilers such as low-NOx, low temperature or condensing boilers	↓ NOx	↓ CO_2 (low-NOx boilers just as low temperature boilers and condensing boilers allow energy savings compared to standard modern boilers)	Measure with synergetic effects
Increased natural gas use	Structural measure	Extension of Natural gas network	↓ SOx, PM, possibly ↑ NOx. Depends on fuel replaced. A shift from coal to gas is beneficial: less PM, SO_2 ; a shift from fuel oil to gas decreases SO_2 and PM emissions but may increase slightly NOx emissions (the flame temperature rises)	↓ CO_2	Measure with potential trade-offs.
Increased use of renewable energy	Structural measure	Through purchase of new renewable energy heating system for existing homes	↓ AP, possibly ↑ PM. Reduced energy demand will reduce emissions of air pollutants also. However increased combustion of biomass will increase particulate matter emissions.	↓ CO_2, CH_4, NO_2	Measure with potential trade-offs.
Use of non biomass renewables	Technical/structural measure	Usage of renewable energy sources in the residential building sector: solar heaters, heat pumps,	Improvement in AQ in general.	↓ CO_2 (CH_4, N_2O)	Measure with synergetic effects

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
		geothermal			
Use of biomass boilers and wood stoves	Technical/structural measure	Usage of renewable energy sources in the residential building sector: biomass boilers & wood stoves	Improvement in AQ in general, but not necessarily on PM.	↓ CO_2	Measure with potential for synergetic effects but not guaranteed
Increasing the share of wood in construction	Technical measure/structural measure		↑ indoors air pollution possible (depending on the treatment, the products used for wood protection and the use of adhesives that can emit emissions, e.g. VOCs); ↓ PA possible if the use of wood reduces energy consumption	↓ CO_2; Logging / transformation of wood consume little energy. The wood acts as carbon sink. Wooden structures provide good insulation performance.	Measure with potentially synergetic effects, for wood coming from a sustainable wood industry.
Increase use of natural gas	Technical measure/structural measure	Substitution of liquids fuels (diesel) by NG	General improvement in AQ.	↓ CO_2	Measure with synergetic effects.
Energy efficiency in end-use appliances	Technical measure	Objective: Reduce energy demand via energy-saving measures and hence reduce primary energy consumption and emissions associated with electricity generation	↓ NO_x, SO_x, VOC, PM, Cd, Hg, Pb	↓ CO_2, CH_4, N_2O	Measure with synergetic effects.

Measure/instrument	**Type**	**Description**	**Effect on air pollutant emissions**	**Effect on greenhouse gas emissions**	**Conclusion / comment**
Use of efficient and low emission boilers, stoves and HVAC systems	Technical measure	Reduce emissions from boilers, stoves by establishing minimum efficiency and emission requirements for boilers, stoves and HVAC systems	↓ NOx, PM	↓ CO_2 (CH_4, N_2O)	Measure with synergetic effects.
Improved heating management	Behavioural change measure		↓ PA linked to a reduction in energy consumption	↓ CO_2 due to reduced energy consumption	Measure with synergetic effects
Limitation of air conditioning	Behavioural change measure		↓ PA linked to a reduction in energy consumption. The effect depends on the energy mix.	↓ GHG directly due to ↓ in fluorinated gases and indirectly due to ↓ in electricity consumption. The second effect depends on the energy mix.	Measure with synergetic effects
Renewables use in heat generation	Structural change/technical measure	Heating systems that use renewables, like solar thermal or biomass heating systems	↓ SOx, NOx, ↑↓ PM (Increased use of biomass may increase PM, depending also on the fuel is substituted for)	↓ CO_2	Measure with potential for trade-offs
Renewables use in generation of heat and electricity in households	Structural change/technical measure	Supply a certain share of energy in buildings by renewable energies for new building	↓ SOx, NOx, PM (effect on PM depends on whether biomass is used and what fuel is substituted for)	↓ CO_2	Measure with potential synergetic effects
Solar water heaters	Structural change/technical measure	Increase domestic uptake of solar water heaters	Improved air quality in general	↓ CO_2, CH_4, N_2O	Measure with synergetic effects

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
Micro wind turbines	Structural change/technical measure	Promotion of micro wind turbines installed on domestic premises.	Improved air quality in general	↓ CO_2, CH_4, N_2O	Measure with synergetic effects
Display of the energy performance of buildings	Information/incentive instrument	Instrument to aimed at setting an incentive for rehabilitation work; Display of energy efficiency and CO_2 level	↓ PA linked to a reduction in energy consumption. ↑ in indoor air pollution possible if the insulation and sealing of buildings increase at the expense of ventilation. ↑ of indoor air quality if the isolation decreases the effects of condensation associated with thermal bridges and water infiltration from defects of leak-tightness.	↓ CO_2 due to reduced energy consumption	Instrument with potential for synergetic effects
Tax credits for private individuals	Economic/incentive instrument	Tax credit for the purchase of equipment (efficient boilers, double glazing, solar water heater...), focused on the most energy-efficient products and enhanced for renewable energy use	↓ PA linked to reduction in energy consumption. ↑ PA (PM, organic pollutants) possible when the instrument leads to the installation of wood (and other biomass) boilers in households.	↓ CO_2 due to reduced energy consumption	Instruments with potentially synergetic effects. Trade-offs possible if the instrument leads to an increase in the use of biomass (and depending on the specific conditions, e.g. boiler type used).

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
Zero-tax credits or tax deductions for building energy efficiency investments	Economic/incentive instrument	Objective: Improve energy efficiency of buildings	Improvement of AQ in general	↓ CO_2 due to reduced energy consumption	Instrument with synergetic effect.
State aid scheme for energy efficiency improvements	Economic/incentive instrument	Public Aids for investment in improved energy efficiency of buildings / dwellings in existing and new buildings, and for efficient boilers, heat pumps, solar collectors ...	↓ PA due to a reduction in energy consumption and to the extent that it does not result in the use of biomass without adequate off-gas treatment	↓ CO_2 due to reduced energy consumption	Instrument a priori with synergetic effects.
Thermal minimum requirements for buildings	Regulatory instrument	Reduction of energy consumption in residential and commercial new buildings - definition of maximum allowable primary energy consumption	↓ NO_x (due energy savings in the building sector); ↑ PA (PM, PAHs, VOCs) possible due to the incentive of using renewable energy, especially wood boilers	↓ CO_2 (energy savings)	Instrument a priori with synergetic effects. However, if the measure leads to an increase in wood heating, negative effects on AP are possible that depend on the type of boiler used.
Eco-design Directive	Regulatory instrument	Minimum energy performance standards for energy-related products on the market in the industry and tertiary sectors	Improvement in AQ in general. All non-GHG emissions related to fossil fuel combustion are reduced.	↓ CO_2	Measure with synergetic effects
Energy efficiency performance of products	Regulatory instrument	Minimum energy performance standards for energy-related	Improvement in AQ in general. All non-GHG emissions related to fossil	↓ CO_2	Instrument with synergetic effects

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
		products and appliances in the industry and tertiary sectors (in some countries beyond Eco-design Directive)	fuel combustion are reduced.		
Energy efficiency requirements for appliances and products such as white goods, lighting, televisions, heating and cooling systems and electric motors	Regulatory instrument	Reduce energy consumption through setting of minimum energy efficiency standards for products on sale	Improved air quality in general	↓ CO_2, CH_4, N_2O	Instrument with synergetic effects
Energy efficiency/performance requirements for Heat Generators for Space Heating and the Production of Hot Water	Regulatory instrument	Regulations prescribing the energy efficiency requirements for water heating boilers, fuelled by gaseous or solid fuels and used for heat supply	Improvement in AQ in general. Reduced use of energy results in less emitting of air pollutants.	↓ CO_2	Instrument with synergetic effects
Distribution of energy saving lamps in the domestic sector	Economic instrument	Objective: foster environment friendly mentality	Improved air quality in general	↓ CO_2, CH_4, N_2O	Instrument with synergetic effects
Rebates on energy efficient domestic appliances	Economic instrument	Objective: To incentivise energy efficient domestic appliances	Improved air quality in general	↓ CO_2, CH_4, N_2O	Instrument with synergetic effects

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
Efficiency and low emission requirements for boilers, stoves and HVAC systems	Regulatory instrument	Reduce emissions from boilers, stoves by establishing minimum efficiency and emission requirements for boilers, stoves and HVAC systems	↓ NOx, PM	↓ CO2	Instrument with synergetic effects
Minimum energy efficiency standards for heating equipment in the residential buildings	Regulatory instrument	Objective: modernisation of heating systems	↓ pollutants related to fossil fuels heating installations	↓ CO2	Instrument with synergetic effects
Incentive for renewable heat generation	Economic instrument	Financial incentive mechanisms for the generation of renewable heat in all sectors from large industrial sites down to the household level.	↓ NOx, PM (effect on PM depends on whether biomass is used, which might increase PM emissions)	↓ CO2, CH4, N2O	Instrument with potential for synergetic effects.
Tax allowances for energy reduction from heating	Economic instrument	Tax allowance for reduction in energy consumption, saving of heat in housing sector.	Improvement in AQ in general. Through reduction in energy (heating) consumption.	↓ CO2	Instrument with synergetic effects
Encouraging the construction of "low energy" and "passive" new residential buildings	Economic instrument	Financial incentives for "low energy" and "passive" new residential buildings	↓ pollutants related to fossil fuels heating installations	↓ CO2	Instrument with synergetic effects

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
Grants/financial support for buildings energy audits	Economic instrument	Objective: improving of energy efficiency in private buildings	↓ SOx, NOx, PM, NH_3, VOC	↓ CO_2, CH_4, N_2O	Instrument with synergetic effects
Energy efficiency of buildings	Economic instrument	Soft loans, grants, tax deductions for meeting (ambitious) energy standards for new buildings and renovations (in some countries for above standard improvements)	↓ SO_2, NOx, PM from reduced energy consumption	↓ CO_2	Instrument with synergetic effects
Energy labelling	Information instrument	Energy labels shall help consumers to choose energy-efficient products, household appliances and also provide incentives for the industry to develop and invest in energy efficient products.	All non-GHG emissions related to fossil fuel combustion are reduced	↓ CO_2	Instrument with synergetic effects
Energy star - labelling of low energy office appliances	Information instrument	Promotion of exemplary role and activities of the public sector	Improvement in AQ in general	↓ CO_2	Instrument with synergetic effects
Public procurement of energy-efficient products	Regulatory instrument	Using energy efficiency as criterion for public procurement decisions	Improvement in AQ in general. All non-GHG emissions related to fossil fuel combustion are reduced.	↓ CO_2	Instrument with synergetic effects. However if use of biomass increases, PM emissions may increase.

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
Common procurement of energy-efficient products	Voluntary agreement	Using energy efficiency as criterion for private procurement decisions	Improvement in AQ in general. All non-GHG emissions related to fossil fuel combustion are reduced.	↓ CO_2	Instrument with synergetic effects
Grants (or other financial support) for energy efficiency projects (public and private sector)	Economic instrument	Grant aid provided energy efficiency projects that will achieve significant energy savings and will create demand for labour-intensive services during implementation.	Reduced energy demand will reduce emissions of air pollutants also. However increased combustion of biomass will increase particulate matter emissions.	↓ CO_2, CH_4, N_2O	Instrument leading potentially to trade-offs (PM).
Accelerated Capital Allowance for investment in energy efficient equipment (private and public sector/services)	Economic instrument	Incentive for companies paying corporation tax to invest in energy efficient equipment. Allows companies to write off 100% of the purchase value of qualifying energy efficient equipment against their profit in the year of purchase	Reduced energy demand will reduce emissions of air pollutants also. However increased combustion of biomass will increase particulate matter emissions.	↓ CO_2, CH_4, N_2O	Instrument leading potentially to trade-offs (PM).
Smart Metering	Information instrument	Increase of energy savings in private households by regular and visible information	All non-GHG emissions related to fossil fuel combustion are reduced	↓ CO_2 (CH_4, N_2O)	Instrument with synergetic effects

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
		on electricity/gas consumption			
CO_2 tax	Economic instrument	CO_2 tax, paid for the consumption of fossil fuels and the incineration of combustible organic substances and charged proportionally to the units of CO_2 emissions caused. Objective: Making the use of fossil fuels less economically interesting	↓ NO_x, PM	↓ CO_2	Instrument with synergetic effects

9.4 *Industry*

9.4.1 Industry: general

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
Improving energy efficiency in industry	Technical measure	Reducing CO2 emissions by reducing energy consumption (by increasing process efficiency, heat reuse ..., use of waste for biogas production, ...)	Improvement in AQ in general (↓ SOx, NOx, PM)	CO2 ↓	Measure generally (but not always) with synergetic effects. Other effects: reduction of energy dependency.
Eco-design	Technical measure (via regulatory instrument)	Objective: Increase energy efficiency over the whole product life cycle of products. Ban low-energy efficiency producers.	Improvement in AQ in general. The measure leads to decrease in energy consumption and consequently to reduction of pollutants emissions.	↓ CO2	Measure with synergetic effects
Energy efficient buildings	Technical measure	Energy Efficiency in Industrial Buildings to Reduce GHG emissions	Improvement in AG in general	↓ CO2	Measure with synergetic effects
Use of highly efficient electric motors and inverters	Technical measure		↓ NOx	↓ CO2	Measure with synergetic effects
CHP (combined heat and power)	Technical measure/Production technology	Objective: construction and use of CHP	Improvement in AQ in general	↓ CO2	Measure with synergetic effects.
Use of natural gas	Structural measure	Substitution of liquids and solid fuels by NG.	↓ SOx, NOx, PM, NH3, VOC	↓ CO2	Measure with synergetic effects.

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
Use of thermal energy (renewable)	Structural measure	Displace part of oil and gas use in the industrial sector by thermal energy	↓ SOx, NOx, NH3, VOC, ↑↓ PM. Reduced energy demand will reduce emissions of air pollutants also. However increased combustion of biomass will increase particulate matter emissions.	↓ CO2, CH4, N2O	Measure with potential trade-offs.
Use of biomass	Structural measure	Increase heat generation from biomass to reduce fossil fuel consumption in industry	↓ NOx, SO2, NMVOC, PM, Cd, Hg, Pb	↓ CO2, CH4, N2O	Measure with synergetic effects.
Eco-design Directive	Regulatory instrument	Minimum energy performance standards for energy-related products on the market in the industry and tertiary sectors	Improvement in AQ in general. All non-GHG emissions related to fossil fuel combustion are reduced.	↓ CO2	Instrument with synergetic effects
Ban low-efficiency products from market	Regulatory instrument	Minimum energy performance standards for energy-related products on the market in the industry and tertiary sectors (beyond Eco-design Directive)	Improvement in AQ in general. All non-GHG emissions related to fossil fuel combustion are reduced.	↓ CO2	Instrument with synergetic effects
BAT for energy efficiency	Regulatory instrument	Objective: improve energy efficiency of plants	Improvement in AQ in general. Reduction of most pollutants due to the regulatory measure that require the application of	↓ CO2	Instrument with potential for synergetic effects

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
			best practices		
Subsidy for investment in energy savings/efficiency by industry	Economic instrument	Objective: Investments in energy efficient technology, establishment of CHP in industry … (subsidy or exemptions from energy tax for industry)	Improvement in AQ in general. All non-GHG emissions related to fossil fuel combustion are reduced ↓ NOx, SO2	↓ CO2	Instrument with synergetic effects
Electricity certificates	Economic instrument	Supporting electric energy saving	↓ NOx	↓ CO2	Instrument with synergetic effects
EU ETS	Economic instrument	Instrument to decrease emissions of greenhouse gases from big sources.	Improvement in AQ in general. The measure leads to decrease in energy consumption and consequently to reduction of pollutants emissions. All non-GHG emissions related to fossil fuel combustion are reduced.	↓ CO2	Instrument with synergetic effects
Tax on CO2 emissions	Economic instrument	To provide economic incentives to reduce CO2 emissions	Improvement in AQ in general. Reduced use of energy, less emitting of air pollutants.	↓ CO2	Instrument with synergetic effects
Fossil fuel tax	Economic instrument	Objective: stimulate energy savings by putting a on the consumption of fossil fuel (excluding transport fuels) which should direct consumers toward more energy	Improvement in AQ in general. Reduced use of energy.	↓ CO2	Instrument with synergetic effects

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
		efficient behaviour.			
Energy audits	Voluntary/negotiated agreement	Promotion of energy efficiency	Improvement in AQ in general. Reduces emissions of other pollutants in energy production.	↓ CO_2	Instrument with synergetic effects
Subsidised energy audits for SMEs	Economic/Information instrument	Provide know-how for SMEs to identify and analyse potential energy-efficiency measures	Improvement in AQ in general. All non-GHG emissions related to fossil fuel combustion are reduced	↓ CO_2	Instrument with synergetic effects
Voluntary agreements for energy efficiency	Voluntary/negotiated agreement	Objective of this these voluntary long-term agreements is promoting energy savings in the industry, service and agricultural sector by substantially reducing the required energy per unit of product or service	Improvement in AQ in general.	↓ CO_2	Instrument with synergetic effects

9.4.2 Industry: combustion

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
Low NOx burners	Technical / primary measure	Reduction of NOx by modifying the means of introducing air and fuel to delay the mixing, reduce the availability of oxygen, and reduce the peak flame temperature	↓ NOx; Risk of unburned carbon in the ash and of CO formation	Possible ↑ CO2 due to increase in energy consumption for external recirculation of flue-gases	No real synergy. Trade-offs possible under certain conditions.
Flue gas recirculation	Technical / primary measure	Reduction of NOx through a reduction of the available oxygen in the combustion zone and decrease of flame temperature	↓ NOx	Risk of ↑ CO2 when excessive amounts of gas are being recirculated due to increased energy consumption for the ventilators	No real synergy. Trade-offs possible under certain conditions (recirculation of excessive amounts of flue gas) that can be avoided by combining the measure with the use of low NOx burners.
Fuel staging (reburning)	Technical / primary measure	Reduction of NOx emissions based on creation of different burning zones in the furnace by staged injection of fuel and air	↓ NOx; risk of hydrogen cyanide (HCN) and ammonia (NH3) formation, risk of incomplete combustion which can be reduced by using gas as fuel and by applying the measure in boilers having a long residence time	↑ CO2, possibility of higher consumption of reburning fuel	No real synergy. Trade-offs possible.

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
Reduced air preheat	Technical / primary measure	Reduction of NOx emissions due to reduced flame temperature in the combustion zone	↓ NOx	↑ CO_2; risk of increased fuel consumption because a higher portion of the thermal energy contained in the flue-gas cannot be used and ends up escaping through the stack. This risk can be reduced by applying energy conservation methods.	Measure with potential trade-offs.
Selective Catalytic Reduction (SCR)	Technical / End-of-pipe measure	NOx reduction by injection of ammonia	↓ NOx ; ↑ NH_3 by definition	↑ N_2O; ↑ CO_2 due to increased electricity consumption	Measure with trade-offs. Nevertheless, according to the BREF "Economic and Cross Media Effects", the overall environmental balance of SCR can in some cases be positive, despite the trade-offs.
Selective non catalytic reduction (SNCR)	Technical / End-of-pipe measure	NOx reduction by injection of ammonia or urea	↓ NOx ; ↑ NH_3 by definition	↑ N_2O	Measure with trade-offs. Nevertheless, according to the BREF "Economic and Cross Media Effects", the overall environmental balance of SNCR can in some cases be positive, despite the trade-offs.

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
Use of low sulphur fuel oil (0,5% S)	Technical / structural measure	Reduction in SO_2 emissions by replacing higher sulphur content fuel oil by fuel oil with reduced sulphur content	↓ SO_2	↑ CO_2	Measure with trade-offs. Reducing the sulphur content of fuels is an energy intensive process, thereby increasing the emissions from refineries.

9.4.3 Industry: chemistry, petro-chemistry

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
Reduction of diffuse VOC emissions (from leaks, loading, treatment basins)	Technical / Organisational measure	Reducing emissions from leaks (valves, pumps...), while loading the products for their transport, in liquid effluent treatment basins ...)	VOC ↓	Difficult to assess, the effects of VOC emissions on climate are complex and may be positive or negative	Further assessment of the measure necessary by analysing the radiative transfer properties of VOCs and the pollutants of which they are precursors (ozone, secondary organic aerosols).
NOx from refineries: SCR	Technical / end-of-pipe measure	Reduction of NOx emissions from catalytic cracking units by selective catalytic reduction, treatment of fuel gases from the regenerator	↓ NOx; Risk of ammonia and SOx emissions	↑ CO_2 due to increased consumption of electricity (effect not mentioned in the Refineries BREF, hypothesis made by analogy to the effects in other industrial plants)	Measure with trade-offs

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
NOx from refineries: SNCR	Technical / end-of-pipe measure	Reduction of NOx emissions from catalytic cracking units by selective non catalytic reduction, treatment of fuel gases from the regenerator	↓ Nox; Risk of ammonia emissions	↑ N2O created due to the use of ammonia	Measure with trade-offs
NOx from refineries: hydro-treatment of petroleum feedstock	Technical / primary measure	Reduction of NOx emissions from catalytic cracking units by reducing the NOx content of the regenerator	↓ NOx ↓ Ni, V	↑ CO2 due to increased energy consumption	Measure with trade-offs

9.4.4 Industry: metallurgy

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
Reduction of SF6 emissions from magnesium foundries	Technical measure	Substitution of SF6 by SO2	↑ SO2 (emitted in small quantities, the problem is rather the exposure of people working in these facilities to toxic gases)	↓ SF6	Measure rather with trade-offs

9.4.5 Industry: industrial processes

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
Limited VOC content in paints and varnishes	Regulatory instrument	Objective: reduce VOC emissions from paints and varnishes	↓ VOC, (O3)	↓ CO2	Instrument with synergetic effects

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
Limitation of VOC emissions by organic solvents in industrial installations	Regulatory instrument	Objective: reduce VOC emissions from industrial installations	↓ VOC, O_3	↓ CO_2	Instrument with synergetic effects
Reduce N_2O emissions from nitric acid production	Voluntary agreement	Objective: Reduce N_2O emissions from nitric acid production	↓ NO_x possible	↓ N_2O	Instrument with potential synergetic effects

9.5 Agriculture and livestock

9.5.1 Agriculture and livestock: Fertilizer Use

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
Reducing fertilizer inputs	Structural / behavioural measure	Reduction in emissions through reduced fertilizer use	↓ NO_x, NH_3	↓ N_2O, ↓ CO_2 (CO_2 reduced during manufacture of fertilizers, in the producing country), ↓ CH_4	Win-win measure, synergetic effects. Other effects: positive effects with regard to N-load of waters, biodiversity, resource efficiency, sustainability
Limitation of use of fertilizers with high volatilization rates (urea, nitrogen fertilizers)	Structural / behavioural measure		↓ NH_3 due to reduced urea	↓ CO_2 (urea causes CO_2 releases during its application - decarbonisation of more or less deep soil layers)	Win-win measure, synergetic effects
Reduction in the use of mineral fertilizers	Structural / behavioural measure	Reduction in emissions by reducing the use of mineral fertilizers	↓ NH_3	↓ N_2O, (CO_2, CH_4)	Measure with synergetic effects. Other effects: ground water and soil protection
Rational use of organic and nitrogen based fertilizers	Behavioural measure	Reduction of GHG emissions from fertilizers and manure usage. Reduction of direct and indirect nitrous oxide emissions by the reduction of N from synthetic fertilizers	↓ NH_3	↓ CH_4, N_2O	Measure with synergetic effects.
Replacement of nitrogen fertilizer by urea	Technical / behavioural measure		↑ NH_3	↓ N_2O, CO_2 ↑? (urea causes CO_2 releases during its application -	Measure with trade-offs

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
				decarbonisation of more or less deep soil layers)	
Replacement of nitrogen fertilizers by liquid manure spreading	Structural / behavioural measure		↑ NH3 to be put into perspective with a possible ↓ of NOx emissions	↓ N2O	Measure with potential trade-offs. Further assessment on air pollution effect necessary
Nearby ground band spreading of liquid manure	Technical measure	Use of drip hose distributors and slurry distribution system by hoses.	↓ NH3	↓ CO2, CH4, N2O	Measure with synergetic effects. Note: Because of terrain with various reliefs, this technique cannot be used on all surfaces. Other effects: ground water and soil protection
Replacement of nitrogen fertilizers by incorporation of manure into the soil	Structural / behavioural measure		↑ NH3	↓ N2O	Measure with trade-offs
Replacement of spreading by manure injection / incorporation into the soil	Technical / behavioural measure		NH3 ↓, ↑ PM possible as injection requires additional labour, and hence fuel consumption	↑ CO2 possible as injection requires additional labour, and hence fuel consumption; ↑ ↓ N2O (depending on soil conditions and weather conditions)	Measure with potential trade-offs. Further assessment on air pollution effect necessary

9.5.2 Agriculture and livestock: Treatment and storage of animal excretions

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
Development of agricultural methanisation (new plants)	Technical measure	Reduction of methane emissions from livestock	Improvement AQ in general	↓ CH_4	Measure with synergetic effects
Recovery of biogas from animal storage system	Technical measure		↓ NH_4	↓ CH_4	Measure with synergetic effects
Construction of manure storage facilities	Technical measure		↓ NO_x	↓ N_2O	Measure with synergetic effects. Other effects: Renewable energy; Energy security of supply. Furthermore: Reduced water pollution and reduced emissions when fertilisers are applied to the soil.
For cattle livestock: Covered manure storage or ventilation	Technical measure	Implement cover on external storage.	NH_3 ↓ low because emissions during storage represent a very small share in total emissions from animal housing up to spreading; the natural crust that forms on the manure is sufficient to limit emissions		Measure without synergistic effects

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
Coverage of slurry storages	Technical measure	Reduction of emissions from slurry storages through coverage. The loss of ammonia in the open slurry storage is significant. This goes along with nutrient losses and an increase in indirect GHG emissions.	Avoids diffuse emissions	↓ CO_2, CH_4, N_2O	Measure a priori with synergetic effects

9.5.3 Agriculture and livestock: Animal feed

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
Reduction of nitrogen supply of livestock feed	Technical / behavioural measure	Reduce N content strictly to the level of dietary recommendations per physiological stage	↓ NH_3	↓ N_2O	Measure with synergetic effects
Multiphase feeding of mono-gastric animals	Technical / behavioural measure	Adjustment of the protein content of the diet to physiological stage, use two-phase or three-phase feed. The influence of the total N uptake and thus reduced N excretion in manure reduces the GHG emissions.	↓ NH_3	↓ N_2O	Measure with synergetic effects

9.5.4 Agriculture and livestock: Livestock numbers and livestock management

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
Reduction of livestock numbers	Structural measure		↓ NH_3	↓ CH_4	Measure with synergetic effects
Decoupling of premiums for suckling cows	Economic instrument	A decoupling of this premium would possibly reduce the beef production - so the total number of cattle decreases	↓ NH_3	↓ CO_2, CH_4, N_2O	Instrument with synergetic effects. A return to milk production is seen only for farms with both meat and milk production because of the expected investments. So, a further decline in the grassland use by cattle and a slight increase in dairy farming respectively are predictable.
Promotion of grazing for cows and suckling cows	Behavioural measure	Increase time for livestock spent outside grazing	↓ NH_3 emissions, ground water and soil protection	↓ GHG (CO_2, CH_4, N_2O), The grazing of cattle caused compared to indoor husbandry lower GHG emissions.	Measure with synergetic effects
Increase the proportion of grazed animals	Behavioural measure	Decrease methane emissions from manure management by increasing the proportion of grazed animals.	↓ NH_3	↓ N_2O, CH_4	Measure with synergetic effects
Efficient animal production	Educational instrument	Reduction of emissions through breeding programmes towards better utilization of energy and protein in cattle, optimization of production process by the means of	↓ NH_3	↓ N_2O, CH_4	Instrument with synergetic effects.

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
		optimal feeding strategies, reproduction.			

9.5.5 Agriculture and livestock: Adaptation of agricultural and farming approaches

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
New crops (leguminous vegetables)	Structural measure	Fertilization measure: increase leguminous vegetables (mix or rotation)	↓ NH_3	↓ CH_4	Measure with synergetic effects
Organic farming	Structural measure	Reduced use of fertilizers by expanding area used for organic farming. “Organic farming” achieved through systematic closed cycle management high prevention of mineral fertilizer use	Improvement AQ in general	↓ CO_2, CH_4, N_2O	Measure with synergetic effects. Other positive effects: support the ecosystem soil, ground water and the production of quality bio-foodstuffs.

9.5.6 Agriculture and livestock: Agricultural waste burning

Measure/instrument	**Type**	**Description**	**Effect on air pollutant emissions**	**Effect on greenhouse gas emissions**	**Conclusion / comment**
Stubble management	Behavioural measure (Regulatory instrument imaginable)	Limitation of stubble burning for agricultural practice. The use of plant residues in agriculture requires both, a change or adjustment of the production processes as well as investment in new equipment and machinery e.g. for tilling soil.	↓ SOx, NOx, NH_3, NMVOC; Use of machinery and thus fuel consumption may lead to some increase in APs.	↓ CH_4, N_2O; Use of machinery and thus fuel consumption may lead to some increase in GHGs.	Measure with a priori overall net synergetic effects.
Ban on burning straw on fields	Regulatory instrument	Less air pollution through banning of burning straw on fields	↓ AP	↓ CO_2, CH_4, N_2O	Instrument with synergetic effects

9.5.7 Agriculture and livestock: Agricultural machinery

Measure/instrument	**Type**	**Description**	**Effect on air pollutant emissions**	**Effect on greenhouse gas emissions**	**Conclusion / comment**
Engine setting for tractors	Technical measure		↑ NOx likely if setting aims at optimizing fuel consumption	↓ CO_2 if setting aims at optimizing fuel consumption	Measure with trade-offs

9.6 Waste treatment

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
Emission limit values (ELVs) for TOC, N_2O for mechanical biological treatment plants	Regulatory instrument	To reduce emissions from MBT plants binding emission limits are implemented for TOC (Total Organic Carbon) and N_2O emissions.	↓ VOC, CH_4	↓ CH_4, N_2O	Synergetic effects possible but not guaranteed: emission reductions of methane will be compensated to a large extent by the energy demand of exhaust air purification by thermal processes.
Application of ELVs for waste incinerators to all installations incinerating waste	Regulatory instrument		Reduction in air pollutants and persistent organic pollutants (POPs)	↓ CO_2, CH_4	Instrument with synergetic effects.
Minimise waste quantities to landfills	Regulatory, Fiscal, Planning instruments	Waste reduction, increase in recycling, decrease in amount of waste landfilled.	↓ VOC, CH_4	↓ CH_4	Instrument with synergetic effect.

Measure/instrument	Type	Description	Effect on air pollutant emissions	Effect on greenhouse gas emissions	Conclusion / comment
Landfill gas flaring and recovery	Regulatory, Fiscal, Planning instruments	Systems for capture and flaring of biogas installed on new and existing landfills.	↓ CH_4, ↑ NO_x, SO_x, PM	↓ CH_4	Trade-offs possible. Combustion of biogas from landfills leads to AP emissions (e.g. NO_x). However, these additional emissions can be reduced through treatment of biogas before flaring or if the produced energy replaces electricity produced from fossil fuels.
Reduction of organic material destined to landfill: composting	Regulatory instrument	Limiting the amount of biodegradable waste going to landfills	↓ CH_4, ↑ NH_3	↓ CH_4, N_2O	Trade-offs. Composting increases NH_3 emissions.

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