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Regulatory Framework to Mitigate Methane Emissions in North America. The Lessons Learned for Europe

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Florence School of Regulation

Highlights

- The discussions on setting the EU long-term target to reach carbon-neutrality by 2050 are ongoing. So is the debate on the future role of gas in Europe. One of the issues under discussion is how to reduce methane emissions across the natural gas value chain.
- Most of the natural gas consumed in the EU is produced outside its borders. While EU's strategic plan for methane is still under preparation it is important to understand the impact of methane regulation in the main natural gas producing countries.
- Between 2016 and 2018, the US, Canada and Mexico adopted policies and regulatory frameworks addressing methane emissions in order to meet the pledge of their leaders to reduce methane emissions from the oil and gas sectors by 40 to 45% from 2012 levels by 2025.
- Despite the significant differences in the scope of regulations and allowed exemptions, the three countries introduced sets of performance standards and requirements that build upon the Best Available Techniques and practices to minimize methane emissions from three categories: fugitive, vented emissions and emissions resulting from incomplete combustion, i.e. flaring. Moreover, all countries introduced regular Leak Detection and Repair programs, which direct operators to regularly inspect and repair leaking components, such as valves or pumps, and to monitor and report their emissions.
- The analysis of these countries' regulations provides important information on the most effective and robust approaches to reduce methane emissions in the gas value chain.
- For the EU the availability of transparent and accurate methane emissions data is of key importance to estimate the GHG footprint of the energy it consumes.
- The cooperation between methane regulatory frameworks could provide for additional dynamic to minimise methane emissions.

Introduction

From Political Declaration to Methane Regulation

Laying down foundations for the decarbonisation of the gas sector is one of the top priorities for the European Commission led by Ursula von der Leyen.

For this reason, the reduction of methane emissions associated with the production and transport of natural gas is increasingly important in Europe. However, the challenge lays partly in the fact that the majority of gas consumed in the EU is produced outside the Union. In the first quarter of 2019, the EU net gas imports increased by 15%, compared to the first quarter of 2018. In the same period, due to the converging LNG prices, the EU LNG imports rose dramatically, up by 126% year-on-year, mainly at the expense of "traditional" imports through pipelines from Algeria and Libya[1]. The data from Q2 2019 demonstrate that in April and May, LNG imports surpassed pipeline imports from Norway, and became the second largest import source for the EU after Russia[2].

On the other side of the Atlantic, the North American leaders made a joint commitment to reduce their 2012 levels of methane emissions from the oil and gas sectors by 40 to 45% by 2025. The 2016 US, Canada and Mexico declaration included the commitment to develop and implement federal regulations aimed at reducing methane emissions. With the publication of new regulations in Mexico on the 6th of November 2018, North America became the first region with the up-to-date regulatory framework for methane in place.

The shale gas revolution turned North America, and the US in particular, into the top energy-producing region in the world. This year, the US became the world's third-largest LNG exporter[3]. For the EU – the major energy consumer and more and more often, the destination of US LNG cargos – it is essential to understand how this main gas provider deals with the issue of methane emissions at home. Moreover, it is of utmost importance to reflect on the lessons learned in the context of discussions on the EU long-term climate strategy and the new EU methane strategy to be announced in the early 2020s[4].

Taking this into account, this Policy Brief seeks to address the following questions:

- How robust is the regulation of methane gas emissions in North America?
- How transparent is it from the perspective of the EU consumers?
- How promising is the potential for global cooperation on methane emissions?

This paper has the following structure: Section 1 provides detailed data on the key trends and sources of the methane emissions in North America. Section 2 analyses the regulatory frameworks targeting methane emissions in the US, Canada and Mexico. In Section 3, the authors address the three research questions. The final part draws conclusions.

1. In Q1 of 2019, the main sources of extra-EU gas imports were: Russian pipeline supplies (40%), Norway (31%), LNG imports (22%) and pipeline imports from North Africa (7%). The main sources of LNG were: Qatar (22% of total LNG imports), Russia (21%) and the US (13%). Data source: Quarterly Report on European Gas markets, DG Energy, Volume 12 (1), first quarter of 2019.
2. Quarterly Report on European Gas markets, DG Energy, Volume 12(2), second quarter of 2019.
3. LNG Monthly, US Department of Energy Office of Oil & Natural Gas, September 2019.
4. The European Commission has commissioned a study on "Limiting Methane Emissions in the Energy Sector" to a consortium composed of Wood with support from TNO, Carbon Limits, and The Sniffers). The final report is due in August 2020.

Methane Emissions in North America

The US, Mexico and Canada are among the major methane emitters globally. In 2014, US emitted 652.47 MtCO2e (Million metric tons of carbon dioxide equivalent), Mexico 191.17 MtCO2e and Canada 109.22 MtCO2e. Methane emissions account for roughly 10% of all GHG emissions in US and Canada, and around 20% of Mexican GHG emissions.[5]

Methane emissions in North America are mainly driven by emissions from three sources: agriculture; energy, including emissions related to production and extraction of fossil fuels; and waste. The data collected by the International Energy Agency (IEA) shows that methane emissions in North American oil and gas sector measured 17.3% of total global methane emissions from this sector in 2017, compared to a 3.3% share of methane emissions from European oil and gas sector[6].

Where do the majority of emissions occur and what type of emissions (fugitive, vented or flared) dominate? The IEA estimates that, downstream gas (fugitive and vented) is the biggest source of emissions in Mexico, followed by offshore oil and onshore conventional oil production. In Canada, onshore conventional oil and unconventional gas production are the key sources of emissions, with a clear predominance of emissions from venting. In the US, unconventional gas is by far the largest source of emissions (mainly vented) followed by the downstream gas, with the prevalence of fugitive emissions[7].

It should be noted that, in contrast to Canada, the emissions from flaring constitute a substantial part of methane emissions in Mexico and the US. It is estimated that in 2018, roughly 14.1 bcm of gas has been flared in the US and 3.9 bcm in Mexico, which places them among the top 10 flaring countries. Moreover, between 2014 and 2018, the flared volumes in the US increased by 5.1%, whereas both Mexico and Canada recorded a decrease in flaring volumes, by 1.0% and 0.7%, respectively[8].

In fact, the substantial methane footprint of these three North American countries has prompted the decision-makers and regulators to create concrete policies and a regulatory framework to tackle this problem.

Methane Regulatory Framework in the US

The US efforts to reduce methane emissions at the federal level should be analysed in the broader framework of the Obama administration's Clean Action Plan released in 2013[9]. The Plan consisted of three pillars: the mitigation of GHG emissions, adaptation to the impacts of climate change, and the promotion of American leadership in global efforts to tackle climate change. Moreover, it postulated the development of an "interagency methane strategy," which was presented one year later. The 2014 "Strategy to Reduce Methane Emissions" targeted major sources of US methane emissions, including the oil and gas sector[10].

5. CAIT Climate Data Explorer (consulted on 30/09/2019).
6. International Energy Agency Methane Tracker (consulted on 30/09/2019).
7. Ibid.
8. The World Bank Zero Routine Flaring by 2030 program. Top 30 flaring countries – tables (2013-2018).
9. The President's Climate Action Plan. Executive Office of the President, June 2013.
10. Climate Action Plan Strategy to Reduce Methane Emissions, March 2014. The Strategy focuses also on emissions from: landfills, coal mines and agriculture.

The Strategy directed the Environmental Protection Agency (EPA) to review available mitigation technologies and to expand the industry's voluntary efforts via the existing Natural Gas STAR program. In addition, the strategy invited the Bureau of Land Management (BLM) to modify standards to reduce venting and flaring on public lands. It also aimed at identifying the "downstream" methane reduction opportunities via the Quadrennial Energy review and the roundtable discussion organised by Department of Energy. Finally, the US methane strategy called for improved methane measurement and monitoring through the development of new measurement technologies and the cost-effective technologies to reduce emissions[11].

The Strategy was ultimately criticised for suggesting changes that would not achieve the Obama administration's promises. The inadequacy of these measures was reinforced by the President Obama announcement in January 2015 of an overarching objective to reduce methane emissions from the oil and gas sector by 40-45% by 2025[12]. EPA received a clear mandate "to initiate a rulemaking effort to set standards for methane and VOC emissions" and adopted the respective methane regulations in May 2016.

The final New Source Performance Standards (NSPS)[13], builds upon the 2012 rule to curb Volatile Organic Compounds (VOCs), and applies to new, reconstructed and modified sources only[14]. The 2016 NSPS covers hydraulically fractured oil wells and other actions related to oil and gas production, processing, transmission and storage, but with an exception of distribution.

The 2016 rule:

- sets emission limits for methane and Volatile Organic Compounds (VOC) (see Table 1)
- requires owners/operators to find and repair leaks: the owners/operators of new and modified well sites must conduct an initial survey within a year after the publication of the rule, or within 60 days following the start of production. After a first survey, the monitoring is conducted twice per year at well sites and four times annually at gathering, boosting and transmission compressor stations.
- allows the use of EPA "Method 21"[15] as an alternative to the optical gas imaging (OGI) for finding leaks. Moreover, the regulation allows the use of innovative technologies to monitor leaks, as it specifies which information needs to be submitted in seeking technology approval.

Moreover, the US EPA undertook efforts to regulate emissions from existing sources. The Agency sent an Information Collection Request (ICR), asking for additional information from the oil and gas companies to develop regulations for the existing sources. It should be noted that the EPA withdrew the ICR on 2 March 2017 on the grounds it could create an excessive administrative burden on the companies[16].

11. Climate Action Plan Strategy to Reduce Methane Emissions, op. cit., pp. 7-11.
12. Fact Sheet: Administration Takes Steps Forward on Climate Action Plan by Announcing Actions to Cut Methane Emissions, 14 January 2015.
13. The US EPA published the final rule on 3 June 2016. The rule took effect on 2 August 2016.
14. The 2016 NSPS applies to crude oil and natural gas facilities that are new, reconstructed and modified after 18 September 2015.
15. EPA Method 21 is used to determine VOC emissions from process equipment, and involves the application of a portable VOC monitoring instrument, such as an organic vapour analyser (a "sniffer").
16. L. Tsang (2018), EPA's Methane Regulations: Legal Overview, Congressional Research Service Report, 24 January 2018, p. 6.

In addition to regulations proposed by EPA, the Bureau of Land Management put into place rules to reduce waste from venting, flaring and leaks on onshore Federal and Indian leases, the so-called Onshore Order 9[17]. In particular, the rule targeted:

- Venting and flaring: venting of natural gas is prohibited, except in certain conditions, such as an emergency. The operators are required to reduce wasteful flaring. The operators are obliged to capture 85 percent of their adjusted total volume of gas emissions produced each month (starting from 18 January 2018) and this threshold rises to 98 percent in 2026. In cases when the flared gas qualifies as waste, it is subject to royalties.
- Implementation of Leak Detection and Repair (LDAR) programs to reduce fugitive emissions (based on 2016 NSPS).
- Reduced venting from equipment (e.g. pneumatic controllers and pumps, storage vessels, well maintenance and liquids unloading) by updating old, inefficient equipment and following best practices to minimise waste through venting.

To sum up, the 2016 NSPS introduced federal regulations targeting methane emissions from the oil and natural gas sector for new and modified sources at well sites, compressor stations and processing plants. In addition to this, some states such as California and Pennsylvania, adopted separate methane-specific regulations. The developments in the US, both at state and federal levels were observed closely by Canadian and Mexican regulators, who embarked on developing their own domestic rules on methane emissions.

Methane Regulatory Framework in Canada

The 2016 Canadian commitment to reduce methane emissions from the oil and gas sector was reaffirmed through the domestic legislation[18]. As part of its Nationally Determined Contribution (NDC), Canada expressed the intention to develop regulations tackling methane emissions from the oil and gas sector and to continue cooperating with "continental trading partners", the US in particular[19]. In fact, one of the regulatory approaches considered upon the development of the methane regulations was to align them with the abovementioned 2016 New Source Performance Standards. However, this approach was rejected, partly because these standards were perceived as an "unnecessary administrative burden" for the regulated companies on the one hand, and incapable of reaching the Canadian reduction objectives on the other, because they did not cover existing facilities[20].

In the end, the federal regulations in Canada were based on performance standards, allowing some degree of flexibility for provinces and territories through equivalency agreements. These provinces are permitted to develop their own regulations, provided they result in a similar or better environmental outcome. Moreover, the requirements concerning well completion involving hydraulic fracturing do not apply to the provinces of British Columbia and Alberta, as those jurisdictions have already adopted

17. Waste Prevention, Production Subject to Royalties, and Resource Conservation. Final Rule. Bureau of Land Management, 18 November 2016. The rule became law on 17 January 2017.

18. Pan-Canadian Framework on Clean Growth and Climate Change: Canada's plan to address climate change and boost the economy, 2016. Strategy on short-lived climate pollutants, 2017.

19. Canada's INDC Submission to the UNFCCC, submitted on 05/10/2016 (consulted on 18/09/2019).

20. Regulations Respecting Reduction in the Release of Methane and Certain Volatile Organic Compounds (Upstream Oil and Gas Sector) (SOR/2018-66). Regulatory Impact Analysis Statement, p. 57

equivalent regulatory measures[21]. It should be noted that British Columbia and Alberta accounted for almost 97% of Canada's natural gas and natural gas liquids national production in 2017[22] and, together with Saskatchewan's output, constitute the major oil and gas producing regions in the country.[23]

The Canadian Regulations were published on the 26 of April 2018. The majority of provisions should be implemented by the 1st of January 2020, with exception of requirements concerning general facility production venting and provisions on venting from pneumatic devices, applicable as of the 1st of January 2023.

The scope of Canadian regulations is limited to emissions from the upstream oil and gas sector, covering both new and existing facilities, located onshore and offshore. The focus on this segment of the value chain comes from the fact that almost 90% of oil and gas methane emissions originated from upstream sources, according to 2014 data[24].

Canadian regulations introduce two types of standards: general facility standards and standards applying to the facilities with a potential to emit above 60 000 m^3 of gas per year (see Table 2).

Methane Regulatory Framework in Mexico

Just over six months after the adoption of methane regulations in Canada, Mexico also delivered on its promise.) The Mexican methane regulations were published on the 6th of November 2018, and entered into force on the following day[25]. It should be noted that the process of developing regulations in Mexico was led by the Agency for Safety, Energy and Environment of Mexico (esp. Agencia de Seguridad, Energía y Ambiente, ASEA)[26] and supported by an international community of experts. The Center for Clean Air Policy (CCAP) jointly with Clean Air Task Force (CATF) organised a series of workshops, which looked at best practices and regulatory experience on methane emissions in the US and Canada, including the provincial and state regulations[27].

In contrast to the US and Canada, Mexican regulations cover the entire value chain, including natural gas distribution. They are applicable to both new and existing onshore and offshore sources[28]. The regulations introduce the bottom-up system building upon special programs (PPCIEMs), in which oil and gas companies specify their reduction targets and how they are going to achieve them. The scheme resembles the Governance of the Energy Union and Cli-

21. *Ibid.*, p. 58.

22. Canada Energy Regulator, Provincial and Territorial Energy Profiles – Canada (consulted on 18/09/2019).

23. Regulatory Impact Analysis Statement, *op. cit.*, p. 90.

24. Regulatory Impact Analysis Statement, *op. cit.*, p. 47.

25. Disposiciones Administrativas de carácter general que establecen los Lineamientos para la prevención y el control integral de las emisiones de metano del Sector Hidrocarburos.

26. Established in 2015, ASEA is a technical regulator overseeing the hydrocarbons sector. In particular, it deals with the issues such as industrial and operational safety and environmental protection.

27. The event aimed at the Mexican policy-makers and the key government agencies: Energy Ministry (SENER), the Environment Ministry (SEMARNAT), the National Agency for Safety, Energy and Environment (ASEA), the Institute for Ecology and Climate Change (INECC), and the National Hydrocarbon Commission (CNH). For more information see: <http://ccap.org/programs/oil-and-gas-mitigation/> (consulted on 23/09/2019).

28. Art. 2 of Mexican methane regulation defines the scope of regulation in the following way: "exploration and extraction of hydrocarbons; treatment, refining and storage of oil; the processing, compression, liquefaction, decompression and regasification, as well as transport per pipeline, storage and distribution of natural gas."

mate Action system with National Energy and Climate Plans (NECPs), which monitors the EU Member States' progress towards the achievement of EU energy and climate targets.

The NECPs are submitted to the European Commission, which assesses the plans and has the right to issue recommendations if the national plan in question is not in line with EU targets. Whereas, the plans prepared under the Mexican methane regulations are verified by an Authorised Third Party. The regulation itself does not specify if ASEA has the right to issue binding recommendations to companies, and more importantly, what actions ASEA could undertake in case aggregated targets submitted by the companies are insufficient to meet the regional pledge. In principle in such situations, ASEA has a power to issue recommendations and to impose administrative penalties (fines).

The Mexican Program for the Prevention and Integral Control of Methane Emissions (PPCIEM) is developed in three steps:

- **Step 1: Emission assessment.** Firstly, the companies identify the (potential) sources of emissions and divide them into three groups: equipment, well operations or non-scheduled activities. Then the types of emissions are categorised as: destruction equipment (flaring); fugitive leaks in well operations, equipment and components; or venting emissions. Once the emissions are identified and classified, the regulated companies are required to quantify their emissions based on one of the methodologies listed in Article 18, including: mass balance, mathematical models, engineering calculations or emission factors. The choice of the methodology needs to be justified.
- **Step 2: Program for the Prevention and Integral Control of Methane Emissions (PPCIEM).** The programs prepared by the regulated companies constitute a basis of prevention and control cycle. The regulated companies set out their percentage reduction target using the emission assessments from the first step as a baseline. They have a maximum of six years to achieve those objectives, counting from the time they submit their PPCIEMs to the Agency. The information and data provided to ASEA is considered public information[29].

The regulation sets different obligations for new (constructed after the 7th of November 2018) as opposed to existing facilities. The new facilities are required not to exceed the level of emissions from the base year, whereas existing facilities are only required to decrease their emissions by the amount specified in their targets. The companies need to specify how they are going to achieve these targets and they can choose from the list of technologies and best practices suggested in Title III of the regulation[30]. For instance, the facilities using reciprocating compressors are required to replace seals on the compressor rods, or adjust and align the rod packing systems, capture the emissions and direct them to a Vapour Recovery System (VRS).

- **Step 3: Continuous improvement.** Every year, the regulated companies outline their annual reduction objectives and actions per facility. They are required to keep track of their progress by evaluating the PPCIEM implementation and preparing the Annual Compliance Report (ACR) at least once per year (internal evaluation). As part of the ACR, the companies re-quantify their methane emissions and include the data in the report. The final ACR is then validated by an Authorised Third Party and handed in to the Agency along with the opinion issued by the

29. Art 5.

30. In particular, it refers to: Vapour Recovery Systems, pneumatic pumps, compressors, pneumatic controls, dehydrators, distribution and transport, separators and tanks, well stimulation and completions operations, liquid unloading, flaring and LDAR programs.

external evaluator in the first quarter of every calendar year and annexed to the Performance Report applicable to the hydrocarbon sector.

Discussion

How Robust is the Regulation in North America?

There are several factors that could influence the robustness of the regulatory framework in North America including: political backing of regulations, stability of the regulatory framework, institutional setting and cooperation with the industry.

To begin with, the adoption of methane regulations in three North American countries within less than three years after the 2016 joint announcement should be considered an important milestone. However, looking at the recent developments in the US, one might say that the methane regulations are only as robust as the political support they receive. The status of the methane regulations in the US is uncertain; the Trump Administration recently initiated the process of repealing the federal methane rules[31]. Nevertheless, this does not mean that the regulatory effort is in vain.

In the absence of federal regulations, some states have taken the initiative and developed their own regulations. One example is New Mexico, home to part of the Permian Basin and the San Juan Basin and thus, one of the major crude oil producing states. The observed increase in methane emissions from leaks, venting and flaring have been under the scrutiny of environmental groups for some time now[32]. In January 2019, New Mexico Democratic Governor Michelle Lujan Grisham issued the Executive Order directing the state authorities to develop methane regulations aiming at 45% reduction in GHG emission by 2030 compared to 2005 levels[33]. Moreover, New Mexico joined the group of governors – U.S. Climate Alliance – opposing the President Trump's decision to withdraw from the Paris Agreement.

Secondly, the regulatory framework adopted in the US, Canada and Mexico incorporates widely acknowledged practices and technologies aimed at methane emissions mitigation. Operators in all jurisdictions are required to conduct the LDAR programs, that is to find and fix leaks. Moreover, the regulations target the major sources of emissions such as pneumatic devices, compressors, well completion operations and suggest performance standards to ensure the minimization of methane emissions from their operations. In fact, the existing regulatory framework contains all the ingredients to be successful in meeting established targets.

Thirdly, the institutional setting and the independence of regulatory bodies are another factor contributing to the robustness of regulatory framework. Here, the Mexican regulatory agency, ASEA, is a positive example of determination to adopt a sound set of regulations and evidences a willingness to learn from the US and Canadian experience. However, there are some challenges that could influence the ASEA's ability to oversee the implementation process, such as the absence of the Executive Director after the resignation of Dr. Luis Vera Morales in mid-2019[34] and the overload of other agency work, such as the permit granting, and budgetary constraints.

Fourthly, despite the general belief that the oil and gas companies are rather reluctant to be regulated, the analysis of the recent regulatory experience in North America has proved that the opposite is true.

31. B. Scheid, "EPA's proposed rollback of methane regulations to impact marginal oil, gas wells", *S&P Global*, 29 August 2019.

32. J. Goldstein, New Mexico Begins Effort to Reduce Methane Pollution and Waste, Environmental Defense Fund, 7 June 2019.

33. Executive Order 2019-003 on addressing Climate Change and Energy Waste Prevention, 29 May 2019.

34. The nomination of the new Executive Director, Ángel Carrizales López, has been announced on 25 November 2019. Some media highlighted the lack of experience with environmental regulation of a new nominee, see: A. Solís, "AMLO impone a inexperto en la ASEA, confirma Semarnat", *Forbes México*, 25 November 2019.

Over the course of the last few years, these companies have begun to realise that a lack of concrete efforts to minimize methane emissions undermines not only their competitiveness, but also more importantly, the viability of natural gas as sustainable energy commodity. In fact, President Trump's retrenchment of methane regulations demonstrated the division between the US oil and gas companies. In contrast to the multinational oil and gas companies distanced themselves from the proposed changes and emphasised that "reducing emissions plays a large role in overall competitiveness in the long term"[35].

How Transparent is this Regulation from the Perspective of EU Consumers?

The three countries in question gather data on GHG emissions, including methane and report this to the United Nations Framework Convention on Climate Change (UNFCCC) Secretariat. It should be noted that the measurement, reporting and verification (MRV) requirements are more stringent for developed countries (US and Canada) and more lenient for developing countries such as Mexico.

However, the accuracy of existing methane inventories is questionable. Konschnik and Jordan (2018) refer to four categories of 'known unknowns' related to the methane inventories: imprecise emissions factors; uncertainty about the magnitude of 'super emitters'; incomplete well and activity data; and the inconsistency between bottom-up inventory estimates and top-down ambient monitoring of methane.

First, the methane emissions factors may not fully correspond to sector emissions. This may stem from the fact that the emissions factors have been calculated in the past, or that they are based on a relatively small sample of direct measurements, or that they do not illustrate the advances in the industry. Second, the existence of 'super-emitters' can skew the data interpretation. Super emitters represent a small number of the total facilities, but contribute disproportionately to total emissions. Emissions factors can also be difficult to assess due to abnormal process conditions such as equipment malfunction or operator error[36]. Third, in some cases, the information on well and activity data is fragmentary. As various organisations and states use differing taxonomy, even well count could be disputable. Moreover, some activities are overlooked: for a long time inventories did not include natural gas emissions from oil wells.

Fourth, there is a discrepancy between the bottom-up and top-down measurements[37]. The two methods have advantages and disadvantages[38]. Despite the fact that bottom-up approaches supply detailed information on the magnitude and patterns of emissions from a given source, their inventories are prone to errors such as overlooking sources or employing inaccurate or uncertain activity data or emission factors. On the other hand, top-down estimates include emissions from all sources, as they rely on atmospheric observations. However, the attribution of observed emissions to specific sources is usually a cumbersome process. Moreover, the accuracy of

35. E. Turner, "US LNG industry sees curbing emissions as key to its long-term future", *S&P Global*, 13 September 2019.

36. D. Zavala-Araiza et al., Super-emitters in natural gas infrastructure are caused by abnormal process conditions, *Nature Communications*, volume 8, Article number: 14012 (2017).

37. The main difference between these approaches refers to the starting point of measurements. Bottom-up methods draw upon measurements from a single facility or source, which can then be generalised to national, regional or global level. Top-down approach rely on atmospheric measurements, which help to assess the emissions from regions covering multiple facilities and sources.

38. National Academies of Science, Engineering, and Medicine 2018. Improving Characterization of Anthropogenic Methane Emissions in the United States. Washington, DC: The National Academies Press, pp. 133-138.

both measures could be further undermined by spatial or temporal sparsity of measurements.

In reality, all four 'known unknowns' require further research and cooperation between various institutions across the globe, which make them an area suitable for global cooperation.

How Promising is the Potential for Global Cooperation on Methane Emissions?

From the beginning, the US has been open to collaboration with foreign partners in efforts to abate methane emissions related to the production and transport of hydrocarbons. The 2014 US Methane Strategy foresaw strengthening its own function through cooperation with well-established international forums such as the Climate and Clean Air Coalition and the Global Methane Initiative. It should not come as a surprise that the announcement of a domestic methane objective evolved into a joint declaration with Canada and Mexico.

The North American energy market is highly interconnected and trade in crude oil, natural gas and refined products is multi-directional[39]. In fact, introducing methane emissions regulation in just one country could raise the issue of domestic companies being put at a competitive disadvantage. For these reason, the common declaration and the adoption of methane emissions regulation in three North American countries was the most efficient solution.

The analysis of methane regulations in North America shows that some practices and technologies, such as the employment of regular LDAR programs, have proven to be effective in some jurisdictions and can be used in other countries as well.

Then the question arises, is there potential to extend this initiative beyond North America? In reality, this already happened. In May 2016, the US, along with five Nordic countries – Denmark, Finland, Iceland, Norway and Sweden – reaffirmed a commitment to address the issue of methane emissions as part of their efforts to implement the Paris Agreement[40]. The Nordic countries pledged not only to prevent their methane emissions from rising, but also to advocate the "development of a global methane emission goal" in the oil and gas sector. Moreover, the issue of methane emissions is also the focus of the Arctic Council, an assembly of Nordic countries, the US, Canada and Russia[41].

There are several factors, which could drive the regulatory spillover in other jurisdictions:

- **Adoption of a Paris Agreement gives less weight to the difference between the developed and developing countries.** The latter group included some oil and gas producers such as Qatar and Algeria. Under the new transparency framework, all countries are required to monitor and report their GHG emissions, including methane. The uncertainty related to methane measurements is one of the key issues preventing policy intervention. However, the 5-year cycles of climate pledge submissions – the Nationally Determined Contributions (NDCs) will put more pressure on policy makers and regulators to introduce and revise their respective climate policies and regulations.
- **Emergence of a global gas market.** The shale gas revolution in the US and the rising role of LNG, as a way to transport gas over long distances, is integrating the regional markets into a more global gas market. The International

39. Council on Foreign Relations, North America. Time for a New Focus, Independent Task Force Report No. 71, 2014.

40. US – Nordic Leaders' Summit Joint Statement, 13 May 2016.

41. Arctic Council Expert Group on Black Carbon and Methane - Summary of Progress and Recommendations, 2019.

Energy Agency IEA expects that this trend will continue[42]. The increasing presence of LNG is bringing about positive effects – it increases the security of supply and the potential for coal-to-gas switching. The relationship between the LNG buyer and exporter is much more flexible than are the parties involved in traditional pipeline deliveries.

- In general, the unabated methane emissions associated with gas production and transport (embedded emissions) cast some doubts on the environmental impact of gas and may decrease the demand for gas among the importers by the year 2050[43].
- **In pursuit of a new leader.** In the absence of the US climate leadership, the European Union – one of the key natural gas importers with the strategy to become the carbon-neutral economy by 2050 and the European Green Deal in the making – is well-placed to become a new advocate of ambitious initiatives to reduce methane emissions, particularly those related to the energy sector. However, the challenge for the EU is two-fold: first, to clean-up EU domestic emissions and second, to ensure that imported natural gas does not involve substantial methane leakage.
- **The Achilles heel of the gas industry – the rising awareness.** The decarbonisation of the EU gas sector, which is one of the energy priorities for the incoming European Commission, will inevitably affect the EU's major natural gas suppliers. There is a consensus that keeping their shares in European market will not be possible without clearly demonstrating the environmental benefits of gas. The companies are now embarked on a process to develop their own narratives. The Russian Gazprom is investigating the possibility of producing clean hydrogen through a process of a thermal methane pyrolysis and of transporting it, blended with methane, to European consumers through the existing infrastructure[44].

US LNG exporters are concentrating on the reduction of methane emissions by cleaning-up the methane emissions at home, and by supporting the research into the GHG Life Cycle Assessment of different LNG supply chains and the available mitigation options[45].

Conclusions

This paper has analysed the policy and regulatory framework, aimed at the reduction of methane gas emissions in the hydrocarbons sector. These developments followed a trilateral pledge of the US, Canada and Mexico leaders to decrease their emissions by 40-45% by 2025, compared to the 2012 baseline.

The adoption of methane regulations in the three North American countries following the 2016 political declaration should be considered as an important milestone. The regulatory framework is robust, partly due to the fact that it builds upon the best practices, which have proved successful in other jurisdictions. The LDAR campaigns are a case in point.

Moreover, the three countries gather data on GHG emissions, including methane, in national inventories and report data to the UNFCCC Secretariat. However, the accuracy of measurements and estimations is questionable. The EU is well-placed

42. IEA (2019), "Global Gas Security Review 2019", IEA, Paris.

43. N. Tsafos, A Global Gas Strategy for the United States, Center for Strategic and International Studies Commentary, 9 May 2019.

44. A. Shiryaevskaya, "Russia Looks to Hydrogen as Way to Make Gas Greener for Europe", *Bloomberg*, 8 November 2018.

45. S. Roman-White, S. Rai, J. Littlefield, G. Cooney, T. J. Skone, "Life Cycle Greenhouse Gas Perspective on Exporting Liquefied Natural Gas from the United States: 2019 Update," National Energy Technology Laboratory, Pittsburgh, September 12, 2019.

to continue the advocacy for ambitious initiatives aimed at building the appropriate measurement, reporting and verification (MRV) framework for methane gas emissions.

The potential spillover of methane regulations could be further influenced by the following factors: the enhanced transparency framework under the Paris Agreement; the emergence of global gas market and changing gas consumer preferences; the potential leading role of the EU as an overarching arbitrator and the rising awareness among the oil and gas companies that, without addressing methane emissions, their long-term competitiveness and the competitiveness of gas as an energy commodity is threatened.

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Table 1. The summary of final standards by key emission sources under the 2016 NSPS.

SOURCE	SOURCE SUB-CATHEGORY	FINAL STANDARDS OF PERFORMANCE FOR GHGs and VOC
Compressors (excl. those located at well sites)	Wet seal centrifugal compressors	95% reduction
	Reciprocating compressors	The rod packing replacement on or before 26,000 hrs of operation or 36 calendar months or route emissions from the rod packing to a process through a closed vent system under negative pressure.
Pneumatic devices	Pneumatic controllers/pumps at NG processing plants	Zero natural gas (NG) bleed rate
	Pneumatic controllers at locations other than NG processing plants	NG bleed rate ≤ 6 standard cubic feet per hour (scfh)
	Pneumatic pumps at well sites	95% control if existing control or process is located on site. Not required if routed to an existing control or if technically infeasible. Limited-use pneumatic pumps – those that operate for less than 90 days per year – are exempt from the requirements.
Well completions	Subcategory 1: Non-wildcat and non-delineation wells	Reduced Emission Completion (REC) combined with a completion combustion device: venting allowed in areas where combustion would present safety hazards Initial flowback stage: route to a storage vessel or completion vessel and separator Separation flowback stage: route recovered gas from the separator to a flow line or collection system, re-inject the gas into the well, use the gas as an onsite fuel or use in other way. If technically infeasible, combust the gas. The operator is required to have a separator onsite during the entire flowback period.
	Subcategory 2: Exploratory and delineation wells and low pressure wells	The operator not required to have a separator onsite. Either: (1) route all flowback to a completion combustion device; or 2) route all flowback into one or more well completion vessels and commence operation of a separator unless it is technically infeasible for a separator to function. Capture and direct recovered gas to a completion combustion device. In some cases, the combustion is not advised e.g. fire hazard or explosion.
Fugitive emissions	From well sites and compressor stations	Monitor and repair fugitive emission components using OGI or Method 21 at 500ppm (parts per million). Develop and implement monitoring plan. Repair time: 30 days from discovery of fugitive emissions, unless the repair requires shutting down of production. In the latter case, the leak must be fixed at the next shutdown or within 2 years.
	Equipment leaks at NG processing plants	Leak and detection program is required if the concentration emanating from a leak is 500 ppm or greater. This does not apply to open-ended valves or lines.

Table 2. The summary of performance standards adopted in the Canadian Regulations Respecting Reduction in the Release of Methane and Certain Volatile Organic Compounds (Upstream Oil and Gas Sector).

APPLICATION	EMISSION SOURCE	PERFORMANCE STANDARD	EXEMPTIONS
All facilities	Venting from well completions involving hydraulic fracturing	No venting Conservation of natural gas for re-use on site or for sale, or flaring / clean incineration of natural gas Date of implementation: January 1, 2020	Alberta and British Columbia; cases where the gas does not have sufficient heating value to support combustion
All facilities	Venting from compressors	Annual measurements of emissions of natural gas from compressor vents Vent limit of 0.68m^3 per minute per compressor in case of large centrifugal compressors with a power rating > 5MW Vent limit of 0.001 m^3 per minute for new reciprocating compressors Corrective action when emissions are higher than the applicable limit Date of implementation: January 1, 2020	The compressors with a rated brake power below 75 kW
Facilities handling > 60.000m^3 of gas	Fugitive leaks	Implementation of a leak detection and repair (LDAR) program to stop natural gas leaks Inspections for leaks three times per year, Standards repair period: within 30 days Corrective action when leaks are found Date of implementation: January 1, 2020	Single wellheads and valve sites on transmission pipelines
Facilities handling > 60.000m^3 of gas	Facility production venting	Venting limit of 1,250 m^3 of natural gas per month (15,000 m^3 per year) Conservation of natural gas for re-use on site or for sale, or flaring / clean incineration of natural gas Date of implementation: January 1, 2023	Not applicable to non-routine venting (e.g. emergencies and blowdowns)
Facilities handling > 60.000m^3 of gas	Venting from pneumatic devices	Venting limit of 0.17 m^3 of natural gas per hour for pneumatic controllers No venting at sites where liquid pumping exceeds 20L/day Conservation of natural gas for re-use on site or for sale, or replacement with non-emitting or low-bleed pneumatic device Date of implementation: January 1, 2023	Not applicable if emissions are directed to control equipment or if the need for a higher-emitting controller is demonstrated

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