

Black carbon and methane emissions from oil and gas activities

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Overcoming emission reduction barriers

This report was prepared by Carbon Limits AS

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Special thanks to companies, technology suppliers, experts and other interviewees that collaborated in the report. You can find the complete list in the Annex 1) Interviewed organizations

About Carbon Limits AS

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Carbon Limits is a consulting company with long standing experience in supporting energy efficiency measures in the petroleum industry. In particular, our team works in close collaboration with industries, government, and public bodies to identify and address inefficiencies in the use of natural gas and through this achieve reductions in greenhouse gas emissions and other air pollutants.

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EXECUTIVE SUMMARY

This report summarizes findings from a project on barriers to black carbon and methane emission reductions in the oil and gas sector and measures to reduce barriers. Barriers are defined as physical, societal, economic, organizational or psychological *factors* that prevents a desired outcome, in this case emission reductions. This project explores the character of these factors and how to deal with them. Barriers can be reduced through national policies and regulations and by collaborative actions. Both are addressed in the report. The project has been financed by the Norwegian Ministry of Climate and Environment.

Methane and black carbon emissions are so-called short-lived climate pollutants which are receiving increased attention from the research community and among policy makers. International initiatives, such as the Climate and Clean Air Coalitions with more than 30 state partners and 40 non-state partners, are actively promoting emission reduction efforts for short-lived climate pollutants. Much focus is on methane and black carbon emissions from oil and gas sector activities as significant emission sources. Some empirical evidence suggest that substantial emission reductions can be achieved in this sector with positive returns or at low or no cost to the investor, but these opportunities are not fully realized due to barriers.

For example the IEA report "Redrawing the Energy- Climate Map" from 2013 states that methane emissions from the upstream oil and gas industry can be almost halved in 2020 at modest or no net costs compared to levels otherwise expected. It is recognized in the IEA study that empirical foundation of their analysis is uncertain and the analysis has little details on how barriers in practise are to be reduced in order to unleash profitable emission reduction opportunities.

The analysis of this project does not offer much additional insight into the scale of oil and gas sector emissions and the costs of abatement, though studies that have been reviewed suggest that considerable amount of methane emission reductions can be made at low costs. It is hoped, however, that the analysis will shed some more light on the character of barriers and what means might work in promoting economic viable emission reductions efforts.

Barriers

In broad terms there are two causes for barriers to exist: i) lack of knowledge about emissions and emission reduction opportunities, and ii) lack of capability and readiness to act. The barriers have their origin both in emitting companies and in public institutions responsible for regulations and policies. Generally there is little awareness of methane and black carbon emissions as major contributors to climate change. The role of black carbon is still debated, whilst methane is being recognized but with less attention compared to carbon dioxide. The technical challenges with measurements and estimation of black carbon and methane emissions adds to the knowledge gap. There is also a knowledge gap on mitigation technologies in the form of internal know-how in oil and gas corporations and with regulators. Lack of trust in technology and related information material is also common. Sharing of knowledge and experiences would help, but a culture of confidentiality is prevalent in much of the oil and gas industry.

Even when the knowledge gap is bridged there are some major challenges with implementing measures to reduce emissions. In companies as well as with regulators these pollutants generally have low priority. Companies typically face a number of challenges and risks in their processes for investments. The characters of black carbon and methane emissions (invisible and low perceived safety risks at low concentrations) prevents them from migrating up to senior management concerns and thus get lower priorities than other matters. In addition, although reduction measures may be economic, the profitability of emission reduction measures is low compared to investments that increase production. Also regulators have to prioritise their scarce resources and as black carbon and methane do not yet have high political attention they tend to be down prioritized. Finally, for both companies and regulators there are a number of practical and methodological issues that hamper implementation.

National policies and measures

Many interviewees highlighted the importance of clear and consistent regulations for achieving significant emission reductions. In order to reduce the knowledge gap regulators in cooperation with industry associations and research institutions can summarize common knowledge on emission sources and emission levels, including emission factors and uncertainty assessments. Regulators may also instruct companies to undertake measurement campaign and disseminate results, with due consideration being taken to commercial sensitivity issues. There is also empirical support for the view that mandatory leak detection and repair programs for methane emission sources do not entail large net costs for companies, and in many instances give positive financial returns. Methane emissions are excluded from most cap-and-trade systems due to the large number of small emission sources. However, so-called offset schemes whereby project specific and verified emission reductions are traded as credits into a cap-and-trade scheme (or in other ways are used for compliance purposes) are being considered in several jurisdictions. Political authorities and regulators can further promote this through pilot programs, including the development of monitoring, reporting and verification procedures and methodologies that secures the environmental integrity of such schemes.

Broader initiatives

Oil and gas sector operators are highly international with most large players being active in many jurisdictions. At the same time several international initiatives are being formed with focus on methane and black carbon emission (e.g. Climate and Clean Air Coalition, Global Gas Flaring Reduction Partnership, Global Methane Initiative). These together with the industry and the international industry associations can provide for forceful internationally coordinated measures.

Based on the consultations and analysis of this project, possible coordinated measures were identified. An important point is that future measures should aim at replicating existing initiatives in other companies, geographical areas and countries to make the awareness journey on emissions and opportunities more efficient.

Key Measures

Emission surveys and knowledge sharing
Emission survey through joint efforts of several institutions offers economies of scale and share benefits. Some surveys have been undertaken and some new are under planning, but this activity can be stepped up.

Pilot projects and sharing of practical experiences
Pilot projects can improve knowledge on best practice technologies and build trust in the applicability of solutions under different conditions. Experiences shared between oil and gas operators and technology providers would reduce costs and risks with emission reduction efforts.

International voluntary programs and standards
Developing voluntary programs and/or standards that companies can join is potentially a forceful means to foster emission reductions. It will require promotion from international industry associations and active involvement from large international oil and gas companies.

Climate and carbon finance of mitigation actions.
Although co-financing of emission reductions from carbon markets, or other climate funds, currently seems to hold little promise, mechanisms that reward emission reduction investment most probably will re-emerge in one form or another as politically induced emission limits are tightened. There are many ongoing and separate initiatives on creating new carbon markets, which eventually may be part of broader international markets. Methane emissions should be part of such markets, as offsets or in other ways. However this will not happen unless oil and gas companies and or other international institutions/initiative actively promoted it.

Although the report sheds light on key barriers for emission reductions of black carbon and methane it is important to stress the importance of further work in this field. There are substantial voids in hard facts (magnitude of emissions both at facility level and national level) and in understanding how best to reduce these emissions (regulatory instruments and incentives). This information is essential to effectively capitalizing on the possible short term gains for the wider climate mitigation effort. International and national organisations, governments and companies can play an important role in closing the knowledge gap, and they can simultaneously enhance their mitigation efforts and collaboration even if much information is lacking.

1. INTRODUCTION

In 2012, Carbon Limits studied technologies and abatement costs for mitigation of methane and black carbon emission from upstream oil and gas production in the Arctic on behalf of the Norwegian Ministry of Environment. This work resulted in a report concluding that numerous technologies are available to minimize such emissions, in particular methane emissions, at low or even negative abatement cost[1]. Despite identification of negative abatement costs for some mitigation options, mitigation efforts have been modest due to various barriers. Eliminating emission reduction barriers can be achieved through national policies and regulations and by collaborative international actions.

As a follow-up to the previous study, Carbon Limits has been commissioned by the Norwegian Ministry of Climate and Environment to examine barriers to black carbon and methane emission reductions in the upstream oil and gas sector. A key objective of this work has been to identify measures to accelerate emission reduction efforts in this sector. This report summarizes the findings of this study.

BACKGROUND AND CONTEXT

As a background for understanding the nature of barriers and challenges with finding effective and efficient measures, some key characteristics with emissions of methane and black carbon from the oil and gas sector are presented below.

Methane and black carbon emissions are so-called short-lived climate pollutants (SLCPs), which over the past few years have received increased attention both in the research community and among policy makers. Various international organisations and initiatives, including the Climate and Clean Air Coalitions with more than 30 state-partners, work to promote reduction in emissions of short-lived climate pollutants as a particularly effective means to combat global warming.

The oil and gas sector is expected to contribute a significant share of global anthropogenic methane emissions. However, there is a lack of measured data on methane emissions from upstream operations. In the public domain, available data predominantly originate from North America (i.e. US and Canada), and very few empirical studies are available for other key oil and gas regions. Methane emissions are spread across more than hundred thousand locations globally, including millions of emission sources. Emissions predominantly occur during gas production and transportation[2] (e.g. from compressors, dehydrators and pumps, pneumatic devices, fugitive leakages, well blow-downs and completions). Production of oil is also a major source of methane emissions in many regions (e.g. degassing of fluids, flaring/cold venting and product storage/loading). Each well site, compressor station, gas plant and pipeline segment may include a few to hundreds of emissions points. Compressor stations in Canada are e.g. estimated to have more than 10 leak points in average (and a number of gas vents)[3], while gas plants include tens of thousands of components of which a few

[1] "Best practice for reduction of methane and back carbon emissions from Arctic oil and gas production"
[2] http://www.epa.gov/methane/gasstar/basic-information/index.html
[3] «Quantifying cost effectiveness of systematic Leak Detection and Repair Programs using Infrared cameras", Carbon Limits report CL-13-27 (2014).

percent are typically leaking. Field data shows that emission rates from similar equipment and processes are highly variable, and depend on the type and the age of the equipment, the season, maintenance practice and the operating conditions[4]. Methane emissions provide limited sensory feedback to humans (not visible, and limited odour and noise in most cases), and this makes it difficult to identify and estimate these emissions without specialized equipment. These characteristics also contribute to high monitoring, reporting and verifications costs of possible emission measures.

Figure 1: Gas tank as seen with human eye (left image), and as seen with an infrared camera (right image).



Black carbon emissions are a result of incomplete combustion. Within the upstream oil and gas sector, the dominant source of black carbon emissions is expected to be flaring of gas. Significant flaring occurs in or near the Arctic region, where black carbon emissions can be deposited on snow and thus result in increased climate forcing. As black carbon has a very short lifetime and climate forcing increases with latitude of the source, reducing the level of emissions could result in a rapid climatic advantage.

Although the oil and gas sector is considered to represent a small share of global black carbon emissions, recent studies suggests flaring could be the dominant source of black carbon above 66 degrees north latitude[5]. Physical measurements of black carbon emissions from flares are difficult to conduct, and there is a large degree of uncertainty related to actual emission rates due to lack of field data, discrepancies of reported flare volumes and limited knowledge of flare gas characteristics and flare design (affecting combustion conditions).

Publicly available inventories for SLCPs primarily rely on multiplying activity data with emission factors. Available inventories vary greatly with respect to (i) their level of detail (i.e. disaggregation of activities into sub-activities with increasingly similar emission characteristics) and (ii) the scientific basis for applied emission factors. Existing inventories show that methane emissions from upstream oil and gas production represent a significant share of global anthropogenic methane emissions. The

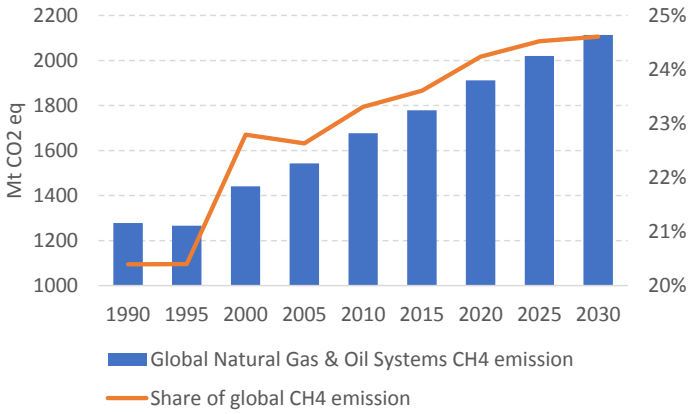
[4] «Quantifying cost effectiveness of systematic Leak Detection and Repair Programs using Infrared cameras", Carbon Limits report CL-13-27 (2014).

[5] Black carbon in the Arctic: The underestimated role of gas flaring and residential combustion emissions, Stohl A, Klimont Z, Eckhardt S, Kupiainen K, Shevchenko VP, Kopeikin VM, Novigatsky AN, Atmospheric Chemistry and Physics, 13(17):8833-8855 (5 September 2013)

US Environmental Protection Agency (EPA) e.g. estimates that about 30% of the US anthropogenic methane emissions originate from the oil and gas sector. A recent research study based on ~13,000 measurements of atmospheric methane in the US indicates that actual emissions from oil and gas operations may be even higher[6]. In the IEA report "Redrawing the Energy- Climate Map" from 2013, it is stated that *"around 1.1 Gt CO_2-eq of methane, a potent greenhouse-gas, was released in 2010 by the upstream oil and gas industry"*. Other sources, e.g. inventories compiled by International Oil and Gas Producers Association (OGP), indicate that global emissions are smaller. Despite the significant uncertainty around total emission volumes, emissions from the upstream oil and gas sector are considerable and expected to increase.

Emission inventories for black carbon emissions are rarely available.

Figure 2: Global methane emissions from the O&G sector and the projections[7]



A number of technologies are available to reduce methane emissions from the oil and gas sector, and black carbon emissions can be reduced through minimizing flaring and improving flaring conditions. While abatement costs can vary significantly between production sites, multiple studies have shown that there are considerable emissions that can be eliminated at low or negative abatement costs (e.g. IEA[8], Natural Gas Star Program[9], and Carbon Limits[10]). Given these modest abatement costs, improving the understanding of the prevailing barriers that prevent mitigation efforts and efforts that can be taken to eliminate these barriers is considered important, and has been the scope of this study.

METHODOLOGY

The analysis of barriers and possible measures to eliminate barriers to reduce methane and black carbon emissions presented in this report are based on literature studies, previous work by Carbon

[6] "Anthropogenic emissions of methane in the United States" (2013).Proceedings of the National Academy of Sciences of the United States of America.
[7] http://www.epa.gov/climatechange/EPAactivities/economics/nonco2projections.html (2011)
[8] "Redrawing the Energy- Climate Map"
[9] http://www.epa.gov/gasstar/tools/recommended.html
[10] Quantifying Cost-Effectiveness of systematic Leak Detection and Repair Programs using Infrared cameras, Carbon Limits, December 2013

Limits and a large number of interviews with stakeholders with in-depth knowledge of methane and black carbon emissions and related policies and regulations. The analysis has been focused on the role of the oil and gas industry, regulators and other stakeholders in efforts to reduce emissions. Ideas and preliminary results of the work have been presented at conferences to gain feedback and build a common knowledge base. It has been important to obtain a comprehensive overview of barriers to action and the view of stakeholders on how barriers can be reduced or eliminated.

Policies and regulations play an essential role in triggering abatement measures. A review of existing regulatory structures and practises has therefore been important. This review has subsequently led to the presentation of elements of "sound" regulatory approaches in this report. National policies and regulations, together with possible international initiatives and measures will present practical recommendation from this work.

The interviews helped in getting a better understanding of what different players see as current practical challenges that hinder further reductions of methane and black carbon emissions. Interviews have been conducted with 28 institutions[11], comprising oil and gas companies (environmental advisors), regulatory authorities, technology providers and researchers, international organisations and initiatives, environmental non-governmental organisations (NGOs) and national/regional government agencies. The interviews primarily addressed the following questions:

- *What is the level of concern and awareness of the issue?*
- *What do you see as obstacles to further reductions and the reasons for that?*
- *What would you improve in order to overcome those obstacles, both internally in your organisation/company and/or externally?*

The interviews, however, were open to any additional information that could help get a better sense of the current situation.

STRUCTURE OF THE REPORT

The report summarizes the findings with respect to barriers identified both from corporate and public perspective (**Chapter 2**), regulatory measures (**Chapter 3**) and broader non-regulatory means to overcome these barriers (**Chapter 4**) and lastly conclusions and recommendations (**Chapter 5**).

During the course of this work a large number barriers and potential measures to reduce emission have been mention by interviewees and have been considered by the project team. Barriers and measures are presented in a tabular format in **Annex 4) Barriers** and respectively **Annex 5) Measures**. In additions a review of relevant regulatory practises and a discussion of elements of "best practise" regulations are included in **Annex 2) Regulations**.

[11] See **Annex 1**.

2. BARRIERS TO EMISSION REDUCTIONS

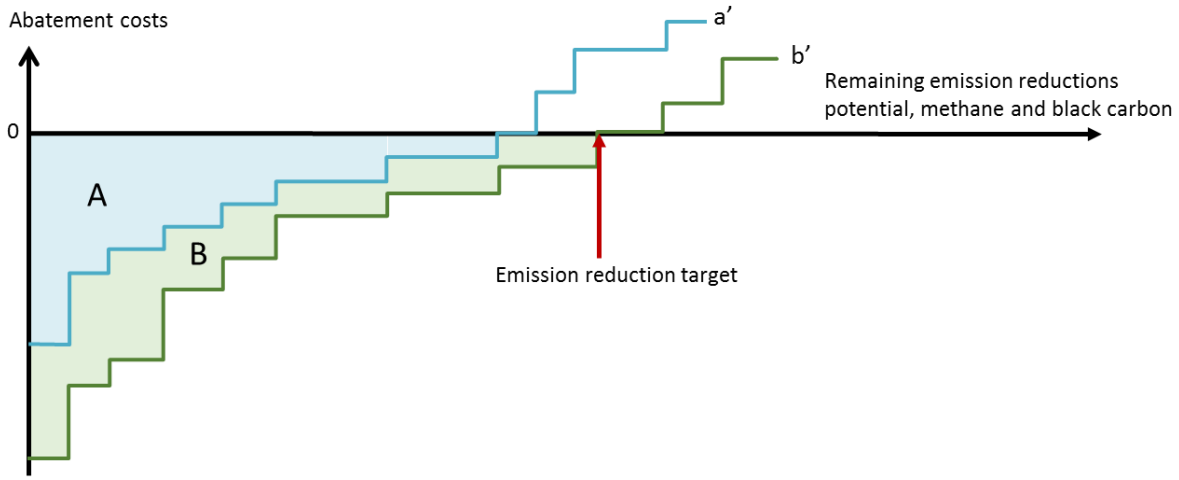
This chapter clarifies what we mean by a barrier both from a company perspective as well as from a societal perspective. We then aim to categorise the barriers into broad categories and lastly we describe in more details the various barriers.

2.1 Definition and categorisation of barriers

The definition of barrier used for this report is: *a physical, societal, economic, organizational or psychological factor that prevents a desired outcome.* The report explores the character of these factors and how to deal with them. For this work it is important to clarify the meaning and scope of *desired outcome.* The desired outcome is to reduce emissions of methane and black carbon, and it seems natural to link it to emission reduction targets set, directly or indirectly, by political authorities.

Emission reduction efforts are often presented according to their abatement costs. Figure 3 shows possible emission reductions, not being implemented currently, ranked according to their net costs. They will typically entail capital costs for new machinery and equipment and operational expenses, and some sales revenues[12] for the resources (gas) no longer wasted. Some investments will from a private perspective be economic, i.e. they have a "negative costs" in that revenues exceed costs (calculated as discounted values over the economic lifetime of the investment), while others will be unattractive from a pure private economic viewpoint. The typical private abatement costs curve is illustrated as curve a' in Figure 3, with zone A being the potential for emission reductions at negative costs.

Figure 3: Schematic of the private (a') and the public (b') abatement cost curves



[12] Other benefits may also apply, such as improved safety through reduced gas leaks.

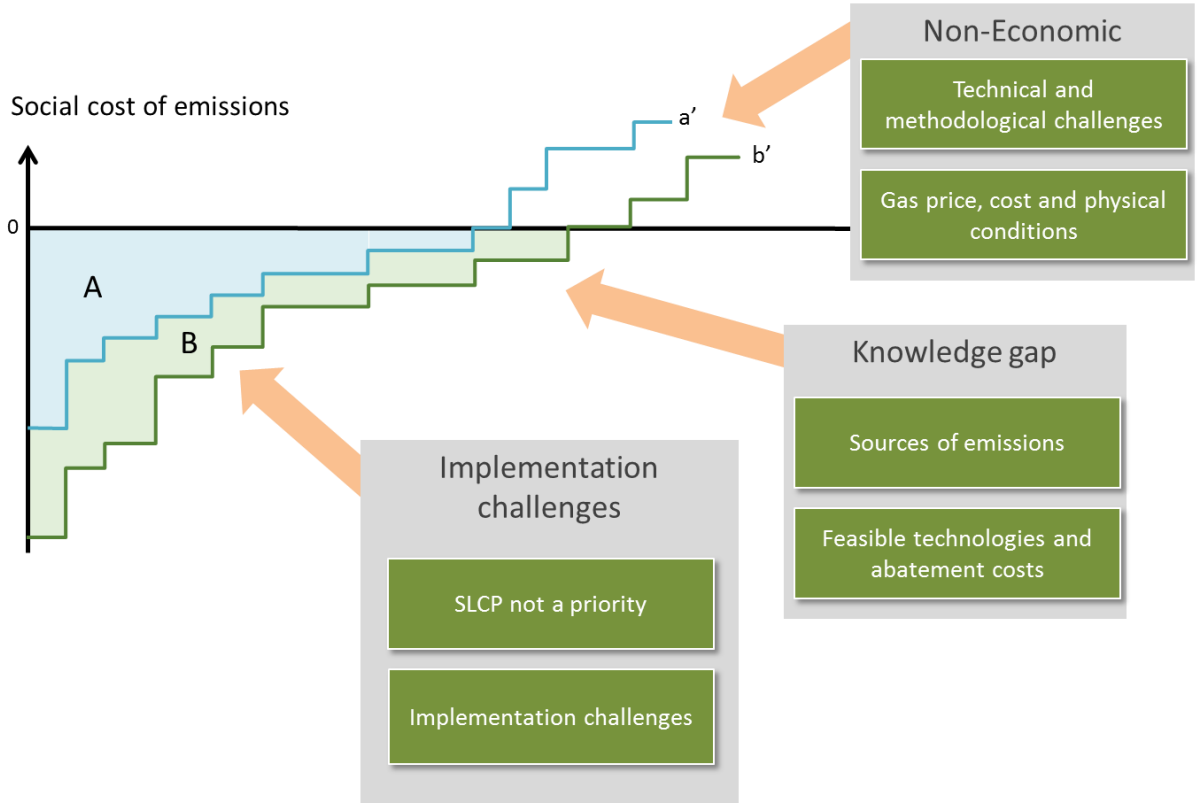
Seen from a societal perspective the potential for attractive emission reduction projects will tend to be greater, illustrated with zone B in the Figure 4. This is because there for each of the investments are additional benefits due to the value of emission reductions (of CO_2, black carbon, NO_x, methane and nmVOC). They create benefits in the form of climate change mitigation and health and local environmental improvements. The societal benefits can also differ from the private benefits due to gas prices which are kept low for political reasons in certain countries. As a result the abatement cost curve including the societal benefits will have a shift to the right (b'). The zones A + B can therefore been seen at a *desired outcome* not being realized due to barriers.

In broad terms there are two causes for barriers to exist (see Figure 4 below):

- Knowledge gap
  Lack of knowledge about emissions and emission reduction opportunities

- Implementation barriers
  Lack of capabilities or readiness to act by investors and authorities

Figure 4: Causes of barriers



Knowledge is a necessary condition for cost efficient action, but even with adequate knowledge there are a number of factors that stop investors from implementing investments that appears to be attractive from a private and/or societal perspective.

The complex nature of methane and black carbon emissions makes lack of knowledge common. Both high costs and practical difficulties may prevent broad measurement campaigns and with companies rather focusing on selected point sources with obvious safety or economic benefits. This in turn impacts on authorities that rely critically on unbiased emissions data from companies and also on other information that can reveal the costs of abatement.

Lack of readiness or capability to implement profitable projects is a well-known phenomenon in the field of energy efficiency and emission reductions. Energy companies typically have their focus on increased production capacity rather than the relatively modest supply increases and economic gains that can be made through energy efficiency and emission reduction investments. For this reason, political and regulatory authorities have a particularly important role to play by introducing measures so that the potentials are realized.

The discussion of the barrier concept above is made within an analytical framework of cost benefit analysis and cost efficiency. This implies that measures that are not implemented because they are clearly uneconomic, from a private investor or society perspective, are not considered to face barriers; they simply should not be implemented. It should be added that monitoring, reporting and verification costs and other administrative expenses related to regulatory compliance can be substantial and should therefore be adequately accounted for in the costs benefit analysis. Such cost can be substantial and may at times undermine the economic rationale for regulatory action. In practise, applying a cost benefit framework as outlined here requires much information which may not be readily available. Hence, determining the scope for action will not be easy.

Knowledge gap and implementation barriers have their origin in two different types of institutions:

- Companies that cause emissions and where mitigation actions should be implemented
- Public sector institutions responsible for policies and regulations affecting emissions

Barriers are presented and described according to their prevalence within these two institutions. Based on information from the interviews and literature studies around 20 barriers were identified. 15 of these barriers, which are the main company and regulation barriers, are listed in Table 1. An indication of their importance (from interviews and subjective judgement) has been made with the blue bullet points in the right- hand column. It should be underlined that there is great variability on the importance of barriers between countries/jurisdictions.

Whilst some countries have done much research to understand emissions and have already some regulation in place, other countries have no inventory at all and no regulation related to methane. Similarly there are differences between companies where some have been proactive in implementing large programme to reduce emissions and other have very limited knowledge/action on these questions.

The following paragraphs thus describe the barriers that could be experienced, but not all the barriers are relevant to all actor. Further description of the barriers is included in **Annex 4) Barriers**.

Table 1: Main Company and regulation barriers and their relative importance to Methane and Black Carbon emissions

Company barriers	CH_4	BC
Lack of company knowledge about emissions and emission reduction opportunities		
Lack of awareness about sources and magnitude of emissions	■■■■	■■■■
Data confidentiality prevents sharing of processes, emission inventories and technology information	■■■■	■■■■
Insufficient knowledge about best practice mitigation technologies	■■■■	■■■■
Lack of reliable estimation of cost of best available mitigation technologies	■■■■	■■■■
Implementation challenges: Lack of capabilities or readiness to act by investors		
High opportunity costs of emission reductions reduces profitability and cash-flow	■■■■	■■■■
Insufficient incentives and motivations to act in the companies	■■■■	■■■■
Complexity and number of actors involved in emission reduction projects	■■■■	■■■■
Risk aversion and conservatism in the companies	■■■■	■■■■
Regulation barriers		
Knowledge gap on the emission reduction potential		
Only rather basic or non-existent knowledge of national/regional emissions	■■■■	■■■■
Ongoing scientific debate or dispute on the effect of black carbon (and methane) on climate	■■■■	■■■■
Knowledge gap on technology and costs at the national level	■■■■	■■■■
Important challenges to implementation of effective regulations		
Insufficient determination of political authorities to promote new regulations	■■■■	■■■■
Lack of public awareness & interest	■■■■	■■■■
Conflicting incentive structures, regulation and enforcement between different authorities	■■■■	■■■■
Challenges in developing and implementing effective tools and quantification methodologies	■■■■	■■■■

Legend

- Not relevant
- Minor importance as barrier to the corresponding emission reduction
- Fairly important barrier to the corresponding emission reduction
- Very importance barrier to the corresponding emission reduction
- Key barrier to the corresponding emission reduction

2.1 The company perspective

Knowledge gap

Both through literature studies and interviews it is clear that there is often significant knowledge gaps in the companies when it comes to level of emissions, what technologies are available and the cost/benefits of such technologies. Although this is the case for both methane and black carbon there are also important differences.

Black carbon emissions have until recently mainly been considered to create negative local health effects while climate change impacts have not been acknowledged and understood, and awareness have hardly penetrated the oil and gas companies beyond environmental advisors. A major source of black carbon emission is, as mentioned, flaring from the oil and gas operations. When these flares are located near densely populated areas and visible smoke is seen, however, the issue is normally getting higher attention and tends to be addressed[13].

Methane is neither generally well known and understood and not regularly measured and reported internally or externally. When methane emissions are reported, the volumes are in most cases based on emission factors which often have a poor empirical foundation and with under-estimation as a result. Companies typically use safety sensors in their facilities to detect important gas leaks. These measurement procedures can give a misleading impression that there is no emission in one facility, since safety sensors only detects dangerous gas concentrations which are associated with only the largest gas emissions. Since CO_2 is perceived as the dominant contributor to climate change it is rare that methane and black carbon emissions surface to the management risk register in the company.

Knowledge gap factors on mitigation technologies

Lack of internal know-how

Even when there is an awareness of the current emissions, in some companies, there still may be a lack of knowledge or experience with technologies in a specific set of operational conditions. This may particularly be the case for smaller companies who may not have much experience or the resources to build this capacity.

Lack of trust in technologies

Some technologies are perceived to be at early commercial stage by the operators, although they are considered mature by the technology providers. Past experiences may have damaged trust in some of the best practices/technologies.

[13] Flaring as a resource waste, however, has over the past 10-15 years been subject to increased attention by public authorities and the oil and gas industry.

Lack of information material or lack of trust in available information

Technical standards describing the instructions, risks and opportunities that have been developed for the technologies are regarded as inadequate and tend to miss comprehensive description of implementation realities.

Culture of confidentiality

It is prevalent in the oil and gas sector. The sector is very competitive and not used to share any information that might be perceived as a competitive advantage. Particularly larger organisation zealously guard and protect what they perceive as sensitive information. This practice of non-sharing may be exacerbated by fear in the company of overstepping the boundaries of anti-competitive behaviour where the penalties may be large.

This section has addressed the knowledge gap that exists on both emissions levels and technology to mitigate. The next section will focus on some of the underlying factors for this gap to prevail.

Implementation barriers

The oil and gas industry is very competitive and subject to the "quarterly reporting tyranny" by the financial markets. They are thus forced to screen and rank projects to ensure that they are only undertaking the best investment opportunities. Only very rarely would emission reduction projects rank in the internal competition for capital compared to project that increases production and cash-flow and yields higher return. It may seem strange to many outside the industry that not all profitable projects are undertaken or invested in. The financial markets (analysts) "reward" capital discipline and are concerned about companies squandering money on projects with mediocre economics.

Another reason is that there is often shortage of qualified people and thus a prioritisation is required. Further, management time is precious and watering down management attention often leads to poorly executed projects. So unless there are specific guidelines for policy reasons ("Licence to Operate") to prioritise such investments they will normally not be selected in the internal completion for resources and will thus not happen. Some companies are aware of this ("risk") and have introduced different return on capital requirement or set aside a separate capital pot for such projects (e.g. energy efficiency projects) with variable success so far. So even if emission reduction projects may show a positive return the project is simply not good enough to be prioritised.

In addition to the low ranking; emission reductions projects may be, and be seen as, very complex (they need to be implemented in many different sites) and typically involve many internal and external actors, thus further reducing the likelihood of project's implementation. Due to the high value stemming from production of hydrocarbons, the risk of potential delays or interruptions to this revenue stream will have high focus at all levels in the companies. Partly for the same reason oil and gas companies are generally known for being risk averse and conservative regarding their practices. Very often projects are stopped at various layers in the company if the technology is not considered to be proven. The business case for such investments which may use technology which is not proven

or well-known is therefore often weak. This risk aversion is further exacerbated by the very strong focus on safety in the business, particularly when it comes to work undertaken in a hot plant (retrofitting outside normal shut-down periods).

Last, but not least, one cannot ignore the element of strategic gaming from some oil and gas companies. By not addressing the issue in earnest, the data and information may not be available for effective regulation that they may fear being developed.

2.2 Public institutions perspective

Knowledge gap

In many countries there is no or only very basic inventories for black carbon or methane. Since the effect of black carbon on climate is not fully understood scientifically, and to a degree controversial, and is currently not reported as part of the national communication under the United Nations Framework Convention on Climate Change (UNFCCC) it is not fully part of the climate change policy agenda. Also for methane, emissions from the oil and gas sector are not reported on a regular basis by developing countries and when reported estimates are uncertain. Several factors play into this non-reporting, including the complexity of the sector and the lack of expertise as well as resources in general to undertake and prioritise these tasks (compared to e.g. CO_2 emissions). As there is no or only rudimentary site monitoring, the data required to develop proper inventories may simply not exist.

Even when methane emission inventories exist, there may be important uncertainties in the estimates as the number of emission sources is significant and the emissions very variable. This tends to confuse and alienate participants in the political debate and prevent consensus building.
An essential ingredient of an effective regulation is good data on technical information and understanding of the risks, costs and opportunities of using a certain technology in certain circumstances. The feedback loop of how this works in practice is also of vital importance.

Implementation barriers

With the exception of a few jurisdictions, see **Annex 2) Regulations**, methane emissions from oil and gas infrastructure have received very limited political attention and are often not on the radar screen for future regulation. A number of circumstances can explain this:

- Climate change mitigation is not considered a political priority. It may be perceived as a threat to oil and gas sector revenues, jobs and industrial activity.
- Given the complexity of oil and gas sector methane and black carbon emissions there are major challenges in developing and implementing good regulations, including the demanding task of establishing competent regulatory institutions.
- Attention and efforts are focused on large and visible point sources, e.g. CO_2 emissions from the power sector

With respect to black carbon, gas flaring has attracted much more political attention (than methane) over the past decade as it is a very visible sign of both resource waste and environmental problem. It is thus regulated in most countries, however not always in an efficient and effective manner.

There is very limited publication and communication for the general public on emissions of short lived climate pollutants in general as well as for the oil and gas sector. The sites and sources of emissions are often in remote areas and thus away from public attention. This contributes to the lower focus of politicians and regulators compared to the activities around e.g. CO_2. Lately there is however an awakening of the adverse effects of leakages from the oil and gas systems, particularly in North America.

Conflicting political priorities are important barriers to policy induced emission reduction effort. Also from a public perspective revenues from oil production dominate and policy objective considered to be in conflict with this will have second priority. For example low profitable emission reductions may be perceived as "crowding-out" more profitable investment and threaten the existence of companies unless a level playing field is established in all relevant markets. In new field developments gas utilization plans often lag behind oil supply systems in the planning and implementation process with large amounts of gas flaring as a result (particularly during early phases of production). This is particularly an important factor in remote places or where each accumulation of hydrocarbons is too small to warrant a gas evacuation or utilisation solution in its own right. Even if there happen to be a pipeline, access may be hampered for capacity reasons, competitive reasons or absence of regulation for 3rd party access. Gas prices, kept low for political reasons in some countries, were mentioned as important barriers discouraging emission reduction investments.

More generally a number of market conditions may not incentivize emissions reductions. Interviewees mentioned inadequate infrastructure, low (but still market based) gas prices, costly retrofitting, immature technology and harsh environment as important factors. These reasons given are all relevant and understandable and often do not constitute a barrier as the emission reductions may not be sensible (economic) to undertake under certain circumstances.

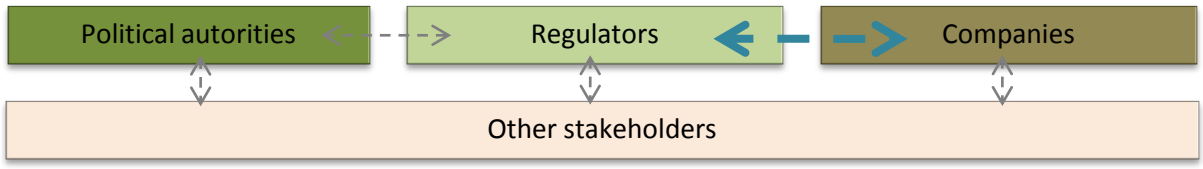
Lastly, the capacity and capabilities of regulatory institutions are important factors, particularly since black carbon and methane emissions from oil and gas industries are new on the policy agenda and due to the complexities of these emissions and measures to reduce them. Regulatory aspects are discussed in the next chapter with emphasis on approaches that can eliminate barriers, and are further described in **Annex 2) Regulations**.

2.3 Key actors - functions and roles in emission reduction efforts

In broad terms, four types of institutions represent the main action parties to address the barriers presented here; the regulators, the regulated companies (polluters), political authorities and other stakeholders.

The interactions between companies and the regulatory authorities, as described in **Chapter 0** and **Annex 2) Regulations**, have been the dominant factor for spurring action and will probably continue to be so, provided that regulation develops so as to become more effective and cost efficient (illustrated with the **thick arrow** in Figure 5). Nevertheless, with the increased focus on methane and black carbon in international climate polices the role of other institutions, such as oil and gas industry associations, environmental NGOs, international initiatives/partnerships and research institutions, will become more important and they are emphasized in the recommendations presented in this report (**Chapter 4**).

Figure 5: Key institutions and their interaction



Political authorities set targets for emission reduction and they set the framework and general rules for the regulatory functions. In most countries (but not all) political and regulatory institutions have distinctly separate mandates and areas of competence, and the regulator acts without political interference in day-to-day operations. Political authorities must have access to information, normally not company specific information, in order to set environmental targets and priorities and possibly for the purpose of imposing fiscal or other relevant policy measures.

Regulators design and implement regulation related to emissions, and review compliance and conduct enforcement of the regulation. As further described in Chapter and Annex 2, the regulator normally exercises the main external pressure on companies ("polluters") to undertake emission reductions actions.

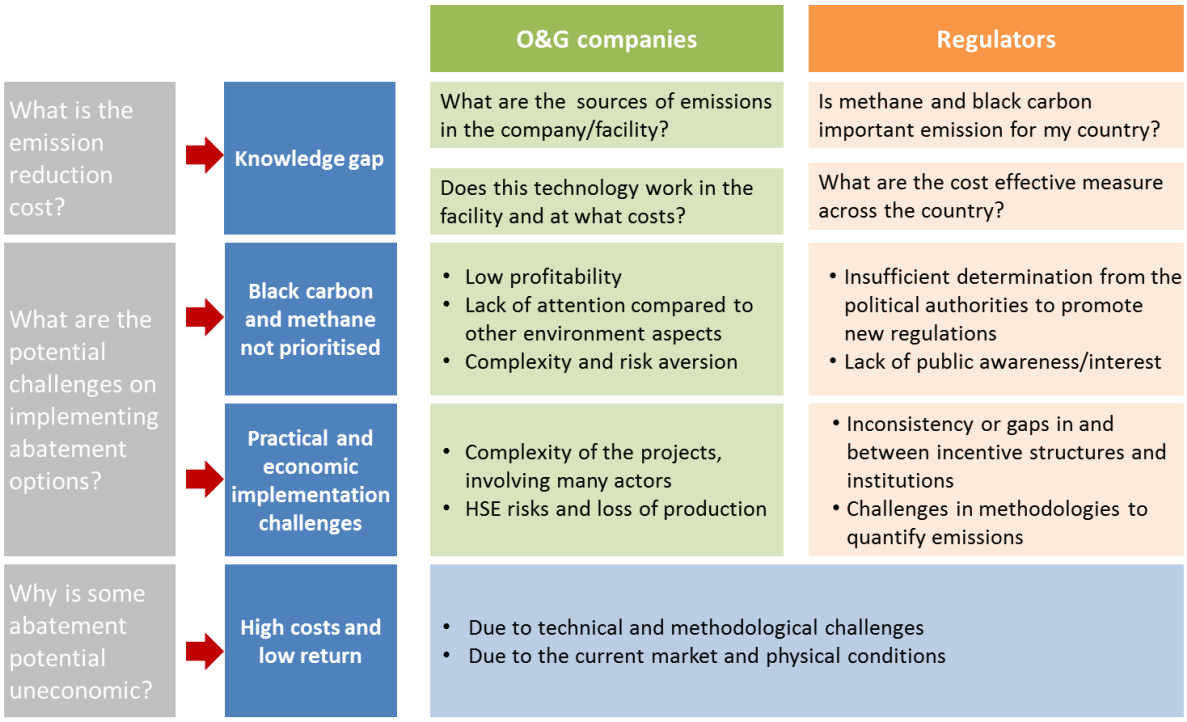
Companies monitor and calculate emissions and explore opportunities and costs for emission reductions, and eventually implement measures that reduce emissions. They are the principal institutions of actions. Emission sources are from installations they own and/or control and they would normally carry all or most of the risks with an investment.

Other stakeholders promote and support actions. They represent a broader group of institutions which can influence and/or be part of actions in a number of different ways. They can also be part of collaborative processes with companies in planning and implementation of investments and other measures. Technology providers, finance institutions and other commercial entities have self-interests in spurring investments and may even take commercial positions in projects. Industry

associations and international initiatives such as the CCAC, GMI and GGFR can play an important role in facilitating coordinated emission reduction efforts of the oil and gas industry. Environmental non-governmental organizations have important functions in retrieving and dissemination in information and through spurring action.

Figure 6 summarises the key barriers and where they originate:

Figure 6: Overview of barriers preventing emission reductions



Selection of the measures presented in **Chapter 5** follows from the interviews with stakeholders and the review of tested and proposed measures. **Annex 4) Barriers** presents proposed measures in more detail.

3. REGULATIONS

3.1 Do best practise regulations exist?

Many stakeholders interviewed for this project highlighted the importance of regulation for achieving significant emission reductions. Reference was made to the need for a well-functioning regulatory regime, but often without clarity on what this would mean in practical terms. This chapter discusses what good regulation might entail for methane and black carbon emissions in the oil and gas sector.

Regulatory approaches to reduce methane and black carbon emissions vary greatly between countries. Amongst other this is because they are part of broader national legal and regulatory structures, and they are rooted in distinct institutional traditions and capabilities. Different regulatory approaches are not necessarily a problem; they can still be effective and cost efficient. Therefore, there is no "blue print" for good regulations. Nevertheless, emissions of methane and black carbon have some typical features which should influence regulatory design, and the existence and nature of barriers should also have a bearing on regulatory priorities and practises. In this chapter we consider these factors and suggest some elements of best practise regulations applicable for oil and gas sector, drawing on the barriers discussed in **Chapter 2**. In addition some suggestions are made for regulatory measures that might be prioritized. **Annex 2) Regulations** includes a more detailed discussion on elements of best practise regulation and a review of existing regulations in some countries/regions.

3.2 Regulatory approaches and best practise criteria

Broad categories for regulatory approaches or tools

Standards include requirements for use of specific technologies and/or operational practises, and quantifiable emission limits. As standalone tools technical standards are most common (often denoted BAT, best available technique). Emission limits are often used in conjunction with technical standards (e.g. to determine the BAT) or combined with economic instruments (e.g emission charges or fines).

Economic instruments cover emission charges and emission fines (for emissions above a permitted level), emission trading systems and so-called offset credit scheme, and tax rebates and financial grants for specific emission reduction investments. Tax rebates and grants normally do not require quantification of emissions and therefore have lower administrative costs than the other economic instruments.

Negotiated agreements can encompass several companies and the regulator, can take different forms and will normally include the following elements: i) an emission reduction targets negotiated and agreed between the regulator/political authorities and companies and ii) one institution to promote and coordinate emission reduction measures to be implemented by companies iii)

procedures for monitoring, reporting and verification of compliance and eventual enforcement measures.

These regulatory approaches will be evaluated against three criteria for good regulation:

Cost-efficiency
For each specific environmental problem low cost measures should be implemented before measures with higher costs. Due to the sensitivity of emission reduction (abatement) costs to site specific conditions and the variability of local environmental impacts, there are considerable practical challenges with ensuring cost-efficiency. Perhaps the most difficult part is to acquire adequate and unbiased information in order to prioritize. The administrative costs of compliance and enforcement, both those covered by the companies and the regulatory agencies, can be significant (particularly monitoring and verification costs) and must be taken into account when cost-efficiency considerations are made.

Clarity and transparency
Rules and procedures for application and approval of emission limits and technologies should be clear and transparent, and the same goes for compliance and enforcement mechanisms. Predictability in the use of regulatory tools and enforcement is also important, not the least for the purpose of reducing the risk associated with investments in new and efficient technologies.

Institutional capability
Regulatory ambitions must be attuned to the capacity and capability of regulatory institutions. Again the complexity of oil and gas sector operations and emissions is a challenge. Regulatory institutions must have staff with adequate sector specific competence, otherwise the principles of cost-efficiency and clarity/transparency will be undermined. More fundamentally, regulatory staff must act impartially and without risk of corruption/mismanagement. Regulatory requirements, data reporting and enforcement procedures which are flexible (e.g. for the sake of cost-efficiency) will generally be more susceptible to corruption than rigid and simple rules. So again, there are difficult trade-offs between cost-efficiency and clarity/transparency. Finally, regulatory institutions should have clear and not overlapping functions. This may also have its practical challenges in the case of methane and back carbon emissions since emissions cause concern for climate change, local environmental damages, safety and health as well as resource conservation. All these issues are rarely handled by one regulatory institution or by one set of coordinated regulatory measures.

The ease with which a regulation can be implemented and the certainty of achieving the set targets, often denoted effectiveness, may be listed as a separate criteria to the three above, but is for the purpose of this analysis considered as part of cost-efficiency.

3.3 Elements of best practise regulation

It can be misleading to give the regulatory approaches a score according to the three criteria, e.g technical standards a low score on cost-efficiency and a high score on clarity and transparency. Some of the regulatory approaches will by design "pick" the emission reduction with the lowest abatement cost first (e.g. economic instruments such as emissions trading and offset schemes and emission charges) while cost efficiency for others will depend on the specificities of the regulation. For example, imposing dry seal as a technical standard on all compressors may often lead to high abatement costs due to the downtime cost, while imposing low bleed device on new equipment may have negative or low abatement costs on most application.

Another complication with a comparative analysis is that the approaches/tools often will be used in combination, and the fact that regulations serve different and sometime conflicting targets (e.g. local versus global environmental concerns, environment versus economic returns). In the practical design and implementation of regulations there are therefore difficult trade-offs to be made, and for this reason it is also difficult to make specific recommendations for regulatory measures here.
What follows here, despite these caveats, is a schematic overview of the qualities of the regulatory approached (as shown in Figure 7) and a further summary of their pros and cons, with reference specifically to methane and black carbon emissions.

Figure 7: Illustrative assessment of regulatory tools

	Cost efficiency		Clarity and transparency	Institutional requirements
	Incentivize cost efficient measures?	Minimize administrative (monitoring) costs?	Clarity and predictability for investors ?	Limits design and enforcement challenges ?
Standards	Depends on the regulation's specificities	Yes	Yes if specific, if not source of disputes	Partially
Emissions trade & offsets, charge & fines	Yes, by design	Variable, but risk of important monitoring costs	Depends on the regulation's specificities	Partially
Negotiated agreement	Variable but likely	Variable but likely	Variable, likely when broad, less likely when few /bilateral	No

Elements of best practice regulation

Technical standards for methane

Technical standards offer a transparent and simple mechanism to reduce emission; in particular this option does not involve the need for cumbersome monitoring. However to be cost-effective, the technical standards must be based on a detailed understanding of the variety of specific conditions in the oil and gas sector. It therefore represents a considerable burden on the regulator for the design, the update and the enforcement of the regulation. Leak detection and repair programs can be

considered as standards, and empirical studies suggest that they can be cost efficient[14]. However, empirical analysis of emission sources and survey & repair costs should be conducted before such programs are designed and operationalized.

Technical standards for black carbon

Technical standards mandating the use of equipment that reduce or eliminate smoke[15] can be cost-efficient in cases where flare elimination is not feasible or prohibitively expensive. Also, technical standards may be considered to reduce or eliminate flaring which earlier has been justified for safety or operational reasons. Impacts of black carbon emissions are sensitive to location, which implies that standards may differ from facility to facility.

Flare restriction or prohibition

A common regulatory approach to flaring is to set quantitative limits on the amount of permissible flaring (typically 5% or less of associated gas production). In its purest form, with none or few exemptions, it requires little regulatory follow up and hence may be a preferred option in countries with weak institutional capacity. However it generally scores low on cost-efficiency because the economics of flare reductions investments vary greatly. With weak regulators this may also lead to lack of compliance. There are many examples of ambitious flare reductions limits/targets not being met due to lack of enforcement. Emission limits/targets of this type therefore works best if they are combined with economic instruments, negotiated agreements, or specific bilateral dialogues/agreements between individual companies and the regulators. However, such approaches require the regulator to have high competence and to be impartial.

Emissions trading offset schemes and emission charge for methane emissions

These mechanisms are by design cost efficient as the most cost effective measures are implemented first. However to be effective, the monitoring and verification aspect of these regulatory approaches needs to be designed carefully to balance the need for accuracy and the associated costs. Emissions trading system or emission charges for all methane emissions are difficult due to the large number and great variety of emission sources. Offset schemes in combination with other regulatory tools can be cost-efficient for certain segments of methane emission sources and this is now under consideration in several countries.

Economic instruments for black carbon emissions

Emissions trading or emission charges directly for black carbon emissions are difficult due to monitoring and reporting problems. Emission trading for CO_2 encompassing flaring of gas is however is increasingly common and will also impact on black carbon emissions.

14 "Quantifying cost-effectiveness of systematic Leak Detection and Repair Programs using Infrared cameras" CL report CL-13-17. Carbon Limits

15 In particular NGL recovery systems

Negotiated agreements

Agreements negotiated and agreed between companies and their industry associations on the one hand and regulators and political authorities on the other are interesting approaches with the promise of being effective and cost efficient. Some conditions, however, must be met: i) there must be strong institutions both on the industry and regulatory/political side who are capable and willing to communicate and agree on practical solutions ii) the scope of the agreement(s) must be carefully delineated so that results can realistically be reported and verified.

3.4 Some recommendations for regulatory measures

It is difficult to make specific recommendations for regulatory measures; circumstances vary greatly and the existing legal and regulatory structures and institutional capabilities inevitably imply that responses will have to differ.

Still, from the interviews with stakeholders one message emerged as unequivocal: without clear and consistent regulatory pressure there will be little progress in methane and black carbon emission reductions[16]. A review of existing regulations (**Annex 2) Regulations**) also shows significant shortcomings. This is not surprising since it is only recently that the full contribution to climate change from methane and black carbon emissions is being recognized.

The analysis of barriers brought two key conclusions: i) there is a considerable knowledge gap and ii) despite this gap it is clear that a considerable potential (though empirical evidence is still scattered and incomplete) exist for emission reductions that entails no net costs for companies (negative abatement costs) even when the value of environmental benefits are not factored in.

A first priority should therefore be to initiate measures to reduce the knowledge gap, and without delay to spur or mandate companies to take steps to reduce emissions that are economic.

Reducing the knowledge gap

Taking stock on knowledge of emissions levels and sources for methane

The regulator, companies and their industry associations can jointly develop a report which summarizes common knowledge of emission sources and level (including relevant emission factors and uncertainty levels) drawing both on available company data, national statistics and international data sources. Relevant research institutions etc. may also be involved in this work.

Primary data collection for methane

The regulator can instruct companies to undertake methane measurement campaigns. Third parties may be involved in conducting these campaigns. Their scope and focus should be determined on the

[16] It should be noted however that those interviewed primarily were occupying various environmental positions within their organizations, and as such may have to some degree conveyed their personal views.

basis of available knowledge on emissions (see above). Results should be disseminated, with due consideration being taken to commercial sensitivity issues, and industry-wide and regular monitoring and reporting procedures should be established and implemented.

On black carbon

The issue is more about initiating and performing basic measurement than taking stock as there is very little work done. There is currently great uncertainty on the magnitude of black carbon emission from gas flares and new measurement data are required to reduce this uncertainty. This could be instigated as part of license conditions in an area or in the form of a collaborative regional, national or international initiative.

Early action to reduce emissions

Even when information on emission sources and abatement costs is poor, adequate empirical evidence often exist in support of early action to reduce methane emissions. Examples include leak detection and repair programs which simultaneous provide for better knowledge and emission reductions, and mandated use of "low bleed pneumatic devices"

Emissions trading and offsets for methane

Several large oil and gas producing countries have emission trading schemes (ETS) for CO_2. For technical or other reasons oil and gas sector methane emissions are in most schemes not included. Bringing in methane as an offset scheme whereby project specific and verified methane emission reductions can be traded as credits into the ETS can give important incentives for emission reductions. Under the assumption that international carbon market eventually will be one of the key means of climate change mitigation developing national offset schemes can be an important building block in such a process. Further, the monitoring, reporting and verification issues required for a credible offset scheme will give insight of great value for regulation of oil and gas sector methane emissions.

Proposed specific measure: National offset schemes methodologies

Develop methodologies and procedures for national oil and gas sector methane emissions offset schemes, including monitoring, reporting and verification protocols.

Although regulation is emphasised by many as a key to progress it is important to look at the whole spectre of possible measures. This is partly due to some of the limitations and challenges of regulations mentioned in this chapter but also to tap the potential that is ripe in the companies, industry associations, national and international initiatives and organisations that could enable and spur early actions and successes. As regulation normally will take time it is important to keep the current identified political and industrial momentum.

In the next chapter some of these measures are addressed as well as an attempt to appoint the right "owners" of these suggestions.

4. BROADER INITIATIVES

Following the considerations on criteria for good regulatory approaches and regulatory measures this chapter includes some further recommendations on measures that involve several more institutions and which may be part of international initiatives. Some of the measures are indirect by facilitating emission reduction measures (e.g. measures to close the knowledge gap) and some are direct in terms of specific actions that reduce emissions or costs of emission reduction.

Oil and gas sector operations are highly international with most of the large players being active in many jurisdictions. This can provide for forceful internationally coordinated measures. As referred to above several international institutions and initiatives/partnerships such as CCAC, GGFR and GMI have emerged and are now important forces for internationally coordinated efforts for oil and gas sector methane and black carbon emission reduction. Industry associations such as IPIECA and OGP are also increasingly engaged in these issues[17]. Measures proposed here build on initiatives and experiences of these institutions and the same institutions are counted on as being key promoters and participants of new measures. More, than anything else, however, measures proposed here are inspired by public private partnership initiatives undertaken in North America for almost 20 years, particularly the U.S. Natural Gas Star program.

Emissions surveys and sharing of knowledge about emissions and methods for estimating emissions

Emissions surveys will for the most part be conducted by individual companies. Still, there are economies of scale in doing surveys as industry wide initiatives and this can in many cases bring shared benefits. GMI has supported methane emission surveys at a number of facilities globally[18] and several public institutions and NGOs have conducted and published emission surveys at numerous natural gas production sites across the United States[19]. On black carbon from gas flares GGFR has supported measurement campaigns (with the Carleton University) in Mexico and Uzbekistan and is planning one in Ecuador for 2014.

It is important that such activities are being stepped up and that information and analysis from the surveys are broadly disseminated. Sharing of information on how surveys are conducted will improve the effectiveness and reliability of new surveys. An important aspect in this regard is the experiences with new technologies for emission detection and measurement. Further, interpretation and sound analysis of primary data is essential for arriving at reliable emission estimates. Sharing of information on methodologies and emission factors is therefore important both for companies and the regulators

[17] See for example presentations from a workshop on short-lived climate forcers in Rome, Italy on 8th and 9th October 2013. http://www.ipieca.org/event/20130509/short-lived-climate-forcers-workshop
[18] https://www.globalmethane.org/activities/indexact2.aspx?sector=oilngas
[19] http://www.pnas.org/content/early/2013/09/10/1304880110.full.pdf

and in the processes of developing good national inventories for methane and black carbon emissions.

Collaborative efforts on emission surveys can offer important information to help improve IPCC guidelines for fugitive emissions[20] and on a broader basis help the development of national specific methodologies and manage the huge uncertainties linked to this work.

Initiatives may also be taken to provide technical support, including measurement equipment and experts, to help develop national inventories in countries with high emissions of methane and black carbon from the oil and gas sector.

Pilot projects and sharing practical experiences

There are broadly speaking two avenues to follow in order to enhance the knowledge on best practice technologies. The first is to facilitate and undertake pilot projects under different operational conditions whilst the other one, which could be linked to pilots, is to develop more transparent, unbiased information material on the technologies for different operational circumstances.

As there are many different emission sources under prolific conditions, particularly for methane, pilot projects that have broad replicating value should be selected. There is a strong need to build trust in applicability of certain solutions under different conditions and provide a sound basis for realistic cost-benefit analysis. It is particularly important to reveal and include "hidden costs" (cost of shutdown, cost of monitoring etc.) in order to increase the credibility of the figures presented. Experience sharing between companies and technology providers and teaming-up would both reduce the cost of developing and applying the technologies, reduce the cost of developing inventories and facilitate wider emission reductions.

Sharing knowledge on mitigation actions and technology

Unbiased and objective information (as opposed to pure "glossy" marketing) induce trust in the performance of the technologies and thereby their application. If this information is prepared by e.g. industry associations (both users and developers' associations) the confidence in the applicability could be enhanced.

Although there are still a number of technologies at immature stages of development, one should at the same time "remind" the industry that many technologies are well proven and open for wider applications. Embracing the challenges of wider action before the results of pilot projects are available is therefore still prudent in many cases.

We see the oil industry associations (with the help of technology providers association) as the most relevant owners of this task. International initiatives and investment organisations could play a role as enabler in this respect.

[20] http://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-4.html

International voluntary programs and standards

Developing voluntary programs and/or standards that companies join is potentially a forceful means to have companies prioritize methane and black carbon emission reductions. Companies being partners of initiatives such as CCAC, GGFR and GMI already represent recognition of methane and black carbon emissions concerns, but more specific commitments would bring further impetus. A specific voluntary standard for flare reduction was established by GGFR in 2004. The standard, which includes a commitment to avoid routine flaring of associated gas, is signed by the companies that are partners the GGFR (14 in total). Although less ambitious, the Carbon Disclosure Projects 2013 Oil and Gas Supplement includes a questionnaire on methane emissions. Other partnerships and industry associations are also increasingly presenting achievement of their partners/member on web sites and through other channels.

Climate and carbon finance of mitigation actions

Revenues from previously wasted gas brought to market are often insufficient to trigger emission reduction investments. If emission reductions are estimated, verified and monetized the additional revenues may represent a significant additional revenue stream. Over the past 5-6 years carbon finance has through the Clean Development Mechanism (CDM) and Joint Implementation (JI) of the Kyoto Protocol contributed funds to flare reduction and methane leak avoidance projects[21]. Alternative mechanisms are now being discussed as funds from the CDM and JI have been radically reduced. The Methane Finance Study Group convened at the request of G8 published a report in April 2013[22] looked at whether and how public funds, utilizing pay-for-performance mechanisms may be used to incentive reduction of methane emissions. Other initiatives are ongoing to develop so-called Nationally Appropriate Mitigation Actions (NAMAs) under the Climate Convention[23].

The diversity of proposals and initiatives to promote climate and carbon financing which are now emerging should encourage stakeholders to help raise funds to co-finance methane emission reductions. Such funds can partly be financial resources from institutions (public or private) who will use the verified emission reductions as compliance units against own targets or commitments to reduce emissions or it can be a grant without an emission reduction compliance purpose. Related to this, it is essential that credible methodologies and procedures are established for monitoring, reporting and verification of emission reductions, albeit not being prohibitively expensive. Currently, for oil and gas sector methane reduction projects, they are in short supply.

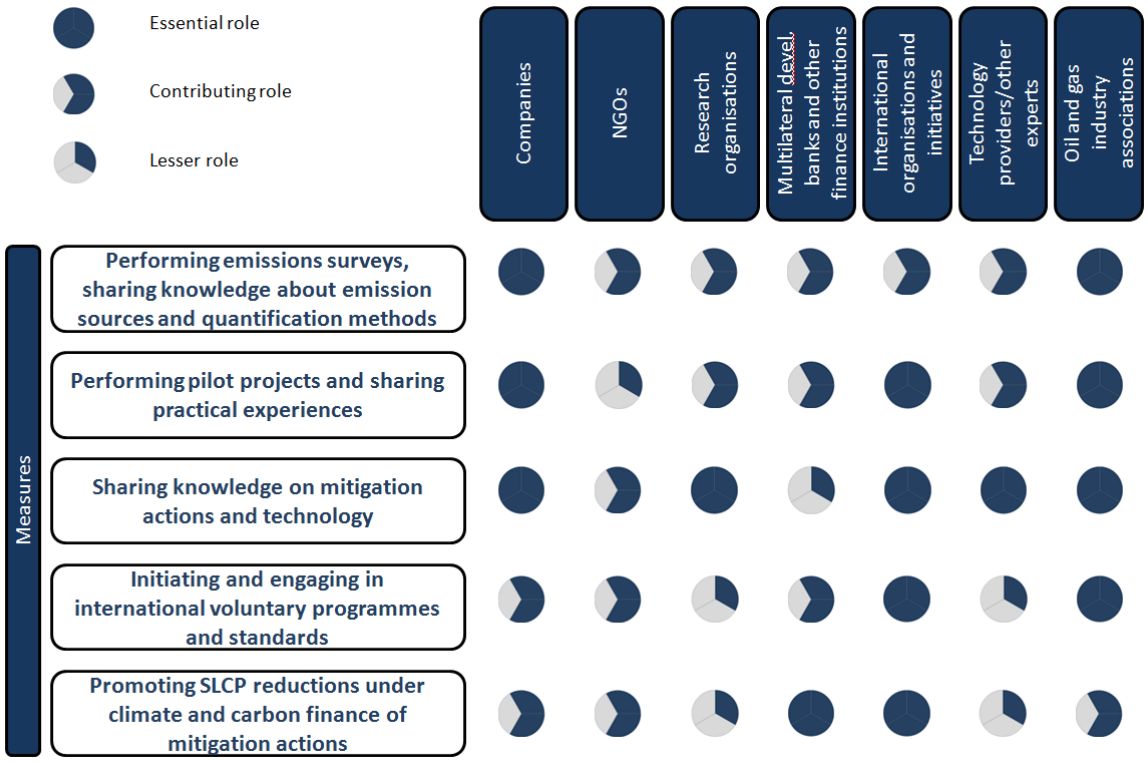
[21] Baseline Methodologies for Clean Development Mechanism Projects. UNEP

[22] Methane Finance Study Group Report. Using Pay-for-Performance Mechanisms to Finance Methane Abatement. April 2013. http://www.climatefinanceoptions.org/cfo/files/Methane_Finance_Study_Group_Report.pdf

[23] Short on what NAMAs are and the ongoing initiatives funded by Canada in Mexico and Colombia

The figure below summarises the broader (non-regulatory) measures addressed in the report:

Figure 8: Main measures and actors - Importance of the roles of various actors in contributing to different non-regulatory measures



It should be noted that the list of action parties is not intended to reflect a standard to-do-list which is applicable in all regions and countries, but rather to summarise the findings of this study with respect to the potential actions that could be taken by different actors; mainly based on previous success stories.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Key barriers to emission reductions

Addressing the problem of emissions of methane and black carbon from oil and gas activities requires a combination of solutions, from developing knowledge and reducing costs to establishing incentive structures and more targeted regulations.

In many regions there is significant uncertainty in methane and black carbon inventories due to lack of systematic approaches to collect comprehensive information.

The high opportunity cost (high alternative value of financial and human resources) of potential emission reduction measures is a particular challenge of the oil and gas industry.

Despite existence and maturity of a number of technological solutions, lack of knowledge on both sources of emissions and potential mitigation options together with scepticism on the technologies' cost efficiency is a major barrier that hinders emission reduction projects and solutions to be implemented. Hence, making efforts to increase knowledge on main sources of emissions by encouraging industry-wide emission surveys are important steps.

On a national level comprehensive emission inventories are vital to understand the existing realities and for the regulatory and political authorities to take the most effective initiatives. In parallel to the importance of realising emission reduction potentials, the knowledge gap on the existing best practices and the most effective technologies needs to be bridged, ideally through systematic sharing of information, success stories and possible challenges that have been faced in different operating conditions. It is essential that information on different solutions and existing technologies in different operational circumstances are presented in a transparent and unbiased manner.

Economic barriers are major bottle-necks towards implementation of methane and black carbon projects. A number of measures, however, could be taken to overcome such barriers. These measures consist of attempts to reduce the overall costs and bring economy of scale by encouraging industry-wide mitigation programmes, as well as investing in expanding applied technology research programmes on mitigation solutions as well as monitoring techniques in order encourage further reductions.

In addition to reducing the direct costs, incentive structures through voluntary programmes, carbon financing and cap-trade systems could also create a great momentum, specifically in case of methane.

5.2 Recommendations

There are a number of policy measures that could potentially incentivise the emission reduction effort and target the existing regulatory barriers. The elements of best policies may vary greatly from country to country. Within the oil and gas sector however, the black carbon emissions could be best targeted by measures that lead to reduction of flared gas and improved flare systems, and the methane emissions could be addressed by a combination of several technical and regulatory actions.

Industry-wide regional cooperation could address a few major barriers, as they can bring the economy of scale to the identification and mitigation efforts and would lead to improvement of information sharing and reduce risks.

In order to achieve the objectives of the measures to overcome the barriers to implement methane and black carbon emission reduction, a number of potentials actors could play different roles to initiate, enable, enforce and apply a variety of actions.

It is important to stress that moving forward, future measures should aim at replicating existing initiatives in other companies, geographical areas and countries to make the awareness journey on emissions and opportunities more efficient. It is also vital to streamline the implementation of emission reduction projects and last, but not least, to explore other options to incentivise emission reductions.

Annexes

Annex 1) Interviews with a number of different players

As a part of the approach to get a better understanding of what different players see as current practical challenges that hinder further reduction of the emissions, a number of actors where interviewed. This included seven oil and gas companies, four regulatory authorities, nine technology providers and researcher, three international organisations and initiatives and five Environmental NGOs and government agencies in a few different regions

The interviews were targeted at i) what is the level of concern and awareness of the issue, ii) what different actors see as obstacles to further reductions and the reasons for that, and iii) what they would improve in order to overcome those obstacles, both internally in their respective organisation/company and externally. The conversations however, were open to any additional information that could help get a better sense of the current situation.

As a result of the conducted interviews, the following points where highlighted as the most important elements which constitute major barriers by all or most interviewees:

- *Lack of information and knowledge about the effect of black carbon and methane emissions on climate change -* CO_2 *is dominating*
- *Lack of information about emissions (emission inventories)*
- *Lack of information on available technical solutions*
- *Regulations are considered as the most relevant vehicle to obtain emission reductions, although there are some that favour companies to be more proactive to avoid regulations*
- *The complexities of oil and gas plants make it very difficult to quantify emissions and to implement reduction measures*

Other elements that were underlined by some interviewees:

- *Emission factors are generally outdated*
- *Stronger cooperation between companies to improve the information about emissions and to share information on technologies*
- *Oil and gas industry is conservative and will most often fight against new regulations*
- *Lack of communication between the administrative and operational levels*
- *Gas price a problem: If it is too high companies do not care about the money that might be saved by implementing measures with negative costs, and when the price is very low there is no incentive to implement energy efficiency measures*
- *Both methane and black carbon are difficult to measure*

Information from the interviews forms an important input to the tabular presentations in Annex 2.

Regulation is considered as the most relevant vehicle to obtain emission reductions, although there are some that favour companies to be more proactive to avoid regulations.

List of the interviewed companies and organisations

The following table lists most of the companies, entities and organisations that were interviewed as a main source of information in this project. There were a few of interviewees (mainly oil and gas companies) that preferred not to be mentioned directly, despite their cooperation in presenting their view on the barriers to implement the methane and black carbon mitigation technologies.

Environment Canada	
US EPA	
GreenPath Energy Ltd	
Clean Air Task Force	
Earth Justice	
International Cryosphere Climate Initiative	
Hy-Bon Engineering	
Natural Resources Defense Council	
Pacific Carbon Trust	
Prasino Group	
Alberta Environment and Sustainable Resource Development	
Canada Ministry of Environment	
FLIR	

ExxonMobil	
Statoil	
Santos	
Cap-op Energy	
Wellmark Co.	
Global Methane Initiative	
National Iranian Oil Company	
Hoerbiger	
NORAD	
PEMEX	

Table 2 List of the interviewed companies and organizations

Annex 2) Regulations

This annex includes a brief review of relevant regulations of oil and gas sector methane and black carbon emissions in four countries or regional jurisdiction: USA (with emphasis on Alaska), Alberta (Canada), Norway and Russia. Further, elements of best practise regulations are discussed in some more detail than in **Chapter 3** in the main body of the report.

Review of existing regulations

Aspects of regulation

All four jurisdictions covered have emissions of black carbon emissions to the Arctic, but none of them have explicit regulation of black carbon from oil and gas sector activities. Though visible smoke emissions from gas flaring are often regulated, they are part of broader regulatory frameworks. Regulation of flaring of associated gas is relevant for black carbon emissions but the extent to which there exists a coherent flare regulation vary. The scope and structure of methane regulation also differ by country. For this reason it is not easy to do a comparative analysis of regulations.

Still, this section seeks to review black carbon and methane emission regulations, respectively, by referring to the following aspects:

1. **Objectives and policy context** of methane and black carbon emissions and how they are linked to policies and regulations. As Short Lived Climate Pollutants (SLCPs) methane and black carbon are important climate change forcers, and resource management and conservation considerations can also motivate emission reduction. However existing policies have not been triggered by climate change concerns. Health and safety concerns and local environmental impacts have been the main focus.
2. **Regulatory approaches and tools** being used to set requirements and spur action. These includes emission limits, technical and practise standards and economic instruments such as penalties/fines, emissions trading schemes and support programs.
3. **Compliance and enforcement tools and practises,** including reports from companies on emissions and mitigation actions.

Regulation of methane emissions

Overall objective and policy context

Safety and health risks: Both authorities and companies have concern for safety and health risks from large gas leaks at oil and gas facilities. Use of Methane Gas Detection Systems is common practise in the industry and often there are specific regulatory requirements, for example through so-called Lower Explosion Limits.

Local and regional impacts: Methane, and even more so non-methane Volatile Organic Compounds (nmVOC), have local and regional impacts through generation of ozone. The Gothenburg Protocol regulates nmVOC but not methane which for this reason has less stringent regulations from a regional environmental perspective.

Climate change: Compared to its contribution to climate oil and gas sector methane emissions has received modest attention. However, this seems to be changing. In Canada, methane is actively addressed in greenhouse gas reduction (policies and regulations) in Alberta and British Colombia. In the U.S climate change is referred to in regulation in Alaska and Texas and recently in a new regulation in Colorado[24]. Further, the US EPA was instrumental in forming the Global Methane Initiative (2004) and the Climate and Clean Air Coalition (2012) which both have as mandates to raise awareness of methane emissions and promote mitigation actions. They build to a considerable extent on the U.S. Natural Gas Star public private partnership formed in the 1990s with the aim to encourage oil and gas companies to adopt cost-effective technologies and practises that improve operational efficiency and reduce emissions of methane. In Norway reported emissions of methane are very low per unit oil and gas production which can explain that methane emission in climate policy has received little attention. This may change as Norwegian authorities soon will launched an action plan for Short-Lived Climate Pollutants.

Regulatory approaches and tools

Regulatory requirements are either given as emission permits/ limits, technical standards, payment of emission charges or fines, and/or as positive incentives through tax rebates, investment support or emissions offset schemes. Since methane emissions in the oil and gas sector cut across many different production segments with a considerable diversity in emission sources, several regulatory approaches may be applicable. Further, requirements for individual facilities may have an element of both emission limits and technology standards.

Standards dominate in *U.S. regulations*, with technical and working standards for the main pollutants and emission sources such as compressors, pneumatic devices and storage tanks. The standards are primarily targeted at new emission sources and equipment. Colorado, as the first state, is proposing to directly regulate detection and reduction of methane emissions associated with exploration and production of oil and gas.

In *Alberta* some minimum technical standards apply but regulatory requirements are primarily set by targets to reduce emissions from facilities with emissions above a size threshold (e.g. sources with emissions per annum greater than 100,000 ton CO_2e should lower their emissions by 12% compared to a baseline level). If this is not achieved a fine[25] must be paid (with the revenues being earmarked for a fund[26]), or a mechanism can be used whereby the company acquire offset credits from other facilities according to specific rules, including from facilities which have emissions below the threshold.

In *Norway* emission permits for most pollutants are granted pursuant to the Pollution Control Act, which generally prescribe emission permits on a case-by-case basis. For methane, permits are given

[24] Make reference to relevant press release
[25] Currently at 15CAD/ton CO2e
[26] Climate Change and Emissions Management (CCEM) Fund. Each year the Alberta government transfers the money from the fund to the CCEM Corporation; an arm-length independent organization that is responsible for investing money collected into initiatives and projects that support emission reduction technologies

based on best available techniques (BAT) which are further defined in directives and guideline (BREFs) issued by the European Union[27]. Emission limits are more stringent for onshore than for offshore installations.

Russia also has case-by-case permits for methane emissions based on environmental damage assessments, but technological factors and regional sensitivities are also taken into account. Emission charges apply to all emission, but with a much higher rate for emissions above a certain level. Since methane emission often are not monitored, default factors apply for calculation of emission charges and hence with weak incentives to reduce emissions. Russia has under consideration new regulations with emphasis on application of "best available technologies".

Compliance and enforcement

Check of compliance and enforcement measures require reliable reports on emissions or other reports that document compliance (e.g. use of technology). In the case of emission reports these are rarely based on direct metering of the emissions. For example in Norway, surveys of fugitive emissions are mandatory for onshore facilities, but there are no requirements for offshore facilities. In Alberta the accuracy of monitoring depends on the amount of emissions. The frequency of monitoring and reporting vary across jurisdictions, but are typically annual report for greenhouse gases, including methane.

The content of reports also varies by jurisdiction. In Alberta and in U.S. the annual reports must include a detailed list of the emissions for each source (compressors, pneumatic devices, fugitives, tanks, etc.). Although methodologies and reporting guidelines often exist they are not always followed by companies, hence making interpretation of data reports difficult. In Russia there exist detailed methodologies for estimating and reporting methane emissions; one developed by the Scientific Research Institute of Atmosphere Protection and approved by the order of State Ecology Committee of Russia #199 dated 08.04.1998, and an alternative method[28] developed by "Scientific-Research Institute of Natural Gases and Gas Technologies" (LLC "VNIIGAZ").

Third party verification of emission reports, including site-inspections, is common in Alberta. Site-inspections can be systematic or result from a suspicion of non-compliance. In Alberta the authority audits 10% of the facilities each year, whereas in Norway and in the U.S., inspections are carried out if the authority suspects discrepancies in the data provided.

Third party verifiers or the authority responsible for site-inspections either check data provided by the operator, or they carry out measurements. For example in Alberta the third-party verifier verifies data and measures directly the emissions if there are discrepancies in the report or based on a risk assessment.

[27] These apply to Norway through the EEA (European Economic Area) agreement with EU. But there is no specific BREF for upstream oil and gas.
[28] Valid from 25th October 2005

Regulation of black carbon emissions

Overall objective and policy context

Local impacts of soot emissions from flare stacks, which is focused in this report, is recognized and addressed in regulation. The health and environmental impacts depend on location but would in many remote sites be limited.

Flare reduction and increased associated gas utilization has gained considerable political attention as a resource waste and environmental problem. Regulation of flaring is therefore an important means for reduced emissions of black carbon emissions for the oil and gas sector.

It is only recently that black carbon emissions have received attention in relation to climate change and its impacts are still disputed. However, there exists now a common understanding among scientists that the impact of black carbon emissions from sources in or near the Arctic are significant for climate change.

Regulatory approaches and tools

Unlike the regulation in the other countries reviewed, US flare regulation has focus on air pollution and air quality. The Minerals Management Service[29] regulates venting and flaring for offshore federal facilities. It allows flaring of small volumes (<50 mcfd in general) or if recovery is demonstrated to be uneconomic. Flaring may also be allowed during equipment failures, well testing or cleaning.

In addition to federal air quality regulations, many oil- and gas-producing states have their own set of rules and standards. In some cases, they may be more stringent than the federal standards. Some states, such as Alaska, also have reporting requirements (monthly report) for venting and flaring.

Alberta in Canada has had an effective policy of flare reductions for two decades with flare levels being reduced substantially. Flaring over a certain volume should be monitored and reported. Ambitious overall targets have been set for flare reduction and measures to achieve the targets have been developed, among others through a dialogue between the regulator and companies. Regulation has therefore been more performance based with emphasis on cooperation and consensus, rather than prescriptive. Economic assessments of flare reduction investments have been central in setting priorities for flare reduction efforts. Still, some claim that many small flare facilities escape regulation and that these in aggregate represent considerable volume of flared gas.

In Norway flaring is prohibited but permits can be granted on a case-by-case basis on technical or safety grounds. Like Alberta Norway has had an active policy of flare reduction. It has been based on ambitious targets set by the authorities, but combined with a close dialogue with companies and a certain level of flexibility in implementation. An important component has been the development of sufficient infrastructure to give market outlets for gas otherwise flared. Norway has a CO_2 tax[30] on gas being flared which has represented a further incentive to reduce flaring.

[29] http://www.law.cornell.edu/cfr/text/30/250.1160

30 In 2012 at USD xx per SM3

Russia has lacked an effective legislative framework for flaring. In 2007 a target was set for end 2012 to reduce flaring of associated gas to 5% of production, but for the whole of 2012 flaring is still at about 25%[31] of production (perhaps higher due to inaccuracies in data reports). Regulatory steps are being taken to improve the situation: i) fines for flaring above the 5% limit are being radically increased and ii) reforms are being implemented which give companies access to gas infrastructure so that flaring can be avoided. There are however exceptions to the fines that reduce the effectiveness of fines and there are issues related to enforcement (see below) which may still hinder a rapid development towards the 5% target.

Compliance and enforcement

Installations in USA, Canada and Norway must report flaring volumes monthly and there are size dependent requirements for metering equipment and accuracy of measurements. Russia also has mandatory reporting of flaring volumes but these are not always based on measurements or verified.

Elements of best practise regulation

Regulatory approaches and best practice criteria

Regulations of methane and black carbon emissions can be divided into categories of regulatory approaches or tools. In this section we distinguish between four different regulatory approaches each for methane and black carbon and discuss their qualities according to three criteria.

The criteria for evaluating the approaches are:

- **Cost-efficiency.** For each specific environmental problem low cost measures should be implemented before measures with higher costs. It is essential that policy makers and the staff of regulatory institutions understand and recognizes the principle of cost-efficiency and that cost-efficiency is reflected in regulatory requirements. Due to the great variation in abatement costs by site and differences in local environmental impacts there are considerable practical challenges with ensuring cost-efficiency. Perhaps the most difficult part is to acquire adequate and unbiased information in order to prioritize. The administrative costs of compliance and enforcement, both those covered by the companies and the regulatory agencies, can be significant (particularly monitoring and verification costs) and must be taken into account when cost-efficiency considerations are made.
- **Clarity and transparency.** Rules and procedures for application and approval of emission limits and technologies should be clear and transparent, and the same goes for compliance and enforcement mechanisms. Predictability in the use of regulatory tools and enforcement is also important not the least for the purpose of reducing the risk of investing in new and efficient technologies.
- **Institutional capability.** Regulatory ambitions must be attuned to the capacity and capability of regulatory institutions. Again the complexity of oil and gas sector operations and

31 Source: Central Dispatch Office of the Russian Fuel and Energy Industry.

emissions is a challenge. Regulatory institutions must have staff with adequate sector specific competence, otherwise the principles of cost-efficiency and clarity/transparency will be undermined. More fundamentally, regulatory staff must act impartially and without risk of corruption/mismanagement. Regulatory requirements, data reporting and enforcement procedures which are flexible (e.g. for the sake of cost-efficiency) will generally be more susceptible to corruption than rigid and simple rules. So again, there are difficult trade-offs between cost-efficiency and clarity/transparency. Finally, regulatory institutions should have clear and not overlapping functions. This may also have its practical challenges in the case of methane and black carbon emissions since the emissions cause concern for climate change, local environmental damages, safety and health as well as resource conservation. All these issues are rarely handled by one regulatory institution or by one set of coordinated regulatory measures.

Some of the regulatory approaches presented above will by design "pick" the emission reduction with the lowest abatement cost first (e.g. economic instruments such as ETS, offset schemes and emission charges) while cost efficiency for others will depends on the specifics of the regulation. For example, imposing dry seal as a technical standard on all compressors may often lead to high abatement costs due to the downtime cost, while imposing low bleed device may have negative or low abatement costs on most application.

Another important aspect is that regulations of methane and black carbon are normally not within only one of the categories listed above. Use of technical standards may be combined with economic instruments, and a regulation based on extensive dialogue and cooperation between companies and the regulator may incorporate use of technical standards and will in most cases include economic instruments, for example fines when agreed targets are not met. Leak detection and repair programs may apply only to specific segments of installations and equipment and is often also combined with the other tools.

Methane emissions

Technical standards

This approach includes both requirements to use specific technologies according to instructions or criteria set by the regulator (e.g. list of Best Available Techniques, BAT) and requirements to implement specific operational practises (e.g mandatory leak detection and repair programs, LDARs). Such standards are often based on or imposed in combination with emission limits.

BAT standards as the only or dominant tool score relatively low on costs-efficiency for three reasons: i) given the complexity of emissions it is not possible to list specific technical standards that are cost-efficient under all conditions, ii) inevitably it is problematic setting technical standards in light of continuous technological progress, and iii) technical standards do not allow the companies to "pick" the most cost efficient technology in the specific installation's condition.

To be cost-efficient, standards needs to be designed and updated with much background information and analysis. Specific technical standards offer clarity and transparency while broad or vague standards may lead to low compliance and create disputes between the regulator and companies, which will further undermine cost-efficiency.

One important advantage with BAT standards is that there is less need for emissions data, which reduces costs of monitoring. Technical standards may therefore be the best option where provision of emission data is difficult and/or very costly. Whether a mandatory LDAR program scores high on cost efficiency depends on the distribution of net economic returns of such programs across facilities. If some facilities are highly economic to repair while other are only repaired at large net costs then the score on cost efficiency is low. Design of a mandatory LDAR program therefore requires some information on characteristics of methane emissions and the costs and benefits of repairs for facilities that potentially may be included. This can be done through surveying samples of facilities.

Economic instruments

Use of economic instruments can take different forms such as:

- Emission charge for all emissions, or fines for exceeding a predefined emissions limit
- A cap-and trade-scheme whereby emission allowances are tradable
- An offset mechanism whereby verified emission reductions can be used for compliance purposes elsewhere (e.g. against other methane or CO_2 emission reduction obligations)
- Tax rebates or other economic incentives that encourage investments in emission reductions

Tax rebates does not require quantification of emissions since they typically are triggered by certain technology applications, which makes this measure distinctly different from the other economic instruments.

Making regular and verifiable measurements of the large number of methane emissions can be an important cost. As a result, a balance must be found between accuracy of the emissions estimates and costs of the measurements. This is a hindrance for including all sources of methane emissions in an emissions trading scheme (and this is one reason for not having methane in the EU Emissions Trading System). The need for accuracy in emissions estimates may be somewhat less important in the case of an emission charge, but it is essential that mitigation actions are properly reflected in the quantification of emissions, otherwise the emission charge does not serve as an impetus for emission reductions.

By design, emission charges, emissions trading and off-set schemes score high on cost efficiency when the efficiency is not undermined by high costs of providing emissions data and such data has a reasonable level of accuracy. Clarity and transparency of economic instruments are in general high.

If emission charges and emissions trading are to function well they require good capability and capacity of regulatory institution, due partly to the data reporting requirements. In addition economic instruments often will be implemented in combination with other regulatory tools. The burden on the regulator, however, can partly be alleviated by imposing a system with competent and reliable third party verifiers.

Negotiated agreements

Negotiated agreements (also referred to as voluntary agreements or simply agreements) between companies and regulatory authorities may be an effective and cost-efficient means of achieving emission reductions targets, both for methane and for other types of air pollutants, and related to flare reduction (see below). A precondition for this to work is that there exist a certain level of

regulatory capacity and capability and that an open and effective dialogue can be established with companies. Normally this would require that an industry association (or several) is involved as the principal focal point for the regulator and the coordinator vis a vis companies.

Negotiated agreements can take different forms but would typically have the following elements:

i. An emission reduction target is negotiated and agreed between the regulator and the companies. The target will be attuned to the broader political ambitions for emission reductions[32] and to the costs for the industry of reaching the target. This also implies that a certain level of information about emission sources and abatement costs should exist prior to negotiation of a target.

ii. One institution will have a role in promoting and coordinating emission reduction measures to be implemented by companies. This can be a public institution (e.g. the regulator) or an institution designated by the companies (e.g. an industry association). This institution must have means to spur emission reduction actions from companies. In Alberta (for methane) and Norway (for NOx) schemes exist whereby companies pay a certain fine for emissions which are placed in a fund from which companies can seek financing for emission reduction measures (in Norway) or research activities (Alberta) . Hence all revenues from the emissions fine are earmarked.

iii. Verification of results is important both for the purpose of grant allocation and for the broader assessment of compliance. The "carrot" of the scheme is that revenues from the emissions fine are recycled to companies and the "stick" is that the regulatory authorities can terminate the agreement and allocate revenues from the fine to public funds if companies are unable to meet the terms of the agreement.

Another variant of dialogue and cooperation is between the regulator and individual companies. Often this is based on specific requirements/obligations to cut emissions but where companies are given flexibility with respect to implementation based on documentation of technical feasibility and investment cost estimates. This a common approach related to flare reduction (see below) and emissions from large point sources, but would normally require much administrative resources from the regulator.

Black carbon emissions

Black carbon from gas flares can be addressed in two ways: i) regulation to reduce flaring through improved productive gas utilization and ii) regulations to improve flaring conditions. Most oil and gas producing countries have ambitious plans to reduce and ultimately eliminate flaring and there are in most cases well established, though not always effective and cost-efficient regulation in place. Regulations aimed at improving flare systems (e.g. through optimizing combustion systems) are less developed, but is highly relevant as long as flaring is not eliminated.

[32] Beyond the sector and emission substances covered in this cooperation (for example nation-wide emission reduction targets for GHGs or methane.

Flare prohibition and/or restrictions – improved productive gas utilization

Broad and rigid flare restrictions are problematic from a cost-efficiency standpoint. This is because the costs and revenues from associate petroleum gas (APG) utilization investments vary greatly. For example, small and medium size flares located far from markets and gas infrastructure can be very costly to eliminate, while investments to make productive use of gas from large flares closer to markets are often economic.

Flare prohibition and restrictions in their purest form, with none or few exemptions, require relatively little regulatory follow-up other than enforcement measures. In countries with relatively weak regulatory capabilities it may therefore be a preferred option. However enforcement is a critical point here. Without consistent and predicable enforcement, flare prohibition and/or restrictions not only lack cost-efficiency, but are also ineffective. There are many examples of ambitious flare reduction targets that are not met due to lack of enforcement. Enforcement can be achieved through a penalty (e.g. ultimately revoking production licences) and there are examples where this has been done, but consistency and fairness of such measures have often been poor, and the costs can be very high if oil production is negatively affected.

It is quite common that for new field development the gas utilization solutions lag behind oil production start-up. From an oil industry perspective it often makes sense to delay the gas utilization investment because there is uncertainty about the level of future associated gas production and need for gas utilization capacity.[33]. In jurisdictions with effective regulations of flaring, however, there are requirements for development and implementation that go parallel with oil processing facilities, or at least with only small deviations.

Technical standards

In cases where flaring cannot be avoided technical standards for optimizing combustion conditions and minimize black carbon emission can be very cost-efficient measures. Studies [34] have shown that using modern but still mature technologies poor flares can have major reductions of black carbon emissions. Flares can achieve smokeless operation and less than 2% unburned hydrocarbon when properly sized, maintained and operated. It may not be the best option to mandate specific technologies, but a regulation that states that “visible smoke” is not allowed may lead the operators to select one out of several available technologies that appropriate for this purpose. As such it is more of an emission standard than a pure technical standard.

New technologies can also help to minimize flaring in cases routine flaring has been eliminated but there continues to be some flaring, typically 4-7% of produced associated gas, for safety or other operational reasons. New technologies or practices can in many cases almost eliminate all flaring, but the costs and benefits of such options may vary considerably by site. Again the actual regulation would probably be an obligation to achieve a higher gas utilization rate (e.g. 98%), with the operators having to install new technologies accordingly.

[33] Such time lags represent is the cause of significant parts of flaring in Russia (large fields in Eastern Siberia) and for new “tight oil” production in the U.S.

[34] http://www.ipieca.org/event/20130509/short-lived-climate-forcers-workshop

Economic instruments

Flaring fines can be a stand-alone tool or be the “carrot/stick” in conjunction with flare prohibition and/or restrictions.

A pure flare fine (with no additional volumetric restrictions on flaring) is a cost-efficient tool; APG utilization investments will in theory be implemented according to their economic return. It requires, however, reliable and verifiable reports on flare volumes which again require institutional capability and capacity from the regulator.

Emission trading and offset schemes work in the same way as a fine; there is an opportunity cost related to flaring. In this case verifiable reports on flaring must also be in place. This means that gas volumes (often also gas composition) must be monitored and be subject to third party verification.

Negotiated agreements

Though formal negotiated agreements are not common for meeting flare reduction targets, more informal targets set through dialogue between companies and regulators have been practised with success (Norway, UK and Alberta). Unlike the model indicated for methane it may in this case be more efficient to have details of an agreement settled bilaterally between the regulator and a company. Still, the broader principles and framework for an agreement may be developed with the involvement of an industry association (on behalf of companies). One reason for this is that the number of emission sources and facilities are much smaller than is the case of methane.

Annex 3) Summary of Barriers (Rows) and Measures (Columns)

		1	2	3	4	5	6	7	8	9	10	11	12	13
		Encourage emission campaigns-invest in industry wide survey initiatives	Support countries to develop emission inventories	Develop technology specs for different operation circumstances	Encourage companies to share info on emissions, technologies & processes	Facilitate transfer of technology/ practices between countries	Increase communication towards political and public bodies	Include SLCP monitoring & mitigation identification as part of license conditions	Leverage international climate and carbon finance	International voluntary programs or standards	Develop/ improve emission estimation & reduction methodologies	Support the development of new monitoring technologies (from pilot to market)	Support regional/national projects to reduce the costs per facility	Support some technology development (from pilot to market)
1	Lack of awareness about sources and magnitude of emissions at facility level													
2	Data confidentiality preventing sharing info on emission inventories & technology													
3	Insufficient knowledge about best practice mitigation technologies and technical													
4	Lack or reliable estimation of implementation costs for the best available													
5	High opportunity costs of emission reduction measures reduces cash-flow and IRR													
6	Insufficient incentives and motivation to act in the companies													
7	Complexity and number of actors involved in the implementation of emission reduction													
8	Risk aversion and conservatism in the companies													
9	Lack of knowledge about national/regional emissions													
10	Ongoing scientific debate on the effect of SLCP on climate													
11	Knowledge gap on technology and costs at the national level													
12	Insufficient determination from the political authorities to promote new													
13	Lack of awareness and interest of the public													
14	Conflicting incentive structure, regulation & enforcement between different authorities													
15	Challenges in developing and implementing effective tools and methodologies to													
16	Insufficient or inadequate gas infrastructure													
17	Low current and forecasted prices of natural gas													
18	Substantial costs and/or additional challenges associated with retrofitting older													
19	Inmaturity of some technologies													
20	Applicability limits for some technologies in some operational circumstances													

Annex 4) Barriers

Barrier 1 : Lack of awareness about sources and magnitude of emissions in company/facility	
Description of the barrier	
Black carbon Black carbon has until recently been a local issue where visibility of smoke and possible health effects have been the main focus amongst the local communities. Black carbon as a SLCP is a relative new issue and the awareness has hardly penetrated oil and gas companies beyond the level of environmental advisors. **Methane** The level and characteristics of methane emission are often not known or understood, and only rarely measured and reported. When methane emissions are reported, the volume of methane loss are often only estimated based on emission factors, which could potentially lead to important under-estimation. Some companies use safety sensors in their facilities (in particular offshore) to detect important gas leaks (and prevent fire or explosion risk). These measurement procedures can give a misleading impression that there is no emission at facilities, since safety sensors only detects dangerous gas concentrations which are associated with the largest gas emissions As a result, there is often a lack of awareness of the volume and sources of gas (methane and nmVOC) losses and thus of the potential economic opportunity.	
Main stakeholder(s) responsible for the barrier	**Other stakeholder(s) who influence the barrier**
Oil and gas companies Oil and gas industry associations	International organisations and initiatives Regulatory bodies Environmental NGOs

Barrier 2: Data confidentiality preventing sharing of information on emission inventories and technology	
Emission: Methane and black carbon	
Description of the barrier	
The oil and gas industry is very competitive and in most regions in the world not used to cooperate on any commercially sensitive issues. Only when there are clear benefits of cooperation on common issues with a common counterpart (government, regulator, unions etc.) does the mode of operandi change. Companies compete for acreage, new technology, “License to Operate” (LtO) etc. and tend to regard all information as sensitive. Information sharing is often controlled centrally by a public relationships department which normally would not accept information sharing. Anti-Competitive rules and regulations may also hinder information flow between actors partly by design but also by default by creating a culture of fear of risk of violation of rules (very punitive). Moreover, there is typically a concern among companies that disclosing their level of emissions would raise public and regulatory scepticism towards their operations. These factors hamper sharing of data and best practices amongst companies at all level as the punishment for “leaks” is hard and the reward for openness is negligible or absent.	
Main stakeholder(s) responsible for the barrier	**Other stakeholder(s) who influence the barrier**

Oil and gas companies and operators (Management) Oil and gas companies and operators (Legal departments) Regulatory bodies	Oil and gas industry associations Research organisations

Barrier 3 : Insufficient knowledge about best practice mitigation technologies and technical specifications	
Emission: Methane and black carbon	
Description of the barrier	
Lack of internal know-how: Even when there is an awareness of the current emissions, in some companies, there still may be a lack of knowledge or experience with specific technologies. This may particularly be the case for smaller companies who may not have any cross company experience nor the resources to build this capacity. It is further common that knowledge is inadequate on the performance of a technology in a specific set of conditions (e.g. does the best practice work in my field?). Lack of trust in the technologies. In addition, there may be a lack of trust on some of the technologies. Some technologies are perceived to be at early commercial stage by the operators, although they are considered mature by the technology providers. Past experiences of operators may have damaged trust in some of the best practices/technologies. Interviewees provided a number of examples: • There has been a number of reliability issues with VRU (vapour recovery units)in the past due to inappropriate design • Desiccant dehydrator, once presented as a promising technology have faced a number of reliability issues • In some cases, operators have failed to perform adequate maintenance after the retrofit and/or application of the new solution has been applied, which could lead to achieving less reduction than the promised potential. Lack of information material or lack of trust in the information available: The technical standards describing the instructions, risks and opportunities for difference sources of methane emissions often only covers a few technologies. They are also short in number of references and case studies for the covered technologies. Comprehensive description of implementation realities is sometimes not presented. In addition, the currently published bulletins are not perceived very reliable (perceived to be technology advertisement rather than solid handbooks reflecting the technical steps and risks.)	
Main stakeholder(s) responsible for the barrier	**Other stakeholder(s) who influence the barrier**
Oil and gas industry associations Technology providers/other experts Oil and gas companies	Research organisations

Barrier 4 : Lack of reliable estimation of implementation costs for the best available mitigation technologies
Emission: Methane and black carbon
Description of the barrier
In many cases, the management and operators of oil and gas facilities do not have a good estimation of the costs of implementing the technologies to mitigate the emissions. Typical examples are:

- The specific circumstances of the site may have significant impact on the costs of implementation. A number of the technologies have not been tested under extreme operational conditions, hence the implementation and adoption costs and not very well known.
- Costs related to shutdown of the operations are often not taken into account in the existing report assessing the expenditure.

Unexpected repair and maintenance costs have not been quantified.

Main stakeholder(s) responsible for the barrier	Other stakeholder(s) who influence the barrier
Oil and gas companies Oil and gas associations Technology providers/other experts	International partnership institutions Research organisations

Barrier 5 : High opportunity costs of emission reductions measures reduces cash-flow and rate of return
Emission: Methane and black carbon
Description of the barrier

The companies have invested in acreage and are focused on rapid development to secure cash-flow and rate of return. They compete and are measured by the market on these metrics. Unless there is an obligation in the license or another form of regulation that requires the company to implement measures there are probably limited (and possibly negative) incentives to do so beyond possible market value of captured methane and perceived "License to Operate" benefits. A company which would still do this would thus be at a disadvantage to their competitors. The value loss of e.g. waiting to produce until a gathering system or compressor is in place could be substantial due to costs and revenue delays. Most of the companies are "measured" in financial markets on a quarterly basis and additional emission reduction costs and negative revenue may impact negatively on the share price. The concept of "level playing field" is strong in the sector.

For companies with many projects competing for capital and human resources these types of emission reduction projects would normally not be able to favourably compete as they normally yield lower return on capital and have longer payback periods than traditional production enhancing projects. Some companies have, as evidenced in the interviews, introduced different hurdle rates for environmental projects, but hitherto this does not seem to help getting such projects to fly.

Thus, even if an emission reduction project is economic in its own right, it may not materialize due to internal competition from higher yielding projects.

In parallel to competition for capital and resources there is an everlasting competition for management time and attention. Emission reduction efforts which are regarded as low importance will therefore often be seen as just another challenge and burden and be "selected out" before reaching management level attention.

Main stakeholder(s) responsible for the barrier	Other stakeholder(s) who influence the barrier
Oil and gas companies and operators Oil and gas industry associations	Research organisations International organisations and initiatives Technology providers/other experts

Barrier 6 : Insufficient incentives and motivations to act in the companies
Emission: Methane and black carbon
Description of the barrier

The economic risks associated with methane and black carbon emissions would normally not appear on a company's high level risk register and thus not come to the attention of senior management and decision makers.

There are some specific reason to this

- Other environmental issue are considered to entail much larger risks (e.g. oil spill)
- When GHG emission reduction are discussed, the focus is traditionally CO_2, not black carbon and methane
- Not enough real and perceived pressure (internally and externally) to make it prioritized and attract talent

It is under the radar screen, literally (odourless, not visible nor audible) and metaphorically sneaky

Main stakeholder(s) responsible for the barrier	Other stakeholder(s) who influence the barrier
Oil and gas companies and operators (Management) Regulatory bodies	Environmental NGOs Research organisations

Barrier 7 : Complexity and number of actors involved in the Implementation of emission reduction projects
Emission: Methane and black carbon
Description of the barrier

Implementing emission reduction projects are at times perceived as complex due to the large number of actors involved::

- Decisions and project implementation involve a large number of departments and actors (due to the number of sources) including subcontractors and often overseas internal stakeholders
- Management and information channel may be complex and the information may not reach the required authority level
- Conversely, corporate decisions may not reach the field operators
- For International Oil Companies there is also the dilemma between the desire to use one global standard versus the national or state requirement and steer.

In addition, some emission reduction measure needs to be implemented during planned maintenance, and thus needs to be planned well in advance

Main stakeholder(s) responsible for the barrier	Other stakeholder(s) who influence the barrier
Oil and gas companies and operators (management at various locations and levels)	Technology providers/other experts Regulatory bodies

Barrier 8 : Risk aversion and conservatism in the companies
Emission: Methane and black carbon
Description of the barrier

Due to the high value stemming from production of hydrocarbons, the risk of potential delays or interruptions to this revenue stream will have high focus at all levels in the companies. This leads to a "proven technology only" mentality and implementation of anything that is new and unproven will attract severe scrutiny and resistance. The business case for such proposals will therefore tend to be weak.
This inherent risk awareness and tendency to stick to the proven is further reinforced by a very strong safety focus in most companies. This is particularly an important factor for retrofitting of equipment as such retrofit could either lead to close down of production and/or significant higher safety risk when done in a hot plant.

Moreover, in some cases, the implementation of emission reduction best practices involves the installation of equipment which are really different in nature than the ones usually managed by oil and gas companies (e.g. GTL plants, gas power systems). Some companies may thus lack expertise, increasing the perception of risk for such project.

Main stakeholder(s) responsible for the barrier	Other stakeholder(s) who influence the barrier
Oil and gas industry associations Oil and gas companies and operators	Technology providers/other experts Research organisations

Barrier 9 : Lack of knowledge about national/regional emissions

Description of the barrier

For black carbon

Black carbon is currently only reported on a voluntary basis in the UNFCCC[35] national communications. Some countries are attempting to put together black carbon inventories.

For methane

For a number of non-annex 1 countries (developing counties and selected "economies in transition"), methane emissions from the oil and gas sector are not reported on a regular basis. When reported, only the overall total emission is provided without any breakdown by emissions by source.

A number of factors can explain this:

- The oil and gas sector is complex and the people in charge of inventory may not have all the expertise required.
- The task of developing a methane inventory is complex, cumbersome and can be quite costly.
- There may be a lack of resources to prepare the national inventory. As a result, priority is given to larger or more straightforward sources of emissions.
- Primary data required to compile inventories simply may be non-existent due to the lack of on-site monitoring or the fact that oil and gas companies may not be willing to share the data available with the authorities for various reasons.

As a result, there is currently a limited understanding of the magnitude of methane and black carbon emissions from the oil and gas sector. Even when inventories exist there are great uncertainties in the estimates as for example shown in the 2008 estimated for the US in the figure below.
The large magnitude of changes in emission factors and methodologies from making estimates highlight the important remaining uncertainty and may also confuse the political debate: as long as there is no agreement on the order of magnitude of the emissions, it is more challenging to discuss and gain support for mitigation options and costs.

[35] http://unfccc.int/2860.php

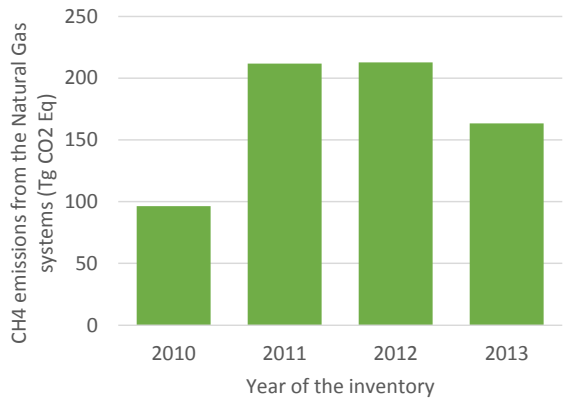


Figure 8: US methane emissions from the natural gas systems in 2008 depending on the year of the inventory

Main stakeholder(s) responsible for the barrier	Other stakeholder(s) who influence the barrier
Political authorities National and international bodies in charge of national communications and international reporting Oil and gas industry associations	International organisations and initiatives Research organisations Environmental NGOs Oil and gas companies

Barrier 10 : Ongoing scientific debate on the effect of black carbon (and methane) on climate
Description of the barrier

The effect of black carbon and methane on the climate is still debated by the scientific community. This scientific uncertainty can result in lack of political attention and action.

The following paragraph describes briefly the status of the scientific debate and the uncertainties.

Black carbon

The effects of black carbon emissions on the Arctic and global climate are complex. Indeed the combination of radiative forcing from aerosol-radiation interaction, cloud interactions and deposition on snow/ice, so called Albedo effect[36] are been fully understood scientifically. Moreover various external parameters influence the magnitude of forcing from black carbon, such as seasonal variations, the type of emission source, the location of the source, the location and type of deposition surface.[37]Despite the recent discoveries, great gaps remain between model-based assessments and black carbon measurements [38] and therefore Radiative forcing calculations based on these concentrations remain uncertain. Recent studies[39] showed that previous

[36]Flanner et Al. 2007, Warren and Wiscombe 1980
[37]Shindell et Al. 2008, Quinn et Al. 2008
[38]AMAP 2011
[39]Bond et Al. 2013, Myrthe et Al. 2013
In its two last reports, AR4 (2007) and AR5 (2013) IPCC adopted estimates for radiative forcing from aerosol-radiation interaction and for the Albedo effect on ice, by grouping all previous studies, based on the "expert judgment" of the working team,.
[39] IPCC 2007 http://www.ipcc.ch/publications_and_data/ar4/wg1/en/contents.html
[39]IPCC 2013 final draft http://www.climatechange2013.org/report/review-drafts/
[39]Forster et Al. 2007
[39]Bond et Al. 2013, http://onlinelibrary.wiley.com/doi/10.1002/jgrd.50171/pdf

estimates, had greatly underestimated the direct radiative effects of black carbon. As a result, in 2013, IPCC[40]re-evaluated its estimates of the radiative forcing due to aerosol-radiation interaction from 0.2 $W.m^{-2}$ (2007)[41]to 0.4 Wm-2 (2013)[42]. The assessment of the Albedo effect has also been a challenge. Indeed, in 2007 IPCC[43] estimated that the Albedo effect was responsible for 0.10 W/m^{-2} of global radiative forcing, whereas more recent studies re-evaluated these figures and revealed radiative effects weaker. As a result, in 2013, IPCC revised its previous estimates to 0.04 $W.m^{-2}$.

Even though there are known biases in current black carbon radiative forcing estimates from aerosol models, together these biases are believed to cause an underestimate of radiative forcing. And most recent studies[44] drew alarming estimates for black carbon total radiative forcing of 1,1 $W.m^{-2}$ for the industrial era, ranking black carbon as the second most powerful warming agent, after carbon dioxide.

Methane

For the last decade, studies have revealed that the effects of methane on climate forcing had also been underestimated. This uncertainty on methane warming potential is due to the various indirect radiative effects (e.g. methane enhances its own lifetime, has effects on tropospheric ozone concentrations, affects stratospheric water vapour amongst others)

In its report ER4 (2007), IPCC attributed a GWP (100 years) of 25 to methane. But due to recent discoveries, IPCC re-examined this figure to take into account the interactions with aerosols, in its latest report (AR5 2013)[45]. The GWP of methane was increased to 34 in order to account climate-carbon feedback[46].Yet there is still a lot of uncertainty around the actual radiative forcing of methane, due to the integration of indirect effects. Indeed according to Reisinger et Al. (2011) the uncertainty in methane GWP is +/- 40% for the GWP_{100}[47]

Main stakeholder(s) responsible for the barrier	Other stakeholder(s) who influence the barrier
Research institutes IPCC	

Barrier 11 : Knowledge gap on technology and costs at the national level
Emission: Methane and black carbon
Description of the barrier
In general, regulatory bodies may not have the knowledge and the expertise on the existing best practices to reduce emissions, and more particularly on which of these best practices can be economic across the country/a region. • Lack of knowledge on the potential solutions would incapacitate the regulatory bodies and national/international authorities to be able to adopt practical legislations into effect. • Lack of understanding of the nature of the methane emissions or of the complexity of oil and gas operations may cause the regulators to try to adopt regulations which lack cost-efficiency and are hard to

[40]In its two last reports, AR4 (2007) and AR5 (2013) IPCC adopted estimates for radiative forcing from aerosol-radiation interaction and for the Albedo effect on ice, by grouping all previous studies, based on the "expert judgment" of the working team,.
[41] IPCC 2007 http://www.ipcc.ch/publications_and_data/ar4/wg1/en/contents.html
[42]IPCC 2013 final draft http://www.climatechange2013.org/report/review-drafts/
[43]Forster et Al. 2007
[44]Bond et Al. 2013, http://onlinelibrary.wiley.com/doi/10.1002/jgrd.50171/pdf
[45]*http://www.climatechange2013.org/report/review-drafts/*
[46]Shindell et Al. 2009, Gillett and Matthews 2010, Collins et Al. 2013, Arora et Al. 2013
[47]http://www.climatechange2013.org/report/review-drafts/

enforce

- In cases that the regulator does not have enough competence on technologies, it may be challenging for them to check operators' compliance

Main stakeholder(s) responsible for the barrier	Other stakeholder(s) who influence the barrier
Regulatory bodies	Oil and gas industry associations International organisations and initiatives

Barrier 12 : Insufficient determination from the political authorities to promote new regulations
Emission: Methane and black carbon
Description of the barrier

Methane

In relative terms, methane emissions from oil and gas infrastructure have received modest political attention. In a number of countries and it is not on the radar screen for future regulation. A number of circumstances can explain this lack of political will:

- Climate change in general is considered a sensitive and controversial topic in oil and gas producing countries.
- Resources and efforts are focused toward larger emissions sources (power sector) and more profiled emission sources (CO_2) which are considered a priority
- Revenues and jobs from the oil development are often key drivers for national and regional authorities and tend to have higher priority than environmental consideration (including methane emissions)
- The regulator may have concerns about the costs for the oil and gas industry (national competiveness)

Black carbon

Gas flaring has attracted much more political attention over the past decade and flaring is regulated in most countries. On the other hand, the focus has generally been gas utilization (which reduce proportionally black carbon) and not black carbon specifically. Visible smoke reduction has also been the focus of a number of regulations, in particular in densely populated areas.

Main stakeholder(s) responsible for the barrier	Other stakeholder(s) who influence the barrier
Political authorities Regulatory bodies	Environmental NGOs International organisations and initiatives Oil and gas companies and operators

Barrier 13 : Lack of awareness and interest of the public
Emission: Methane and black carbon
Description of the barrier

Generally, there is very limited communication for the general public on methane and black carbon emissions from the oil and gas sector. The current debate (media, NGO, politicians...) often focuses on CO_2 emission or on specific technologies (e.g. renewable).

Methane emissions are generally odourless and not visible. As a result, the public is not aware of the emissions occurring. Associated emissions of VOC may attract the attention of the public (due to health and safety issues) only when emissions occur close to populated area.

It should be noted, however, that methane emissions from oil and gas systems is being discussed increasingly

in USA (with the active participation of the Environmental Protection Agency (EPA) and of a number of NGO), and also with emerging discussion and actions at the state level, in particular related to the production of unconventional oil and gas. (10)
Black carbon emissions from flares are not noticeable and their effect on health or on the local environment may be debated when they are located in the vicinity of some inhabited areas. However, flares located far from any population (in Siberia, offshore, etc.) are less visible and thus attracts less attention from the general public or from the (local) Environmental NGOs.

Main stakeholder(s) responsible for the barrier	Other stakeholder(s) who influence the barrier
Environmental NGOs Political authorities	Media

Barrier 14 : Conflicting incentive structures, regulation and enforcement between different authorities and government bodies

Emission: Methane and black carbon

Description of the barrier

Methane and black carbon
Market condition and/or regulatory arrangements may entail barriers to the productivity of gas, hence leading to wastage and emissions. A few examples are provided below:

- Existing incentives or regulatory structure may create counter effects for methane emissions. For example flaring ban may lead some actors to vent the gas (less visible) which have an important negative effect on emissions.
- There may also be "gaps" in Production sharing agreement (PSA). For example, PSA may not cover properly associated gas production utilization and flare avoidance. As a result, no entities has responsibility (or have any incentive) to manage this gas and reduce the emissions.
- Entities responsible for managing and maintaining infrastructure/facilities may not have incentives to gather, process and transport "stranded gas", which then is flared. (for example: often in the US, the owners of transmission stations do not own the gas flowing through the pipes)

Local or regional exceptions and specific incentives may also influence the applicability of any regulation or incentive structure. For example in some countries, such as Uzbekistan, the requirement to comply with national standards creates a barrier to entry for technology providers.

In some countries, there may be gaps or conflict in responsibilities for the definition of a regulation (or incentive structure) or its enforcement:

- Between energy and environment regulatory bodies
- Between national regulatory entities and local/regional regulatory entities.[48]

[48]For example in the US, the *Clean Air Act(CAA)* gives EPA the authority to regulate "Hazardous Air Pollutants" and "oversee" the states actions. And the states adopt and implement EPA requirements in their regulation. Yet in some cases the "oversight" role of EPA has been challenged. Such as Alaska DEC which sued EPA[48], in 2002, because the agency prevented Alaska state from issuing a PSD permit, considering that the Best Available Control Technology (BACT) required in the permit was not sufficient. This argument is based on the interpretation of "best available" in the regulation and the share of responsibilities between the states and EPA.

In addition, depending on the regulatory context, developing and implementing a regulation may take years.

Main stakeholder(s) responsible for the barrier	Other stakeholder(s) who influence the barrier
Regulatory bodies Political authorities	Environmental NGOs Research organisations Oil and gas industry associations

Barrier 15 : Challenges in developing and implementing effective tools and methodologies to quantify emissions and emission reduction
Emission: Methane and black carbon
Description of the barrier

For black carbon

Currently there is no recognised methodology to measure (or estimate) black carbon emissions from gas flaring. A few approaches have been tested[49] but it is currently not possible to perform any routine measurement of black carbon emissions based on a standard and recognised protocol.

For methane

There are a large number of practical/technical challenges to measure methane emissions or methane emission reductions:

- Fragmented emissions: Due to the very large number of emissions sources, reliable sampling approaches may need to be developed ("which emissions sources should be measured")
- Variable emissions: As the emissions can vary significantly between different sources, a very large number of data may be required in order to develop "Emission Source Specific" and "Ambient Specific" emission factors.
- Sneaky gas: Given the specificity of methane emissions, approaches need to be developed to ensure that all the possible emissions sources are covered (for example: emissions from reciprocating compressors includes both the degassing unit and the seal face, emissions from centrifugal compressor include both the packing cup vent and distance piece; measurement procedures should cover all sources of emissions.)

As a result, monitoring emission of methane can easily become either

- Expensive and cumbersome, which can heavily impact the attractiveness of methane emissions reduction compared to other emission reduction project (eg. CO_2)
- Or uncertain, which can impact the credibility of the emissions reduction achieved.

These challenges can influence the cost of both implementation and enforcement of a number of regulatory mechanisms: ETS, flexible mechanisms, and emissions limits.

Looking more specifically at methodologies/protocol for flexible mechanisms (offset project): Apart from a few protocols in Canada and two methodologies developed under the CDM, methane emission reductions in the oil and gas sector are not able to enjoy benefit from a credible, reliable and verifiable emission reduction methodology. Therefore, the number of projects with an objective to demonstrate a verified amount of emission reductions from a methane abatement/mitigation projects are very limited as compared to other

[49] Carleton University and Aerodyne in particular

greenhouse gases.

Main stakeholder(s) responsible for the barrier	Other stakeholder(s) who influence the barrier
Oil and gas industry associations International organisations and initiatives Multilateral development banks and other finance institutions	Research organisations Technology providers/other experts

Barrier 16 : Insufficient or inadequate gas infrastructure
Emission: Methane and black carbon
Description of the barrier
For black carbon and methane Normally for companies oil production drives the development and dominates the revenue generation. Time is of essence and often the production in remote areas starts before a gas infrastructure is in place. Thus investing in emission reductions is harder as the potential use of the captured gas is limited to a few options (reinjection, local power, small-scale gas-to-liquids solutions). In less remote areas, new gas infrastructure may not be economic due to the low or fast declining production from each well or province. The ability to enhance transportation capacity in existing pipelines may be limited and often costly, and normally would require significant critical mass to be justified. Gas development may again be individually small and thus not be able to carry such investments. Unless there is properly regulated and functioning third party access to infrastructure (owned by others) access may also be difficult as it may not be in the interest of the pipeline owner to allow third party access. (the pipeline owner may have own competing gas.) Last but not least there may be gaps in the infrastructure development between different parts of the system, (regional, national local distribution systems)

Main stakeholder(s) responsible for the barrier	Other stakeholder(s) who influence the barrier
Political authorities Regulatory bodies Oil and gas companies and operators	Multilateral development banks and other finance institutions Oil and gas industry associations

Barrier 17 : Low current and forecasted prices of natural gas
Emission: Methane
Description of the barrier
This is possibly the most frequent mentioned barrier in the US/Canada reflecting the shale gas revolution and the low Henry Hub gas price. The low price and price expectations makes the business case for investing in emission reduction projects very hard to justify as the revenue of such investment is low whilst the capital and operational expenditures are more independent of gas prices. One could argue that relatively speaking this should not disfavour such investments as other investments for enhanced production will face the same obstacle. However, when the price is low, the cash flow suffers and it is extremely hard for a producer to find or justify capital for any investments. The outlook for gas prices in the US is fairly subdued and thus this barrier is likely to remain an important barrier for some time. There is also the typical psychological effect that has been a key feature in the oil and gas industry: When the situation (price) is bleak, the expectation is bleaker (and vice versa)

In many other countries, the gas price is subsidized/regulated to shelter (poor) consumers from high and volatile prices. Not seldom is the contract and incentive structure between producer and off takers not conducive to incentivize investment in emission reductions

In principle, this is a barrier that could have relevance elsewhere, but currently the gas prices are holding up in most part of the world, although under pressure in Europe due to looming oversupply.

Main stakeholder(s) responsible for the barrier	Other stakeholder(s) who influence the barrier
-	

Barrier 18 : Substantial costs and/or additional challenges associated with retrofitting older installations
Emission: Methane
Description of the barrier

For methane
While a number of methane emission reduction can be achieved without any production's interruption, some project require complete or partial shutdown of the operation (for example to replace wet seal by dry seal on centrifugal compressors). Interrupting production for the implementation of a retrofit solution significantly decrease the attractiveness of a methane emissions project[50].
Alternatively, companies can organise the retrofit during planned maintenance. Limitation of time during normal shutdowns further squeezes any such measures and projects out of the ranking order.

In addition, the retrofit projects may not be perceived as attractive when the remaining facility's lifetime is either short or uncertain.

Main stakeholder(s) responsible for the barrier	Other stakeholder(s) who influence the barrier
Oil and gas companies and operators	Oil and gas industry associations Technology providers/other experts

Barrier 19 : Immaturity of some technologies
Emission: Methane and black carbon
Description of the barrier

Some mitigation technologies are at early stage of development (pilot or early commercial stages), as a result their costs and reliability in various operational conditions are not fully understood. Examples include mini GTL solutions, mini LNG,

Main stakeholder(s) responsible for the barrier	Other stakeholder(s) who influence the barrier
Technology providers/other experts	Research organisations Multilateral development banks and other finance

[50] To the exception of projects impacting safety of operation

	institutions International organisations and initiatives Oil and gas industry associations

Barrier 20: Applicability limits for some technologies in some operational circumstances	
Emission: Methane	
Description of the barrier	
For Methane Some best practices are known not to be applicable or too costly in some operational circumstances. A number of practical examples are given below: • Where the mitigation technology is dependent on a centralised and reliable source of electricity (Air driven pneumatic devices, Electric pumps in place of Energy-Exchange pumps) • Implementing plunger lift systems is more challenging on horizontal wells • Low bleed devices can be damaged very quickly (6 months) when they are powered with wet or sour gas. • Sometimes recovery of too sour and too corrosive methane and vapours is technically too challenging. • IR camera may not detect leaks when there is a strong wind or rain • In some cases the costs are actually higher in specific operational circumstances than planned.	
Main stakeholder(s) responsible for the barrier	**Other stakeholder(s) who influence the barrier**
Technology providers/other experts	Oil and gas industry associations International organisations and initiatives

Annex 5) Measures

Measure 1 : Encourage emission survey campaigns and form industry wide collaborative initiatives to invest in such campaigns
Emission: **Methane and black carbon**
Description of the measure
Pilot emissions surveys at individual sites (or for specific regions) can help provide insight into the main sources and the magnitude of emissions and support identification of the most promising mitigation options in a given context. If the results are made public, these surveys could also be used to improve emission factors for specific source of emissions. Hence, oil and gas companies could be encouraged to perform surveys (either for individual facilities or preferably on a regional scale): • Such surveys could be made a mandatory part of regional Environmental Impact Assessment before opening new acreage (but conducted once in operations) or become part of licence conditions   ○ Surveys could e.g. be undertaken by an independent body and results "sold" to the industry (precedence: Seismic surveys in Norway performed by the Petroleum Directorate and made available to the industry) • Helping the industry to see that this is in the best long term interest of the industry
Barrier(s) targeted
Main barrier targeted • Lack of awareness about sources and magnitude of emissions at the oil & gas facility level • Only rather basic or uncertain knowledge of national/regional emissions Other barrier targeted • Culture for data confidentiality preventing effective sharing of processes, emission inventories and technology information • Severe challenges in developing and implementing effective tools and methodologies to quantify emissions and emission reduction
Past example(s)
The Global Methane Initiative (GMI) has supported the implementation of emission surveys in a number of facilities globally. American Petroleum Institute (API) and America's Natural Gas Alliance (ANGA) did a collaborative effort on Unconventional Natural Gas Production [51]

[51] http://www.api.org/~/media/Files/News/2012/12-July/Task2-API-ANGA-Survey-Report-19-July.pdf

The US Environmental Defence Fund initiated in 2013 a series of studies characterizing methane emissions in production, gathering and processing, transmission and storage sites of natural gas industry in the country with cooperation of a number of researchers, technology providers and gas operators. [52]
Global Methane Initiative has been actively sharing information and success stories and supporting survey programmes.

Actors	Actions
▪ Oil and gas industry associations ▪ International organisations and initiatives ▪ Environmental NGOs	▪ To initiate the team-up processes and encourage the companies to cooperate ▪ To share the success stories and provide technical support to the oil and gas operators ▪ To promote the managerial improvements to address issues of instructional gaps
▪ Oil and gas companies and operators	▪ To create a company-wide methane survey programmes with clear action plans ▪ To share information and actively participate in industry-side methane identification campaigns
▪ Multilateral development banks and other finance institutions ▪ Environmental NGOs	▪ To support pilot projects and with the aim of identifying mitigation opportunities ▪ To strengthen cooperation between different operators and fund ground breaking projects

Measure 2 : Support countries to develop emission inventories
Emission: Methane and black carbon
Description of the measure

[52] http://www.pnas.org/content/suppl/2013/09/11/1304880110.DCSupplemental/sapp.pdf

National inventories are an important basis for raising awareness and setting of political priorities. A number of actions can be undertaken to support the development of such inventories:

- Provide guidelines or improve existing guideline for estimates of methane and black carbon emissions. Guidelines should be flexible to accommodate variable countries circumstances and should leverage international knowledge/research results on these questions.
- Provide methodologies to manage uncertainties. Given the large amount of information required to develop comprehensive and reliable inventories, it is crucial to develop methods that help assess the uncertainties in the absence of all the data required and thus allow decision based on uncertain inventories.
- Provide technical support (measurement equipment, experts) to help the development and/or the improvement of national inventories in countries with potentially high methane and black carbon emissions from the oil and gas sector.

Note: Given the particularly complex nature of the oil and gas business, developing and refining inventories can represent a long process. It is important that these developments do not slow down the implementation of mitigation measure when possible and relevant.

Barrier(s) targeted

Main barrier targeted

- Only rather basic or non-existent knowledge of national/regional emissions

Other barrier targeted

- Lack of awareness about sources and magnitude of emissions at the oil and gas facility level
  - Severe challenges in developing and implementing effective tools and methodologies to quantify emissions and emission reduction

Past example(s)

IPCC published guidelines for methane inventories in 2006[53] and started a process to revise these guidelines this year. The Convention on Long-range Transboundary Air Pollution (LRTAP) also developed a methodology for black carbon emission inventory

Global Methane Initiative supported Pemex to develop inventories. [54]

The Climate and Clean Air Coalition (CCAC) has recognised the importance of national inventories as the programme on Supporting National Planning for action on Short Lived Climate Pollutants (SLCPs) [55]

Actors	Actions
▪ International organisations and initiatives	▪ To provide guidelines, templates, capacity building and support to the national authorities in charge of emission inventories
▪ Investment organisations, Dev. funds	▪ To support country-wide activities with the purpose of gathering reliable inventories of emission sources

[53] http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_4_Ch4_Fugitive_Emissions.pdf
[54] https://www.globalmethane.org/expo-docs/india10/postexpo/oil_betancourt_1.pdf
[55] http://www.unep.org/ccac/Actions/SLCPNationalActionPlans/tabid/104670/Default.aspx

▪ Political authorities	▪ To take active steps towards understating the details of the sources of emissions in their respective countries Examples: EPA in USA and MFA in Norway
▪ Regulatory bodies	▪ To provide suitable regulatory framework promoting establishment of reliable emission inventories
▪ Environmental NGOs	▪ Contribute to awareness of the importance of inventories and to the sharing of knowledge

Measure 3 : Develop transparent and unbiased information material on technologies for different operational circumstances (or complement existing ones)

Emission: Methane and black carbon

Description of the measure

Developing more material on technologies could provide specific and unbiased overview of the challenges and benefits of a technology and could be an important pillar in bringing confidence to the mitigation technologies. The information material should:

- Transparently reflect the operational challenges and technical considerations of different technologies (as opposed to solely promoting).
- Take into account all different cost components in a manner that builds trust among the operators.
- Be prepared in collaboration with industry associations to bring confidence in implementation of the technology
- Accurately describe the prerequisite for implementing certain solutions
- Clearly indicate the required downtime for the retrofit options.
- Implementing the technologies and solutions in different operating conditions to examine applicability and the costs of technologies.
- Review specific considerations under extreme situations (temperature, humidity, wind, offshore-specific conditions, etc.).
- Form working groups to develop project which cover different operating conditions
- Facilitate or perform pilot projects under different operation conditions
- Reduce costs of establishing inventories by teaming up and perform large programmes as opposed to small unrelated activities
- The material could be prepared by research organisation, or independent industry player.

As there are very many different emission sources under prolific conditions pilot project should be conducted and experiences shared in order to increase knowledge on best practice technologies, build trust in applicability of certain solutions under different conditions and provide capacity for realistic cost-benefit analysis

This measure can be implemented by operators individually and through collaborative efforts. The replicating value of the pilots depends critically on the dissemination and sharing of experiences, which to some extent (but not excessively) may be restricted by commercial sensitivity considerations.

Barrier(s) targeted

Main barrier targeted

- Lack of reliable estimation of direct and indirect costs of implementing the best available mitigation technologies under specific operational conditions

- Insufficient knowledge about best practice mitigation technologies and their technical specifications at oil and gas facility level
- Knowledge gap on technology and costs at the national level

Other barrier targeted

- Risk aversion and conservatism in the companies
- Insufficient incentives and motivations to act in the companies

Past example(s)

EPA (*Lessons Learned from Natural Gas STAR Partners*)[56]
Arctic council *(Best Available Technologies Report)*[57]
Natural Resources Defence Council (*Leaking profits report*)[58]
IIGCC, INCR and IGCC (*Controlling methane emissions in the O&G sector*)[59]

Actors	Actions
▪ Oil and gas companies and operators	▪ To actively participate in planning, implementation and sharing the results of deploying technologies and solutions
▪ Oil and gas industry associations ▪ International organisations and initiatives ▪ Environmental NGOs	▪ To act as focal point in collecting the implementation results from different oil and gas operators and provide thorough analysis
▪ Research organisations	▪ To provide in-depth review of theoretical/practical aspects of the technologies, their effectively and their operability in different conditions
▪ International organisations and initiatives	▪ To provide technical expertise and in implementation of different technologies and use the results to improve specifications and material
▪ Multilateral development banks and other finance institutions	▪ To promote implementation of pilot projects by financing pilot programmes, technology development and research activities

Measure 4 : Encourage oil and gas companies to share information (at least between themselves) on emissions, technologies, and procedures

Emission: **Methane and black carbon**

[56] http://www.epa.gov/gasstar/tools/recommended.html
[57] http://www.arctic-council.org/index.php/en/document-archive/category/447-slcf-tf?download=1764:task-force-on-short-lived-climate-forcers-final-summary-report-english
[58] www.nrdc.org/energy/files/Leaking-Profits-Report.pdf
[59] http://www.ceres.org/files/methane-emissions/investor-joint-statement-on-methane-emissions

Description of the measure
Sharing information between different oil and gas companies can support the acceleration of methane emission reduction, as learning of best practices can be transferred. In addition, wider information sharing on these issues is essential to build trust between the oil and gas industry and the public/regulator and give the public/ regulator the assurance that the industry is transparent about their conduct Assuming a certain level of encouragement and pressure from various authorities and sustained signals that such information is beneficial both for the society and the industry (alternative could be ill designed regulation) several initiatives could be envisaged: • International organization could support and encourage industry association to overcome confidentiality concerns and sponsor some trial information sharing • Industry associations could themselves highlight the need for information sharing as well as develop simple guidelines and "code of conducts" for information to be shared i.e. to overcome the confidentiality concerns • Industry associations could sponsor, in cooperation with technology providers, best practice work-shop or seminars There is excellent precedence for cooperation in the industry of sharing best practice on Safety management, operations and procedures which could be leveraged to reduce potential scepticism for info sharing
Barrier(s) targeted
Main barriers targeted ○ Culture for data confidentiality preventing effective sharing of processes, emission inventories and technology information ○ Insufficient knowledge about best practice mitigation technologies and their technical specifications at oil and gas facility level ○ Lack of awareness about sources and magnitude of emissions at the oil & gas facility level ○ Severe challenges in developing and implementing effective tools and methodologies to quantify emissions and emission reduction ○ Lack of reliable estimation of direct and indirect costs of implementing the best available mitigation technologies under specific operational conditions Other barrier targeted ○ Knowledge gap on technology and costs at the national level
Past example(s)
Global Methane Initiative and Natural Gas Star Programme Interstate Natural Gas Association of America[60] American Petroleum Institute and America's Natural Gas Alliance (API ANGA) survey on the sources of methane emissions from natural gas production

[60] http://www.axpc.us/download/issues_and_info/environment/environment_15jan2007.pdf

Actors	Actions
▪ Oil and gas industry associations	▪ To initiate dialogue between different operators to find collective solutions and share technical information on implementation challenges and lessons learned
▪ International organisations and initiatives	

Measure 5 : Facilitate transfer of technologies/practices between countries
Emission: **Methane and black carbon**
Description of the measure
Some countries/regions have performed, over the last few years, a number of measurements and of (pilot) projects to reduce methane emissions. The experience and the lessons learned from these projects can be transferred internationally to other countries with less experience to accelerate the deployment of methane emission reductions. Actions can include: • Organize capacity building events (between companies or between regulators) to share information on emissions and technology • Support the implementation of pilots projects with the aim of demonstrating the applicability of specific emission reduction technologies and solutions • Translate existing material (scientific papers, report etc..) in relevant languages • Summarize/organize existing information material: there are currently a large number of papers/report/document available on these questions, sometimes contradictory. This material could be organized (for example in a communication platform) to allow actors who wants to start working on these questions to quickly find relevant information.
Barrier(s) targeted
Main barriers targeted o Insufficient knowledge about best practice mitigation technologies and their technical specifications at O&G facility level o Knowledge gap on technology and costs at the national level o Lack of reliable estimation of direct and indirect costs of implementing the best available mitigation technologies under specific operational conditions Other barriers targeted o Only rather basic or uncertain knowledge of national/regional emissions o Lack of awareness about sources and magnitude of emissions at the oil & gas facility level
Past example(s)

Global Methane Initiative has been working for years on sharing information on best practices with a number of target countries.
Global Gas Flaring Reductions Partnership (GGFR) has over the past ten years promoted flare reduction through a number of initiatives including the establishment of a voluntary standards for flaring and venting reduction, dissemination of best practises in monitoring and measurements and in associated gas utilization investments[61]
Canada has participated in a collaboration under the Canada-China Climate Change Group as part of which transfer of mitigation technologies are planned [62]
Norway has a 3 year programme to support transfer of methane mitigation technologies and methodologies to Kazakhstan (in addition to other GHGs).

Actors	Actions
▪ Oil and gas industry associations ▪ International organisations and initiatives	▪ To initiate and coordinate dialogue between different countries and regions to facilitate transfer of technological achievement to less developed regions with regards to emission technologies
▪ Multilateral development banks and other finance institutions	▪ To finance technology owners to perform pilot projects in less developed regions to showcase effectiveness and applicability of mitigation options
▪ Oil and gas companies	▪ To actively participate in the mitigation programmes and collective solutions, to share information with the aim of improving knowledge on technologies

Measure 6 : Increase communication towards politician/public

Emission: Methane and black carbon

Description of the measure

Currently, in a number of countries, there is limited communication towards the public and the politician on these issues. Increasing communication would:

- Raise awareness on the actual (if known) or potential role of black carbon and methane emission in the country and their role as climate change precursors
- Raise awareness and knowledge of mitigation opportunities

A number of actions can be undertaken to achieve this:

- Develop communication material towards the public on methane and black carbon emissions from the Oil and gas sector.
- Engage media to disseminate information
- Promote the inclusion of emission reduction under existing or future regulation.
- Engage local communities when relevant

Encourage collaboration between politician from various regions on these issues

[61] Ref to ggfr
[62] http://www.climatechange.gc.ca/default.asp?lang=En&n=65383442-1

Barrier(s) targeted
Main barrier targeted ○ Lack of awareness and interest of the public Other barrier targeted ○ Insufficient determination from the political authorities to promote new regulations
Past example(s)
The CCAC for example developed a video which describe in general the potential in terms of SLCP (not specific to the oil and gas sector).[63] The Institute for Governance & Sustainable Development on the influence of SLCP on climate change and health impacts. [64]

Actors	**Actions**
▪ Environmental NGOs	▪ To raise public awareness with regards to the level and impact of emissions ▪ To put pressure on political authorities to take effective actions towards understanding and mitigating emissions
▪ Research organisations ▪ International organisations and initiatives	▪ To investigate and publish the impacts of SLCF on local and global well-being ▪ To raise public awareness with regards to the level and impact of emissions

Measure 7 : Include methane and black carbon monitoring and mitigation identification as part of license conditions
Emission: Methane and black carbon
Description of the measure
For methane and black Carbon In order to ensure that the industry has the right and necessary information to develop cost-efficient emission reduction measures one could make monitoring and reporting part of licence conditions. By instigating this and enforcing compliance one could get a realistic picture of how much abatement should be done and at what costs. In most jurisdictions it is the prerogative of a regulator or other authority body to set the conditions in a license – as a result, such conditions could be applied: • When licensing new acreage • When renewing existing license

[63] http://www.unep.org/ccac
[64] http://www.igsd.org/documents/PrimeronShort-LivedClimatePollutants23april2013EV.pdf

To ensure fair and equitable treatment, dialogue with the industry is important prior to the introduction of such requirement. A well designed dialogue could also enhance the awareness and attitudes in the industry.

Barrier(s) targeted

- Insufficient incentives and motivations to act in the companies

Past example(s)

Actors	Actions
▪ Regulatory bodies	▪ To put into effect requirements regarding SLCP monitoring and mitigation measures before license issuance
▪ Oil and gas companies and operators	▪ To submit thorough review of the SLCP emission sources within their operations, quantification plans and mitigation options

Measure 8 : Leverage international climate and carbon finance

Emission: **Methane and black carbon**

Description of the measure

Carbon financing (through the existing Clean Development Mechanism, or through new mechanisms, like the NAMA) could be leveraged to identify and finance a number of methane[65] emissions reduction project.

Barrier(s) targeted

- Insufficient incentives and motivations to act in the companies
- High opportunity costs of implementing emission reductions measures may negatively impacts cash-flow and rate of return

Past example(s)

[65] In the absence of a GWP of black carbon, it is more challenging to use this measure for black carbon emissions.

Mexico and Columbia are currently developing a NAMA project to reduce black carbon emissions from gas flaring.Canada (in Alberta and British Columbia) has established an offset scheme where verified methane emission reductions can be used for compliance purposes or traded. [66][67]

Actors	Actions
▪ International organisations and initiatives	▪ To develop new mechanisms to expand on methane reduction projects ▪ To improve the existing mechanisms
▪ Regulatory bodies	▪ To prepare suitable regulatory framework to help the project developers to verify and monetise the emission reductions achieved
▪ Multilateral development banks and other finance institutions	▪ To invest in identification and development of methane reduction projects with the aim of achieving emission reduction credits

Measure 9 : International voluntary programs or standards

Emission: **Methane and black carbon**

Description of the measure

Sharing more widely information on emissions and achievement can trigger both more activities in oil and gas companies, and increase the awareness of the politician/regulators of the current status. Actions could include:

- Encourage or develop voluntary standards or programs for oil and gas companies to measure/estimate and reduce emissions (all greenhouse gases or methane/black carbon).
- Publicize or encourage publication of past successful actions by oil and gas companies to reduce emissions
- Publicize or encourage publication of emissions information.
- Publicize or encourage publication of compliance or non-compliance to existing schemes

Barrier(s) targeted

- Lack of awareness about sources and magnitude of emissions at the oil and gas facility level
- Culture for data confidentiality preventing effective sharing of processes, emission inventories and technology information
- Insufficient knowledge about best practice mitigation technologies and their technical specifications at oil and gas facility level
- Lack of reliable estimation of direct and indirect costs of implementing the best available mitigation technologies under specific operational conditions
- Insufficient incentives and motivations to act in the companies

[66] http://environment.alberta.ca/02275.html
[67] http://pacificcarbontrust.com/documents-and-forms/protocols/

Past example(s)	
The Carbon Disclosure Project's 2013 Oil and Gas Supplement include a questionnaire on methane emissions. GMI highlight in its newsletters the achievement of some of the partners.[68] GGFRs Voluntary Standard for Global Gas Flaring and Venting Reduction[69]	
Actors	**Actions**
▪ Oil and gas industry associations	▪ Initiate and consult with oil and gas companies on scope and content of programs or standards ▪ Manage process to establish programs or standards
▪ International organisations and initiatives	▪ Participate in development of programs or standards including liaising with government/regulators and other relevant stakeholders

Measure 10 : Develop and improve methodologies to estimate emissions or emissions reductions

Emission: **Methane**

Description of the measure

Developing cost-effective, reliable and verifiable emission estimation methodologies/approaches is an important step to ensure;

- That emission variation are credible
- That emission reduction can be achieved cost efficiently

A number of different actions can be pursued to improve existing approaches and develop new ones:

- Develop reliable and specific emissions factors for different type of equipment and operating conditions to facilitate baseline or emissions determination. This can be achieved by commissioning measure campaign
- For fugitive emission sources, develop specific methodologies and protocols on minimum requirements to achieve reliable and conservative calculation of emission reductions and Monitoring Plans specifying the required frequency and quality of inspections to ensure credible emission reductions.
- Develop methodologies to implement projects in large programs (i.e. implement a large number of projects together), to combine the costs of reporting and verification and thus to improve the cost efficiency of the monitoring

Barrier(s) targeted

- Severe challenges in developing and implementing effective tools and methodologies to quantify emissions and emission reduction
- High opportunity costs of implementing emission reductions measures may negatively impacts cash-flow and rate of return

[68] https://www.globalmethane.org/news-events/miarchive.aspx
[69] Make ref to GGFRs report number 2

Past example(s)	
An agreement between the Canadian Association of Petroleum Producers (CAPP) and the Ministry of Environment's Climate Action Secretariat (CAS) would allow for an alternative method for monitoring and reporting Greenhouse Gas emissions from pneumatic instrumentation and pumps. This method would be based on sampling of a statistically-valid field sample of pneumatic devices and pumps to determine emission factors that can be applied to industry's fleet for the purpose of complying with reporting requirements. [70][71]	
Actors	**Actions**
▪ Oil and gas industry associations ▪ International organisations and initiatives	▪ To initiate development of credible methodologies to set conservative baseline scenarios for difference emission sources through analysis of adequate amount of data ▪ To initiate establishment of monitoring and reporting methodologies to ensure verifiable emissions reductions are achieved
▪ Research organisations	▪ To investigate the magnitude, frequency and occurrence of emissions per source and publish analysis to help develop monitoring methodologies
▪ Technology providers/other experts	▪ To provide technical support to developers in preparing reliable methodologies

Measure 11 : Support the development of new monitoring technologies (from pilot to market)
Emission: **Methane and black carbon**
Description of the measure
A number of new technologies are currently being developed and tested to monitor methane and black carbon emissions[72]. These technologies could potentially: • Reduce the costs of monitoring by allowing the quick detection of the largest source of emissions and/or • Support a better understanding of emissions (for example over a basin) Providing technical/economic[73] support to the most promising technologies/approaches could allow them to move from the research/pilot stage, to a more commercial stage and accelerate their deployment. Alternatively, pilot's implementation could be supported to gain visibility on the potential of some technologies.
Barrier(s) targeted

[70] http://www.scek.ca/sites/default/files/scek-project-profile-sample-pneumatic-devices-develop-emision-factors-ver-1.pdf

[71] http://www.capopenergy.com/1/post/2013/09/cap-op-is-participating-in-the-largest-field-study-of-pneumatic-devices-to-establish-baseline-bleed-rates-for-methane-emissions.html

[72] Examples include but are not limited to: SkyLOSA technique (Carleton University), Picarro solutions (http://www.picarro.com/products_solutions/solutions/picarro_investigator), NOAA sampling plane (http://www.dailykos.com/story/2013/08/07/1229636/-NOAA-Investigation-Finds-Massive-Methane-Emissions-from-Utah-Fracking-6-to-12-Lost-to-Atmosphere#),

[73] Or organisational

Main barrier targeted
- Severe challenges in developing and implementing effective tools and methodologies to quantify emissions and emission reductions

Other barriers targeted
- Lack of awareness about sources and magnitude of emissions at the oil & gas facility level
- High opportunity costs of implementing emission reductions measures may negatively impacts cash-flow and rate of return
- Only rather basic or uncertain knowledge of national/regional emissions

Past example(s)

A number of technologies are tested and developed from other applications to methane leak detection and measurement for petroleum industry, e.g. infrared cameras or Picarro surveyor for pipeline detection.[74]
action:
- select the most promising technologies
- provide economic /technical support to first develop pilot and then to move to commercialization (incubator)

Actors	Actions
▪ Research organisations	▪ To investigate the needs for R&D within the sector with regards to MRV technologies
▪ Oil and gas companies	▪ To cooperate with R&D bodies and technology providers in understanding the needs and improving the existing monitoring technologies ▪ To open sites for pilot testing
▪ Technology providers/other experts	▪ To develop solutions to respond to the needs

Measure 12 : Support regional/national projects to reduce the costs per facility

Emission: Methane and black carbon

Description of the measure

The implementation of regional gas infrastructure can significantly reduce the gas utilization costs per facility and thus accelerate gas utilization. The gas infrastructure can be developed by an independent company or by a consortium of gas operators.
A number of actions can be performed to facilitate
- Identify existing and future stranded gas
- Evaluate the cost and benefits of developing regional/national network
- Evaluate different business models to build and operate shared gas infrastructure.

[74] http://www.edf.org/energy/innovation/gas-leak-detection-innovation

Barrier(s) targeted
Main barrier targeted o Insufficient or inadequate gas infrastructure High opportunity costs of implementing emission reductions measures may negatively impacts cash-flow and rate of return Other barrier targeted o Insufficient incentives and motivations to act in the companies
Past example(s)
The formation of Gasled in Norway is a good example of development of a cost efficient and open transportation system

Actors	**Actions**
▪ Regulatory bodies	▪ Making such joint development or collaboration part of licence conditions
▪ Oil and gas industry associations	▪ To promote industry-wide team-ups with the objective of achieving economy of scale in detection, measurement, identification of best mitigation opportunities
▪ International organisations and initiatives ▪ Development funds or banks	
▪ Oil and gas companies	▪ To actively participate in large scale regional/national programmes, share information and make institutional decisions to address the issue of SLCP systematically

Measure 13 : Support some technology development (from pilot to market)
Emission: Methane
Description of the measure
A number of new technologies are currently being developed and tested to reduce gas flaring, or to reduce methane emissions[75]. These technologies could potentially: Be applied in remote area and/or Be applied for smaller facilities or smaller volume of gas available and/or Be mobile (i.e. can easily be transferred to a new location when the production decline is really fast) Providing technical/economic[76] support to the most promising technologies/approaches could allow them to move from the research/pilot stage, to a more commercial stage and accelerate their deployment. Alternatively, pilot's implementation could be supported to gain visibility on the potential of some technologies.

[75] For example for gas flaring: mini GTL, Mini LNG, Mini Methanol plants, for methane emissions: wet seal degassers, VOC recovery systems, package materials for fugitive leaks…
[76] Or organisational

Barrier(s) targeted	
Main barrier targeted ○ Immaturity of some technologies Other barrier targeted ○ High opportunity costs of implementing emission reductions measures may negatively impacts cash-flow and rate of return	
Past example(s)	
The Government of Canada is collaborating with the Petroleum Technology Alliance of Canada (PTAC) to support the development of plans for Nationally Appropriate Mitigation Actions (NAMAs) in the oil and natural gas sector (including on black carbon emissions) in Mexico and Colombia. [77]	
Actors	**Actions**
Research organisations	To investigate the R&D needs within the O&G sector concerning mitigation technologies
Oil and gas companies	To cooperate with R&D bodies and technology providers in understanding the needs and improving the mitigation technologies
Technology providers/other experts	To develop solutions to respond to the needs

[77] http://ccap.org/assets/PTAC-Oil-and-Gas-NAMA_EC.pdf