

## Chapter 3:

# Policies and Measures to Reduce Short-Lived Climate Forcers

### 3.1 Strategic approach

The preceding chapter highlighted the SLCFs of interest to this report: black carbon, methane and tropospheric ozone. The benefits of mitigating emissions have also been highlighted in the *Integrated Assessment of Black Carbon and Tropospheric Ozone* (UNEP/WMO, 2011). In order to develop effective policies for mitigation of these SLCFs, the following guiding principles could be useful:

- *Building on current policies.* Strategies to address SLCFs can efficiently build on a number of existing policies and initiatives. One option is to incorporate SLCFs into existing air pollution policies and regulatory frameworks, including those at the international level. Another is to incorporate them into climate change agreements and regulations. In addition, it would be useful to integrate SLCF mitigation into development policies.
- *Developing an integrated approach.* Society would benefit from a more integrated approach to climate change and air pollution in policy making, because it would utilise the large overlap between the two areas and thereby make policy making more efficient and less costly.
- *Setting common goals.* Setting common goals on national, regional, or international levels, can encourage national efforts by enabling progress to be measured against targets. In the case of air quality, international guidelines such as those for particulate matter and ground-level ozone from the World Health Organisation (WHO, 2006) can be used as targets. In the case of climate change, the goal of limiting temperature increase to less than 2°C above preindustrial temperatures can be used as a comparable target. Global goals regarding total emissions of black carbon, methane and other tropospheric ozone precursors could play an equally useful role. Countries could choose to set national targets in relation to achieving these global goals. This could also apply to near-term climate goals and air quality objectives.
- *Rapid implementation of measures.* Chapter 1 makes it clear that it is important to reduce imminent climate impacts, and Chapter 4 explains that this can

accomplished by reducing SLCFs and slowing down global warming over the next two to four decades. Meanwhile, Chapter 4 also explains that air pollution impacts on health and crops are large and can be addressed by reducing SLCFs. From this dual perspective, it is clear that there are many benefits to be gained by reducing SLCFs as quickly as possible, and to consider options for near-term implementation of policies and measures focussing on the reduction of black carbon and methane emissions.

- *Central role of national action.* Special emphasis should be given to action at the national level because the health and agricultural benefits of implementing the measures are normally greatest close to emission sources. This is the case for the black carbon and other particulate matter emissions from smoky stoves and poorly operating brick kilns which endanger the health of local people. Moreover, measures can be better targeted to specific emission sources and policies by integrating them into national priorities for air pollution.
- *Enabling activities at regional and global levels.* Although it makes sense to give priority to national action for abating SLCFs, there are also advantages for cooperating at the regional and global level. One reason is that some SLCFs spread beyond national borders and are distributed across regions (e.g. black carbon), across hemispheres (such as tropospheric ozone and some of its precursors), and even across the globe (for example, methane). Often international action is needed to bring down levels of SLCFs within a particular country. Another reason for cooperating at the regional level is that emission sources and abatement measures tend to be similar for several countries within a region. International cooperation also promotes technology transfer and capacity building.

A suitable starting point is to identify measures that can clearly achieve the emission-reduction targets in a sustainable manner, taking into consideration the circumstances of any particular country. Identified

strategies should be readily implementable, and success should be relatively easy to measure and assess. It is especially important that the selected measures are cost effective, generating positive short-term returns on capital expenditure, and have low maintenance costs.

### 3.2 Identifying priority control measures

A variety of technical and regulatory SLCF measures are available to control emissions. Mitigation measures for black carbon, in most instances, will usually result in changes in emissions of other co-emitted pollutants. Therefore, to understand the full climate and public-health implications, as well as other air pollution-related impacts of each measure, it is important to look at the impact of a measure on a suite of pollutants. For example, some co-emitted substances, including sulphur dioxide (that gives rise to sulphate) and/or organic carbon (often co-emitted with black carbon), cool the atmosphere and these can potentially offset the climate benefits of reducing black carbon. Sulphate and organic carbon are particles that scatter light and hence reflect a portion of incoming sunlight back into space, thereby cooling the Earth. However, over snow-covered reflective surfaces, organic carbon actually contributes to warming. Understanding the effect of these co-emitted substances on warming, climate change and the composition and concentrations of air pollutants is important when evaluating measures to reduce concentrations of black carbon and tropospheric ozone.

To identify 'win-win' measures that simultaneously achieve air quality and climate change benefits, an analysis of available measures that focus on reducing emissions of black carbon and methane was performed. The analysis was undertaken using information on measures compiled within the Greenhouse Gas and Air Pollution Interactions and Synergies (GAINS) model (Amann *et al.*, 2011; Klimont *et al.*, 2009; Kupiainen and Klimont, 2004). The model considered all key documented pollution control options, amounting to about 2 000 measures, that reduce black carbon and methane emissions. All black carbon measures reduce fine particulate matter (PM<sub>2.5</sub>) while ozone precursor emissions are reduced by both black carbon and methane measures, resulting in reduced air pollution impacts on health, crop yields and ecosystems.

The GAINS model determined which of these measures would give net climate benefits. To do this, the measures were ranked according to their potential climate impact using published values of the global warming potential (GWP) for all substances emitted that affect climate and that are controlled by the measures. The net effect of the emission reduction of 'warming' substances compared

to the emission reduction of 'cooling' substances was calculated. As a result, measures that reduce warming overall were identified. The resulting list therefore contains 'win-win' measures that reduce both air pollution and climate change impacts. Further details on the methodology used to derive the selected measures are provided in the on-line Appendix.

Of the 2000 measures, the GAINS model identified approximately 130 that would achieve a reduction of global warming, with the top 16 measures realizing nearly 90 per cent of the maximum reduction potential in equivalent CO<sub>2</sub> emissions by 2030. These 16 measures (Tables 3.1 and 3.2) were therefore selected to form the basis of the analysis in the *Integrated Assessment of Black Carbon and Tropospheric Ozone* (UNEP/WMO, 2011) and in this report. Whilst they account for a large part of the climate benefit from a global perspective, they are not the only measures available to policy makers in different regions, but this selection does provide a sound starting point from which to develop effective policies targeted at reducing SLCFs.

### 3.3 Baseline year and reference scenario emissions

The effectiveness of SLCF mitigation measures was analyzed relative to a baseline year - 2005, and also relative to a reference scenario - a 'business-as-usual' scenario.

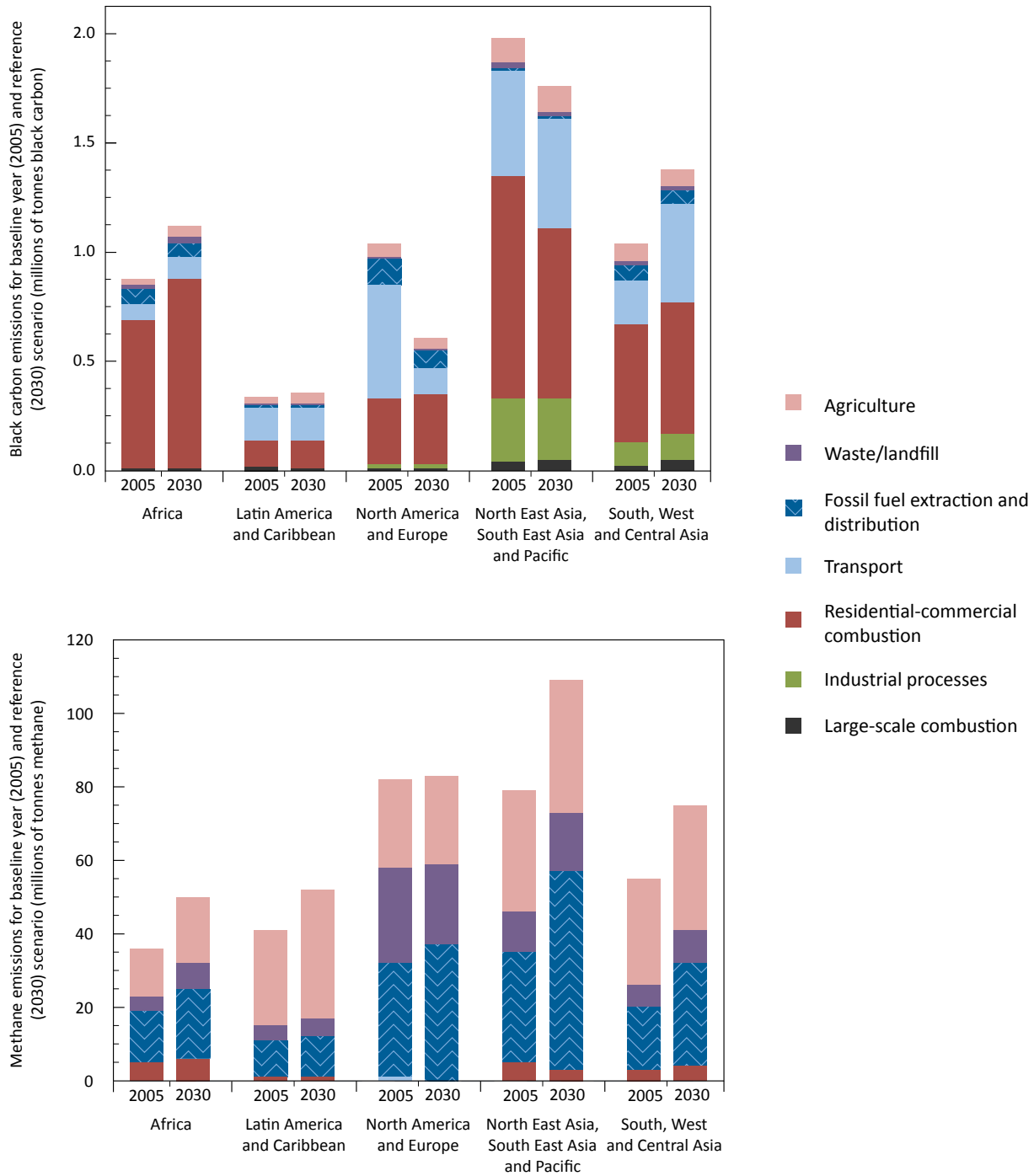
The baseline year (2005) emissions were estimated with the GAINS model, using available statistical data and data from Lamarque *et al.*, (2010) (See UNEP/WMO, 2011).

The reference scenario refers to emissions that would occur without deployment of further mitigation measures, apart from already existing ones. The values of the emissions were computed taking into consideration future energy and fuel demand as projected by the International Energy Agency (IEA) and incorporating the effects of all presently agreed policies that could affect the SLCF emissions (further details in the on-line Appendix).

The projected methane and black carbon emissions under the reference scenario in 2030 are shown in Figure 3.1. The figure shows the contributions of different sectors to emissions in each region. Details of the emission trends for other relevant substances – carbon monoxide, organic carbon, nitrogen oxides, non-methane volatile organic compounds, PM<sub>2.5</sub>, sulphur dioxide and methane – are also provided in the on-line Appendix of this report.

At the global level three key sources of methane contribute about 94 per cent of the total anthropogenic emissions in 2005: 43 per cent from agriculture, including livestock rearing and rice production; 34 per cent from

**Figure 3.1:** Emissions of black carbon (top) and methane (bottom) for the baseline year 2005, and projections for 2030 based upon the UNEP/WMO assessment reference scenario for five different world regions (see Chapter 2 of UNEP/WMO, 2011). The emissions are broken down by major sector.



Note: shipping and aviation are not included in this regional analysis

fossil fuel production and distribution; and 17 per cent from municipal waste and wastewater management. Asia accounts for 46 per cent of global methane emissions compared with 28 per cent in North America and Europe, 14 per cent Latin America and 12 per cent in Africa. Without further mitigation efforts, baseline methane emissions are expected to grow by about 25 per cent by 2030, with no significant changes in the regional and sectoral contributions.

At the global level, anthropogenic emissions of black carbon are dominated by residential-commercial combustion and transport sources that make up nearly 80 per cent of the total. Another 14 per cent originates from industrial production and the open burning of agricultural waste. There are significant regional differences in the importance of particular sectors – residential-commercial combustion dominates anthropogenic emissions of black carbon in Africa and Asia, while transport is currently a key contributor in North America and Europe. In Latin America and the Caribbean, both sectors are equally important black carbon sources. Industrial processes (e.g. production of bricks and coke in traditional kilns and ovens) are significant sources of emissions in some developing countries. As a global total, the reference scenario does not show a large change in total black carbon emissions by 2030 (Figure 3.1). However, significant regional and sectoral shifts are expected with, for example, declining shares from North America and Europe where emissions are estimated to fall by about half, primarily due to measures implemented in the transport sector. Meanwhile, the share of emissions from South, West and Central Asia and Africa increases significantly because of increases from the transportation and residential sectors. Combustion within the residential-commercial sector is expected to remain an important emission source over the next two decades.

### 3.4 Identifying key methane measures

Seven out of the 16 identified measures are focussed on reducing methane emissions (Table 3.1) from three sectors: fossil fuel production and transport, waste management, and agriculture.

The impact of these measures on emissions of methane relative to the reference scenario in 2030 is shown in Figure 3.2, assuming full implementation of measures in each region.

The identified measures are expected to reduce reference methane emissions by about 38 per cent in 2030 (Figure 3.2). A third of that figure is achieved by reducing emissions from oil and gas production in North America and Europe, Africa and South, West and Central Asia. Another third of the potential can be reduced from coal mining, especially from North East Asia, South East Asia and the Pacific region. The improved management of municipal waste could contribute one fifth of the potential reduction, half of which could be achieved in North America and Europe. Lastly, the agricultural measures considered here could account for about one tenth of global methane reductions in 2030.

A more detailed discussion of the measures and their application to different sectors is presented in Section 5.2.

### 3.5 Identifying key black carbon measures

Nine out of the 16 identified measures are focussed on reducing black carbon emissions (Table 3.2) from four sectors: transport, residential, industry and agriculture.

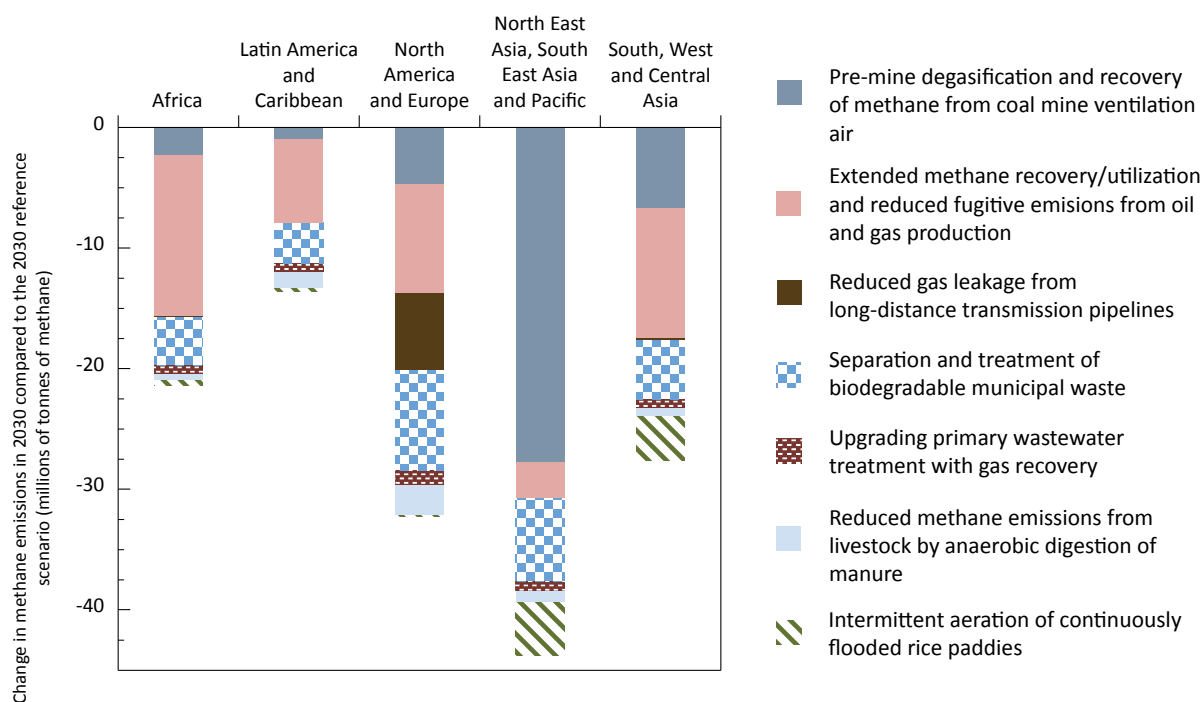
The impact of the identified measures on reference scenario emissions in 2030 is shown in Figure 3.3, again assuming full implementation of the measures in each region. The impact of the measures on emissions of other substances is given in the on-line Appendix.

These key measures achieve about 77 per cent of the potential emission reduction for black carbon in 2030 (i.e.

**Table 3.1:** Key methane abatement measures identified for this report (after UNEP/WMO, 2011)

Measure	Sector
Extended pre-mine degasification and recovery and oxidation of methane from ventilation air from coal mines	Fossil fuel production and transport
Extended recovery and utilization, rather than venting, of associated gas and improved control of unintended fugitive emissions from the production of oil and natural gas	
Reduced gas leakage from long-distance transmission pipelines	
Separation and treatment of biodegradable municipal waste through recycling, composting and anaerobic digestion as well as landfill gas collection with combustion/utilization	Waste management
Upgrading primary wastewater treatment to secondary/tertiary treatment with gas recovery and overflow control	
Control of methane emissions from livestock, mainly through farm-scale anaerobic digestion of manure from cattle and pigs	Agriculture
Intermittent aeration of continuously flooded rice paddies	

**Figure 3.2:** Methane emission reductions in 2030 achieved with the identified measures in Table 3.1 compared to the reference scenario in 2030 (in millions of tonnes of methane)



**Table 3.2:** Key black carbon abatement measures identified for this report (after UNEP/WMO, 2011)

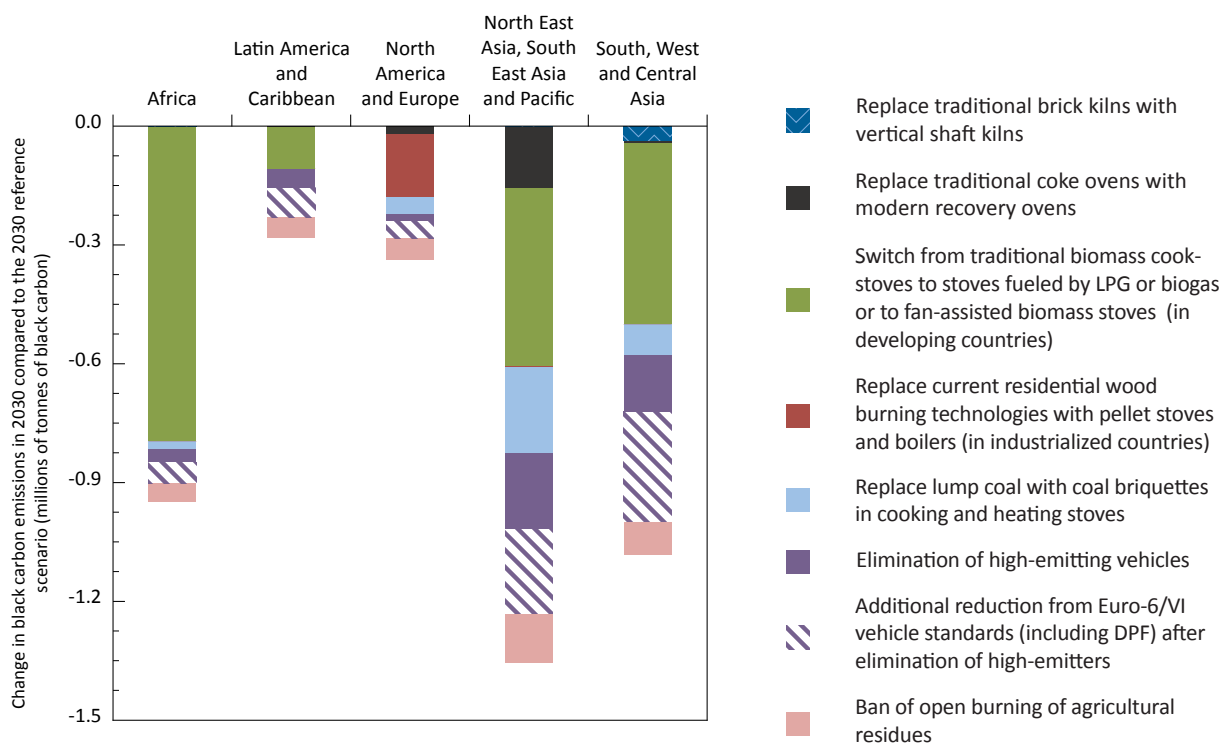
Measure	Sector
Standards for the reduction of pollutants from vehicles (including diesel particle filters), equivalent to those included in Euro-6/VI standards, for road and off-road vehicles	Transport
Elimination of high-emitting vehicles in road and off-road transport	
Replacing lump coal by coal briquettes in cooking and heating stoves	Residential
Pellet stoves and boilers, using fuel made from recycled wood waste or sawdust, to replace current wood burning technologies in the residential sector in industrialized countries	
Introduction of clean-burning (fan-assisted) biomass stoves for cooking and heating in developing countries <sup>1, 2</sup>	
Substitution of traditional biomass cookstoves with stoves using clean-burning fuels (liquefied petroleum gas (LPG) or biogas) <sup>1, 2</sup>	Industry
Replacing traditional brick kilns with vertical shaft brick kilns <sup>3</sup>	
Replacing traditional coke ovens with modern recovery ovens	
Ban on open burning of agricultural waste <sup>1</sup>	Agriculture

1. Motivated in part by its effect on health and regional climate including its impact on areas of ice and snow

2. For cookstoves, given their importance for black carbon emissions, two alternative measures are included

3. Zig-zag brick kilns would achieve comparable emission reductions to vertical-shaft brick kilns

**Figure 3.3:** Black carbon emission reductions in 2030 achieved with the identified measures in Table 3.2 compared to the reference scenario in 2030 (in millions of tonnes of black carbon)



Note: for biomass cookstoves, only the effect of substitution with LPG and biogas stoves is shown for clarity; with 100 per cent substitution with fan-assisted biomass cookstoves, the emissions reduction would be about 6 per cent less

compared to all 2000 measures). Black carbon measures also have a significant effect on various co-emitted substances. For example, they reduce organic carbon emissions, which is an important consideration when assessing the net change in climate impact caused by the measures. They also reduce a number of ozone precursors - carbon monoxide, non-methane volatile organic compounds and nitrogen oxides – and therefore have the effect of reducing tropospheric ozone concentrations (see the on-line Appendix).

Measures addressing traditional biomass cookstoves would reduce emissions mostly in Africa and Asia, whilst those addressing emissions from the transport sector, especially by implementing Euro-6/VI vehicle-emission standards that include diesel particle filters, would bring

about the largest reduction in black carbon emissions in Latin America and the Caribbean. In regions other than North America and Europe, eliminating high emitting vehicles would also have a significant beneficial impact on black carbon emissions. In North America and Europe, the largest black carbon emission reductions would come from replacing current wood-burning technologies in the residential sector with pellet stoves and boilers or another technology with equally low emissions.

Regionally, the potential to implement the measures differs depending on the source structure and the state of emission legislation. A broader discussion on the measures and their potential application to different sectors is presented in Section 5.2.